PART Ⅲ
TECHNICAL STUDY
OF THE PROJECT

Part III TECHNICAL STUDY OF THE PROJECT

Chapter 1 FERTILIZER INDUSTRY OF ZAMBIA

1.1 Fertilizer Production Plant

In Zambia, there is one fertilizer manufacturing plant of Nitrogen Chemicals of Zambia Ltd. (NCZ), a state enterprise member of ZIMCO. The plant is located in the Industrial Estate of Kafue, approximately 44 km south from Lusaka and has two trains of ammonia production facility using Maamba coal as raw material with annual combined capacity of 96,000 TPY of ammonia. Product ammonia is captively consumed for the production of nitric acid, ammonium nitrate, ammonium sulfate and granular compound fertilizer.

The first train (Plant I) was completed in 1970 and the second plant (Plant II) in 1982, however due to the technical troubles of the second plant, the overall capacity utilization of the facility has been approximately less than a half, and could supply a third of nitrogen fertilizer and chemicals requirements of Zambia. The first plant was rehabilitated in 1986 and the second plant is now under rehabilitation works which will be completed by the end of 1988 for full production. The plant has approximately 1,120 personnel in the 390,000 m^2 plant site of Kafue.

Historical capacity utilization of individual plant of NCZ is summarized as follows:

Historical Capacity Utilization of NCZ — Unit: %

	Ammonia		Ammonium Nitrate		Sulfuric Acid	Compound Fertilizer
Plant	Plant I	Plant II	Plant I	Plant II		Plant II
Rated Capacity, TPY	30,000	66,000	50,000	70,000	60,000	142,320
Year						
1971/2	63%	-	63%	-	-	-
2/3	56	-	56	-	-	-
4/5	100	-	100	-	-	-
6/7	94	-	94	-	-	-
8/9	94	-	94	-	-	-
1980/1	70	-	70	-	-	-
2/3	68	27%	68	27%	35%	32%
4/5	40	35	40	35	35	43
6/7	na	na	na	na	(40)	na

After the completion of the rehabilitation works in 1988, the overall inputs and outputs of the NCZ is projected as follows:

Production Balance Projection at NCZ — Unit: 1,000 TPY

Inputs		Intermediates		Salable Products	
Coal, Maamba	191.7	Ammonia	96	Nitric Acid	7.7
Pyrite, Nampundwe	40	Nitric Acid	120	Sulfuric Acid	10
Lime, CSSL	8.5	Sulfuric Acid	60	Ammonium Nitrate	
DAP, Import	27.5	Ammonium Nitrate	140	- Fertilizer	85
TSP, Import	23.7	Ammonium Sulfate	50	- Explosives	24
SOP, Import	9.6	Compound Fertilizer	142.32	Compound Fertilizer	142.32
MOP, Import	3.8	Methanol	1.65	Methanol	1.65
Conditioner, Import	1.5	Carbon Dioxide	1	Carbon Dioxide	1
Raw Water, Kafue River	21,600 TPD				
Electricity, ZESCO	46 MW				

Compound fertilizer is produced by using imported phosphate and potash jointly with the own products ammonium sulfate and nitrate.

The details of the plant production capacity, raw material and utility consumption, plant completion date and the plant supply contractors are illustrated in Table III-1.

Table III-2 summarizes the compound fertilizer product specification, raw material consumption and major agricultural crops of the compound fertilizer product applied in Zambia.

The specific features of the compound fertilizer plant at NCZ are:

- The process is basically solid mixing granulation using ammonium nitrate melt in rotation drum

- The largest production grades are "D" (10-20-10-11-0) and "R" (20-20-0-11-0) which are applied for maize in Zambia

- All compound fertilizer contains nitrate nitrogen approximately one fourth of total nitrogen, therefore the fertilizer handling is cautioned with bag label "Oxidizing Agent Assist Fire"

- All compound fertilizer contains high sulfur nutrient which comes from ammonium sulfate, sulfuric acid, single super phosphate and potassium sulfate

The rated capacity of compound fertilizer plant is 142,320 TPY, but is considered that the capacity will be increased up to 170,000 TPY with minor debottlenecking modification works. It is preferable that the proposed product phosphate fertilizer will be used as raw material for the production of compound fertilizer at NCZ for the substituting the imported phosphate by the domestic product produced from the proposed project.

All the fertilizer product from NCZ is sold to NAMBOARD, parastatal agency under the Ministry of Cooperatives for domestic marketing and physical distribution in Zambia and the domestic transport of the products are in bags and through railways and/or road vehicles to the NAMBOARD's depots at 15 locations in Zambia. NAMBOARD receives subsidies for fertilizer price differential and

fertilizer handling cost and has monopoly role over the procurement of fertilizer both from the domestic plant and imports (commercial and bilateral aid). Final marketing and distribution of fertilizer is undertaken by Provincial Cooperative Marketing Units (CMU) under the Ministry of Cooperatives, which have 18 fertilizer depots throughout Zambia.

The total staffing of NCZ was peaked in 1984 with 1,580 personnel and 59 expatriates when the second plant was commissioned, but now reduced to 1,120 under the Zambia-Fertilizer Industry Restructuring Project, sponsored by the World Bank. The latest organization and personnel at NCZ is illustrated in Table III-3.

1.2 Fertilizer Control and Regulation

In Zambia, regulation and control of fertilizer are as stipulated in the Agriculture (Fertilizers and Feed) Act - Chapter 351 of the Law of Zambia and The Agriculture (Fertilizers) Regulations - Subsidiary Legislation which define the fertilizer, method of analysis and maximum variation allowance for nutrients as well as the quantity and quality control of fertilizer in Zambia.

The main features of fertilizer regulation in Zambia are that fertilizer is quantified in terms of elements instead of oxides, only water soluble phosphate is recognized as legal effective phosphate fertilizer and nitrate nitrogen and sulfate type potash are given high importance in the legislation. However, among industry and commerce the international practices are widely accepted in Zambia.

There is no standards on fertilizer in Zambia Bureau of Standards (ZABS) under Ministry of Commerce and Industry (MCI) at present and in near future. The ZABS is responsible for the establishment of industrial standards, and have published already 28 standards by 1986, but no attempt has been taken on fertilizer issue in Zambia so far. It is understood that it will take at least three years for the establishment of new standard at ZABS under routine procedure.

The tender documents for fertilizer at the NAMBOARD and NCZ reveal the practical procedure for fertilizer control in Zambia. It may be noted that the Customs and Excise Act - Chapter 662 of the Law of Zambia has fertilizer classification for duty on guano, basic slag, thermophos, fused phosphate and others which have no water solubility of phosphate. Analytical method at NCZ

shows the citric and citrate soluble phosphate are defined for product quality control at the plant. All relevant document on fertilizer regulation in Zambia are summarized in Table III-4.

There are several unconsistencies and discrepancies among them and recommendation may be made for reviewing and revising the existing regulations of fertilizer in Zambia in view of developing technologies for fertilizer usage and production in the world.

Chapter 2 SUPPLY OF RAW MATERIALS

For the production of proposed phosphate fertilizer products, several raw materials are required and their suppliability in Zambia was studied. The major product alternatives are fused magnesium phosphate and single super phosphate, and as reference product alternatives triple super phosphate, diammonium phosphate and nitric phosphate were also studied. The combination of raw material and product is summarized as follows:

Product Alternatives and Raw Materials

Product Alternatives	Raw Materials
Fused Magnesium Phosphate	Phosphate Concentrate and Serpentine
Single Super Phosphate	Phosphate Concentrate and Sulfuric Acid
Triple Super Phosphate	Phosphate Concentrate and Sulfuric Acid
Diammonium Phosphate	Phosphate Concentrate, Sulfuric Acid and Ammonia
Nitric Phosphate	Phosphate Concentrate, Nitric Acid, Ammonia and Carbon Dioxide

At present, there is no supply source of commercial phosphate concentrate and serpentine in Zambia, but phosphate ore will be mined and concentrated at phosphate reserves in Chilembwe and serpentine will be mined at serpentine reserves in Mkushi.

Sulfuric acid is now produced at NCZ, Kafue and ZCCM in Copperbelt Province. Ammonia, nitric acid, carbon dioxide are produced at NCZ, Kafue.

During the course of the field works from November to December, 1986 in Zambia, general surveys at Chilembwe and Mkushi were made to take representative samples for analysis and testing in Japan. The list of sampled representative ores are shown in Table III-5. The analysis and testing results are reported in Chapter 3 of Part III. From technical consideration, these samples are adequate in quality for the production of various phosphate fertilizer alternatives.

2.1 Phosphate

In Zambia, at least four igneous phosphate reserves have been confirmed by MINEX, ZIMCO: Chilembwe and Kaluwe, East Province, Nkombwa Hill, Northern Province and Mumbwa, Central Province.

MINEX concluded that the development of Chilembwe phosphate ore was the most promising in Zambia, and a detailed study was undertaken in 1984/85. The study results are presented in "A Pre-Feasibility Study for the Phosphate Development Project, the Republic of Zambia, 1985, Japan International Cooperation Agency".

The study demonstrates that the minable phosphate reserve in Chilembwe is 1.55 million tons of 11.5% P_2O_5 quality and 40,000 TPY-wet of phosphate concentrate with 30.0% P_2O_5 quality (dry) will be recovered annually by the flotation process. The reserve is small and limited, and will be mined out in 15 years of project life. The total investment cost is estimated US$12.8 MM and ex-mine phosphate concentrate is priced US$77.0/Ton-dry. The financial internal rate of return on investment of the mining and concentrate project is calculated 7.1% before tax and 5.9% after tax (tax rate of 45%) assuming 27% of equity and 73% long term loan financing with 4.0% annual interest rate. Economic return is estimated 12.8% assuming imported phosphate concentrate pricing of US$90.0/Ton. The transport cost of phosphate concentrate from Chilembwe to 540 km distance by road is estimated US$59.8/Ton-dry. These project profile was adjusted and modified in accordance with the latest economic condition in Zambia for the present study.

The phosphate ore mining and concentrate project in Chilembwe as proposed in the original report is summarized in Figure III-1, Table III-6 and III-7, respectively. The revised project scheme will be discussed and summarized in Chapter 5 of Part III.

2.2 Serpentine

MINEX, ZIMCO made a study on the serpentine reserve at Muloba, Mkushi in 1986. The study results are documented in "Occasional Report on the Muloba Serpentine, Mkushi District, Central Province, Zambia, MINEX, ZIMCO, September, 1986". The reserve is located at 55 km north-east of Kapiri Mposhi along Great North Road and TAZARA railways system. Zamanglo Exploration Ltd. discovered the Muloba Serpentine Hill in 1974 during the geophysical investigations for nickel reserves.

According to the report, the major minerals of the reserves are antigorite ($3MgO \cdot 2SiO_2 \cdot 2H_2O$) and calcite. Tourmaline, chrysotile and serpophite are associated. The crystalline size averaged 0.2 mm in diameter and specific gravity of the minerals is measured as 2.5.

There are three hills of serpentine as follows:

Serpentine Reserve at Mkushi, Zambia

Serpentine Hill	Hill Size, Meter			Proved and Probable Reserve, MM, Ton	Average Analysis, MgO, %
	Height	Length	Width		
South High	22.5	250	100	0.640	32.8
Middle Low	13.0	250	140	0.293	19.1
North Low	4.0	100	80	0.071	31.0
Total/Average	-	-	-	1.004	27.0

The South High Hill is the largest and richest in MgO content and suitable for the raw material of fused magnesium phosphate production. Annual requirement of serpentine for the proposed project is 20,000 TPY, therefore the reserve of South High Hill alone is adequate for 32 years of operation.

The investment cost and production cost of the serpentine is estimated as US$0.96 MM and US$20.34/Ton - dry in 1991, respectively. It is assumed that MINEX, ZIMCO will implement the serpentine mining project and supply crushed serpentine to the fused magnesium phosphate project upon the approval of the project. The transportation cost of serpentine from Mkushi to Kafue by road and railways is estimated US$25.89/Ton - dry in 1991. The serpentine mining project will empoly 20 personnel as permanent staff.

The geology map with magnesia content measured by MINEX is shown in Figure III-2 and topography of Muloba, Mkushi is shown in Figure III-3.

2.3 Sulfuric Acid and Others

For the production of single super phosphate, approximately 20,000 TPY of sulfuric acid is required for the proposed project, annually. Sulfuric acid is produced at NCZ, Kafue and ZCCM, Chambishi and Nkana, both near Kitwe, Zambia.

At present, sulfuric acid is produced at ZCCM as objective product by using smelting flue gas as well as pyrite roasting gas, and the product is captively

consumed for leaching of copper from copper oxide ores and tailings. Annual production of sulfuric acid is estimated 293,000 TPY. Therefore, ZCCM has no surplus sulfuric acid for the proposed single super phosphate project. However, it is understood that ZCCM is now investigating the modernizing project of copper smelting plant and upon the completion of the project, ZCCM may have surplus acid for outside sales. The available tonnage, year and pricing are not clear at this moment.

NCZ has a sulfuric acid plant at Kafue using pyrite from Nampundwe Mines of ZCCM, approximately 50 km west of Lusaka. Annual design capacity of the plant is 60,000 TPY and was completed in 1983. The supply of pyrite is considered adequate but the capacity utilization in 1986 is less than a half because of the low operating rate of the down-stream ammonium sulfate plant.

Sulfuric acid balance at NCZ upon the completion of rehabilitation works in 1988 is estimated as follows:

Sulfuric Acid Balance at NCZ, 1989

Design Capacity	60,000 TPY
Annual Production	60,000
Consumption	
- NCZ's Captive Uses	50,075
- Ammonium Sulfate (50,000 TPY)	(39,075)
- Direct Use for Compound Fertilizer (142,300 TPY)	(11,000)
Outside Sales	
- Alum Production in Kafue	7,000
Surplus	2,925

Therefore, in principle, under the assumed conditions above, sulfuric acid supply is not adequate for the proposed single super phosphate project in Zambia. However, in practice, considering the objectives of ammonium sulfate production at NCZ is to supply sulfur nutrients in compound fertilizer for applying sulfur to sulfur deficit soil in Zambia, then the diverting sulfuric acid from present ammonium sulfate production to single super phosphate production will create a same result in sulfur balance in Zambian agriculture, because the new product of single super phosphate is containing sulfur nutrient and destined to the farm soil in Zambia.

The deficit of nitrogen supply, in association with the production reduction of ammonium sulfate at NCZ will be supplemented with increased use of ammonia and/or ammonium nitrate in the products or imported nitrogen fertilizers, and will be resulted in increased supply of phosphate which will substitute the present phosphate import and keeping a same level of sulfur supply (ammonium sulfate or gypsum in single super phosphate) for the economy of Zambia.

From the discussion above, it may be reasonable to assume that NCZ will agree to divert a portion of sulfuric acid from the present production of ammonium sulfate to the proposed single super phosphate production according to the pricing of sulfuric acid and other national economic benefits, if manifested.

Therefore, the proposed project for the production of single super phosphate will be further studied and analyzed assuming an adequate supply of sulfuric acid from NCZ in Kafue. However, if NCZ is not in a position to supply sulfuric acid under present condition the possibility of sulfuric acid supply from ZCCM and expansion of existing sulfuric acid plant at NCZ should be considered as an alternatives. Even if sulfuric acid is coming from ZCCM, Copperbelt Province, the location of single super phosphate plant is optimized in Kafue location because of raw material and product logistics in Zambia.

The production cost of sulfuric acid at NCZ from July to September, 1986 is documented as follows:

Production Cost of Sulfuric Acid at NCZ, ZK/Ton - 1986

	Actual-1986	Estimate for Full Production
Capacity Utilization, %	42	100
Production Cost, ZK/Ton-1986		
- Variable Cost*	412	412
- Fixed Cost	438	184
- Financing and Administrative Overheads	94	39
Total Cost	944	635
Sales Realization	1,407	-
Sales to Chem. Engg. Supply Ltd. (Alum Production in Kafue)	1,130	-

* Pyrite is priced ZK420/Ton in 1986 and unit consumption is 0.90 TPT for sulfuric acid production.

The other raw material such as ammonia, nitric acid and carbon dioxide are available only at NCZ, Kafue in Zambia which is adequate in quantity for the proposed project as is shown in Chapter 1 of Part III.

Chapter 3 PRODUCTION TESTS

3.1 Phosphate Concentrate

The representative phosphate ore was taken at Chilembwe on November 28, 1986 in consultation with MINEX and a 220 kg weight sample was taken back to Japan for the detailed analysis and for preparation of phosphate concentrate which are further used for the production tests of fused magnesium phosphate and single super phosphate.

The size of the ore is 10 cm in diameter and its analysis is P_2O_5 18.6%. The ore is ground 50% pass through 80 mesh screen and beneficiated by flotation using caustic soda, water glass and flotation reagents: Lilaflot-BS, anionic collector derivatives of fatty acid, produced at KenoGard AB, Sweden. The processes applied are rougher flotation and cleaning to obtain phosphate concentrate with P_2O_5 concentration of 33.69% at 97.2% phosphate recovery. The flotation is by batch-wise using 1.0 kg ore for processing. Total sample produced is 60 kg in weight for further tests.

The test results are summarized in Table III-8. The analysis and physical properties of serpentine, dolomite and silica sand of Zambia are also summarized in Table III-8. The analysis shows that phosphate concentrate is high in analysis of P_2O_5 as well as flotation recovery. The quality of serpentine is high in MgO and SiO_2, and suitable for fused magnesium phosphate production. The analysis of dolomite and silica sand are also adequate for fused magnesium phosphate production, but these minerals are not used for further testings because serpentine is more economical for the production of fused magnesium phosphate.

The minerals in the phosphate concentrate from Chilembwe ore are identified by X-ray diffraction and chemical analysis that the major minerals are fluorapatite [$3Ca_3(PO_4)_2 \cdot CaF_2$] and hydroxyapatite [$3Ca_3(PO_4)_2 \cdot Ca(OH)_2$], and quartz ($SiO_2$) and hornblende ($2CaO \cdot 5MgO \cdot 8SiO_2 \cdot H_2O$) are associated as minor contaminants.

The analysis of recovered phosphate concentrate is 33.69% P_2O_5 and 46.18% CaO on a dry basis and production tests were carried out using the phosphate concentrate, but the conceptual design of phosphate fertilizer plants were formulated assuming that phosphate with 30.00% P_2O_5 and 41.11% CaO analysis will be supplied from Chilembwe as an average during the project life because of allowance of design basis of phosphate mining and concentrate project.

3.2 Fused Magnesium Phosphate

The production tests for fused magnesium phosphate were undertaken by using the phosphate concentrate recovered from Chilembwe phosphate ore and serpentine from Mkushi, Zambia. The tests were designed to make comparison between phosphate concentrates from Florida, USA and Chilembwe, Zambia, because in Japan, fused magnesium phosphate is commercially produced from Florida phosphate.

The mineral composition of phosphate concentrate of the USA and Zambia are similar except the size distribution and fluorine contents. The size is smaller in Zambian phosphate but it is concluded that the phosphate is usable without pelletizing by adjusting electricity discharge method in the furnace to cover powder phosphate with molten product. The fluoride discharge is lower for Zambian phosphate.

The production tests were carried out by using batch-wise experimental electric furnace with 7 kg batch sample which is melted at 1,300°C for 50 minutes and the molten reaction product is quenched in water bath to obtain glassy fused magnesium phosphate product. The product quality is high in citric acid solubility of phosphate. No difference in quality is observed between Zambian and Japanese product in chemical analysis and X-ray diffraction analysis.

The production test results of fused magnesium phosphate are summarized in Table III-9 which are utilized for the conceptual design of the proposed phosphate fertilizer project.

The X-ray diffraction chart of Chilembwe and Florida phosphate concentrates as well as produced fused magnesium phosphate from the two phosphates are shown in Figure III-4. The two products show homogeneous quenched glassy state which is considered to give high solubility of phosphate by citric acid.

3.3 Single Super Phosphate

Single super phosphate is a reaction product between phosphate concentrate and sulfuric acid, and its production reaction is expressed in the case of fluorapatite as follows:

$$\underset{\text{(Fluorapatite)}}{3Ca_3(PO_4)_2 \cdot CaF_2} + 7H_2SO_4 + 3H_2O$$

$$= \underset{\text{(Single Super Phosphate)}}{3Ca(H_2PO_4)_2 \cdot H_2O} + 7CaSO_4 + 2HF$$

It is well known that some igneous phosphate is unreactive and difficult to produce single super phosphate with high solubility of phosphate.

Production tests of single super phosphate were undertaken by using phosphate concentrate recovered from Chilembwe phosphate ore in comparison with Florida phosphate concentrate, the USA because Florida phosphate is widely used for the commercial production of single super phosphate fertilizer throughout the world.

As preliminary tests indicated the unreactivity of Zambian phosphate, the raw material were ground more finely: 90% through 200 mesh screen for Zambian and 80% through 200 mesh for Florida, however the energy requirement for grinding is not increased so much because the recovered phosphate concentrate by flotation is already finely ground. Production tests were carried out batch-wise by using a 100 g phosphate concentrate to find out the optimized reaction conditions and product quality after 28 days of aging period. Major factors tested are as follows:

- Size distribution of phosphate concentrate
- Quantity of sulfuric acid
- Concentration of sulfuric acid
- Reaction temperature

The production test results are summarized in Table III-10 which is utilized for the conceptual design of the proposed single super phosphate fertilizer plant. The results indicate that standard grade single super phosphate is produced from phosphate concentrate recovered from Chilembwe phosphate ore in Zambia.

It is noted that the reactivity of phosphate from Chilembwe is lower than that of Florida and takes longer den residence time and higher temperature for complete reaction and solidification of the reaction mass.

Finely grinding of phosphate and/or addition of a small amount of calcium carbonate for the acceleration of reaction by carbon dioxide generation in the mass will help the reaction. The Zambian product quality is identical with standard product from Florida.

Chapter 4 PROJECT SITE SELECTION AND UTILITY SUPPLY

4.1 Alternative Sites

During the course of the field work from November to December, 1986 in Zambia, four alternative sites for the proposed phosphate fertilizer plant project have been pre-selected in consultation with INDECO. Major factors taken into consideration were the raw materials and product transport, utilities supply of industrial water and electricity as well as the infrastructure development situation and technical level of personnel available in the region at present and in near future.

The pre-selected candidate sites in Zambia are as follows:

Township of Alternative Sites	Locality
(1) Kafue	Southwest of NCZ
(2) Kabwe	Chimanimani Village
(3) Ndola	Industrial Area
(4) Kitwe	Industrial Area

The basic requirements for site selection for the product alternatives applied during the field works are cited as follows:

Basic Requirements for Site Selection

Product Alternatives	Process Plant	Raw Material, TPD: Phosphate Concentrate	Raw Material, TPD: Others	Utility Supply: Electricity MW	Utility Supply: Raw Water TPD	Utility Supply: Fuel TPD	Site Area m^2
(1) FMP	Electric Furnace	117	77 -Serpentine	8.0	1,000	10	50,000
(2) FMP	Open Hearth Furnace	117	77 -Serpentine	1.5	1,000	35	50,000
(3) SSP	Acidulation	117	71 -Sulfuric Acid	0.5	1,000	5	50,000
(4) TSP	Phos Acid	117	70 -Sulfuric Acid	0.5	1,000	5	50,000
(5) DAP	Phos Acid	117	105 -Sulfuric Acid, 16-NH_3	0.5	1,000	5	50,000
(6) NP	Crystallization	117	45-NH_3, 145-HNO_3, 55-CO_2	1.5	1,000	15	50,000

Location map of the sites are illustrated in Figure III-5 and general description of the sites are discussed below:

4.1.1 Kafue

Kafue is located 44 km south from Lusaka on Great North Road and ZR railways system, and has Industrial Estate with established factories such as NCZ (only one fertilizer plant and one of the largest industrial plant in Zambia, total plant site area: 390,000 m^2, employee: 1,120 in 1987), Bata (Zambia) Bata Shoe Co., Ltd., Kafue Reinforced Plastics Ltd., Kafue Textiles of Zambia Ltd. and Chemical and Engineering Supply Ltd. The proposed site in Kafue is located at the southwestern portion of NCZ's property where NCZ has no plan for future utilization. The location is advantageous in the access of railways siding, road connection, water intake from Kafue River (3.0 km), ZESCO's Substation and well developed industrial infrastructure in the Estate. The supply of sulfuric acid from NCZ will be met by pipeline and product SSP will be sent by belt conveyor to NCZ for compound fertilizer production at NCZ. The soil bearing capacity of the site is estimated as 5.0 Ton/m^2.

4.1.2 Kabwe

Kabwe is situated 138 km north from Lusaka on Great North Road and ZR railways system, and is the mid-point between Lusaka and Copperbelt. Kabwe is the geographical gravity center of Zambia. There are several factories such as Zinc Smelting Plant of ZCCM, General Pharmaceutical Ltd., Kabwe Industrial Fabrics Ltd. and others. A proposed site is identified in Chimanimani Village on ZR's railways approximately 5.0 km from the center of Kabwe. Access to ZESCO's Kabwe Substation is approximately 3.0 km, however at present the availability of water supply is rather limited up to 30,000 TPD for the total regional uses.

A large scale water development plan is now underway for the construction of reservoir dam at Mulungushi River under bi-lateral agreement with Italian Government. The Kabwe Surface Water Scheme will be supplying of water: 40,000 TPD at the first phase project by 1989 and additional 40,000 TPD in the second phase project. Population of Kabwe was 140,000 in 1980.

4.1.3 Ndola and Kitwe

Ndola and Kitwe are the industrial center of Copperbelt Province with 280,000 and 315,000 population in 1980, respectively. There are adequate utility supply and transport infrastructure as well as the highest industrial level in the Republic. Water will be supplied from Kafue River. ZCCM in Ndola and Kitwe will be able to supply sulfuric acid for the production of SSP for the proposed project, if ZCCM will implement the modification works of its existing smelting plants in the future.

4.2 Site Comparison and Selection

4.2.1 Site Conditions

The site conditions for the four pre-selected project sites: Kafue, Kabwe, Ndola and Kitwe, and the sites for raw materials supply project of phosphate concentrate and serpentine: Chilembwe and Mkushi, are surveyed for the selection of the project plant site and for the subsequent conceptual design of the project facilities.

The survey items cover the general description of site conditions, soil data, climatic, labour, raw material and product physical distribution facilities. The comparison of such basic data are summarized in Table III-11.

Further, the supply of electricity and its tariff, raw water supply and its tariff, expansion and investment cost for the access road and railways siding are calculated and compared in Table III-12.

4.2.2 Infrastructure

(1) Railways

There are two railways systems in Zambia: Zambia Railways Ltd. (ZR) and Tanzania-Zambia Railway Authority (TAZARA). ZR starts at Victoria Falls Bridge, Livingstone and goes up north to Choma, Kafue, Lusaka, Kabwe, linked with TAZARA at Kapiri Mposhi and further goes to Ndola, Kitwe, Chambishi and Chingola in Copperbelt Province with total length of 1,273 km.

TAZARA starts at Dar-es-Salaam Port of Tanzania and goes west to Morogoro, Iringa, Mbeya and comes into Nakonde, Mpika of Zambia and links to ZR at Kapiri Mposhi with total length of 1,859 km.

Railways systems are the most important transport infrastructure in Zambia and widely utilized for cargoes as well as passengers. The tariff is lower than road transport for industrial commodities. For the transport of machinery and equipment for the project, TAZARA from Dar-es-Salaam will be utilized, for the transport of raw material of serpentine, loading at Lunsemfwa Station of TAZARA and ZR will be utilized and for the product phosphate fertilizer transport, ZR and TAZARA will be extensively used.

The weight limit of wagon is 44 ton for machinery, 40 ton for minerals and 36 ton for bagged fertilizer, and the dimension limit for abnormal load is 2.95 m in height and 11.3 m in length.

Tariff of ZR and TAZARA in January, 1987 is as follows:

Railways Tariff in Zambia, ZK/Ton - metric-km

Distance, km	ZR			TAZARA
	Machinery	Minerals	Bagged Fertilizer	General
50	1.12	0.65	-	1.00
100	0.61	0.35	0.29	0.50
200	0.48	0.25	0.20	0.30
500	-	-	0.16	0.20
1,000	-	-	0.14	0.15
1,500	-	-	-	0.13

A brief statistics of the railways systems are given below and a simple route map is shown in Figure III-6.

Railways Systems in Zambia

Items	ZR	TAZARA
Total Length, km	1,273	1,859
Gauge, m	1.067	1.067
Passengers, Millions-1985	1.8	1.16
- Passenger-km, Million	434	-
Cargoes, Ton-Millions-1985	4.9	0.98
- Ton.km, Million	1,403	
Locomotives	79	102
Passenger Coaches	88	100
Cargo Wagons	6,800	2,150

(2) Roads

The total length of roads of Zambia in 1983 is 37,000 km: 5,708 km of bitumen and 8,645 km of gravel, and the total number of vehicles in 1983 is 125,000: 15,000 of governmental and 110,000 of private.

The growth of road transport is higher than the railways, despite the higher tariff but due to the quick delivery and developing road infrastructure in Zambia.

A simple road map is shown in Figure III-7, it should be noted that the transport of phosphate concentrate from Chilembwe to the phosphate fertilizer plant sites is only possible by road transport because of the lack of railways facilities in the region. There are several road haulage firms such as Contract Haulage Ltd., ZIMCO and Manica Freight Services (Zambia) Ltd. who will carry cargo under long-term contract in Zambia. Average haulage tariff is estimated as ZK 0.80/Ton-km for large and long term haulage contract in 1987 which is considerably higher than railways tariff for longer haulage over 100 km distance. Simplified transport tariff comparison between railways and road are illustrated in Figure III-8 and transport route is shown in Figure III-9.

(3) Aviation

Zambia has a total of 18 airport of which 3 are international airport: Lusaka, Ndola and Livingstone. Domestic number of flights, passengers, freight and mail tonnage in 1982 were 42,700, 677,000 and 15,900 TPY, respectively.

The aviation routes and major airport are shown in Figure III-10.

(4) Electricity

Over 99% of electricity generation in Zambia is hydroelectric at Kafue and Zambezi Rivers. The major hydroelectric power plants are:

Major Hydroelectric Power Plant in Zambia

Location	Capacity MW	Completion Year
Victoria Falls	108	1938, 68, 72
Kafue Gorge	900	1972, 77
Kariba North	600	1976
Sub-Total	1,608	

Two third of the domestic consumption is for the mining and smelting uses in Copperbelt Province. Annual domestic consumption growth has been recorded 2.0% last ten years, and expansion of hydroelectric power generation is scheduled as follows:

Major Hydroelectric Power Plant Expansion in Zambia

Location	Capacity MW	Completion Year
Kariba North	300	1994
Itezhi-tezhi	80	1996
Kafue Stage	450	1997
Sub-Total	830	

The generation and transmission of electricity in Zambia is controlled by ZESCO and its tariff is charged as a sum of fixed charge, demand charge and energy charge, and additional governmental sales tax of 15% on the tariff.

Table III-13 summarizes the electricity financial pricing and long run marginal cost as well as the export pricing to Zimbabwe, sales tax and sectoral sales revenue.

It may be noted that the export pricing to Zimbabwe is the lowest followed by industrial bulk tariff for CPC/ZCCM, industrial, commercial and household tariff.

The export tariff to Zimbabwe is 36% of domestic industrial tariff before sales tax and 32% after sales tax. The long run marginal cost (for the year 1994 at 1987 price level) is much higher than the present tariff: 5.2 times for industrial tariff before tax and 4.5 times after tax. These factors should be reflected in financial and economic analysis of the proposed project in Zambia. The major electricity generation and transmission line of ZESCO are illustrated in Figure III-11. The maximum electricity requirement for the proposed project is approximately 8 MW for the production of fused magnesium phosphate, which is considered marginal for ZESCO's present surplus electricity and its pricing is extremely low in comparison with the other countries where thermal power plants are operated.

(5) Raw Water

Major sources of raw water in Zambia are from Zambezi, Kafue, Luangwa and Chambeshi Rivers. Water requirements up to 1,000 TPD for the proposed phosphate fertilizer project is marginal at Kafue, Ndola and Kitwe except in Kabwe at present.

In Kabwe, water supply will be adequate upon the completion of water dam at Mulungushi River in 1989.

The typical water analysis of Kafue River is cited below:

Raw Water Analysis at Kafue River

Items	Analysis, ppm
Total Suspended Solid	255
Cl	13
SO_4	20
BOD	40
Total Hardness	112
pH	7.65

4.2.3 Environmental Standards

In Zambia, there is waste water control standards stipulated by the regional council in 1985 as shown in Table III-14. The major environmental standards related to the proposed phosphate fertilizer project is 45 ppm of phosphorus and 30 ppm of fluoride in waste water discharged in public waste water systems in Zambia. There is no regulation for atmospheric standards in Zambia at present.

In Table III-15, a comparison of industrial air and water effluent control standards in Zambia, the USA and Japan are summarized. Prior to the basic design of the proposed project, a more detailed study on environmental standard and assessment should be undertaken referring to the effluent standards in the industrialized countries such as the USA, Japan and European countries.

4.2.4 Raw Material and Product Transport Cost

The pre-selected four project sites have different features, but Kafue, Ndola and Kitwe are almost identical in utility, infrastructure and technical level while Kabwe is disadvantageous in water supply at present.

The most important factor for the selection of the site is the transport cost for raw material and product. For the production of fused magnesium phosphate, approximately 40,000 TPY of phosphate concentrate from Chilembwe, 20,000 TPY of serpentine from Mkushi to the project site and 50,000 TPY of product should be transported annually. For the production of single super phosphate, approximately 40,000 TPY of phosphate concentrate from Chilembwe, 20,000 TPY of sulfuric acid from NCZ, Kafue to the project site and 57,000 TPY of product to NCZ, Kafue should be transported annually.

For the comparison of raw materials and product transportation costs, the product destinations are assumed according to the present phosphate fertilizer consumption in Zambia. The largest consuming regions are Monze, Chipata, Lusaka and Kabwe. Assuming railways and road transport tariffs as well as loading, unloading and transhipment costs, annual transport costs for raw material and product for each candidate plant site were calculated in Table III-16 and summarized as follows:

	Sites and Annual Transport Cost, ZK, MM-1987			
	Kafue	Kabwe	Ndola	Kitwe
Fused Magnesium Phosphate				
- Phosphate Concentrate	18.1	21.1	26.9	28.2
- Serpentine	3.5	3.1	3.2	3.3
- Product	7.8	8.5	10.7	11.4
- Annual Transport Cost	29.4	32.7	40.8	42.9
- (Unit Transport Cost, ZK/Ton)	(583.3)	(648.8)	(810.5)	(851.4)
Single Super Phosphate				
- Phosphate Concentrate	18.1	21.1	26.9	28.2
- Sulfuric Acid	0.2	1.1	1.7	1.8
- Product to NCZ	0.0	3.1	4.7	5.2
- Annual transport Cost	18.4	25.4	33.4	35.2
- (Unit Transport Cost, ZK/Ton)	(321.1)	(443.8)	(583.4)	(614.6)

The overall transport cost is the lowest at Kafue and the highest in Kitwe. The product transport is destined to market place for fused magnesium phosphate and to the compound fertilizer granulation plant of NCZ for single super phosphate.

However from the analysis, regardless to the product destination to market place or to NCZ, the transport cost is the lowest in Kafue. The average transport cost from Kafue to the average weighted transport center is ZK155.2/Ton-1987.

Therefore, the proposed phosphate fertilizer project should be located in Kafue as the optimal site in view of raw material and product transport. Phosphate concentrate should be transported by road from Chilembwe. Kafue is located nearest to Chilembwe and also nearest to the center of the phosphate fertilizer market in Zambia. The utility supply, infrastructure and technical aspects are considered almost identical among Kafue, Ndola and Kitwe except in Kabwe where raw water supply is tight at present. Kafue is also advantageous in view of the well established operations of NCZ which will be able to assist and collaborate with the phosphate fertilizer project in utility supply, maintenance and operation as well as project management during implementation and operation stages.

Chapter 5 CONCEPTUAL DESIGN OF THE PROJECTS

5.1 Basis for Conceptual Design

In this feasibility study, there are three projects to be studied. One up-stream project: the phosphate mining and concentrate project located in Chilembwe, and two alternative down-stream projects: the fused magnesium phosphate project or the single super phosphate project, both located in Kafue. There is another small scale project of up-stream: the mining of serpentine project located in Mkushi, but in view of smaller investment cost required the project is assumed as an independent operation of MINEX to deliver the crushed serpentine to the fused magnesium phosphate project in Kafue at cost.

In principle, the phosphate mining and concentrate project is also independent from the two down-stream projects, because the feasibility study was completed in 1985 and MINEX will implement the project to supply phosphate concentrate at financially viable pricing to the down-stream projects of phosphate fertilizer production for INDECO, now under study.

However, in practice, the phosphate concentrate product from the up-stream project is non-traded and non-tradable commodity without the realization of the down-stream project in Zambia. Therefore, the financial and economic analysis should be undertaken to investigate an overall return on investment, cash flow as well as cost and benefit comparison as an integrated project of up-stream and down-stream projects. A fair transfer price of phosphate concentrate will be defined to realize a same return on investment for up-stream and for down-stream project, therefore the transfer price will be specific to each down-stream project: fused magnesium phosphate or single super phosphate.

If such transfer price of phosphate concentrate is too high financially for down-stream project, pricing of imported phosphate concentrate should be examined to find out the project feasibility. But this approach may be contradictory because the investigation of phosphate reserves in Chilembwe must be initiated to find out domestically available as well as financially and economically beneficial source of phosphate concentrate than merely importing it at market price. Market price of non-traded commodity does not necessarily mean financially and economically viable price for the proposed project.

The linkage of these projects are illustrated in Figure III-12. Whole complex is designed to start with the annual phosphate concentrate output of 35,181 TPY-dry with project life of 15 years commencing the commercial production on July 1, 1991 at Chilembwe. The production of phosphate fertilizer at Kafue is limited up to a half to one third of present consumption of phosphate fertilizer in Zambia because of the limited minable phosphate reserves so far confirmed in Chilembwe.

5.2 Phosphate Mining and Concentrate Project

The conceptual design and feasibility study of the up-stream project was completed in 1985. A simplified process configuration is cited in Figure III-13. The project will be located in Chilembwe to mine and process 332,400 TPY of phosphate ore to produce 35,181 TPY-dry phosphate concentrate: 30.00% P_2O_5 and 41.11% CaO. The phosphate concentrate is coming out as wet with 12% free moisture which will be transported for 541 km on road under a long term haulage contract to Kafue.

For the operation of the project, 117 personnel is required as permanent staff and the organization and personnel allocation for the project is given in Table III-17. The project implementation schedule is developed by assuming the construction contract award in July, 1989 and the commencement of the commercial production in July 1, 1991. The implementation schedule is illustrated in Figure III-14. The details of the project conceptual design will be referred in the original pre-feasibility study report of 1985.

5.3 Fused Magnesium Phosphate Project

The project will be located in Kafue and consume 35,181 TPY-dry of phosphate concentrate from Chilembwe as well as 19,103 TPY-dry serpentine from Mkushi to produce 50,400 TPY of fused magnesium phosphate as final product.

The overall material and utility balance, production and product specification are shown in Table III-18. Process flow diagram and general plot plan of the project facility are illustrated in Figure III-15 and III-16, respectively. The process is to at first dry the delivered phosphate concentrate and mix with crushed serpentine in pre-determined ratio and feed into electric furnace for complete melting and reaction. The molten mass is quenched in high speed stream of

water to obtain the pulverized glassy phosphate. The wet product is dried and bagged as straight phosphate fertilizer for final shipment.

Specification of the product is C-P_2O_5 20.11%, C-MaO 14.05% and S-SiO_2 26.16%, and citric acid solubility of phosphate is over 99% in the product. The fluorine in the phosphate concentrate is recovered as calcium fluoride in thickener slurry.

The process configuration is shown in Figure III-17. The project will need 83 personnel for the operation and maintenance as permanent staff as is shown in Table III-19. The project implementation schedule is assumed to start construction works in July, 1989 and to commence the commercial production in July 1, 1991 as is shown in Figure III-18.

5.4 Single Super Phosphate Project

The project will be located in Kafue and consume 35,181 TPY-dry of phosphate concentrate from Chilembwe as well as 19,850 TPY of sulfuric acid from NCZ to produce 57,205 TPY of single super phosphate as final product.

The overall material and utility balance, production and product specification are shown in Table III-20. Process flow diagram and general plot plan of the project facility are illustrated in Figure III-19 and III-20, respectively. The process is to at first dry and crush the delivered phosphate concentrate and mix with sulfuric acid in pre-determined ratio and feed into mixer and moving den for complete reaction and solidification. The solidified mass is aged in storage at high temperature for at least 28 days. The aged product is further disintegrated by cutter and shipped directly as bulk to the compound fertilizer granulation plant of NCZ at Kafue by belt conveyor.

Specification of the product is Av-P_2O_5 17.20%, W-P_2O_5 15.15% and available phosphate solubility is over 96% in the product. The fluorine in the phosphate concentrate is recovered as calcium fluoride in thickener slurry.

The process configuration is shown in Figure III-21. The project will recruit 74 personnel for the operation and maintenance as permanent staff as is shown in Table III-21. The project implementation schedule is assumed to start construction works in July, 1989 and to commence the commercial production in July 1, 1991 as is shown in Figure III-22.

5.5 Integrated Projects

For the financial and economic analysis of the overall projects, an integrated project scheme should be formulated. There are two integrated projects: the phosphate mining and concentrate project with the fused magnesium phosphate project or the phosphate mining and concentrate project with the single super phosphate project.

The integration of up-stream and down-stream projects is rather simple because the individual project is formulated for such smooth combination in terms of material balance as well as implementation schedule. The operating personnel, working capital as well as sales expenses are assumed simple additive for the integrated project.

The road transport cost of phosphate concentrate from Chilembwe to Kafue is regarded as variable cost in terms of utility and transport cost of phosphate concentrate production which will be transferred into variable cost of fertilizer production cost in the integrated project. The scope of integrated project is illustrated in Figure III-12. A reasonable transfer price of phosphate concentrate will be determined by assuming a same return on investment after tax between up-stream and down-stream industries.

Table and Figure

for

Part III

TECHNICAL STUDY OF THE PROJECT

Table III-1 to Table III-21

and

Figure III-1 to Figure III-22

Table III-1 MAJOR FACILITIES OF NITROGEN CHEMICALS OF ZAMBIA LTD AT KAFUE

Construction Phase	Process Plant and Design Capacity, TPY (TPD)								Raw Materials and Utilities Plant					Completion Date	Contractors
	NH_3	NA	SA	AN	AS	CF	MeOH	CO_2	Coal TPY	Pyrite TPY	Water TPD	Electricity MW	Steam TPH		
1. Plant I - Original	30,000 (95.3)	50,000 (172.4)	- -	60,000 (205.5)	- -	- -	- -	- -	65,000 - (Stand-by)	-	6,000 -	13.0 -	27.0 -	May 27,1970	Kobe Steel Ltd., Japan
			(ANBA: 20,000 Fert: 40,000)												
2. CO_2 Plant	- -	- -	- -	- -	- -	- -	- -	1,000 (3)	- -	- -	- -	- -	- -	August,1979	Ube Industries Ltd., Japan
3. Plant II - Expansion	66,000 (220)	70,000 (212)	- -	80,000 (242)	50,000 (151)	142,320 (432)	1,650 (5)	- -	191,700 -	- -	12,000 -	40.0 -	44.0 -	October 20,1982	Klockner Industrie -Analagen GmbH, (Krupp-Koppers, Spie-Batignolles, Zublin, Indumont and CdF Chimie), Federal Republic of Germany
					CF "A"	1,220									
					"C"	11,200									
					"D"	48,000									
					"R"	22,600									
					"V"	4,900									
					"X"	54,400									
4. SA Plant	- -	- -	60,000 (182)	- -	- -	- -	- -	- -	- -	40,000 -	3,600 -	3.0 -	- -	September 28, 1983	Kobe Steel Ltd., Japan
5. Rehabilitation of Plant I	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	July 8, 1986	Kobe Steel Ltd., Japan
6. Renovation of Plant II	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	(December 31, 1988)	Klockner Industrie -Analagen GmbH, Federal Republic of Germany
Total	96,000 (315.3)	120,000 (384.4)	60,000 (182)	140,000 (447.5)	50,000 (151)	142,320 (432)	1,650 (5)	1,000 (3)	191,700 -	40,000 -	21,600	46.0	71.0	-	-

Notes: 1) Coal (C: 69.4%, VM: 21.7%, Ash: 17.1%) from Maamba Collieries Ltd., Maamba is supplied by railways of ZR at NCZ.
2) Pyrite (S: 45%) from ZCCM, Nampundwe is supplied by truck on road at NCZ but occasionally by railways of ZR transshipped at Lusaka siding.

Table III-2 COMPOUND FERTILIZERS PRODUCTION AT NITROGEN CHEMICALS OF ZAMBIA LTD IN KAFUE

Product Code		Nutrient Analysis, %						Raw Material Consumption, kg/Ton											Major Crops
		T-N	Av-P_2O_5	S-K_2O	T-S	S-B	Moisture		NH_3	AN	SA	AS	DAP	TSP	SSP	MOP	SOP	Borax	Coating	Total	
"A"	G*	2.0	18.0	15.0	9.0	0.1	3	Wt	8	29	-	21	-	213	455	-	296	9	10	1,041	Tabacco
	C*	2.1	18.0	15.2	12.0	0.1	-	NPK	6.6	10.0	-	4.4	-	99.0	80.5	-	152.4	-	-	352.9	
								SB	-	-	-	5.1	-	4.3	59.2	-	51.8	1	-	121.4	
"C"	G*	6.0	18.0	12.0	9.0	0.1	3	Wt	6	87	-	126	-	275	288	50	178	9	10	1,029	Tabacco (Virginia, Burley), Cotton (B Deficient Soil)
	C*	6.3	18.0	12.2	10.5	0.1	-	NPK	4.9	30.0	-	28.5	-	127.9	51.0	30.5	91.7	-	-	364.5	
								SB	-	-	-	30.9	-	5.5	37.4	-	31.2	1	-	106.0	
"D"	G*	10.0	20.0	10.0	11.0	0.0	1	Wt	-	145	32	237	15	408	-	-	197	-	10	1,044	Maize, Cotton
	C*	10.3	19.7	10.2	11.2	0.0	-	NPK	-	50.0	-	49.8	2.7/7.0	189.7	-	-	101.5	-	-	400.7	Potatoes,
								SB	-	-	10.4	58.1	0.5	8.2	-	-	34.5	-	-	111.7	Vegetables, Tabaco Seed Bed
"R"	G*	20.0	20.0	0.0	11.0	0.0	1	Wt	-	116	-	463	423	-	-	-	-	-	10	1,012	Maize
	C*	21.4	19.7	0.0	12.6	0.0	-	NPK	-	40.0	-	97.2	77.4/197.0	-	-	-	-	-	-	411.6	(Kafue Basin, K_2O Sufficient Soil), Cotton, Irrigated Lucerne
								SB	-	-	-	113.4	12.7	-	-	-	-	-	-	126.1	
"V"	G*	4.0	18.0	15.0	9.0	0.1	3	Wt	6	58	-	76	-	259	331	63	222	9	10	1,034	Tabacco
	C*	4.1	17.9	15.3	10.6	0.1	-	NPK	4.9	20.0	-	16.0	-	120.4	58.6	38.4	114.3	-	-	372.6	(Virginia, Turkish), Fruit (Orchards)
								SB	-	-	-	18.6	-	5.2	43.0	-	38.9	1	-	106.7	
"X"	G*	20.0	10.0	5.0	11.0	0.0	1	Wt	-	261	-	427	153	59	-	-	99	-	10	1,009	Maize, Cotton
	C*	20.8	9.9	5.1	12.8	0.0	-	NPK	-	90.0	-	89.7	28.0/71.1	27.4	-	-	51.0	-	-	357.2	
								SB	-	-	-	104.6	4.6	1.2	-	-	17.3	-	-	127.7	

Notes: 1) G* = Guaranteed, C* = Calculated analysis assuming no loss during production.

2) Assumed analysis of raw materials (N - P_2O_5 - K_2O - S - B) in percentage.

NH_3 = (82.2 - 0 - 0 - 0 - 0), TSP = (0 - 46.5 - 0 - 2.0 - 0)
AN = (34.5 - 0 - 0 - 0 - 0), SSP = (0 - 17.7 - 0 - 13.0 - 0)
SA = (0 - 0 - 0 - 32.6 - 0), MOP = (0 - 0 - 61.0 - 0 - 0)
AS = (21.0 - 0 - 0 - 24.5 - 0), SOP = (0 - 0 - 51.5 - 17.5 - 0)
DAP = (18.3 - 46.5 - 0 - 3.0 - 0), Borax = (0 - 0 - 0 - 0 - 11.3)

3) Compound fertilizer plant capacity is 142,320 TPY (24 TPH or 576 TPD but 20 TPH or 480 TPD for "C"). The dimension of major equipment: drum granulator (3.0mD x 6.0mL, 150 TPH, 75 kWh, 7RPM) and drum dryer (3.3mD x 25.0mL, 150 TPH, 160kWh, 3RPM). The plant was designed by CdF Chimie, France.

4) Major product grades at NCZ are "D", "R" and "X", but "A" and "V" have never been produced up to 1987.

5) The standard method of NPK analysis at NCZ is CdF Chimie Central Lab Methods [T-N, A-N, N-N, T-P_2O_5, S-P_2O_5, C-P_2O_5, W-P_2O_5, S-K_2O, Free Moisture] and AOAC Method-12th Edition, 1975 [T-N, A-N, N-N, T-P_2O_5, W-P_2O_5, Av-P_2O_5 (pH = 7, Sp Gr = 1.05), S-K_2O, T-S (SO_3), Free Acidity, Free Moisture]. The rapid methods at NCZ are for A-N, N-N, T-P_2O and K_2O.

6) The particle size is 95% (2/4 mmD) and 5% (1/2 mmD) and packaging is 50 kg net in PP woven and PE inter bag.

Table III-3 ORGANIZATION AND PERSONNEL AT NITROGEN CHEMICALS OF ZAMBIA LTD

Organization	Function	Personnel						
		Managing Director, General Manager	Manager	Foreman, Supervisor	Superintendent, Engineer	Clerk, Technician	Typist, Operator	Total
1. Top Management and Board	Development Policy, Integration with government	(2)	-	( )	( )	( )	( )	(12)
- Managing Director	Management of Rehabilitation Project and Operation	1	-	-	-	-	-	1
- Marketing	Marketing and Sales Strategies	-	-					4
- Auditing	Rehabilitation Contracting	-	-					6
- General Manager	Coordination of Plant Operation	1	-					1
- Management Committee	All Managers for Production Performance	-	-	-	-	-	-	-
2. Administration		-	(1)	( )	( )	( )	( )	(194)
- Personnel and Organization	Development and Training							90
- Financial and Accounting	Management/General Accounting and Payroll	-	1	2	4	9	11	27
- Sales and contracts Department	Product Sales and Raw Material Purchase							6
- Computer Science Department	Computerisation							6
- Energy Management	Energy Control							2
- Coordination of Services								65
3. Production		-	(1)	(9)	( )	( )	( )	(584)
- Area I	Gasfication, Coal Handling, Utility	-	-	1	4	8	36+	111
- Area II	Ammonia and Air Separation	-	-	1	14	28	76+	119
- Area III	NA and AN	-	-	1	18	16	64+	99
- Area IV/V	SA, AS and NPK	-	-	1	12	16	64+	96
- Material Handling	Storage, Packaging and Loading	-	-	1	-	-	-	150
- Development Works		-	1	4	-	-	4	9
4. Maintenance		-	(1)	(6)	(38)	(56)	(179)	(279)
- Planning and Administration	Planning and Inspection, Tools Warehouse	-	1	2	7	3	5	18
- Mechanical	Mechanical Workshop and Maintenance	-	-	1	16	20	110	147
- Electrical	Electrical Workshop and Energy Distribution	-	-	1	9	14	26	56
- Instrument	Instrument Workshop and Maintenance	-	-	1	6	17	21	45
- Civil	Insulation, Painting, Plumber, Bricklayer	-	-	1	-	2	17	20
5. Chemical Laboratory	Process and Product Control, Environment and Hygiene	-	( )	( )	( )	( )	( )	(50)
6. Total		2	4	-	-	-	-	1,120

Reference: Annual Wage and Salary, ZK/Man·Year
- Including social welfare and fringe benefits

Notes: 1) Nitrogen Chemicals of Zambia Ltd. is a parastatal company and a direct subsidiary of ZIMCO since April 1, 1985. Organization and staffings are as of January 1, 1987, which are based upon the extensive organizational restructuring in 1986.

2) The table does not include the expatriates from the Operations Management Firm (OMF) under the World Bank financed project which will provide 423 man.months services from 1985 to 1989 as the Zambia-Fertilizer Industry Restructuring Project.

Table III-4 FERTILIZER CONTROL REGULATION IN ZAMBIA (1/3)

Regulation and Authority	Major Coverage	
	Scope	Specification
1. The Agriculture (Fertilizers and Feed) Act ... Chapter 351 of the Law of Zambia, January 1, 1970, Zambia	The regulation and control of : Agricultural Fertilizers and Farm Feed on : Manufacture, Processing, Importation and Sales for: Minimum Standards of Effectiveness and Purity	Fertilizer : Improvement or maintenance of plant growth or soil productivity Fertilizer Control : Minister, Registering, Officer, Analyst, Inspector, Lab and Plant Sub-Standard Fertilizer : Detaintion
2. The Agriculture (Fertilizers) Regulations ... Subsidiary Legislation, 1966, Zambia	The regulation on : Fertilizers for: Plant, Analyst and Lab, Search and Seizure, Sampling and Analysis, Limit of Variation	Sampling : One package/Ton-Bags and two samples/Ton-Bulk Analysis and Statements : - Moisture (100°C, 3 hours) - T-N, A-N, A-N(+) N-N, U-N - W-P_2O_5 as P (Sample 100g/400ml H_2O, shaking for 0.5 hour) - T-K_2O as K in Chloride or Sulfate (Sample 10g/incinerated at 500°C, dissolved in diluted HCl) - T-S - T-B - Free Acid in Ammonium Sulfate Maximum Variation : - N : 1/10N, % (0.3/1.0%) - W-P_2O_5 as P: 1/20P, % (0.2/0.9%) - T-K_2O as K : 1/20K, % (0.6/1.7%) - Cl : 1/20 Cl, % - B : 1/5 B, % - S : No variation is allowed below minimum
3. Customes and Excise Act ... Chapter 662 of the Law of Zambia, July 1, 1955	Customs duty and surtax payable on fertilizer	Classification of Fertilizer:

Heading	Fertilizer	Duty Rate (%)
31.01	Guano and others	0.0
31.02	SN,AN,CAN,AC,ASN, Urea, CMN, CCN and others	0.0
31.03	Basic slag, Thermophos, Fused Phosphate, Al Ca Phosphate, SSP,DSP, TSP and others	0.0
31.04	MOP, SOP, KMgS and others	0.0
31.05	MAP and DAP	30.0

Table III-4 FERTILIZER CONTROL REGULATION IN ZAMBIA (2/3)

Regulation and Authority	Major Coverage	
4. Zambia Bureau of Standards (ZABS) ... Ministry of Commerce and Industry (MCI), Lusaka, Zambia	Specification, Testing, Requirements, Codes, Unit, Symbols for Industrial and Agricultural Products (43 Items)	None standards so far published or studied for fertilizers at ZABS (December, 1986)
5. Tender Document for Fertilizer ... National Agricultural Marketing Board of Zambia (NAMBOARD), Lusaka, Zambia - MF/PSB/125, March 17, 1986 - No. 2/86, April 7, 1986 - No. 3/86, May 30, 1986	Fertilizer Tender - Pricing (net weight) in US$, CIF, Free on Rail; Kasama, Livingston, Lusaka, Mkushi or Mpika; Dar-es-Salaam, Beira or East London Liner Shipment Terms at 90 days usance basis (interest free) - Shipping Tolerance: ± 5% - Spare Bag: 2% - Bid Bond: 10% - SGS's Inspection - Agriculture Act - Size: (+)2.0mm 11% max (-)3.8mm 3% max	Fertilizer Specification:

Fertilizer	Analysis, (%) N	W-P_2O_5	K_2O	S	B	Mo	Zn	Other
Urea	46	-	-	-	-	-	-	Biuret: 1.0
AN	34	-	-	-	-	-	-	-
Mixture								
"C"	6*	18	12**	8-10	0.1	-	-	-
"D"	10*	20	10***	10-12	-	-	-	-
"R"	20*	20	0***	10-12	-	-	-	-
"V"	4*	18	15**	8-10	0.1	-	-	-
"X"	20	10	5***	10-12	-	-	-	-
Solubor	-	-	-	-	20.5	-	-	-
Sodium Molybdate	-	-	-	-	-	39	-	-
Zn Sulfate	-	-	-	-	-	-	46	-

Note: * A-N/T-N = 0.75, N-N/T-N = 0.25
** $K_2O(SO_3)/K_2O$ = 0.75, K_2O (Cl)/K_2O = 0.25
*** $K_2O(SO_3)/K_2O$ = 1.00

Bag Specification:
- Outer Bag: PP Woven Bag (50kg Net, 2.6 oz/sq. yd)
- Liner : PE Bag (4 mil)

6. Tender Document for Fertilizer ... Nitrogen Chemicals of Zambia Ltd. (NCZ), Kafue, Zambia NCZ/64/86, December 8, 1986	- Pricing - FOB Unit Price - Ocean Freight to Dar-es-Salaam - Road Freight to Kafue - C&F, Dar-es-Salaam	Fertilizer Specification:

Fertilizers	Analysis, (%) N	P_2O_5	K_2O	Moisture	Size %, mm
DAP	16-18	46-48	-	1.0	95(1.4-3.3)
MOP	-	-	61	1.0	95(0.6-3.0)

Bag Spcification:
- Outer Bag: PP Woven Bag (50kg Net, 0.56 x 1.04 120 g min)
- Liners : PE (0.61 x 1.17m, 0.06mm - LDPE, 0.03mm - LDPE + LLDPE, 0.025mm - HDPE)

Table III-4 FERTILIZER CONTROL REGULATION IN ZAMBIA (3/3)

Regulation and Authority	Major Coverage	
7. Product Guide .... Nitrogen Chemicals of Zambia Ltd., (NCZ) Kafue, Zambia, March 14, 1985	Product Marketing	Fertilizer Specification:

Fertilizer	Analysis, (%) N	P_2O_5	K_2O	S	B	Moisture	Size mm
AN	34.5	-	-	-	-	0.3	1-3
AS	20.5	-	-	-	-	0.2	0.75(+)
Compound Fertilizer							
"C"	6	18	12	-	0.1	3.0	2-4
"D"	10	20	10	-	-	1.0	2-4
"R"	20	20	-	-	-	1.0	2-4
"V"	4	18	15	-	0.1	3.0	2-4
"X"	20	10	5	-	-	1.0	2-4

Fertilizer Bag: 50 kg Net PP Woven/PE Liner

8. Standard Analytical Method ... Nitrogen Chemicals of Zambia Ltd., (NCZ), Kafue Zambia	The fertilizer analytical method are adopted from (1) CdF Chemie's Method, France (NFU) and (2) Official Methods of Analysis of the Association of Official Analytical Chemists, 12th Edition, 1970, Association of Official Analytical Chemists, Washington DC, The USA	Analytical Method: - N : T-N, A-N, N-N - P_2O_5: T-P_2O_5, W-P_2O_5, Av-P_2O_5 (pH 7, Sp Gr 1.05, Agitation at 65°C for 1.0 hour) S-P_2O_5 (Joulje Citrate), C-P_2O_5 (NF U 42 212) - K_2O : W-K_2O (Water soluble at boiling temperature for 0.25 hour) - S : Acid soluble sulfate - Free Acidity : Acetone soluble as P_2O_5 - Free Moisture: Vacuum drying or Karl Fisher titration
9. Rapid Analytical Method ... Nitrogen Chemicals of Zambia Ltd., (NCZ), Kafue, Zambia	The rapid analytical methods for plant control	Analytical Methods: - N : T-N, A-N, N-N - P_2O_5: (H_2SO_4 soluble and $AgNO_3$ titration) - K_2O : T-K_2O
10. Process Design Study for the Beneficiation of Chilembwe Phosphate Ore ... Dr. Wilfred C. Lombe, School of Mines, University of Zambia (UNZA), September 1985	Solubility of P_2O_5 in Chilembwe Phosphate Concentrate	Analytical Results : - Av-P_2O_5: 1.3% - F-P_2O_5 : 3.5% Not useful for direct application

Table III-5 REPRESENTATIVE MINERAL SAMPLES IN ZAMBIA

ZIMCO LIMITED
MINEX DEPARTMENT

ANNEX - 4

COLLECTION OF REPRESENTATIVE MINERAL SAMPLES IN ZAMBIA. DECEMBER 11. 1986

In connection with the Feasibility Study on the Establishment of Fused Magnesium Phosphate Fertilizer Plant in the Republic of Zambia, the JICA Study Team, INDECO (Counterpart Agency for the Study) and MINEX formed a collaboration group to take representative mineral samples which are required for the production tests as well as evaluation studies on phosphate fertilizers in Japan.

Based on the available information regarding the mineral reserves and on-the-spot geological observations, the following samples were taken and packaged to send to Japan as the representative samples for the study. The sampling was undertaken under direct supervision of the Group.

Minerals	Sample Weight Kg	Sampling Point	Sampling Date
Phosphate Ore, Chilembwe, Eastern Province			
1.	50.0	Ore Body -1 Trench Crossing Point	November 28, 1986
2.	180.0	Ore Body -2 South and Middle Trench	November 28, 1986
3.	20.0	Ore Body -4, Trench	November 27, 1986
Sub-Total	250.0		
Serpentine, Muloba, Mkushi, Central Province			
1.	20.0	Top Surface of South High Hill	December 01, 1986
Silica Sand, Kapiri Mposhi, Central Province			
1.	1	Quarrying at Kapiri Glass Product Ltd.	December 02, 1986
2.	1	Washed Silica Sand Fines in the Plant	December 02, 1986
Sub. Total	2	of Kapiri Glass Products Ltd.	
Dolomite, Lusaka, Lusaka Province			
1.	20.0	Quarrying at Crushed Stone Sales Ltd.	December 03, 1986
Total	292		

The above statements are noted and confirmed by the Group:

Tom G. Rukimirana,
Projects Officer, INDECO
-Counterpart Agency for the Study

Sandfor Mambwe,
Project Geologist
MINEX

Satoshi Usui,
JICA Study Team Member

Table III-6 PHOSPHATE MINING AND CONCENTRATE PROJECT AT CHILEMBWE OF ZAMBIA (1/2)

Project Facility	Design Capacity	Annual Consumption: Raw Water TPD	Electricity MW	Fuel Oil kl	Material and Consumable Consumption TPY	Material and Consumable Cost $,MM	Personnel and Others: Staff	Worker	Total	Cost $,MM	Investment Cost $, MM
1. Production											
- Mining Plant and Waste Dump	Open Pit Mining - Raw Ore (P_2O_5: 11.5%) 50 TPH x 8HPD x 260 DPY = 104,000 TPY - Waste Ore (P_2O_5: 3.0%) = 218,400 TPY - Cut-Off P_2O_5 Grade = 6.0% - Waste Ore/Raw Ore = 2.08 - Mine Out = 15.0 Years	-	0.162	212.2	ANFO 69 Dynamite 17 Tire- Piece 26 Others -	0.111	5	+ 25	+ 30	= 0.075 Maintenance = 0.085	2.315
- Beneficiation Plant	All Slime Single Plain Flotation - Phosphate Concentrate (P_2O_5: 30.0%, Dry) 5.05 TPH x 24 HPD x 290 DPY = 35,181 TPY - Tails (P_2O_5: 2.0%, Dry) = 68,848 TPY - P_2O_5 Recovery = 88.4%	720	2.830	32.4	Flotation Agent 41 Water Glass 208 Mill Ball 83 Others -	0.354	8	+ 22	+ 29	= 0.074 Maintenance = 0.006	4.030
- Tail Pond	Rock Filled Embankment - Tails (P_2O_5: 2.0%, Dry) = 68,848 TPY - Capacity (15.0 Years) - 1,033,100 m^3 (Sp Gr=1.0)	-	-	-	-	-	-	-	-	-	0.180
2. Utility Supply											
- Electric Power and Telephone	ZESCO Electricity - 33 kV, 0.9 MW, 40 km - Power Factor = 0.8 - Load Factor = 0.8 - Diversity Factor = 1.1 Telephone - 50 sets	-	-	-	-	-	-	-	-	-	0.832
- Water	Mankwala Dam at Kasangazi River, - 4"D, 855 TPD, 7.8 km	-	0.202	-	-	-	-	-	-	-	0.466
3. Auxiliary											
- Maintenance	Building and Equipment - 366 m^2 Floor	15	-	-	-	-	4	+ 11	+ 15	= 0.042 Maintenance = 0.055	0.652
- Administration and Storage	Building and Equipment - Office = 200 m^2 - Others = 840 Total = 1,040 m^2	20	-	-	-	-	11	+ 32	+ 43	= 0.103 Overhead = 0.056	0.110
- Security	-	-	-	-	-	-	-	-	-	-	0.092

Table III-6 PHOSPHATE MINING AND CONCENTRATE PROJECT AT CHILEMBWE OF ZAMBIA (2/2)

Project Facility	Design Capacity	Annual Consumption: Raw Water TPD	Electricity MW	Fuel Oil kl	Material and Consumable: Consumption TPY	Material and Consumable: Cost $,MM	Personnel and Others: Staff	Worker	Total	Cost $,MM	Investment Cost $, MM
4. Project Infrastructure											
- Road and Bridge	Mine Road - 5 mD x 35 km Water Dam Road - 3 mD x 4.5 km Bridge - 14 units	-	-	-	-	-	-	-	-	-	0.504
- Housing Colony	Housing (45) 1,172 m^2 School 288 Store 300 Others 492 Total 2,252 m^2	100	0.124	-	-	-	-	-	-	-	0.723
- Temporary	Electricity Generator, Camp, Storage, Fence (2,800 m)	-	-	-	-	-	-	-	-	-	0.051
Total	-	855	3.318	244.6	-	-	27	+ 90 + 117	= 0.294		9.955
								Maintenance	= 0.146		
Annual Cost, $, MM		0.00	0.0498	0.1369	-	0.465		Overhead	= 0.056		1.192*
Unit Cost	-	0.00	15,000	560	-	-	Personnel	2,513/Man·Year			33.88*
Per Ton of Phosphate Concentrate											
- Consumption	-	8.87	94.3	0.00695	-	-	Personnel	0.00333 Man·Year			-
- Cost	-	0.00	1.42	3.89	-	13.22		8.36			33.88*

Notes: 1) This summarizing table is prepared by referring "A Pre-Feasibility Study for the Phosphate Development Project, The Republic of Zambia", 1985, Japan International Cooperation Agency, MPN, CR(3), 85-90.

2) Price estimates are as of September/November, 1984 and foreign currency exchange rates of US$1.0 = ZK1.8 = Yen 245.0 are applied in the above study.

3) Total project cost is estimated as follows by additing other cost components:

- Project Facility	$9.955 MM	- Inventory	$0.780 MM
- Construction Management	0.153	- Test Run	0.114
- Engineering Fee	0.481	- Working Capital	0.086
- Training	0.111	- Interest during Construction	0.467
- Contingency	1.120	Grand Total	$13.267 MM

4) Additional investment for vehicles and equipment of $2.029 MM is required during 7th and 12th year after commercial production which will be considered as maintenance cost for financial cash flow. Sales of $0.505 MM during test run period is neglected for project income.

5) Financing plan is assumed as Equity/Loan = $3.500/$9.767 MM (Interest: 4%, Repayment: 3+15 years). Therefore, the estimation of fixed cost is calculated as $33.88/Ton* of phosphate concentrate by applying a capital recovery factor (0.0899, i=0.04, N=15) on total financing of $13.267 MM.

6) Operating cost for chemicals, utilities, consumables, personnel, maintenance and overhead is $32.60/Ton of phosphate concentrate or annually $1.147 MM.

Table III-7 SUMMARY OF PHOSPHATE MINING AND CONCENTRATE PROJECT AT CHILEMBWE OF ZAMBIA (1/4)

1. Annual Operation

	Annual Quantities	Price and Cost	
	Ton	Unit $/Ton	Annual $, MM
1) Production			
- Phosphate Concentrate (P_2O_5: 30.0%)	35,181	77.00	2.7089
2) Operating Cost			
(1) In-Puts			
- Raw Material and consumable			
- Raw Ore (P_2O_5: 11.5%)	104,000	0.00	0.0000
- Flotation Reagent	41.6	2,750	0.1142
- Chemicals	-	-	0.1049
- Explosives	-	-	0.0423
- Consumables	-	-	0.2037
		(13.220)	0.4651
- Utilities			
- Fuel Oil	244.5	560	0.1369
- Electricity	3,318,000 kWh	0.015	0.0498
- Raw Water	312,075	0.00	0.0000
		(5.307)	0.1867
- Sub-Total		(18.527)	0.6518
(2) Personnel	117	(8.354)	0.2939
(3) Maintenance	-	(4.141)	0.1457
(4) Overhead	-	(1.578)	0.0555
- Sub Total		32.60	1.1469
3) Gross Profit	-	44.399	1.5629

Note: (Per Ton of Phosphate Concentrate)

Table III-7 SUMMARY OF PHOSPHATE MINING AND CONCENTRATE PROJECT AT CHILEMBWE OF ZAMBIA (2/4)

2. Investment Cost

1) Investment Cost

	Foreign Currency Portion	Local Currency Portion	Total
- Production, Utility and Auxiliary Facility	6.208	2.469	$8.677 MM
- Project Infrastructure	0.097	1.181	1.278
- Inventory	0.756	0.024	0.780
- Management and Engineering Fees	0.481	0.153	0.634
- Training Fee	0.000	0.111	0.111
- Contingency	0.713	0.407	1.120
	(8.255)	(4.345)	12.600
- Working Capital and Test Run	0.072	0.128	0.200
- Interest during Construction	0.467	-	0.467
	8.794	4.473	13.267

2) Financing Plan

- Equity	26.38%	$3.500 MM
- Long Term Loan (4%/Annum, (2+15) Years Repayment)	73.62	9.767
	100.00	13.267*

* Sales of $0.505 MM during test run period is neglected.

3) Assumption

- Exclusion	Exploration, Lease Purchase, Mineral Tax
- Working Capital	Personnel charge for 3 months
- Construction Period	3 years (Rain season of November to March is considered)
- Import Equipment	30% for marine and inland transport and insurance on FOB price, Japan
- Tax	45%
- Depreciation	Accelerated (10 Years)
- Escalation	Zero
- Salvage Value	Zero
- Maintenance Cost	Zero (Annual consumable)
- Minimum Cash	Zero
- Overhead	Zero (Administration)
- Insurance	Zero
- Local Tax	Zero
- Sales and Administration	Zero
- Test run product sales	$0.505 MM (No existing consumer to purchase in Zambia)

Table III-7 SUMMARY OF PHOSPHATE MINING AND CONCENTRATE PROJECT AT CHILEMBWE OF ZAMBIA (3/4)

3. Unit Prices for Study

Material and Equipment

Items	Unit	Unit Cost $
Gasoline	m3	750
Diesel Oil	m3	560
Lube Oil	m3	1,560-2,890
Caustic Soda	Ton	500
Water Glass	Ton	230
Flotation Reagent	Ton	2,750
Floculant	Ton	5,300
Explosive	Ton	500
ANFO	Ton	460
Detonator	Piece	0.636
Sand	m3	12
Crushed Stone	m3	17
Concreat Block	Piece	0.34
Wood	m3	417
Bit, 102 mmD	Piece	200
Mill Ball	Ton	750
Mill Liner	Ton	1,627
Truck, 20 Ton	Ton	72,408
Tire	Piece	1,172
Haulage	Ton.km	0.097-200 km
		0.099-400 km
		0.100-540 km
		0.099-600 km
Electric Power (Including Sales Tax of 12.5%)	kWh	0.015
Housing		1,379
Road Construction	5 mW x m	13.5
Electricity Distribution	1 mW x m	9.0
Water Pipeline	4"D x m	32.1
Bridge	Piece	2,300

Personnel Annual Charge*

Itmes	Number	Charge $
Mine Manager	1	7,200
Engineer/ Superintendent	4	5,400
Surveyor/Geologist	2	4,320
Foreman/Chief	20	3,960
Driver/Mechanic	-	3,240
Operator/Mechanic/ Electrician	53	2,400
Technical Worker	-	2,100
Office Worker	32	1,700
Helper	5	1,500
Minimum Wage	-	(382)
	117	Av.2,513

Notes: 1) US$1.0 = ZK1.8 = Yen 245 as of observed in September/November, 1984.

2) * Personnel charge is including basic salary, social security and welfare, bonus and retirement allowance.
Overtime is (+) 66% and over-night stay is $5/night.

Table III-7 SUMMARY OF PHOSPHATE MINING AND CONCENTRATE PROJECT AT CHILEMBWE OF ZAMBIA 4/4)

4. Financial and Economic Analysis

	Financial Analysis	Economic Analysis
1) Benefits		
- Product Price	$77/Ton 71 ... Product Cost (+) 6 ... Profit of 8% with sales which is derived from Zambian mining average operation of 6.5% in 1983	$90/Ton ... Border price of South African phosphate concentrate (P_2O_5: 36.4%, $40/Ton-FOB) plus railway transport cost (2,400 km, $69.2/Ton) and analysis adjusted
- Social	None	None
2) Costs		
- Sunk Cost	None	None (Water Dam)
- Commodity Cost		
- Import	Marine and inland transport through Dar-es-Salaam and insurance cost of 30% on FOB prices. Import duty is exempted	A same as Financial Cost
- domestic	Current prices including state sales tax of 10%	Current prices excluding state sales tax of 9.09%
- Personnel Charge		
- Skilled	Current price	A same as Financial Cost
- Un-skilled		
- Operation	Current price	Excluding training fee from initial investment cost
- Construction	Current price	Minimum wage...$1.27/Man·Day
- Power Line Wiring	Current price	Labor cost is adjust to substrate 5.0% on work costs
- Electricity	ZESCO Tariff ... $0.015/kWh - Tariff D2 ... May 1,1983 - Power Factor 0.8 - Load Factor 0.8 - Diversity Factor 1.1 including state sales tax of 12.5%	Current prices excluding state sales tax of 11.1%
3) Foreign Currency Exchange Rate	Current float rate...ZK1.8/$; September/November,1984	Correction for imbalance of export and import ...ZK1.9/$ (R = 1.056 for 1983)
4) Return on Investment		
- IRROI		
- Before Tax	7.1%	12.8%
- After Tax	5.9	-
- IRROE		
- Before Tax	-	-
- After Tax	9.3	-
- Long Term Loan Interest Rate	4.0	4.0

Table III-8 ZAMBIAN RAW MATERIAL ANALYSIS SUMMARY

Items	Phosphate Ore, Chilembwe, Zambia	Phosphate Concentrate, Chilembwe, Zambia,	Serpentine, Mkushi, Zambia	Dolomite, Lusaka, Zambia	Silica Sand, Kapiri Mposhi, Zambia
Sampling Date	November 28, 1986	January 19, 1987 (Beneficiation)	December 01, 1986	December 03, 1986	December 02, 1986
Present Ownership	MINEX/ZIMCO	-	MINEX/ZIMCO	CSSL/INDECO/ ZIMCO	Kapiri Glass Product Ltd./ INDECO/ZIMCO
Chemical Analysis, %					
- P_2O_5	18.60	33.69	-	-	-
- SO_3	-	0.23	-	-	-
- CO_2	-	0.04	-	-	-
- F	0.92	1.89	-	-	-
- Cl	-	0.03	-	-	-
- CaO	29.95	46.18	0.02	32.56	0.03
- MgO	1.82	0.41	38.45	20.27	0.03
- FeO	-	0.32	-	-	-
- Fe_2O_3	1.66	0.57	5.36	0.45	0.21
- Al_2O_3	2.36	2.23	1.76	-	0.13
- SiO_2	38.63	12.49	41.44	0.26	98.38
- Na_2O	-	0.21	-	1.16	-
- K_2O	-	0.14	-	0.12	-
- Cd, ppm	-	1.0 (-)	-	-	-
- As	-	3.1	-	-	-
- F/Cl Adjustment, %	-	(-) 0.803	-	-	-
- NiO	-	-	0.19	-	-
- Cr_2O_3	-	-	0.03	-	-
- Ignition Loss	2.21	0.54	11.96	44.79 (CO_2)	0.23
- Free Moisture	-	0.13	-	-	-
Total	98.05	98.297	99.21	99.61	99.01

Particle Size, %	Flotation Feed	Flotation Product/ FMP Test	SSP Test	FMP Test	(Block)	(Block)
(+) 6 Mesh	-	-	-	-	-	-
(+) 12	-	0.0	0.0	10.0	-	-
(+) 32	0.0	0.7	0.0	80.0	-	-
(+) 60	5.0	14.5	0.0	95.0	-	-
(+) 80	50.0	31.2	0.0	100.0	-	-
(+) 100	75.0	42.2	1.9	-	-	-
(+) 200	90.0	68.0	12.8	-	-	-
(-) 200	10.0	32.0	87.2	0.0	-	-
Total	100.0	100.0	100.0	100.0	100.0	100.0
Density, g/cm^3						
- True	3.03	3.08	3.08	2.57	2.84	-
- Bulk	1.80	1.80	1.54	1.6	1.6	-
Work Index, kWh/Ton	12.0	12.0	-	11.0	10.0	-
Angle of Repose, Degree	33.0	45.0	48.0	41.0	41.0	41.0

Notes:

1) Phosphate concentrate (60 kg) is prepared at Central Research Center of Nippon Mining Co., Ltd. in Toda-Shi, Saitama, Japan during January, 1987, with P_2O_5 recovery of 97.2% and 12% free moisture by flotation (one batch of 1.0 kg feed) and is dried by hot air prior analysis and testing. Principle minerals in phosphate concentrate are judged as mixture of fluorapatite and hydroxyapatite by X-ray diffraction analysis and chemical analysis.

2) Principle mineral in Serpentine is identified as antigorite by X-ray diffraction analysis and chemical analysis.

Table III-9 PRODUCTION TEST RESULTS OF FUSED MAGNESIUM PHOSPHATE

Items	Raw Materials				Product	
	Phosphate Concentrate		Serpentine		Fused Magnesium Phosphate (FMP)	
	Chilembwe, Zambia	Florida, USA	Mkushi, Zambia	Maizuru, Japan	Zambian	Japanese
1. Chemical Analysis, %						
P_2O_5	33.69	34.18	-	-	20.28	20.30
F	1.89	3.77	-	-	0.72	1.41
CO_2	0.04	-	-	-	-	-
CaO	46.18	48.55	0.02	0.36	29.09	30.20
MgO	0.41	0.31	38.45	38.67	18.79	15.80
Fe_2O_3	0.89	0.79	5.36	8.19	-	-
Al_2O_3	2.23	0.98	1.76	1.02	-	-
SiO_2	12.49	4.26	41.44	38.93	26.53	23.50
Ignition Loss	0.59	5.41	11.96	11.01	-	-
Free Moisture	0.50	0.50	4.50	4.50	0.50	0.50
Unit Consumption, TPT	0.618	0.599	0.470	0.518	(-)1.000	(-)1.000
2. Fertilizer Nutrients, %						
T-P_2O_5	33.69	34.18	-	-	20.28	20.30
C-P_2O_5 (pH: 2, Sp Gr: 1.09)	6.05	13.16	-	-	20.11	20.20
F-P_2O_5 (pH: 1.75, Sp Gr: 1.01)	7.14	15.03	-	-	20.03	19.83
C-P_2O_5 (pH: 4, Sp Gr: 1.02)	2.00	7.61	-	-	20.09	20.15
Av-P_2O_5 (pH: 7, Sp Gr: 1.09)	2.25	7.05	-	-	14.38	17.02
S-P_2O_5 (pH: 9.6, Sp Gr: 1.08)	0.86	3.56	-	-	14.25	13.92
W-P_2O_5 (pH: 7, Sp Gr: 1.00)	0.08	0.15	-	-	0.04	0.03
S-SiO_2	-	-	-	-	26.19	23.20
C-MgO	-	-	-	-	18.70	15.50
Total Akaline	-	-	-	-	54.07	53.50
3. Physical Property - Dry						
Bulk Density	1.80	1.57	1.60	1.60	1.46	1.47
Angle of Repose, Degree	35.0	33.0	41.0	41.0	36.0	36.0
Size Distribution, %						
(+) 12 Mesh	0.0	1.5	10.0	17.0	1.1	1.3
(+) 32	0.7	17.3	80.0	98.0	55.6	52.6
(+) 100	42.2	94.7	100.0	100.0	94.9	92.7
(+) 200	68.0	97.6	100.0	100.0	96.9	95.4
(-) 200	32.0	2.4	0.0	0.0	3.1	4.6

Notes:

1) Zambian FMP was produced at Hinode Kagaku Kogyo KK, Maizuru, Japan using Chilembwe phosphate concentrate and Mkushi serpentine on February 10, 1987 at experimental electric furnace (one batch of 7.0 kg). Stamping of experimental furnace by magnesia makes a higher analysis of MgO in product than commercial continuous operation product.

2) Japanese FMP was produced at Hinode Kagaku Kogyo KK, Maizuru, Japan using Florida phosphate rock and Maizuru serpentine on February 10, 1987 at commercial open hearth furnace using oil coke as fuel (design capacity of 80,000 TPY).

3) Fluorine losses during FMP production are 36.7% for Zambian and 37.0% for Japanese, respectively.

Table III-10 PRODUCTION TEST RESULTS OF SINGLE SUPER PHOSPHATE

Items	Raw Materials				Product	
	Phosphate Concentrate		Sulfuric Acid		Single Super Phosphate (SSP)	
	Chilembwe, Zambia	Florida, USA	Ube, Japan	Ube, Japan	Zambian	Japanese
1. Chemical Analysis, %						
P_2O_5	33.69	30.39	-	-	19.12	19.16
F	1.89	3.72	-	-	0.65	1.76
CO_2	0.04	2.71	-	-	-	-
CaO	46.18	44.73	-	-	26.12	28.33
MgO	0.41	0.31	-	-	0.25	0.18
Fe_2O_3	0.89	1.79	-	-	0.47	1.19
Al_2O_3	2.23	0.95	-	-	1.24	0.62
SiO_2	12.49	4.76	-	-	6.99	2.87
Ignition Loss	0.59	1.97	-	-	-	-
Sulfuric Acid Consumption			-	-	-	-
- Stoichiometric, H_2SO_4	100	100	65.34	61.90	-	-
- Experimental, H_2SO_4	100	100	60.06	55.72	-	-
Consumption, TPT	0.580	0.600	0.367 (72% H_2SO_4)	0.356 (70% H_2SO_4)	(-)1.000	(-)1.000
2. Fertilizer Nutrients, %						
T-P_2O_5	33.69	30.39	-	-	19.12	19.16
C-P_2O_5 (pH: 2, Sp Gr: 1.09)	6.05	7.81	-	-	18.05	18.20
F-P_2O_5 (pH: 1.75, Sp Gr: 1.01)	7.14	7.62	-	-	17.88	17.96
C-P_2O_5 (pH: 4, Sp Gr: 1.02)	2.00	2.60	-	-	.	.
Av-P_2O_5 (pH: 7, Sp Gr: 1.09)	2.25	2.79	-	-	17.79	17.83
S-P_2O_5 (pH: 9.6, Sp Gr: 1.08)	0.86	1.07	-	-	17.50	17.26
W-P_2O_5 (pH: 7, Sp Gr: 1.00)	0.08	0.07	-	-	16.38	15.72
Free Acid as P_2O_5	-	-	-	-	4.04	2.90
Free Moisture	-	-	-	-	10.54	10.66
pH of 10% Solution	-	-	-	-	2.65	2.86
3. Physical Property						
Bulk Density	1.54	1.28	-	-	1.10	0.97
Angle of Repose, Degree	48.0	48.0	-	-	46.0	49.0
Size Distribution, %						
(+) 12 Mesh	0.0	0.0	-	-	0.0	0.0
(+) 32	0.0	0.0	-	-	29.2	34.6
(+) 100	1.9	10.0	-	-	53.4	59.1
(+) 200	12.8	30.0	-	-	75.9	80.4
(-) 200	87.2	70.0	-	-	24.1	19.6

Notes:

1) Zambian SSP was produced at Ube Industries Ltd., Ube, Japan using Chilembwe phosphate concentrate on February 20, 1987 at experimental apparatus (one batch of 0.2 kg). Analysis is made after 4 weeks aging conditioning.

2) Japanese SSP was produced at Ube Industries Ltd., Ube, Japan using Florida phosphate rock on February 20, 1987 at commercial continuous mixing plant (design capacity of 45,000 TPY). Analysis is made after 4 weeks aging conditioning for both products.

3) Stoichiometric sulfuric acid consumption (H_2SO_4 gr/100 g Phos Rock) = 1.75 CaO% + 1.84 Fe_2O_3% + 2.88 Al_2O_3% - 0.69 P_2O_5% - 1.23 SO_3%.

4) Fluorine losses during SSP production are 39.4% for Zambian and 25.0% for Japanese, respectively.

Table III-11 SITE CONDITIONS FOR PHOSPHATE FERTILIZER PLANT AND RAW MATERIAL SUPPLY IN ZAMBIA (1/2)

	Potential Site for Phosphate Fertilizer Plant				Site for Raw Material Supply	
	Kafue	Kabwe	Ndola	Kitwe	Chilembwe	Muloba, Mkushi
	Industrial Estate (Plot No.6)	Chimanimani Village	General Area	General Area	Phosphate Rock Supply	Serpentine Supply
1. Province/Location	Lusaka Province E28°10', S15°46'	Central Province E28°27', S14°24'	Copperbelt Province E28°40', S12°58'	Copperbelt Province E28°12', S12°50'	Eastern Province E31°4', S13°59'	Central Province E29°00', S13°41'
2. General Description						
- Vegetation	Short Weeds	Very Short Weeds	Weeds	Weeds	Bush	Bush
- Undulation, m	4	2.5	3	3	10	30
- Adjacent Township and Urban Population - 1980	Kafue-29,794	Kabwe-143,635	Ndola-282,439	Kitwe-314,794	Katate- 5,504, Petauke-7,531	Mkushi-4,104 Kapiri Mposhi-13,677
3. Site Date						
- Soil Bearing Capacity, Ton/m^2	5	(5)	(5)	(5)	3+	(5)
- Available Area, m^2	60,000	120,000	50,000+	50,000+	100,000+	100,000+
- Site Filling, m	2	2	-	-	-	-
- Lease (14 year), ZK/m^2	0.62+1.44/Year	(0.62+1.44/Year)	(0.62+1.44/Year)	(0.62+1.44/Year)	(0.62+1.44/Year)	(0.62+1.44/Year)
- Mean Sea Level, meter	988	1,194	1,250	1,250	910	1,227
- Atmospheric Pressure, mbar	898	877	870	870	915	870
- Wind, m/sec						
- Maximum Velocity	31.3	32.6	29.9	29.9	31.2	29.9
- Design Velocity	30.0	30.0	30.0	30.0	30.0	30.0
- Prevailing Direction	-	-	-	-	-	-
4. Climatic Conditions						
- Temperature, °C						
- Maximum	38.3	36.7	35.0	35.0	37.8	35.0
- Minimum	3.9	0.0	(-)2.2	(-)2.2	2.8	(-)2.2
- Average	20.2	20.2	20.3	20.3	20.3	20.3
- Relative Humidity, %						
- Maximum	87	83	78	78	78	78
- Minimum	37	25	39	39	41	39
- Rainfall, mm						
- Maximum Hourly	-	-	-	-	-	-
- Maximum Daily	113	102	125	125	126	125
- Mean Annual - 30 Years	803	952	1,212	1,212	1,014	1,212
5. Earthquake						
- Seismic Zone	-	-	-	-	-	-
- Design Seismic Factory, -	0.05	0.05	0.05	0.05	0.05	0.05

Table III-11 SITE CONDITIONS FOR PHOSPHATE FERTILIZER PLANT AND RAW MATERIAL SUPPLY IN ZAMBIA (2/2)

	Potential Site for Phosphate Fertilizer Plant				Site for Raw Material Supply	
	Kafue	Kabwe	Ndola	Kitwe	Chilembwe	Muloba, Mkushi
	Industrial Estate (Plot No.6)	Chimanimani Village	General Area	General Area	Phosphate Rock Supply	Serpentine Supply
6. Transport Infrastructure						
- Road Condition, (km)	Good (0.5) to the Great North Road	Good (0.5) to the Great North Road	Good (0.5) to the Great North Raod	Good (0.5) to the Great North Road	Poor (35) to the Great East Road	Poor (15) to the Great North Road
- Railway Connection, km	0.05 to ZR	0.05 to ZR	0.1 to ZR	0.1 to ZR	None	21 to Lunsemfwa Station, TAZARA
- Air Transport, (km)	Lusaka, (44)	Lusaka, (140)	Ndola, (4)	Kitwe, (10)	Chipata, (220)	Ndola, (200)
- River and Ocean Transport	None	None	None	None	None	None
7. Utilities						
- Water Supply						
- Source, (km)	Kafue River, (3)	Mulungushi Dam,(10)	Kafue River, (40)	Kafue River, (10)	Mankwala Dam, (8)	None
- Availability	Available	Depend on Project	Available	Available	Limited	-
- Quality	High	High	High	High	High	-
- Pricing, Month*	Free of Charge	ZK60 + ZK0.44/m^3	NA	NA	Free of Charge	-
- Electric Power						
- Sub-Station, (km)	ZESCO, (0.6)	ZESCO, (5.0)	ZESCO (CPC), (5.0)	ZESCO (CPC), (5.0)	ZESCO, (40-Ketete)	ZESCO, (10)
- Voltage, kV	33, 11	33, 11	66, 33, 11	66, 33, 11	33, 11	11
- Frequency, Hz	50	50	50	50	50	50
- Pricing by ZESCO-Tariff**	D3	D3	D3	D3	D2	D1
- Fixed Charge, ZK/Month	13,250	13,250	13,250	13,250	1,325	70
- Demand Charge, ZK/kVA/Month	9.08	9.8	9.08	9.08	10.62	11.87
- Unit Charge, ZK/kWh	0.027	0.027	0.027	0.027	0.041	0.053
- Fuel Oil/Coal	Available	Available	Available	Available	Available	Available
8. Labour						
- Availability	Avaibale	Avablable	Available	Available	Available	Available
- Skill Level	High	Middle	High	High	Low	Middle
9. Physical Distribution						
- Raw Materials Transport, ZK/Ton, (km)						
- Phos Concentrate, Chilembwe, Road	541 (453)	635 (528)	818 (674)	856 (705)	-	-
- Serpentine, Mkushi, Road/Railways	299 (173)	131 (155)	191 (160)	257 (166)	-	-
- Product Distribution, km on Road/Railway						
- Ndola	356	187	0	66	-	-
- Kasama	864	696	756	822	-	-
- Lusaka	48	120	308	374	-	-
- Monze	108	277	464	530	-	-
- Mongu	627	624	807	845	-	-

Notes: Pricing is as of January 01, 1987 and foreign exchange rate is assumed as ZK8.00/US$1.00 for financial and economic calculation
* ; ZK60 for the initial monthly consumption of 45 Ton of water
** ; Government sales tax of 15% on the tariff is charged additionally

Table III-12 UTILITY SUPPLY AND PROJECT INFRASTRUCTURES IN ZAMBIA

	Potential Site for Phosphate Fertilizer Plant										Site for Raw Material Supply	
	Kafue											
	Independent from NCZ		Integration with NCZ		Kabwe		Ndola		Kitwe		Chilembwe	Muloba, Mkushi
	FMP -EF	Others	FMP -EF	Others	FMP -EF	Others	FMP -EF	Others	FMP -EF	Others	Phos Rock	Serpentine
1) Electricity Supply												
- Distribution and Substation												
- Distance, km	0.6	0.6	0.6	0.6	5.0	5.0	5.0	5.0	5.0	5.0	40.0	10
- Capacity, MW	10	1.5-	55+10	55+1.5-	10	1.5-	10	1.5-	10	1.5-	1.0	0.1
- Voltage, KV	33	11	33	33	33	11	66	11	66	11	11	11
- Investment, ZK, MM	9.50	2.83	9.50	1.00	13.75	4.85	11.32	4.85	11.32	4.85	3.75	2.88
- Tariff*, ZK/kWh (MW)												
- FMP-EF (7.7)	0.0462		0.0423		0.0462		0.0462		0.0462		-	-
- FMP-OHF (1.1)	0.0624		0.0423		0.0624		0.0624		0.0624		-	-
- SSP (0.5)	0.0644		0.0423		0.0644		0.0644		0.0644		-	-
- TSP (0.3)	0.0668		0.0423		0.0668		0.0668		0.0668		-	-
- DAP (0.3)	0.0668		0.0423		0.0668		0.0668		0.0668		-	-
- NP (1.4)	0.0620		0.0423		0.0620		0.0620		0.0620		-	-
- Phos Rock (0.9)	-		-		-		-		-		0.0657	-
- Serpentine (0.1)	-		-		-		-		-		-	0.0754
2) Raw Water Supply												
-In-Take and Distribution												
- Source	Kafue River				Mulungushi Dam		Kafue River		Kafue River		Mankwala Dam	Wells
- Distance, km	3				10		40		10		7.8	0.0
- Capacity, TPD	1,000				1,000		1,000		1,000		855**	100
- Electricity, MW	0.05				0.10		0.10		0.10		0.05	0.0
- Investment, ZK, MM	0.40				1.10		1.10		1.10		0.84**	0.10
+US$, MM	0.058				0.184		0.184		0.184		0.000	0.000
- Tariff, ZK/Ton												
- Initial 45 Ton/Month	Free				1.33		NA		NA		Free	-
- Over 45 Ton/Month	Free				0.44		NA		NA		Free	-
3) Road Expansion/Construction												
											Mine / Dam	
- Distance, km	0.5				0.5		0.5		0.5		35 / 4.5	15
- Width, m	6				6		6		6		5 / 3	3
- Bridge	1				0		0		0		14 / 0	0
- Investment, ZK, MM	1.08				0.46		0.46		0.46		0.91**	0.30
4) Railway Siding Construction												
- Direct Distance, km	0.05				0.1		0.1		0.1		-	-
- Track	2				2		2		2		-	-
- Total Length, km	1.50				1.50		1.50		1.50		0.00	0.00
- Investment, ZK, MM	1.13				1.13		1.13		1.13		0.00	0.00
5) Investment Total,												
ZK, MM	11.75	5.44	11.75	3.61	16.44	7.54	14.01	7.54	14.01	7.54	5.50	3.28
+US$, MM	0.058	0.058	0.058	0.058	0.184	0.184	0.184	0.184	0.184	0.184	0.000	0.000
US$, MM	1.037	0.511	1.037	0.359	1.554	0.812	1.352	0.812	1.35	0.812	0.458	0.273

Notes: 1) * Basic electricity contracting and consumption factors are assumed as follows:

	Power Factor	Load Factor	Coincidence Factor	Diversity Factor
Fertilizer Plant	0.90	0.83	0.909	1.10
Raw Material Supply	0.90	0.72	0.909	1.10

Government sales tax of 15% on the tariff is charged additionally

2) Price estimate is as of January 01, 1987 and foreign exchange rate is assumed as ZK8.00/US$ for financial and economic calculation

Table III-13 FINANCIAL AND ECONOMIC PRICINGS OF ELECTRICITY IN ZAMBIA

Items	Electricity Pricings, ZK/kWh									Notes
	Domestic Sale								Export Sale	
	Industrial Bulk	Industrial			Commercial	Household			Zimbabwe	
	CPC/ZCCM	D3	D2	D1	E4	E3	E2	E1		
0. Assume Load, MW	-	8.0	1.0	0.1	0.01	0.01	0.004	0.001	-	
1. Financial Price										- Load Factor = 0.75 - Power Factor = 1.00
- Tariff of ZESCO (August, 1986)	0.0377	0.0461	0.0624	0.0760	0.0776	0.0721	0.0717	0.0735	0.0168	- Export Contract (1984/July 1987) is based on exchange rate of ZK1.756/US$
- Government Sales Tax (Chapter 663 of the Law of Zambia, Sales Tax - 1975: 15%)	0.0057	0.0069	0.0094	0.0114	0.0116	0.0108	0.0108	0.0110	0.0000	
Total	0.0434	0.0530	0.0718	0.0874	0.0892	0.0829	0.0825	0.0845	0.0168	
2. Economic Price										- Study Report by Electricite de France (EDF), 1984/5
- Short Run Marginal Cost	-	-	-	-	-	-	-	-	-	- Self Financing = 50% (Domestic)
- Long Run Marginal Cost	0.1166	0.2407	0.2608	0.2579	-	0.2254	0.3142	0.3756	0.0633	- ROI = 8% - DSCR = 1.5 - Exchange Rate = ZK6.00/US$
- Government Sales Tax (Chapter 663 of the Law of Zambia, Sales Tax - 1975: 15%)	0.0000	0.0000	0.0000	0.0000	-	0.0000	0.0000	0.0000	0.0000	- Period = 1986/7-1993/4
Total	0.1166	0.2407	0.2608	0.2579	-	0.2254	0.3142	0.3756	0.0633	
3. Economic/Financial Prices Ratio										
- Before Tax	3.1	5.2	4.2	3.4	-	3.1	4.4	5.1	3.8	
- After Tax	2.6	4.5	3.6	2.9	-	2.7	3.8	4.4	3.8	
4. Annual Sales, MM kWh/Year - 1984	4,274				1,840				3,168	
- (Ratio)	(46%)				(20%)				(34%)	

Notes: 1) Annual Report of ZESCO-1984
2) Mr. D.K. Kundu, Engineering Services Manager, ZESCO, March 12, 1987
3) Pure long run marginal cost is formulated by EDF for the year 1993/4 at 1986/7 price level, according to the ZESCO's financial requirements for the expansion of Kariba North Hydro Power Generation Station in 1993/4.

Table III-14 ENVIRONMENTAL STANDARDS OF ZAMBIA (1/2)

TABLE OF STANDARDS FOR TRADE AND OTHER EFFLUENTS

Column 1 SUBSTANCE	Column 2 TRADE EFFLUENT INTO PUBLIC SEWER	Column 3 SEWAGE AND OTHER EFFLUENT
A. PHYSICAL		
1. Temperature (Thermometer)	60°C. After mixing of the waters, the temperature should not exceed 40°C the sewer	40°C at the point of entry
2. Colour Hazen (Spectrophotometer)	The treatment plant ensure discolouration dyestuffs in the waste water	Must not cause any colouration of the receiving water
3. Odour and Taste (Threshold odour Number)	The odour must not cause any nuisance	Must not cause any deterioration in taste or odour as compared with the natural state
4. Total suspended solids (Gravimetric method)	1 200 mg/L (Avoid blockage of sewer, effect free flow)	50 mg/L. Must not formation of sludge or scum in receiving waters
5. Settleable matter sedimentation ml/L (Imhoff funnel)	1.0 ml/L in 2 yours (Avoid blockage of of sewer, effect free flow)	0.5 ml/L in two hours. Must not cause formation of sludge in receiving water
6. Salinity/Residue mg/L (Evaporation and Gravimetric method)	7 500 mg/L. The salinity must not affect the discharge and treatment or installations or their functioning	3 000 mg/L. The salinity of waste water must not adversely affect surface water
B. CHEMICAL		
7. pH (0–14 scale) (Electrometric method)	6–10	6–9
8. Dissolved Oxygen mg oxygen/L (Modified Winkler method and Membrane-electrode method)	No requirements	After complete mixing, the oxygen content must not be less than 5 mg/L. Extreme temperature may result in lower values
9. Chemical Oxygen Demand (COD) (Dichromate method)	1 800 mg/L	COD based on the limiting values for organic carbon 60–90 mg O_2/L average for 24 hours
10. Biochemical Oxygen Demand (BOD) (Modified Winkler method and Membrane Electrode method)	1 200 mg/L	50 mg O_2/L (mean value over a 21 hours period) According to circumstances in relation to the self-cleaning capacity of the waters
11. Nitrates (NO_3 as nitrogen (Spectrophotometric method and Electrometric method)	80 mg/L	The nitrates burden must be reduced as far as possible according to circumstances: Watercourse < 50 mg/L; Lakes < 20 mg/L
12. Nitrite (NO_2 as nitrogen/L) (Spectrophotometric sulfanilamide)	10.0 mg NO_2 as N/L	1.0 mg NO_2 as N/L
13. Organic Nitrogen (Spectrophotometric method N-Kjeldhal) (*the % of nutrient elements for degration of BOD should be 0.4–1% for phosphorous (different for processes using algae))	300 mg N/L	5.0 mg/L mean
14. Ammonia and Ammonium (Total) (NH_3 as N/L) (Nesslerization method and Electrometric method)	50 mg/L	The burden of ammonium salts must be reduced as far as 10 mg/L (dependingupon temporature, pH and salinity)
15. Cyanides (Spectrophotometric method)	0.5 mg/L	0.1 mg/L
16. Phosphorous (Total) (PO4 as P/L) (Colorimetric method)	45 mg/L	Treatment installation located in the catchment area of lakes: 1 mg/L located outside the catchment area: reduce the load of P as low as possible (PO_4 < 6 mg/L)
17. Sulphates (Turbidimetric method)	500 mg/L	The sulphate burden must be reduced as low as possible
18. Sulfite (Iodometric method)	10 mg/L	1 mg/L (presence of oxygen changes SO_3 to SO_4)
19. Sulphide (Iodometric and electrometric method)	1 mg/L	0.1 mg/L (depending on temporature, pH and dissolved O_2
20. Chlorides Cl/L (Silver nitrate and Merouric nitrate)	1 000 mg/L	Chloride levels must be as low as possible as < (600 mg/L)
21. Active chloride Cl_2/L (Iodometric method)	(0.5–3.0 mg/L)	0.5 mg/L
22. Active Bromine (Br_2/L) (Iodometric method)	(0.5–3.0 mg/L)	0.1 mg/L
23. Flourides F/L (Electrometric method and Colorimetric method with distillation)	(<30 mg/L)	10 mg/L

Table III-14 ENVIRONMENTAL STANDARDS OF ZAMBIA (2/2)

Column 1 Substance	Column 2 Trade Effluent into Public Sewer	Column 3 Sewage and Other Effluent
C. Metals		
24. Aluminium compounds (Atomic Absorption method)	<20 mg/L	<10mg/L
25. Antimony(Atomic Absorption method)	0.5 mg/L (inhibition of oxidation)	0.5mg/L
26. Arsenic compounds (Atomic Absorption method)	1.0 mg/L	1.0 mg/L
27. Barium compounds (water soluble concentration)(Atomic Absorption method)	1.0 mg/L	0.5 mg/L
28. Beryllium salts and compounds (Atomic Absorption method)	0.5 mg/L (inhibition of oxidation)	0.1–0.5 mg/L (according to circumstances)
29. Boron compounds (Spectro photometric method—Curcumin method)	<50 mg/L	<10 mg/L
30. Cadmium compounds (Atomic Absorption method)	1.5mg/L	0.5 mg/L
31. Chromium Hexavalent. Trivalent (Atomic Absorption method)	5.0mg/L	0.1mg/L
32. Cobalt compounds (Atomic Absorption method)	0.5 mg/L	0.5 mg/L
33. Copper compounds (Atomic Absorption method)	3. 0 mg/L	1.0 mg/L
34. Iron compounds (Atomic Absorption method)	15.0 mg/L	<2 mg/L
35. Lead compounds (Atomic Absorption method)	1.5mg/L	1.5 mg/L
36. Magnesium (Atomic Absorption method and Flame photometric method)	<1000 mg/L	<500.0 mg/L
37. Manganese (Atomic Absorption method)	10.0 mg/L	<3.0 mg/L
38. Mercury (Atomic Absorption method)	0.01 mg/L	0.00 1mg/L
39. Molybdenum (Atomic Absorption method)	5.0mg/L	0.5–5.0 mg/L
40. Nickel (Atomic Absorption method)	2.0 mg/L	2.0 mg/L
41. Selenium (Atomic Absorption method)	<1.0 mg/L	<0.05 mg/L
42. Silver (Atomic Absorption method)	0.1 (inhibition of oxidation)	0.1 mg/L
43. Thallium mg (Atomic Absorption method)	1.0 mg/L	<0.5 mg/L
44. Tin compounds (Atomic Absorption method)	2.0 mg/L	2.0 mg/L
45. Vanadium compounds (Atomic Asorption method)	1.0 mg/L	1.0 mg/L
46. Zinc compounds (Atomic Absorption method)	25.0mg/L	10.0 mg/L
D. Organics		
47. Total hydrocarbons (Chromatographic method)	20.0gm/L	10.0 mg/L
48. Oils (Mineral and Crude (Chromatographic method and Gravimetric method)	100.0 mg/L (after installation of oil separators) 20.0 mg/L (after installation of demulsifier)	1–2 mg/L
49. Phenols (steam distillable) (Non-steam distilled) (Colorimetric method)	5.0 mg/L 1.0 mg/L	0.2 mg/L 0.05 mg/L
50. Fats and saponifiable oils(Gravimetric method and Chromatographic method)	No requirement but installation of oil and fat separators	20.0.mg/L
51. Detergents (Anionic) (Atomic Absorption Spectrophotometric)	10.0 mg/L Alkybenzene sulfonate not permitted	2.0 mg (Detergents should contain at least biodegradable compounds)
52. Pesticides and PCB'S (Total) (Chromatographic method)	1.0 mg/L	0.5 mg/L (Reduce to a minimum)
53. Trihaloforms (Chromatographic)	1.0 mg/L	0.5 mg/L (Reduce to a minimum)
E. Radioactive Materials		
54. Radioactive materials as specified by IAEA	No discharge acceptol	Not permitted

Table III-15 INDUSTRIAL AIR AND WATER EFFLUENT CONTROL STANDARDS

Items	Zambia	The USA		Japan
1. Air Effluent				
- Regulation Title	None	Environmental Protection Agency, Regulations on Standard of Performance for New Stationary Source (40CFR60), 1971		Air Polution Control Law, 1968, Japan
- Standards				
- Phosphorus (P)	-	-		-
- Fluorides (F)	-	5 g of F/Ton of P_2O_5 Production		0.015 g/Nm^3 for Phosphate Fertilizer
- SO_2	-	2,000 g of SO_2/Ton of H_2SO_4 Production		11.9 Nm^3/Hour (K=14.5, 25 mH, 25 mH, 10 m/sec) for Phosphate Fertilizer
- Cd	-	-		0.001 g/Nm^3 for Cement Kiln
- Dust	-	50 g/Ton of Cement Clinker Production		0.200 g/Nm^3 for Phosphate Fertilizer Production
2. Water Effluent				
- Regulation Title	The Local Administration (Trade Effluent) Regulations, 1985	Environmental Protection Agency, Effluent Guidelines and Standards for Fertilizer Manufacturing (51FR24996), July 9, 1986		Water Polution Control Law, 1970, Japan
		One Day Maximum	Daily Value Average for 30 Days	
- Standards, mg/liter				
- Phosphorus (P)	45	105	35	-
- Fluorides (F)	30	75	25	15
- Total Suspended Solid (TSS)	1,200	150	50	200
- Biological Oxygen Demand (BOD)	1,200	-	-	160
- Chemical Oxygen Demand (COD)	1,800	-	-	160
- pH	6-10	-	-	5.8-8.6

Table III-16 PHOSPHATE FERTILIZER RAW MATERIALS AND PRODUCT PHYSICAL DISTRIBUTION COSTS COMPARISON (1/2)

Product Alternatives	Material Movement TPY	Potential Phosphate Fertilizer Plant Sites																					
		Kafue						Kabwe						Ndola						Kitwe					
		Modes					Annual Costs	Modes					Annual Costs	Modes					Annual Costs	Modes					Annual Costs
		RD km ZK/T	ZR km ZK/T	TZR km ZK/T	HDL Times ZK/T	TTL km ZK/T	ZK, MM	RD km ZK/T	ZR km ZK/T	TZR km ZK/T	HDL Times ZK/T	TTL km ZK/T	ZK, MM	RD km ZK/T	ZR km ZK/T	TZR km ZK/T	HDL Times ZK/T	TTL km ZK/T	ZK, MM	RD km ZK/T	ZR km ZK/T	TZR km ZK/T	HDL Times ZK/T	TTL km ZK/T	ZK, MM
Fused Magnesium Phosphate																									
- Raw Materials, Bulk																									
- Phosphate Rock from Chilembwe																									
		541	-	-	2	541		635	-	-	2	635		818	-	-	2	818		856	-	-	2	856	
	39,978	433	-	-	20	453	18.110	508	-	-	20	528	21.108	654	-	-	20	674	26.945	685	-	-	20	705	28.184
- Serpentine from Mkushi																									
		21	232	46	4	299		21	64	46	4	131		21	124	46	4	191		21	190	46	4	257	
	20,023	17	56	60	40	173	3.464	17	38	60	40	155	3.104	17	43	60	40	160	3.204	17	49	60	40	166	3.324
Sub-Total	60,001						21.574						24.212						30.149						31.508
- Product, Bagged and Destination to:																									
- Monze		-	108	-	2	108		-	277	-	2	277		-	464	-	2	464		-	530	-	2	530	
	18,849	-	25	-	20	45	0.848	-	53	-	20	73	1.376	-	76	-	20	96	1.810	-	84	-	20	104	1.960
- Lusaka		-	48	-	2	48		-	120	-	2	120		-	308	-	2	308		-	374	-	2	374	
	5,846	-	20	-	20	40	0.234	-	28	-	20	48	0.281	-	57	-	20	77	0.450	-	66	-	20	86	0.503
- Ndola		-	356	-	2	356		-	187	-	2	187		-	-	-	-	0		-	66	-	2	66	
	2,117	-	64	-	20	84	0.178	-	39	-	20	59	0.125	-	-	-	-	0	0.000	-	20	-	20	40	0.085
- Kabwe		-	168	-	2	168		-	-	-	-	0		-	187	-	2	187		-	253	-	2	253	
	5,544	-	36	-	20	56	0.310	-	-	-	-	0	0.000	-	39	-	20	59	0.327	-	49	-	20	69	0.33
- Mkushi		-	232	46	2	278		-	64	46	2	110		-	124	46	2	170		-	190	46	2	236	
	3,931	-	45	60	20	125	0.491	-	20	60	20	100	0.398	-	28	60	20	108	0.425	-	39	60	20	119	0.468
- Solwezi		173	490	-	4	663		173	321	-	4	494		173	134	-	4	307		173	68	-	4	241	
	302	138	81	-	40	259	0.078	138	59	-	40	237	0.072	138	30	-	40	208	0.063	138	20	-	40	198	0.060
- Chipata		612	-	-	2	612		705	-	-	2	705		888	-	-	2	888		926	-	-	2	926	
	8,972	490	-	-	20	510	4.576	564	-	-	20	584	5.240	710	-	-	20	730	6.550	741	-	-	20	761	6.828
- Mongu		627	-	-	2	627		624	-	-	2	624		807	-	-	2	807		845	-	-	2	845	
	504	502	-	-	20	522	0.263	499	-	-	20	519	0.262	646	-	-	20	666	0.336	676	-	-	20	696	0.351
- Mansa		175	488	-	4	663		175	319	-	4	494		175	132	-	4	307		175	66	-	4	241	
	1,008	140	80	-	40	260	0.262	140	59	-	40	239	0.241	140	29	-	40	209	0.211	140	20	-	40	200	0.202
- Kasama		-	232	632	2	864		-	64	632	2	696		-	124	632	2	756		-	190	632	2	822	
	3,327	-	45	110	20	175	0.582	-	20	110	20	150	0.499	-	28	110	20	158	0.526	-	39	110	20	169	0.562
Sub-Total	50,400						7.822						8.489						10.698						11.402
- Total	110,401						29.396						32.701						40.847						42.910
(Ratio)						Minimum ...	(1.000)						(1.112)						(1.390)					Maximum ...	(1.459)

Notes: 1) RD = Road, ZR = Zambia Railways Ltd., TZR = Tanzania Zambia Railway Authority, HDL = Loading and Unloading Handling (ZK10/Ton), TTL = Total Transport Distance and Cost

2) Cost estimates are as of January 01, 1987 and foreign currency exchange rate is assumed as ZK8.00/US$

Table III-16 PHOSPHATE FERTILIZER RAW MATERIALS AND PRODUCT PHYSICAL DISTRIBUTION COSTS COMPARISON (2/2)

Product Alternatives	Material Movement TPY	Potential Phosphate Fertilizer Plant Sites																					
		Kafue						Kabwe						Ndola						Kitwe					
		Modes					Annual Costs	Modes					Annual Costs	Modes					Annual Costs	Modes					Annual Costs
		RD km ZK/T	ZR km ZK/T	TZR km ZK/T	HDL Times ZK/T	TTL km ZK/T	ZK, MM	RD km ZK/T	ZR km ZK/T	TZR km ZK/T	HDL Times ZK/T	TTL km ZK/T	ZK, MM	RD km ZK/T	ZR km ZK/T	TZR km ZK/T	HDL Times ZK/T	TTL km ZK/T	ZK, MM	RD km ZK/T	ZR km ZK/T	TZR km ZK/T	HDL Times ZK/T	TTL km ZK/T	ZK, MM
Single Super Phosphate																									
- Raw Materials, Bulk																									
- Phosphate Rock from Chilembwe		541	-	-	2	541		635	-	-	2	635		818	-	-	2	818		856	-	-	2	856	
	39,978	433	-	-	20	453	18.110	508	-	-	20	528	21.108	654	-	-	20	674	26.945	685	-	-	20	706	28.184
- Sulfuric Acid																									
- from NCZ Kafue		-	-	-	1	0		-	168	-	2	168		-	356	-	2	356		-	422	-	2	422	
	20,255	-	-	-	10	10	0.203	-	36	-	20	56	1.135	-	63	-	20	83	1.682	-	70	-	20	90	1.823
Sub-Total	60,233						18.313						22.243						28.627						30.007
- Product, Bulk and Destination to:																									
- Kafue		-	-	-	1	1		-	168	-	2	168		-	356	-	2	356		-	422	-	2	422	
	57,205	-	-	-	10	10	0.057	-	35	-	20	55	3.147	-	63	-	20	83	4.749	-	70	-	20	90	5.150
- Monze		-	108	-	2	108		-	277	-	2	277		-	464	-	2	464		-	530	-	2	530	
	-	-	25	-	20	45	-	-	53	-	20	73	-	-	76	-	20	96	-	-	84	-	20	104	-
- Lusaka		-	48	-	2	48		-	120	-	2	120		-	308	-	2	308		-	374	-	2	374	
	-	-	20	-	20	40	-	-	28	-	20	48	-	-	57	-	20	77	-	-	66	-	20	86	-
- Ndola		-	356	-	2	356		-	187	-	2	187		-	-	-	-	-		-	66	-	2	66	
	-	-	64	-	20	84	-	-	39	-	20	59	-	-	-	-	-	-	-	-	20	-	20	40	-
- Kabwe		-	168	-	2	168		-	-	-	-	-		-	187	-	2	187		-	253	-	2	253	
	-	-	36	-	20	56	-	-	-	-	-	-	-	-	39	-	20	59	-	-	49	-	20	69	-
- Mkushi		-	232	46	2	278		-	64	46	2	110		-	124	46	2	170		-	190	46	2	236	
	-	-	45	60	20	125	-	-	20	60	20	100	-	-	28	60	20	108	-	-	39	60	20	119	-
- Solwezi		173	490	-	4	663		173	321	-	4	494		173	134	-	4	307		173	68	-	4	241	
	-	138	81	-	40	259	-	138	59	-	40	237	-	138	30	-	40	208	-	138	20	-	40	198	-
- Chipata		612	-	-	2	612		705	-	-	2	705		888	-	-	2	888		926	-	-	2	926	
	-	490	-	-	20	510	-	564	-	-	20	584	-	710	-	-	20	730	-	741	-	-	20	761	-
- Mongu		627	-	-	2	627		624	-	-	2	624		807	-	-	2	807		845	-	-	2	845	
	-	502	-	-	20	522	-	499	-	-	20	519	-	646	-	-	20	666	-	676	-	-	20	696	-
- Mansa		175	488	-	4	663		175	319	-	4	494		175	132	-	4	307		175	66	-	4	241	
	-	140	80	-	40	260	-	140	59	-	40	239	-	140	29	-	40	209	-	140	20	-	40	200	-
- Kasama		-	232	632	2	864		-	64	632	2	696		-	124	632	2	756		-	190	632	2	822	
	-	-	45	110	20	175	-	-	20	110	20	150	-	-	28	110	20	158	-	-	39	110	20	169	-
Sub-Total	57,205						0.057						3.147						4.749						5.150
- Total	117,438						18.370						25.390						33.376						35.157
(Ratio)						Minimum ...	(1.000)						(1.382)						(1.817)					Maximum ...	(1.914)

Notes: 1) RD = Road, ZR = Zambia Railways Ltd., TZR = Tanzania Zambia Railway Authority, HDL = Loading and Unloading Handling (ZK10/Ton), TTL = Total Transport Distance and Cost

2) Cost estimates are as of January 01, 1987 and foreign currency exchange rate is assumed as ZK8.00/US$

Table III-17 ORGANIZATION AND PERSONNEL FOR THE PHOSPHATE MINING AND CONCENTRATE PROJECT

Product : Chilembwe Phosphate Concentrate, P_2O_5 30.0%, Bulk
Capacity: 35,181 TPY (Dry)/39,978 TPY (Wet)
Location: Chilembwe, Zambia

	Director and Manager	Senior Engineer and Officer	Foreman, Officer, Technician	Operator, Worker, Secretary	Total
Factory Head Office and Factory Complex					
1. Factory Director's Office	(1)	(0)	(1)	(2)	(4)
2. General Affair Department	(1)	(3)	(13)	(22)	(39)
- Administration Section	1	0	2	2	5
- Personnel Section	0	0	2	2	4
- Financing/Accounting Section	0	1	2	2	5
- Purchasing/Logistics Section	0	1	2	2	5
- Housing and Welfare Section	0	1	2	3	6
- Security and Health Section	0	0	2	10	12
- Legal Section	0	0	1	1	2
3. Production Department	(0)	(12)	(18)	(19)	(49)
- Mining Section	0	5	10	10	25
- Concentration Section	0	7	8	9	24
4. Utility Department	(0)	(0)	(0)	(3)	(3)
- Water Treatment Section	0	0	0	1	1
- Electric Power Section	0	0	0	1	1
- Other Utility and Environment Section	0	0	0	1	1
5. Maintenance and Inspection Department	(0)	(2)	(2)	(6)	(10)
- Maintenance Management Section	0	1	0	1	2
- Mechanical Section	0	1	0	2	3
- Electrical and Instrumental Section	0	0	1	1	2
- Civil and Erection Section	0	0	1	1	2
- Inventory Control Section	0	0	0	1	1
6. Materials Handling Department	(0)	(0)	(2)	(5)	(7)
- Storage Section	0	0	1	1	2
- Loading and Unloading Section	0	0	1	4	5
7. Technical and Development Department	(1)	(1)	(1)	(2)	(5)
- Production Management Section	1	0	0	0	1
- Development and Engineering Section	0	1	0	0	1
- Analytical Laboratory	0	0	1	1	1
- Training Section	0	0	0	1	1
- Marketing Technical Assistance Section	0	0	1	0	0
Total Personnel Number	3	18	37	59	117
Personnel Charge, ZK/Man·Year-1987	40,000	25,000	10,000	8,000	Average: 11,726
					Total Amount: ZK1.372 MM/Year

Notes: 1) Additional contract laborers for product loading is assumed and which costs are included in product transport costs.
2) During annual maintenance works for 40 days, additional maintenance supervisor and laborers are contracted (Vendor specialist; 2, Inspector; 5, Laborer 50, Total 57 persons) whose costs are included in maintenance costs.
3) Personal charge includes direct salary, overtime, social welfare and fringe benefits covered by the company.

Table III-18 RAW MATERIAL CONSUMPTION CALCULATION FOR FUSED MAGNESIUM PHOSPHATE PRODUCTION (1/2)

1. Raw Material Supply for Fused Magnesium Phosphate Production

Phosphate Concentrate, Chilembwe, Zambia		
Item	Experimental	Design Base
Specification, %		
- P_2O_5	33.69	30.00
- CaO	46.18	41.11
- F	1.89	1.68
- Other	17.70	26.67
Solid Sub-Total	99.46	99.46
- Free Moisture	0.54	13.56(12%)
Total Weight	100.00	113.02
Production, TPY		
- Wet Material	-	39,978
- Dry Material	-	35,181
- P_2O_5	-	10,554
Transportation from Chilembwe Concentration Plant to FMP Plant, Kafue, Zambia		
- Road, km	-	541
- Railway, km	-	0
- Total, km	-	541
- Transportation Charges, ZK/Ton-1987		433
- Loading and Unloading		20
		453

Serpentine, Mkushi, Zambia		
Item	Experimental	Design Base
Specification, %		
- MgO	38.45	38.45
- SiO_2	41.44	41.44
- Others	7.36	7.36
- Ignition Loss	11.96	11.96
Solid Sub-Total	99.21	99.21
- Free Moisture	0.79	4.78(4.5%)
Total Weight	100.00	103.99
Production, TPY		
- Wet Material	-	20,023
- Dry Material	-	19,103
- MgO	-	7,345
Transportation from Mkushi Mine to FMP Plant, Kafue, Zambia		
- Road, km	-	21
- Railway, km	-	278
- Total, km	-	299
- Transportation Charges, ZK/Ton-1987		133
- Loading and Unloading		40
		173

2. Product Specification of Fused Magnesium Phosphate

Chemical Analysis, %	
- T-P_2O_5	20.31 (100.0%)
- T-MgO	14.15
- T-F	0.72 (54.6%)
- T-S	0.06
- Free Moisture	0.50
Fertilizer Nutrient, %	
- C-P_2O_5	20.11 (99.0%)
- F-P_2O_5	20.03 (98.6%)
- Av-P_2O_5	14.38 (70.8%)
- S-P_2O_5	14.25 (70.2%)
- W-P_2O_5	0.04 (0.2%)
- S-SiO_2	26.19
- C-MgO	14.05
- Total Alkalinity	42.00
Physical Property, %	
- Size, (+) 32 Mesh	55.6
(+) 100 Mesh	94.9
Packaging, kg Net	50.0 in PP Woven Bag/PE Inner Sack

Table III-18 RAW MATERIAL CONSUMPTION CALCULATION FOR FUSED MAGNESIUM PHOSPHATE PRODUCTION (2/2)

3. Raw Material and Utility Consumption for Fused Magnesium Phosphate Production

Items	Product Design of FMP	Conceptual Design for FMP Plant Production		
	TPT	Unit TPT	Daily TPD	Annual TPY
Raw Material, Ton				
- Phosphate Concentrate, Dry (P_2O_5 : 30.00%, CaO : 41.11%)	0.677	0.698*	117.27	35,181
- Serpentine, Dry (MgO : 38.45%, SiO_2 : 41.44%)	0.368	0.379*	63.67	19,103
- Electrode	-	0.005	0.84	252
- Calcium Hydroxide ($Ca(OH)_2$: 100%)	-	0.010	1.68	504
- Other Chemicals, $	-	0.100	16.80	5,040
Utility, Ton				
- Raw Water	-	6.250	1,050.00	315,000
- Fuel Oil (10,000 kcal/kg, S: 0.5%)	-	0.028	4.70	1,411
- Electricity, kWh	-	910	152,880	45.87 MM
Packaging				
- PP Woven/PE Inner Sack, 50 kg Net	-	20.200	3,394	1.018 MM

4. Production and Outputs for Fused Magnesium Phosphate Production

Fused Magnesium Phosphate, Bags, Ton	1.000	1.000	168.00	50,400
Calcium Fluoride (CaF_2 : 100%), Bulk, Ton	-	0.015	2.52	756
Exhaust Gas (50°C, F : 2 mg/Nm^3, Dust : 30 mg/Nm^3), Nm^3	-	-	-	-
Waste Water (35°C, F : 10 ppm, P_2O_5 : 1.0 ppm), Ton	-	3.000	504.00	151,200

Notes: 1) * Losses for transportation (1.0%), processing (1.0%) and in-plant material handlings (1.0%) are assumed total 3.0% from ex-mines of raw materials to salable product loading of FMP at the FMP plant.

2) Annual operation of 300 DPY is assumed.

3) Calcium fluoride is recovered as thickener slurry of 5% CaF_2, others are 2.1% of SiO_2 and 92.9% of free moisture. Physical property of solid; bulk density; 1.70 and angle of repose; 41°.

Table III-19 ORGANIZATION AND PERSONNEL FOR THE FUSED MAGNESIUM PHOSPHATE PROJECT

Product : Fused Magnesium Phosphate, C-P2O5: 20.11%, Bags
Capacity: 50,400 TPY
Location: Kafue, Zambia

	Director and Manager	Senior Engineer and Officer	Foreman, Officer, Technician	Operator, Worker, Secretary	Total
Factory Head Office and Factory Complex					
1. Factory Director's Office	(1)	(0)	(1)	(2)	(4)
2. General Affair Department	(1)	(1)	(4)	(4)	(10)
- Administration Section	1	0	0	0	1
- Personnel Section	0	0	1	0	1
- Financing/Accounting Section	0	0	1	0	1
- Purchasing/Logistics Section	0	1	0	1	2
- Housing and Welfare Section	0	0	1	0	1
- Security and Health Section	0	0	0	3	3
- Legal Section	0	0	1	1	1
3. Production Department	(0)	(1)	(8)	(36)	(45)
Fused Magnesium Phosphate Plant					
- Raw Material Feed	0	0	2	12	14
- Electric Furnace	0	1	2	8	11
- Quenching	0	0	2	8	10
- Drying	0	0	2	8	10
4. Utility Department	(0)	(0)	(2)	(3)	(5)
- Water Treatment Section	0	0	1	2	1
- Electric Power Section	0	0	1	2	2
- Other Utility and Environment Section	0	0	0	1	1
5. Maintenance and Inspection Department	(0)	(1)	(1)	(4)	(6)
- Maintenance Management Section	0	1	0	1	2
- Mechanical Section	0	0	0	1	1
- Electrical and Instrumental Section	0	0	1	1	2
- Civil and Erection Section	0	0	0	0	0
- Inventory Control Section	0	0	0	1	1
6. Materials Handling Department	(0)	(0)	(1)	(7)	(8)
- Storage Section	0	0	0	1	1
- Packing Section	0	0	1	5	6
- Loading and Unloading Section	0	0	0	1	1
7. Technical and Development Department	(0)	(1)	(3)	(1)	(5)
- Production Management Section	0	1	0	0	1
- Development and Engineering Section	0	0	1	0	1
- Analytical Laboratory	0	0	1	1	2
- Training Section	0	0	0	0	0
- Marketing Technical Assistance Section	0	0	1	0	1
Total Personnel Number	2	4	20	57	83
Personnel Charge, ZK/Man·Year-1987	40,000	25,000	10,000	8,000	Average: 10,072
					Total Amount: ZK0.846/Year

Notes: 1) During annual maintenance works for 35 days, additional maintenance supervisor and laborers are contracted (Vendor specialist; 2, Inspector; 5, Laborer 40, Total 47 persons) whose costs are included in maintenance costs.
2) Personal charge includes direct salary, overtime, social welfare and fringe benefits covered by the company.

Table III-20 RAW MATERIAL CONSUMPTION CALCULATION FOR SINGLE SUPER PHOSPHATE PRODUCTION (1/2)

1. Raw Material Supply for Single Super Phosphate Production

Chilembwe Phosphate Concentrate, Zambia		
Item	Experimental	Design Base
Specification, %		
- P_2O_5	33.69	30.00
- CaO	46.18	41.11
- F	1.89	1.68
- Other	17.70	26.67
Solid Sub-Total	99.46	99.46
- Free Moisture	0.54	13.56(12%)
Total Weight	100.00	113.02
Production, TPY		
- Wet Material	-	39,978
- Dry Material	-	35,181
- P_2O_5	-	10,553
Transportation from Chilembwe Concentration Plant to SSP Plant, Kafue, Zambia		
- Road, km	-	541
- Railway, km	-	0
- Total, km	-	541
- Transportation Charges, ZK/Ton-1987		433
- Loading and Unloading Charges		20
		453

Sulfuric Acid NCZ, Kafue, Zambia		
Item	Experimental	Design Base
Specification, %		
- H_2SO_4	98.0	98.0
Sub-Total	98.0	98.0
- Free Moisture	2.0	2.0
Total Weight	100.0	100.0
Supply from NCZ, Kafue, TPY		
- Wet Material (98%)		20,255
- Dry Material (100%)		19,850
- Sulfur		6,483
Transportation from NCZ, Kafue to SSP Plant, Kafue, Zambia		
- Pipeline, km		1
- Transportation Charge, ZK/Ton-1987		0
- Loading and Unloading		10
		10

2. Product Specification of Single Super Phosphate

Chemical Analysis, %	
- T-P_2O_5	17.91 (100.0%)
- T-MgO	0.23
- T-F	0.79 (70.0%)
- T-S	11.10
- Free Moisture	8.40
Fertilizer Nutrient, %	
- C-P_2O_5	17.46 (97.5%)
- F-P_2O_5	17.40 (97.2%)
- Av-P_2O_5	17.20 (96.0%)
- S-P_2O_5	17.10 (95.5%)
- W-P_2O_5	15.15 (84.6%)
- Free Acid (P_2O_5)	3.70 (20.7%)
Physical Property, %	
- Size, (+) 12 Mesh	35.0
(+) 60 Mesh	80.0
Packaging, kg Net	Bulk

Table III-20 RAW MATERIAL CONSUMPTION CALCULATION FOR SINGLE SUPER PHOSPHATE PRODUCTION (2/2)

3. Raw Material and Utility Consumption for Single Super Phosphate Production

Items	Product Design of SSP	Conceptual Design for SSP Plant Production		
	TPT	Unit TPT	Daily TPD	Annual TPY
Raw Material, Ton				
- Phosphate Concentrate, Dry (P_2O_5 : 30.00%, CaO : 41.11%)	0.597	0.615*	117.27	35,181
- Sulfuric Acid (H_2SO_4 : 100.0%)	0.340	0.347*	66.17	19,850
- Calcium Hydroxide ($Ca(OH)_2$: 100%)	-	0.010	1.91	572
- Other Chemicals, $	-	0.100	19.07	5,722
Utility, Ton				
- Raw Water	-	5.500	1,048.74	314,628
- Fuel Oil (10,000 kcal/kg, S: 0.5%)	-	0.010	1.91	572
- Electricity, kWh	-	45.000	8,580.60	2.575 MM
Packaging				
- PP Woven/PE Inner Sack, 50 kg Net	-	-	-	-

4. Production and Outputs for Single Super Phosphate Production

Single Super Phosphate, Bulk, Ton	1.000	1.000	190.68	57,205
Calcium Fluoride (CaF_2 : 100%), Bulk, Ton	-	0.012	2.288	687
Exhaust Gas (50°C, F : 2 mg/Nm^3, Dust : 30 mg/Nm^3), Nm^3	-	1,185	0.226 MM	67.8 MM
Waste Water (35°C, F : 10 ppm, P_2O_5 : 1.0 ppm), Ton	-	5.240	999.17	299,754

Notes: 1) * Losses for transportation (1.0%), processing (1.0%) and in-plant material handlings (1.0%) are assumed total 3.0% from ex-mines of raw materials to salable product loading of SSP at the SSP plant.

2) In-plant losses for sulfuric acid is assumed 2.0%.

3) Annual operation of 300 DPY is assumed.

4) Calcium fluoride is recovered as thickener slurry of 5% CaF_2, others are 2.1% of SiO_2 and 92.9% of free moisture. Physical property of Solid: bulk density; 1.70 and angle of repose; 41°.

Table III-21 ORGANIZATION AND PERSONNEL FOR THE SINGLE SUPER PHOSPHATE PROJECT

Product : Single Super Phosphate, Av-P_2O_5: 17.20%, Bulk
Capacity: 57,205 TPY
Location: Kafue, Zambia

	Director and Manager	Senior Engineer and Officer	Foreman, Officer, Technician	Operator, Worker, Secretary	Total
Factory Head Office and Factory Complex					
1. Factory Director's Office	(1)	(0)	(1)	(2)	(4)
2. General Affair Department	(1)	(1)	(4)	(4)	(10)
- Administration Section	1	0	0	0	1
- Personnel Section	0	0	1	0	1
- Financing/Accounting Section	0	0	1	0	1
- Purchasing/Logistics Section	0	1	0	1	2
- Housing and Welfare Section	0	0	1	0	1
- Security and Health Section	0	0	0	3	3
- Legal Section	0	0	1	1	1
3. Production Department	(0)	(1)	(8)	(28)	(37)
Single Super Phosphate Plant					
- Raw Material Feed	0	0	3	12	15
- Acidulation and Gas Treatment	0	1	3	8	12
- Conditioning	0	0	2	9	10
4. Utility Department	(0)	(0)	(2)	(3)	(5)
- Water Treatment Section	0	0	1	0	1
- Steam Generation Section	0	0	0	1	1
- Electric Power Section	0	0	1	1	2
- Other Utility and Environment Section	0	0	0	1	1
5. Maintenance and Inspection Department	(0)	(1)	(1)	(3)	(5)
- Maintenance Management Section	0	1	0	1	2
- Mechanical Section	0	0	1	1	1
- Electrical and Instrumental Section	0	0	0	1	1
- Civil and Erection Section	0	0	0	0	0
- Inventory Control Section	0	0	0	1	1
6. Materials Handling Department	(0)	(0)	(1)	(7)	(8)
- Storage Section	0	0	1	2	3
- Packing Section	0	0	0	0	0
- Loading and Unloading Section	0	0	0	5	5
7. Technical and Development Department	(0)	(1)	(3)	(1)	(5)
- Production Management Section	0	1	0	0	1
- Development and Engineering Section	0	0	1	0	1
- Analytical Laboratory	0	0	1	1	2
- Training Section	0	0	0	0	0
- Marketing Technical Assistance Section	0	0	1	0	1
Total Personnel Number	2	4	20	48	74
Personnel Charge, ZK/Man·Year-1987	40,000	25,000	10,000	8,000	Average: 10,324
					Total Amount: ZK0.764 MM/Year

Notes: 1) During annual maintenance works for 35 days, additional maintenance supervisor and laborers are contracted (Vendor specialist; 2, Inspector; 5, Laborer 40, Total 47 persons) whose costs are included in maintenance costs.
2) Personal charge includes direct salary, overtime, social welfare and fringe benefits covered by the company.

Figure III-1 PHOSPHATE MINING AND CONCENTRATE PROJECT AT CHILEMBWE OF ZAMBIA

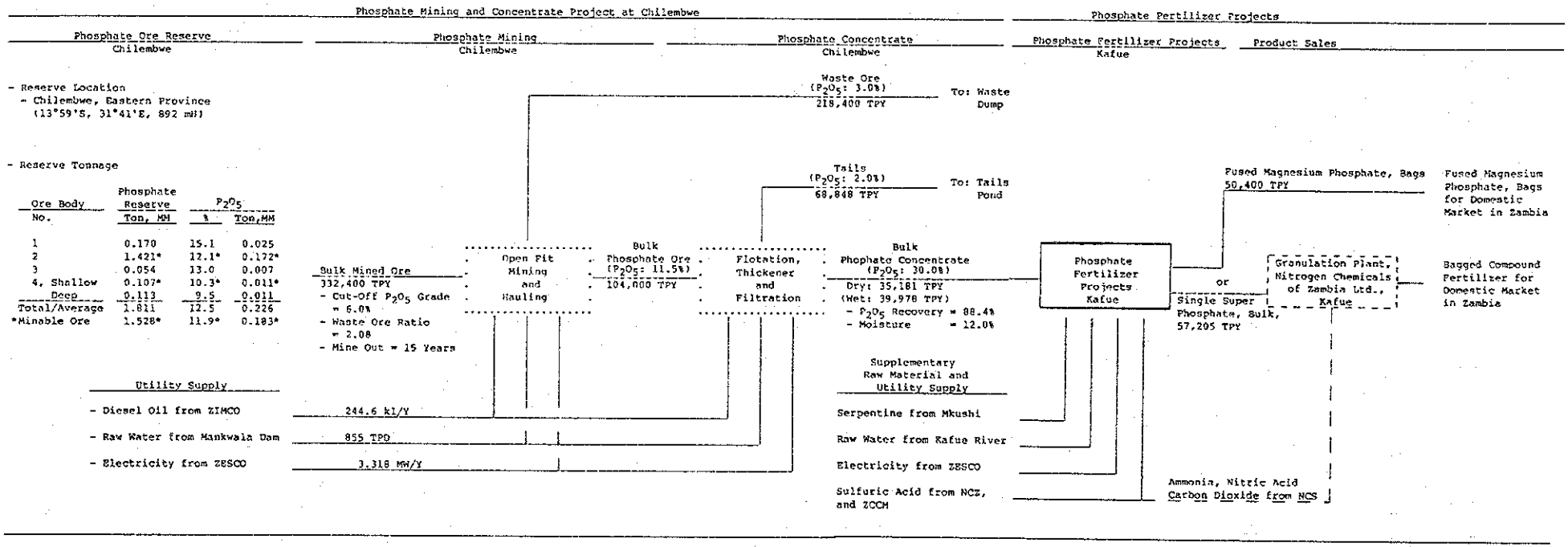
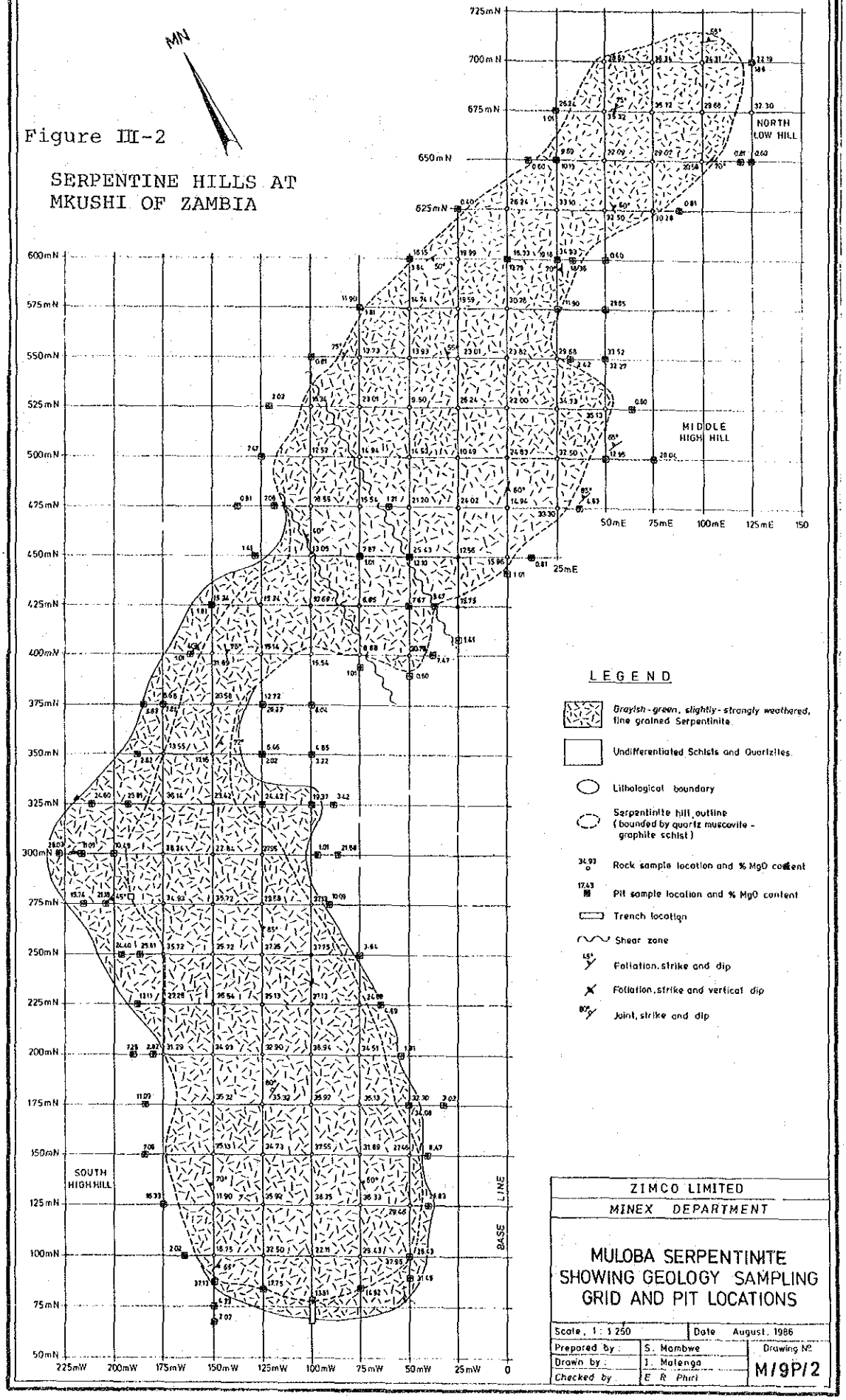


Figure III-2

SERPENTINE HILLS AT MKUSHI OF ZAMBIA



ZIMCO LIMITED
MINEX DEPARTMENT

MULOBA SERPENTINITE SHOWING GEOLOGY SAMPLING GRID AND PIT LOCATIONS

Scale, 1 : 1 250		Date August, 1986	
Prepared by :	S. Mambwe	Drawing N°	M/9P/2
Drawn by :	I. Malenga		
Checked by	E R Phiri		

Figure III-3

TOPOGRAPHY MAP OF SERPENTINE HILLS AT MKUSHI OF ZAMBIA

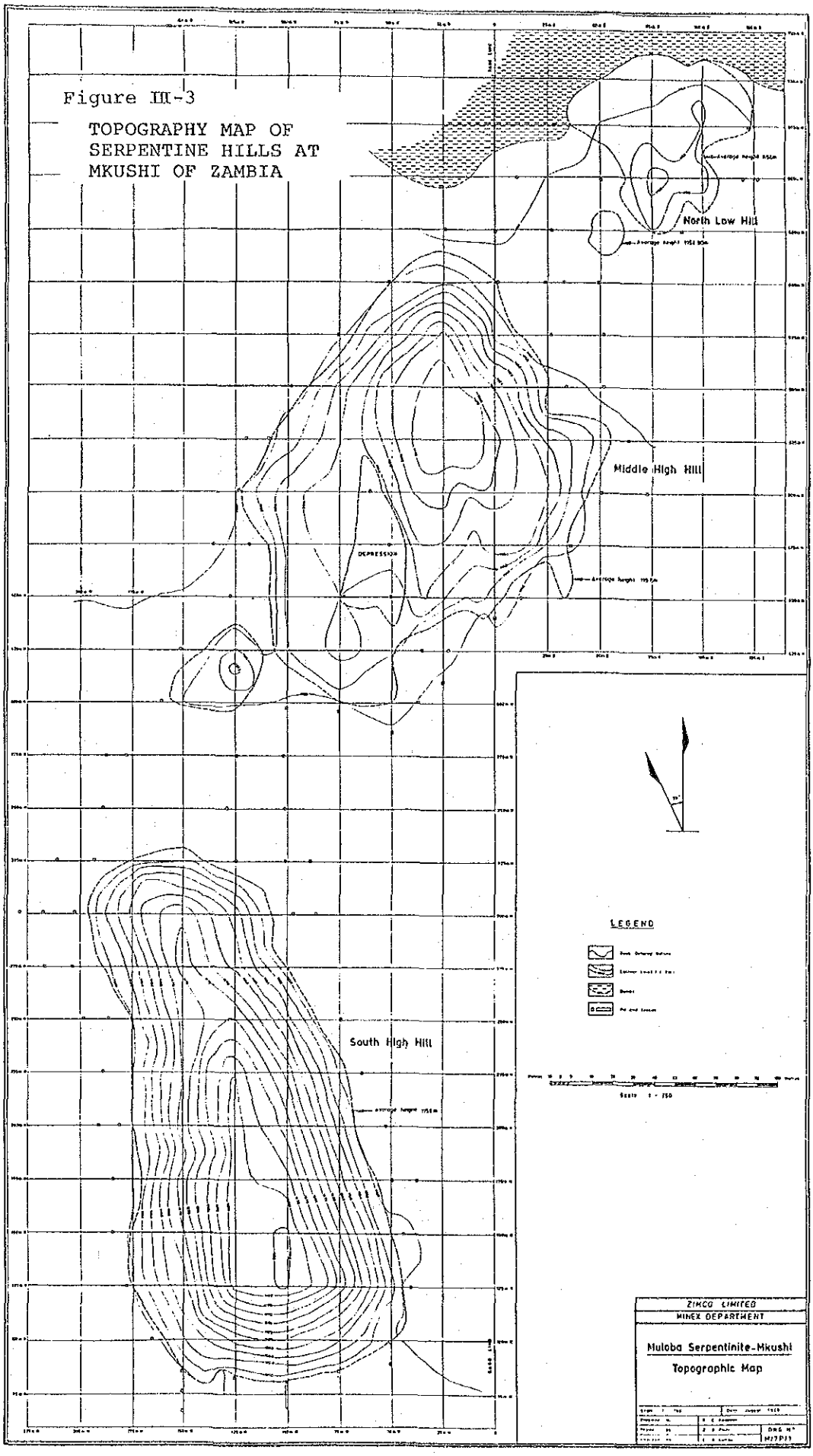
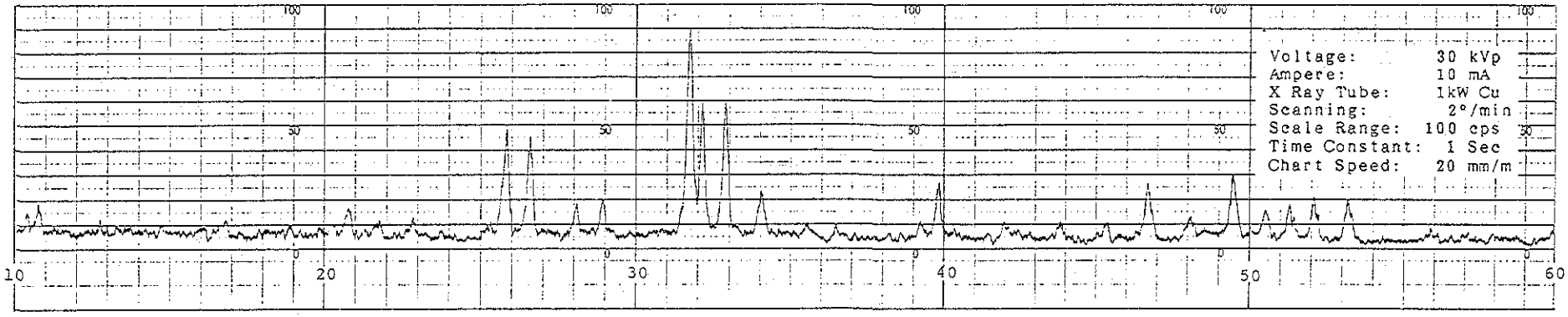


Figure Ⅲ-4 X RAY DIFFRACTION CHART (1/2)

Phosphate Concentrate: Chilembwe, Zambia



Phosphate Concentrate: Florida, USA

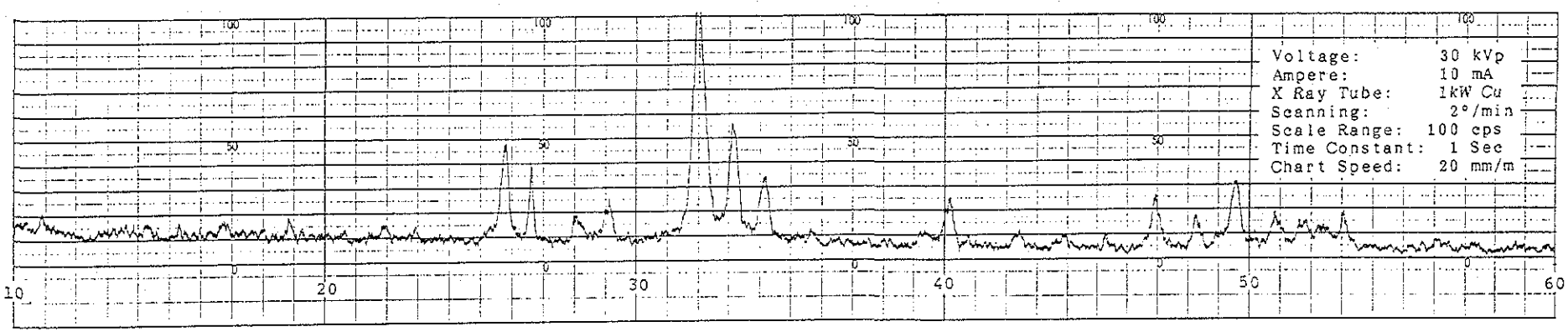
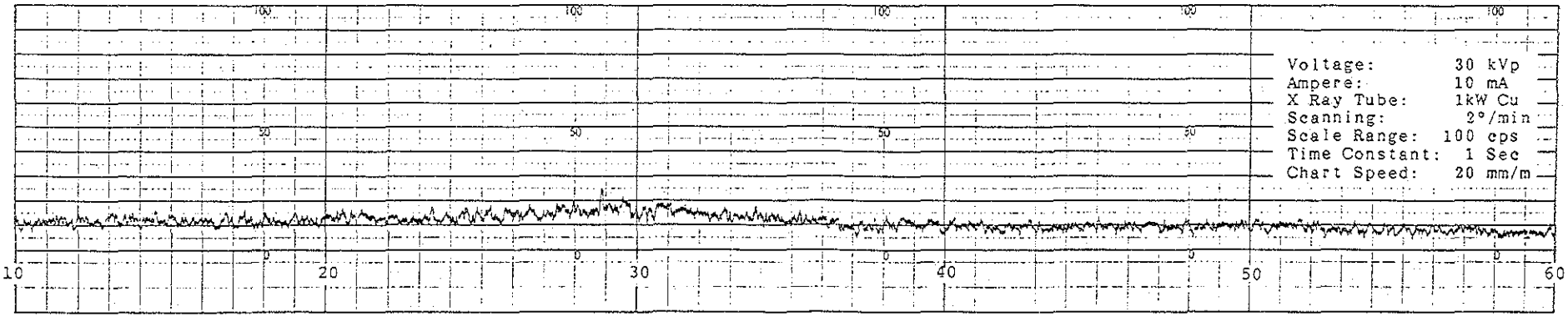


Figure Ⅲ-4 X RAY DIFFRACTION CHART (2/2)

Fused Magnesium Phosphate produced from Chilembwe Phosphate Concentrate, Zambia



Fused Magnesium Phosphate produced from Florida Phosphate Concentrate, USA

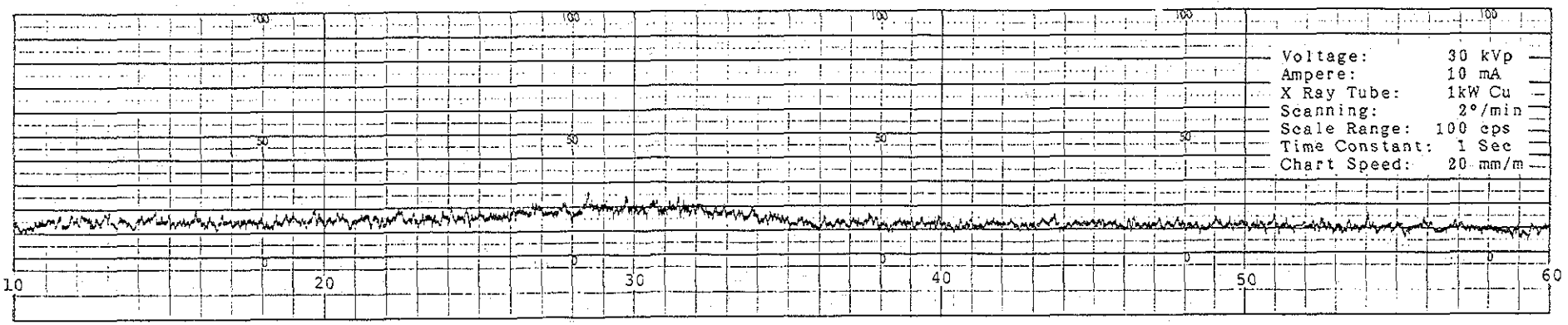


Figure III-5 PROJECT SITE ALTERNATIVES (1/4)

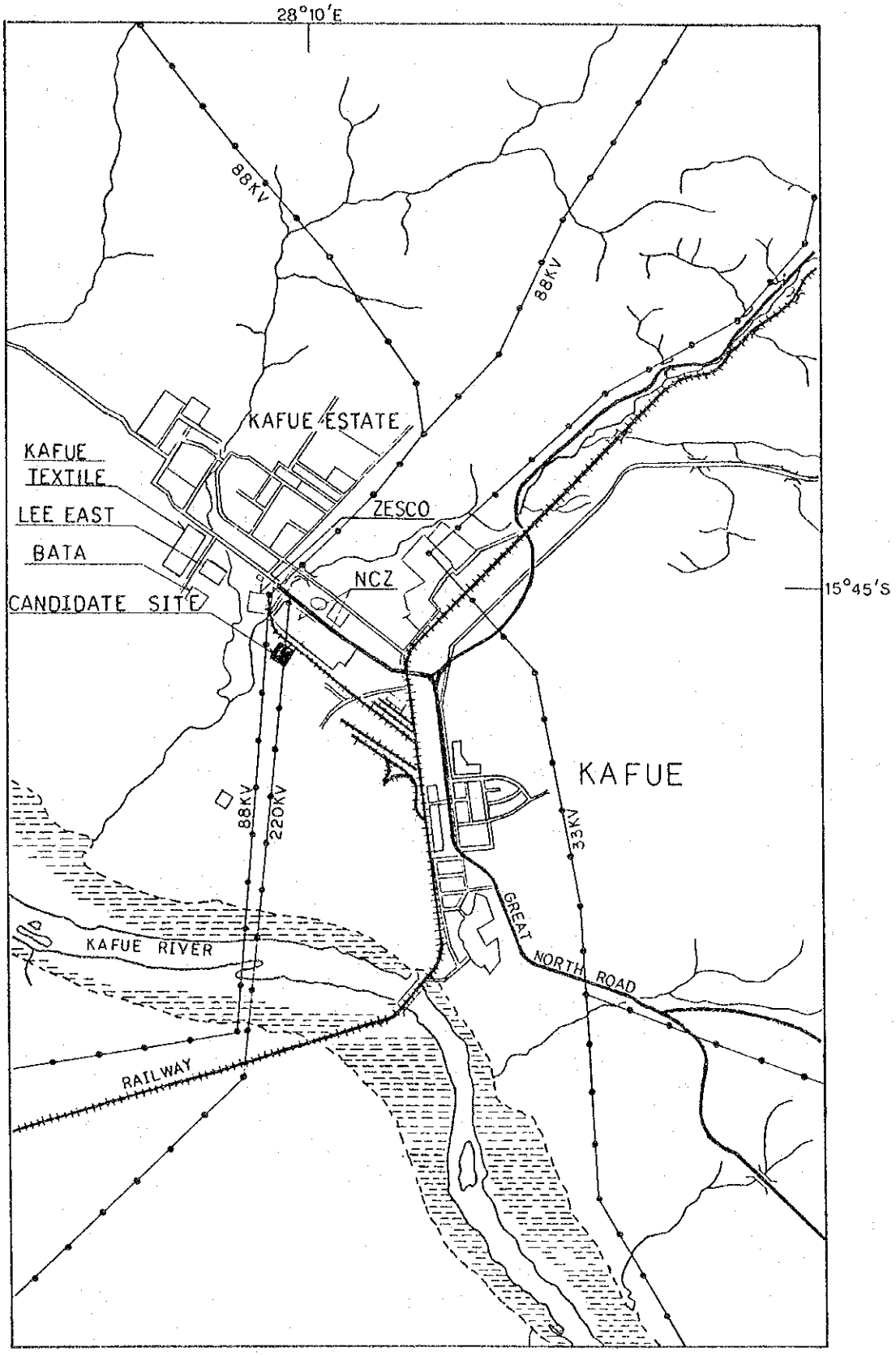


Figure III-5 PROJECT SITE ALTERNATIVES (2/4)

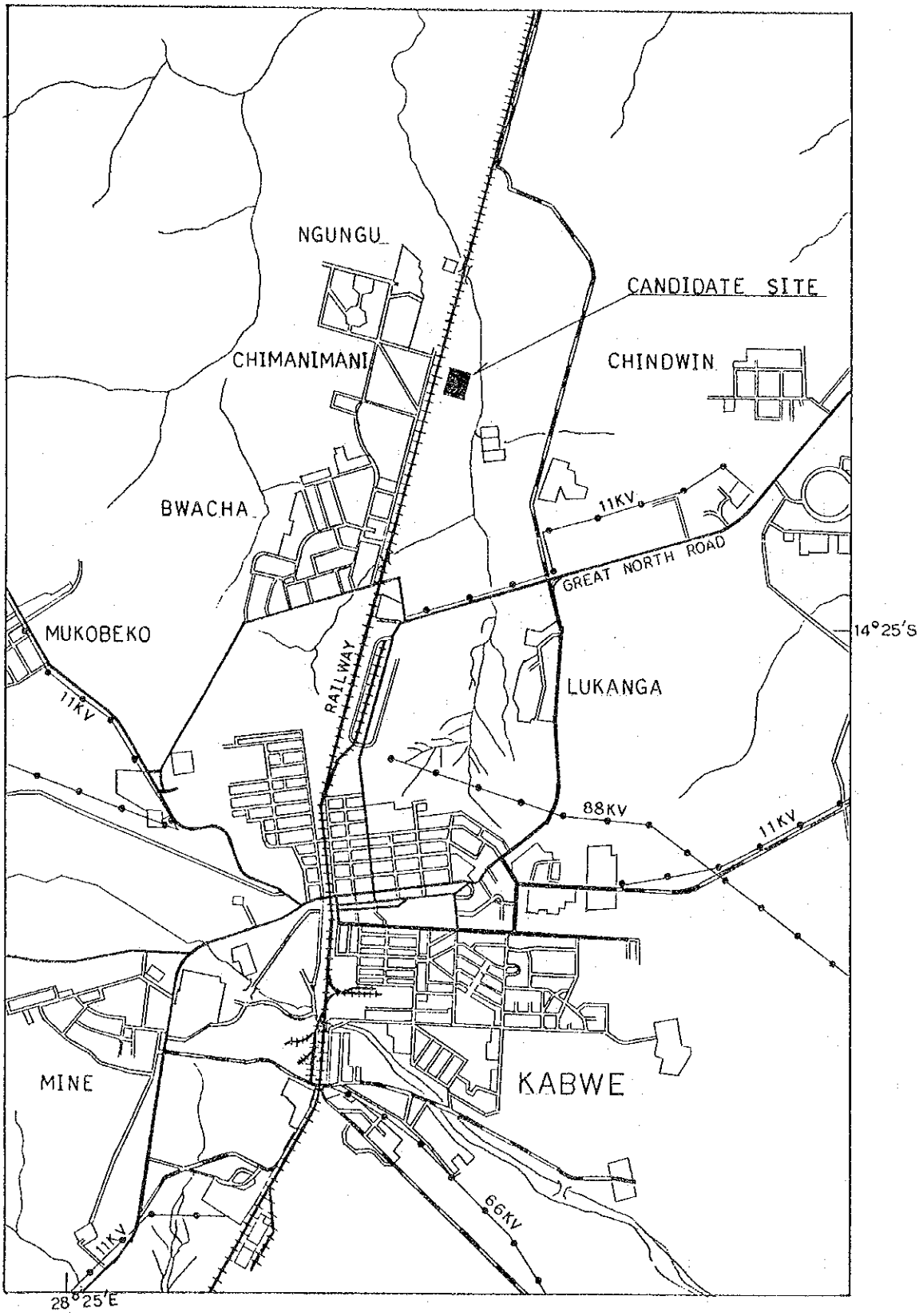


Figure III-5 PROJECT SITE ALTERNATIVES (3/4)

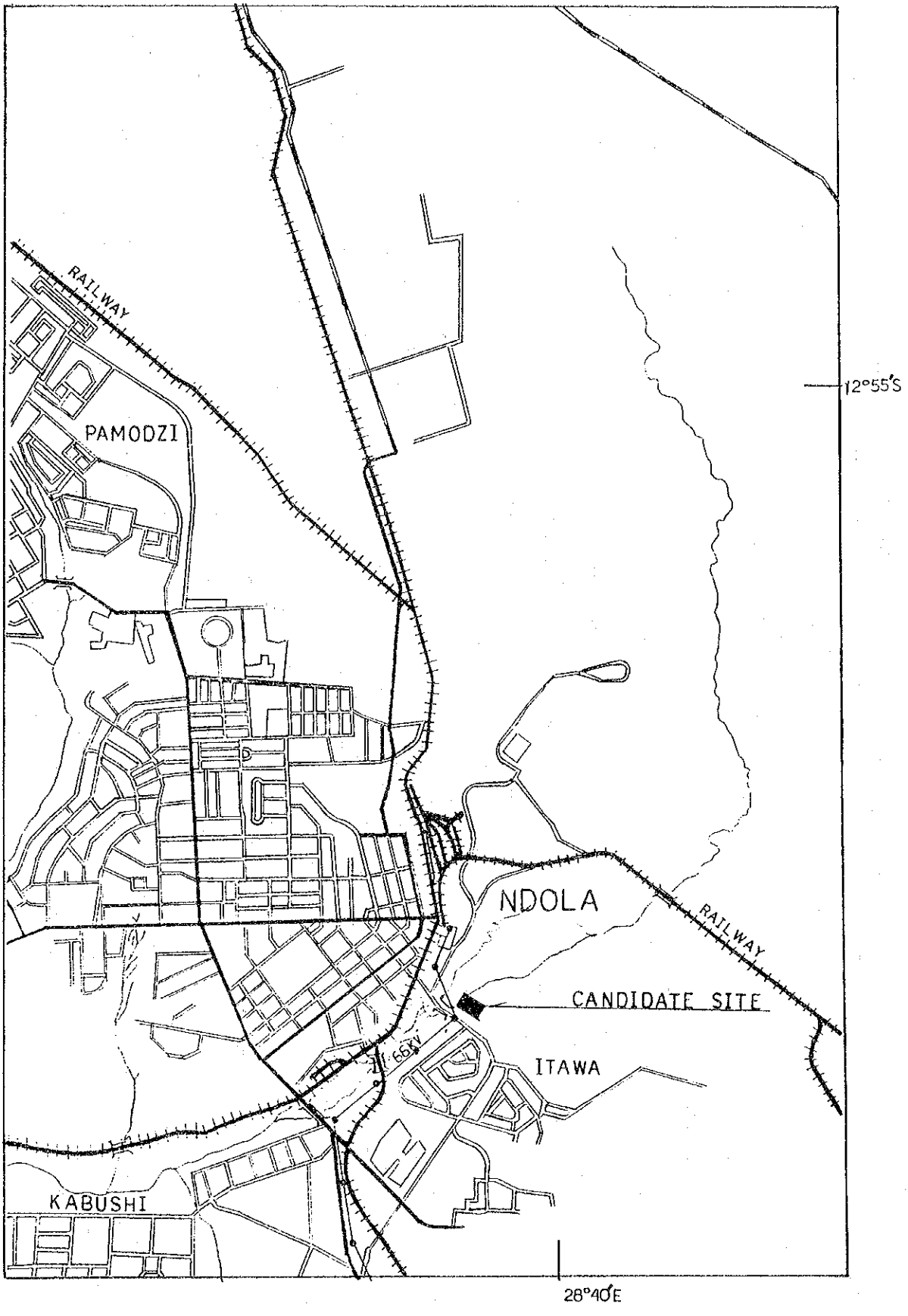


Figure III-5 PROJECT SITE ALTERNATIVES (4/4)

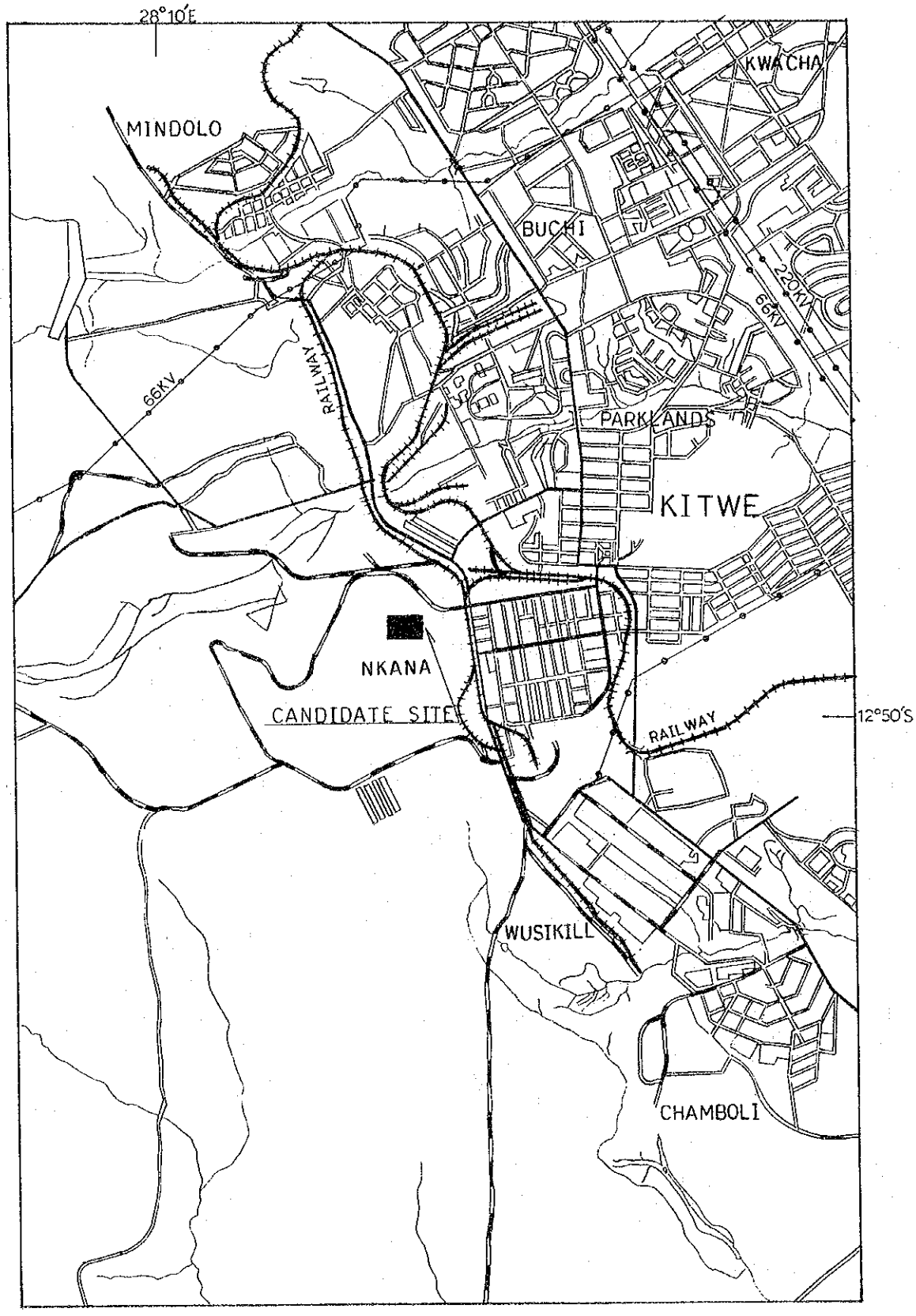


Figure III-6 RAILWAYS SYSTEMS IN ZAMBIA

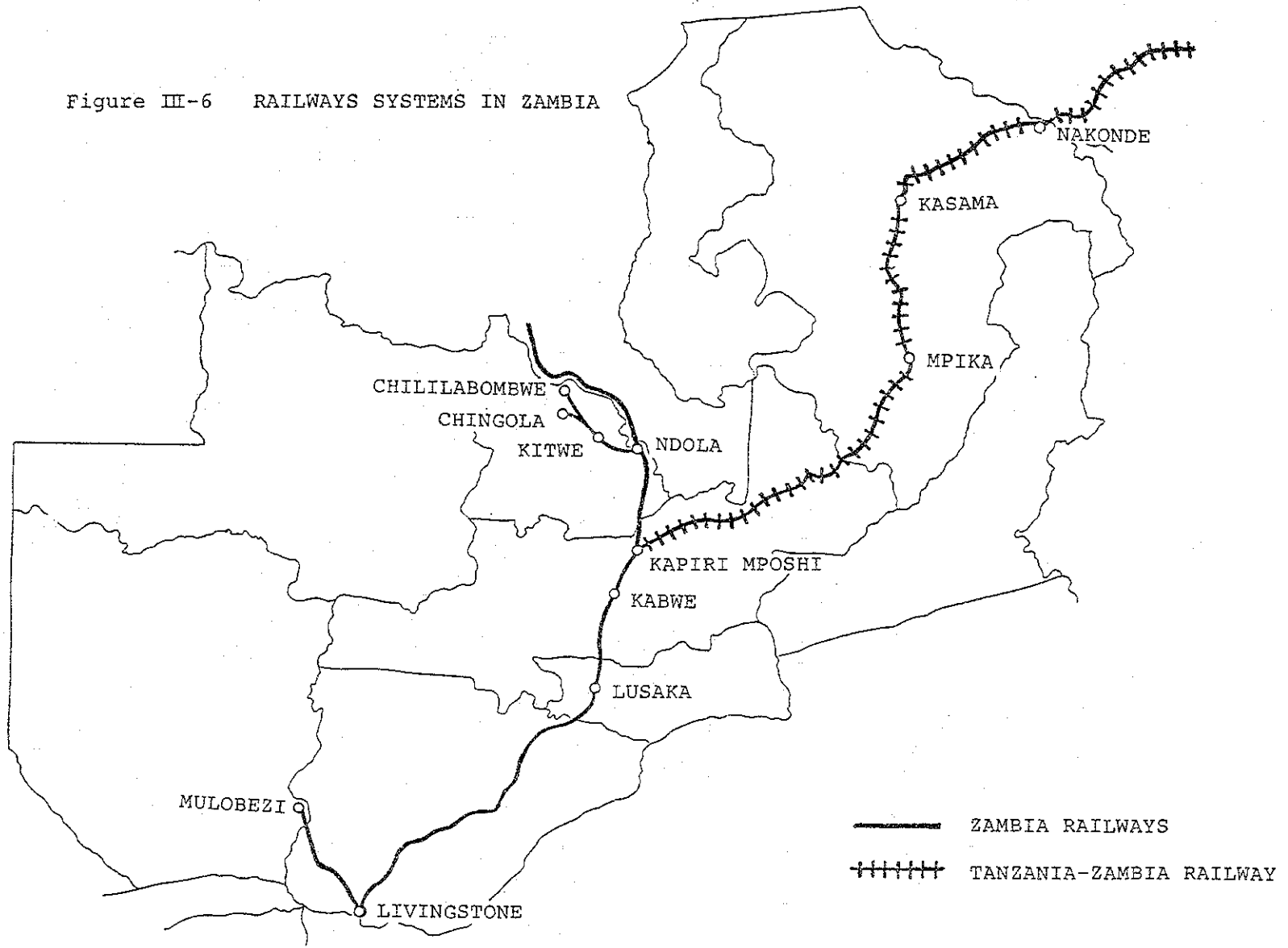


Figure Ⅲ-7 ROADS SYSTEM IN ZAMBIA

Figure III-8 TRANSPORT TARIFFS IN ZAMBIA

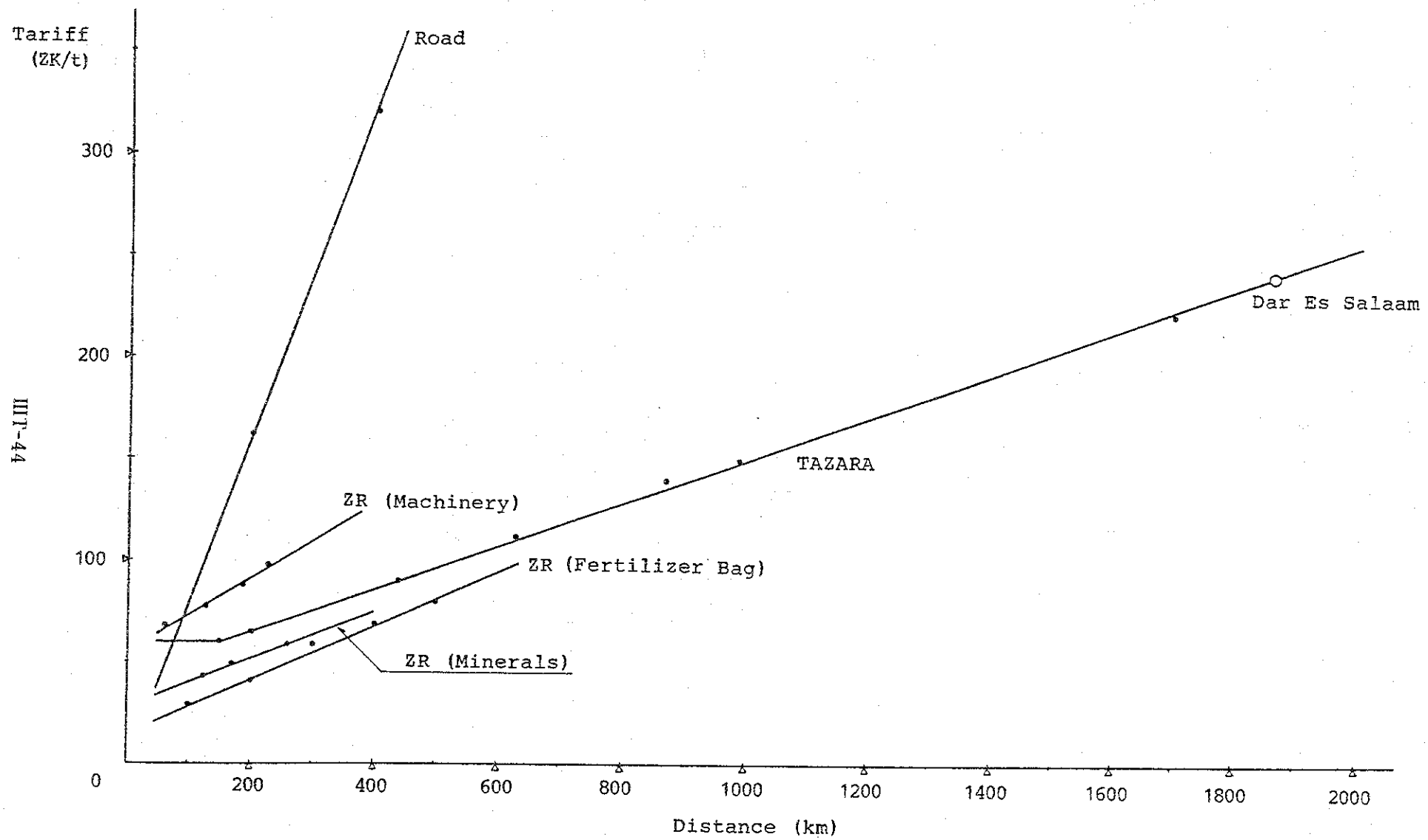


Figure III-9 TRANSPORT ROUTES AND DISTANCE IN ZAMBIA

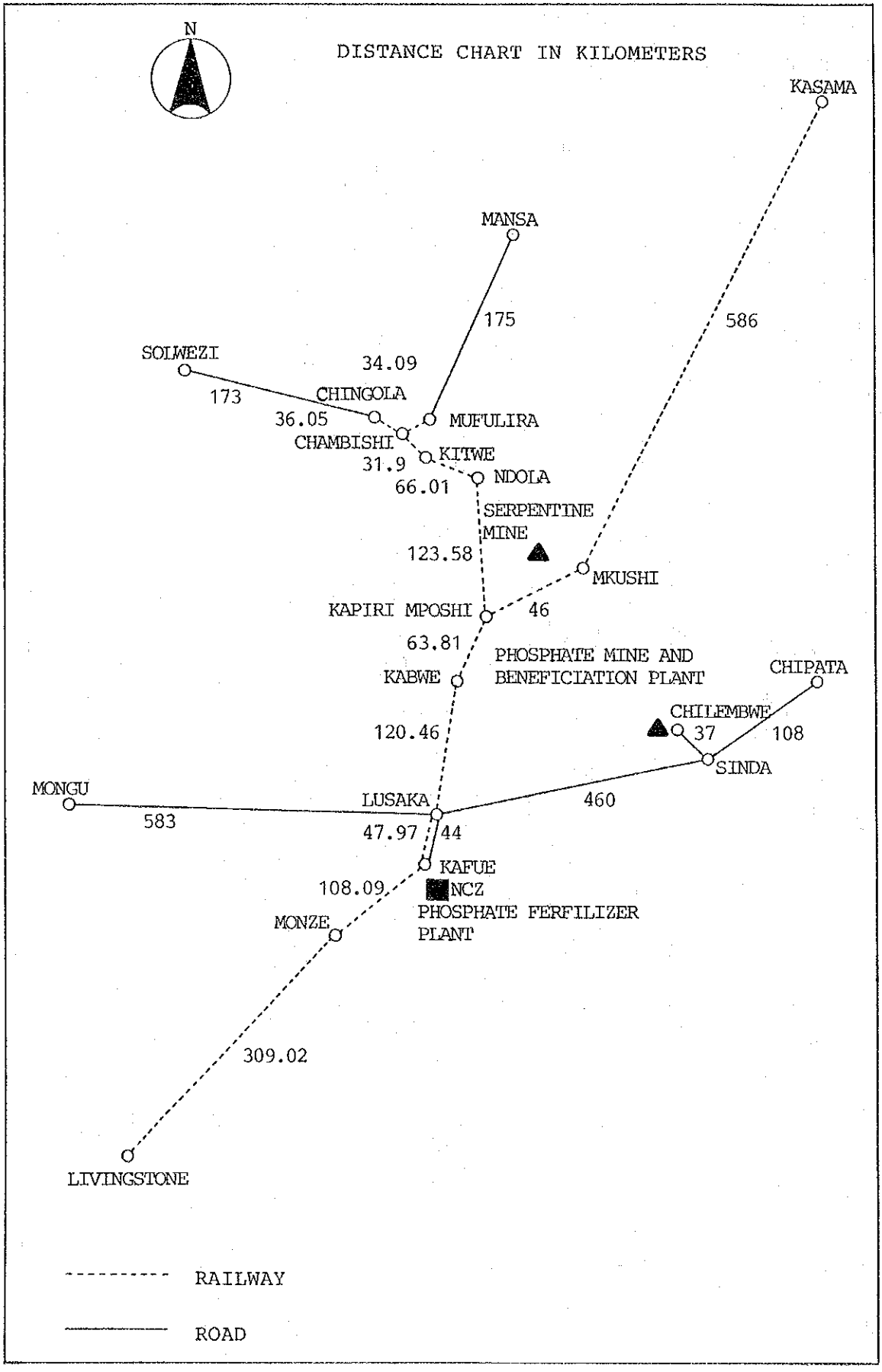


Figure III-10 AVIATION ROUTES IN ZAMBIA

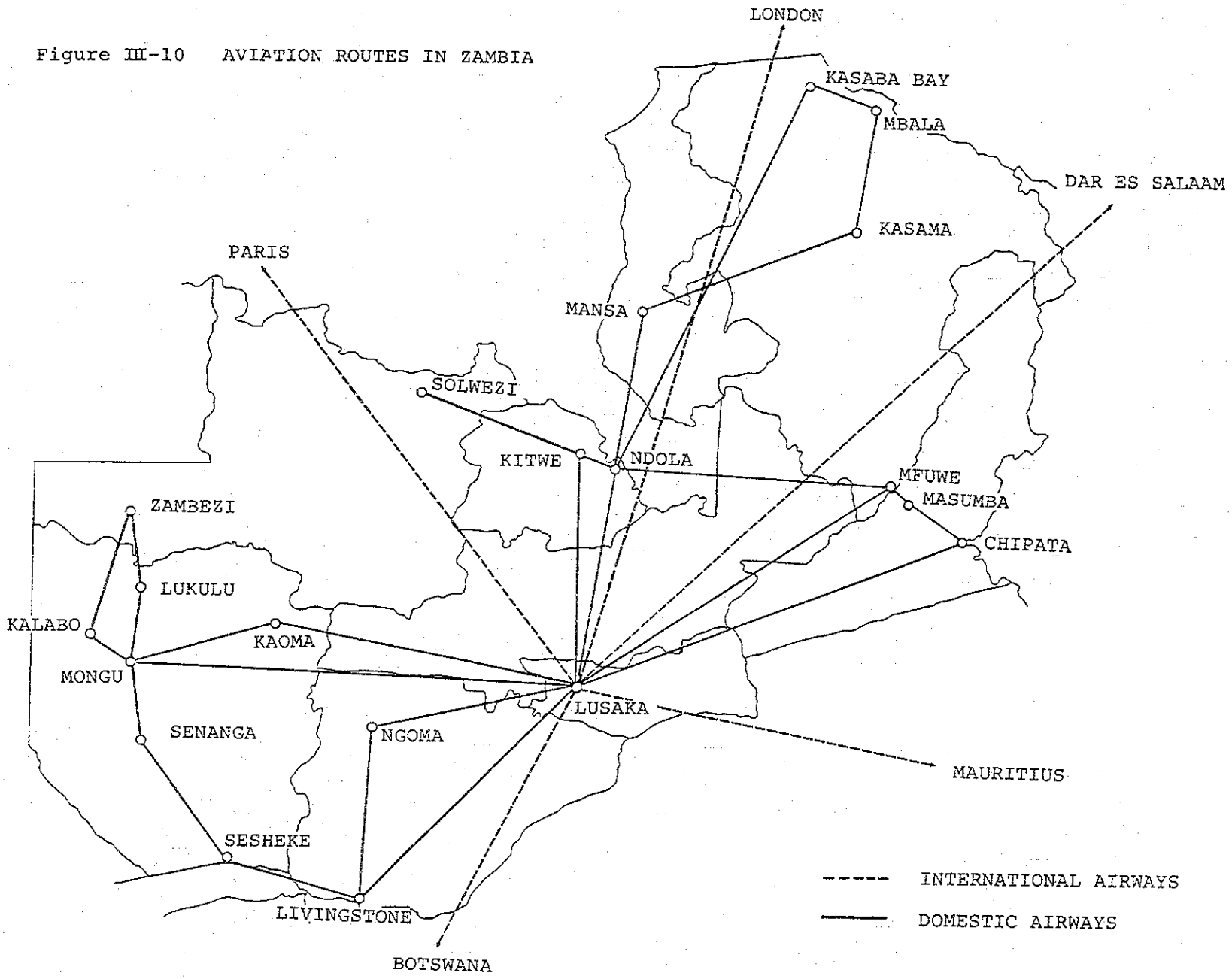


Figure III-11 ELECTRICITY GENERATION AND TRANSMISSION SYSTEMS IN ZAMBIA

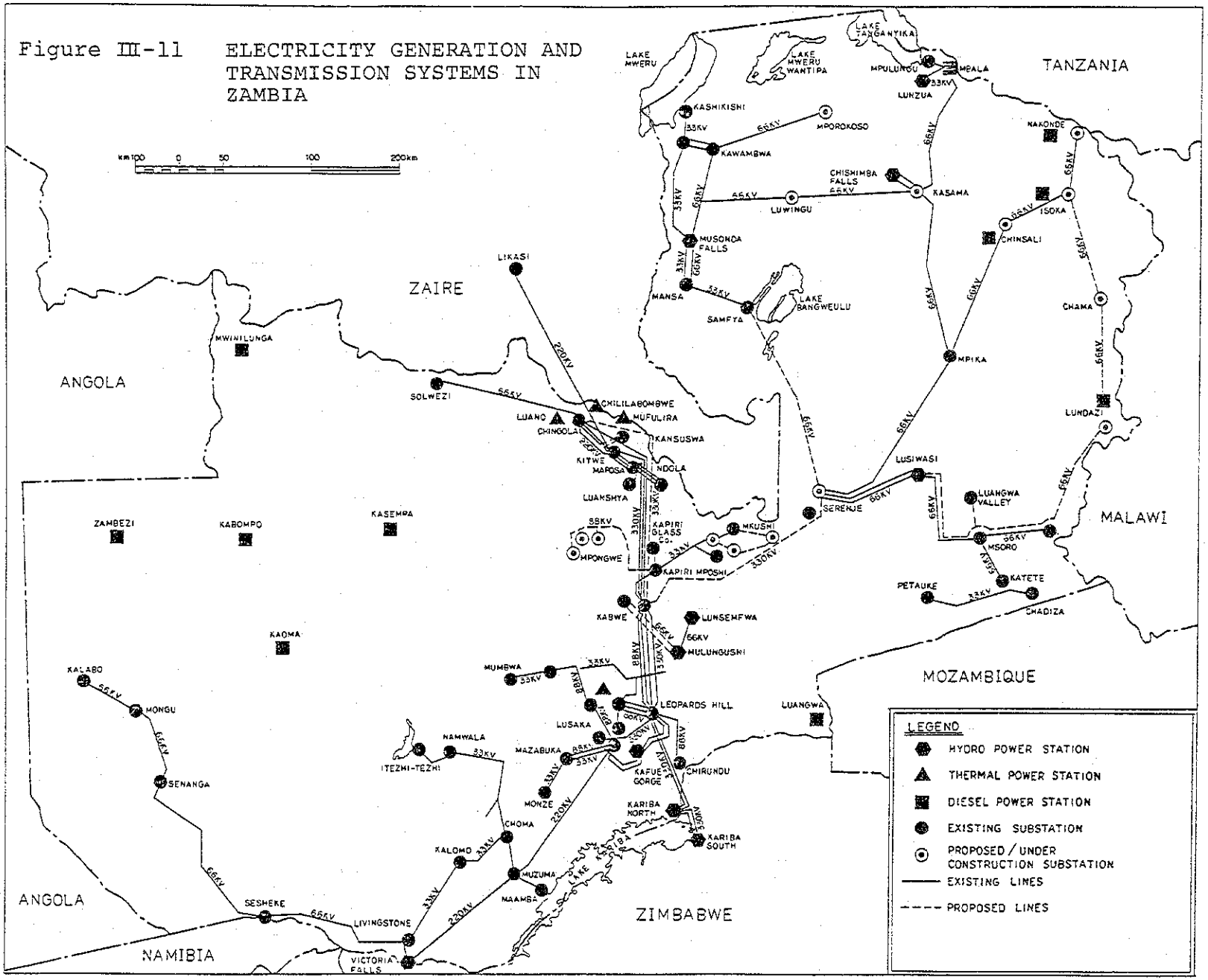
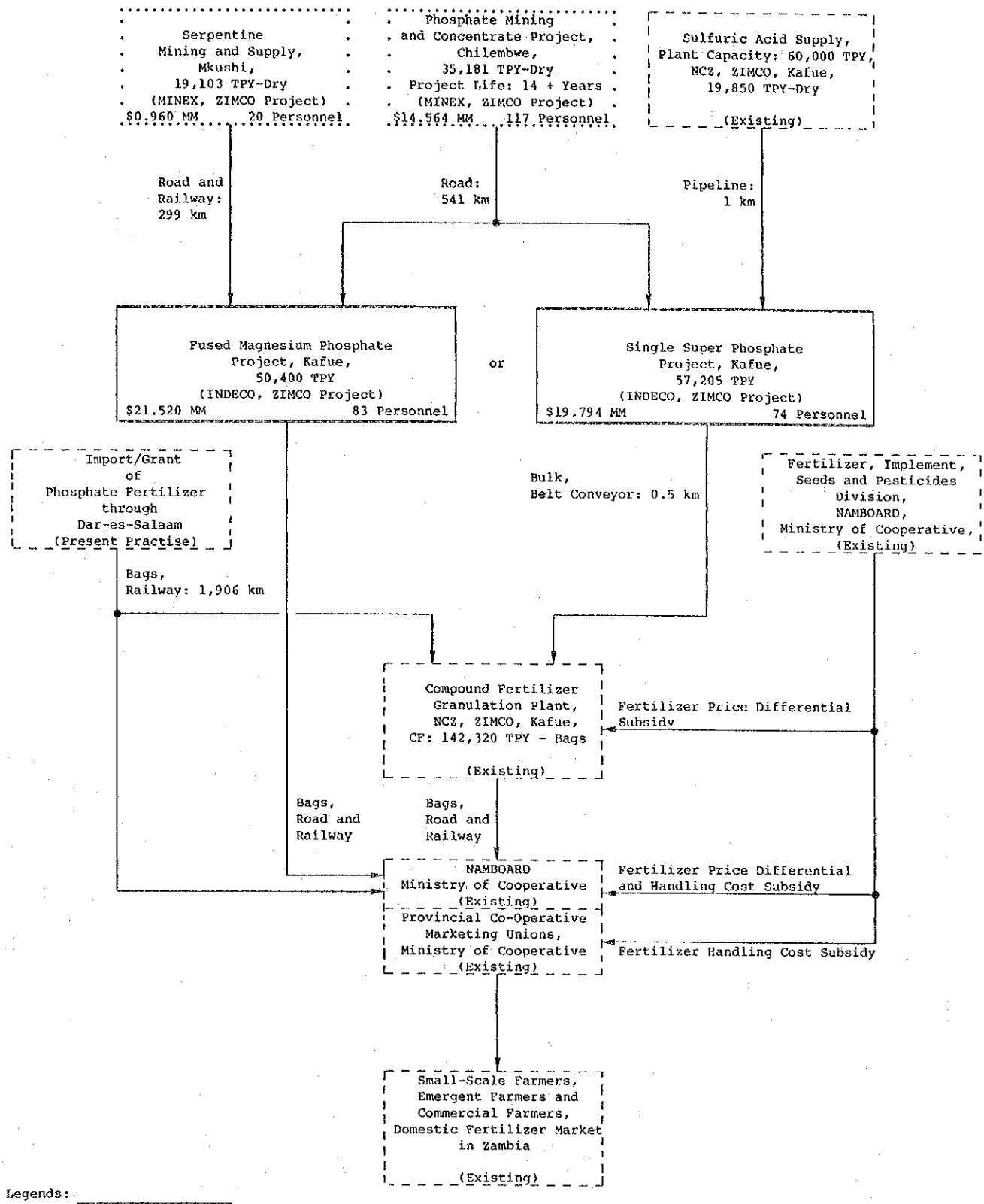


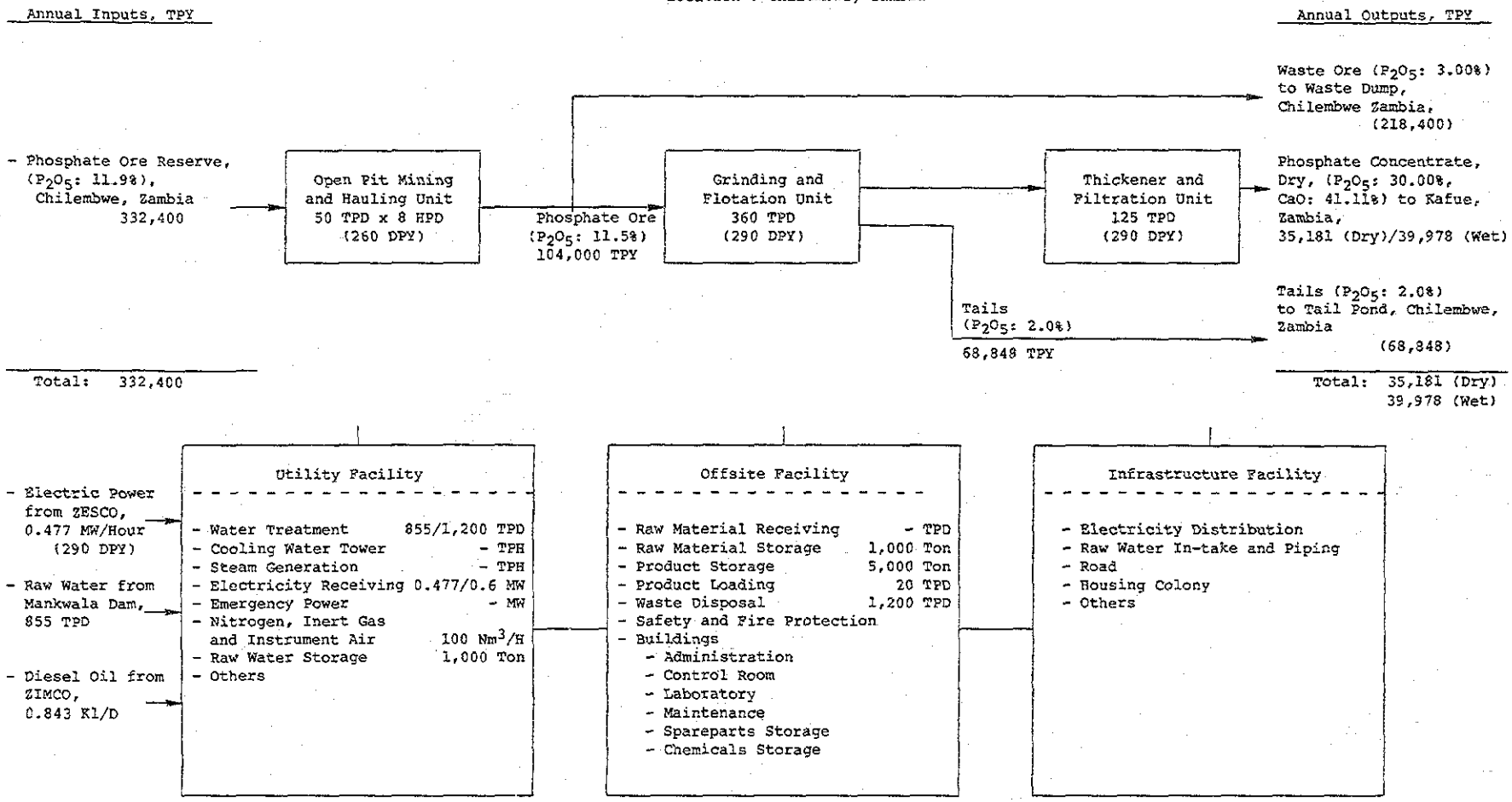
Figure III-12 INTEGRATION OF PHOSPHATE MINING AND CONCENTRATE PROJECT AND PHOSPHATE FERTILIZER PROJECTS IN ZAMBIA



Notes:
- Commercial Production; July 01, 1991
- Exchange Rate ; ZK8.00/US$
- Interest Rate ; 12%/year
- Escalation during 1991/1987
  - Foreign ; 14.23%
  - Zambian ; 14.23%

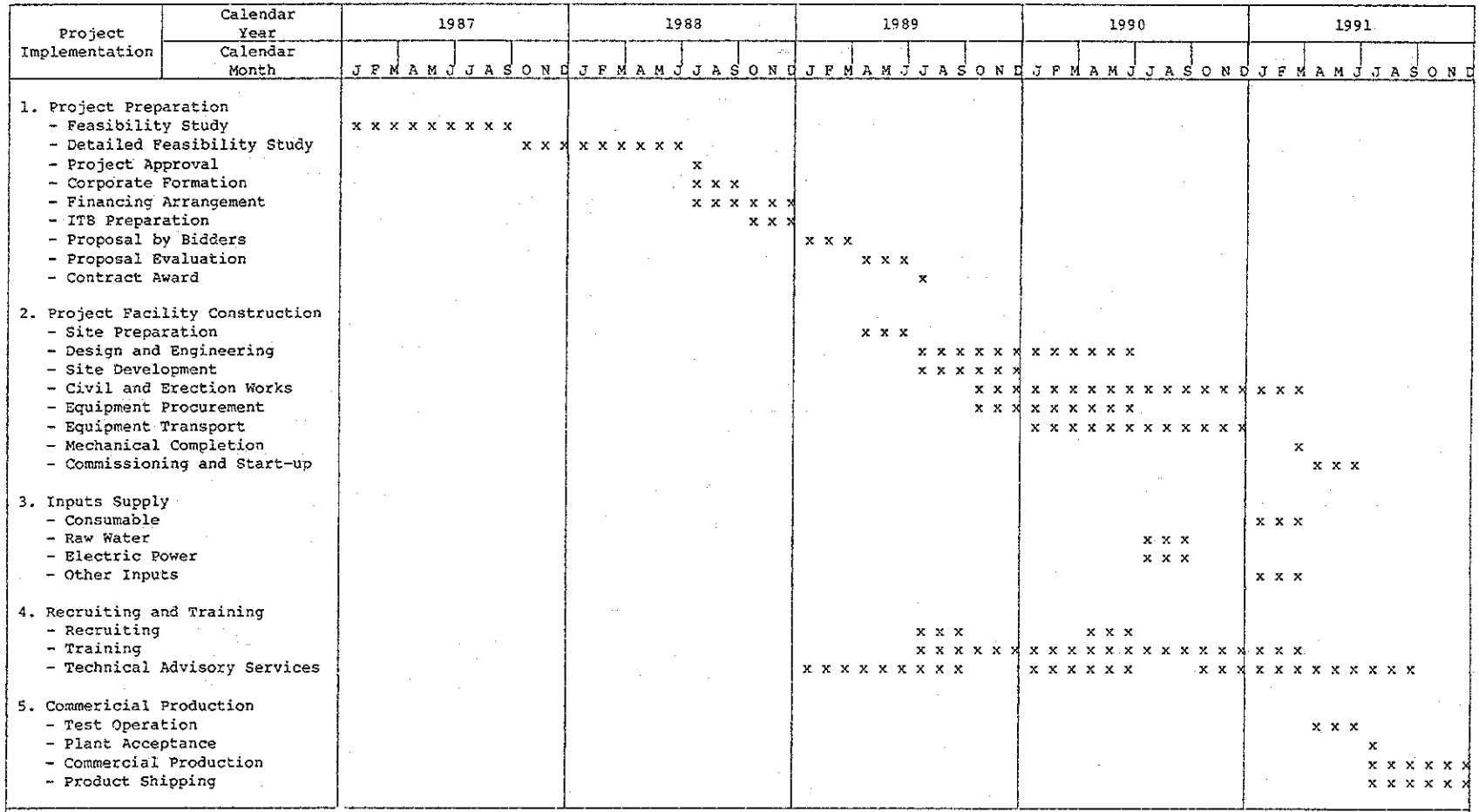
Figure III-13 PROCESS CONFIGURATION FOR THE PHOSPHATE MINING AND CONCENTRATE PROJECT

Product : Phosphate Concentrate, Bulk
Capacity : 35,181 (Dry)/39,978 (Wet) TPY
Location : Chilembwe, Zambia



Notes: 1) Material flow under normal operating conditions at design capacity for 290 DPY of annual operable days is illustrated.
2) Normal flow and facility design capacity with allowance for utility and offsite are shown in normal flow/design capacity, respectively.

Figure III-14 IMPLEMENTATION SCHEDULE FOR THE PHOSPHATE MINING AND CONCENTRATE PROJECT



Project:
- Location : Chilembwe, Zambia
- Product/Capacity: Phosphate Concentrate/35,181 TPY-Dry
- Project Life : July 1, 1991 to June 30, 2006 for 15 years

Estimate Date

Contract Award
Foundation Works Start
Foundation Works Completion
Mechanical Completion
Acceptance/ Commercial Production

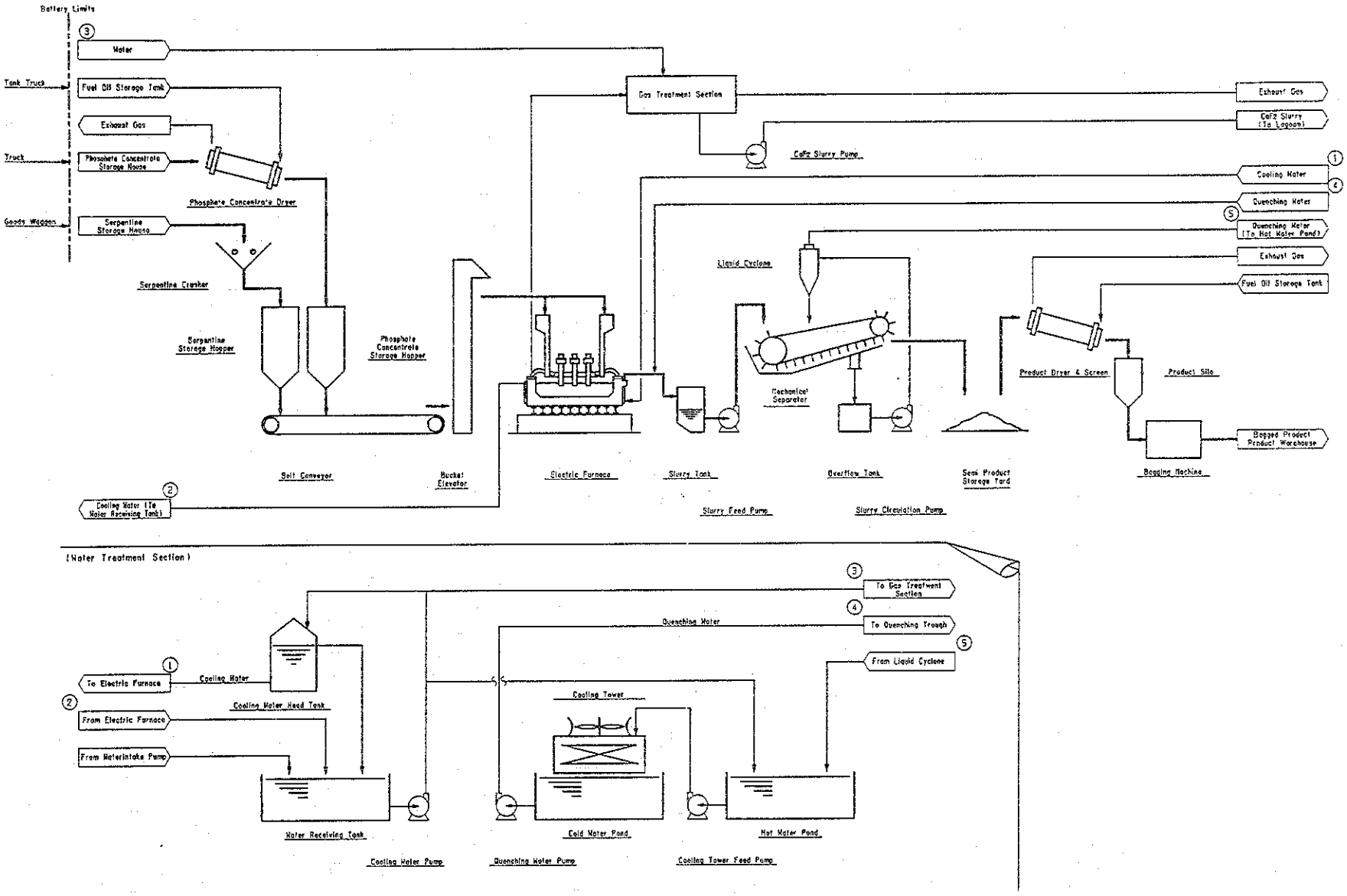


Figure III-15 PROCESS FLOW DIAGRAM FOR FUSED MAGNESIUM PHOSPHATE PRODUCTION

FMP PLANT
FLOW SHEET

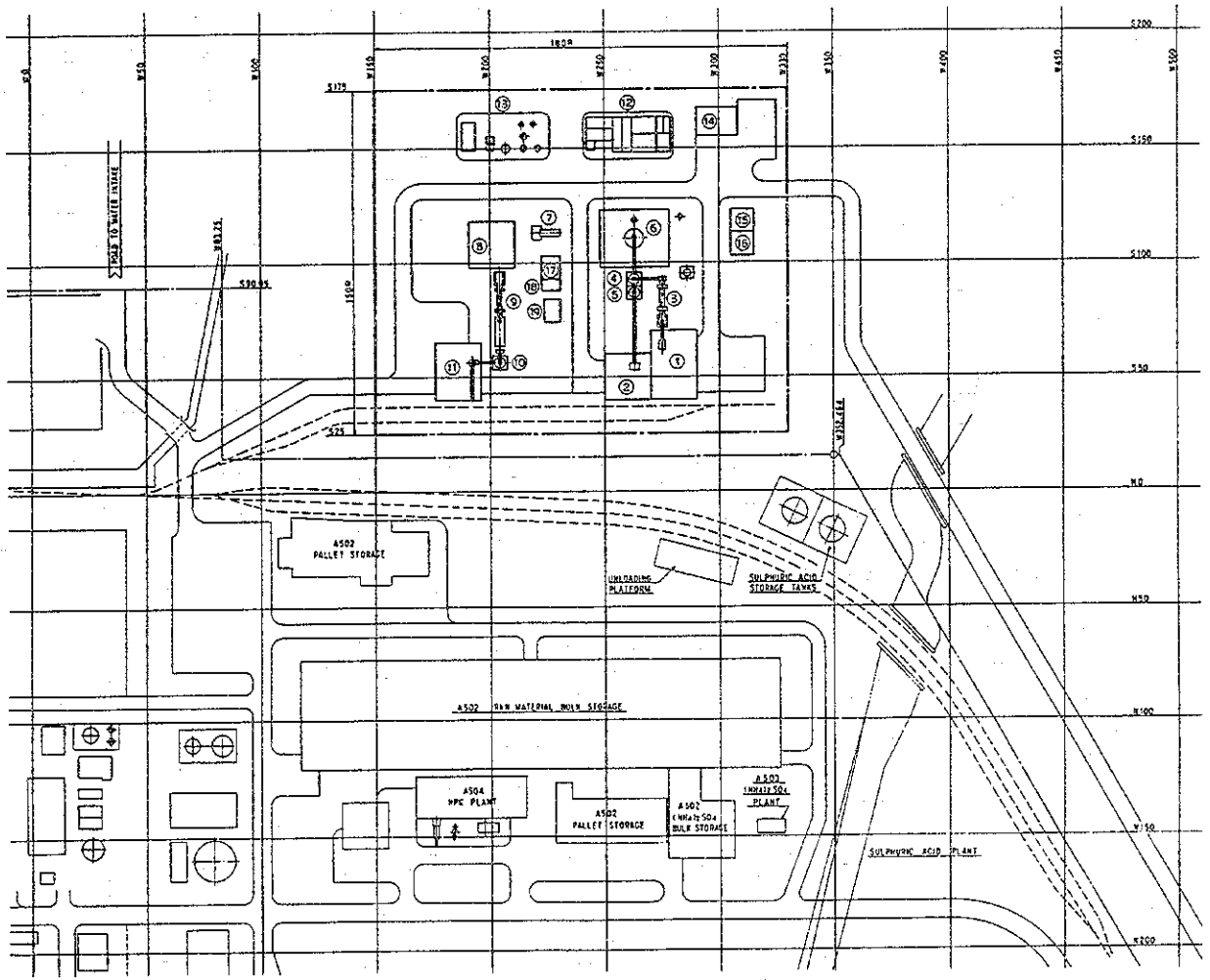
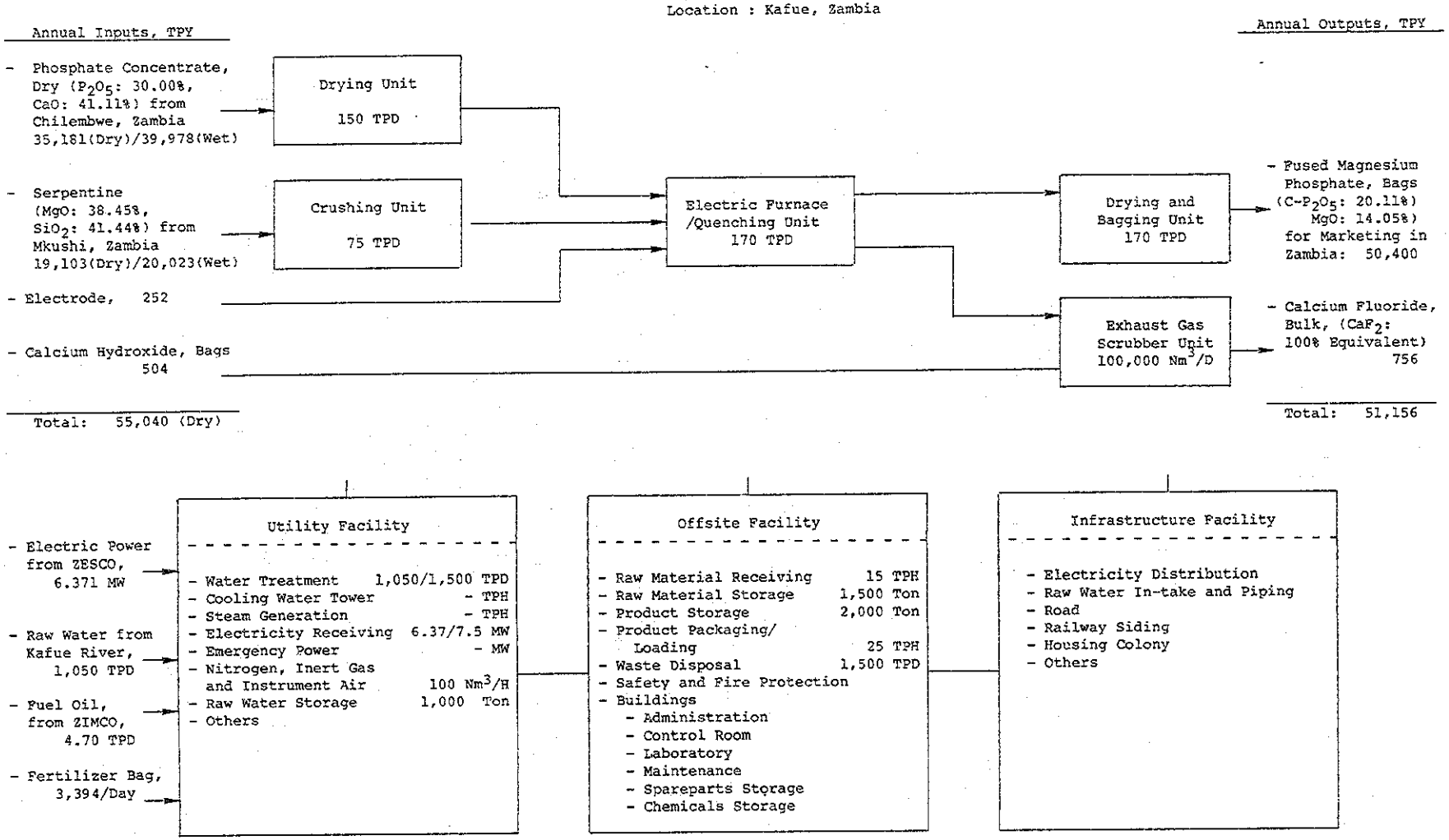


Figure Ⅲ-16 GENERAL PLOT PLAN OF FUSED MAGNESIUM PHOSPHATE PROJECT

ZAMBIA FMP PLANT
GENERAL LAYOUT

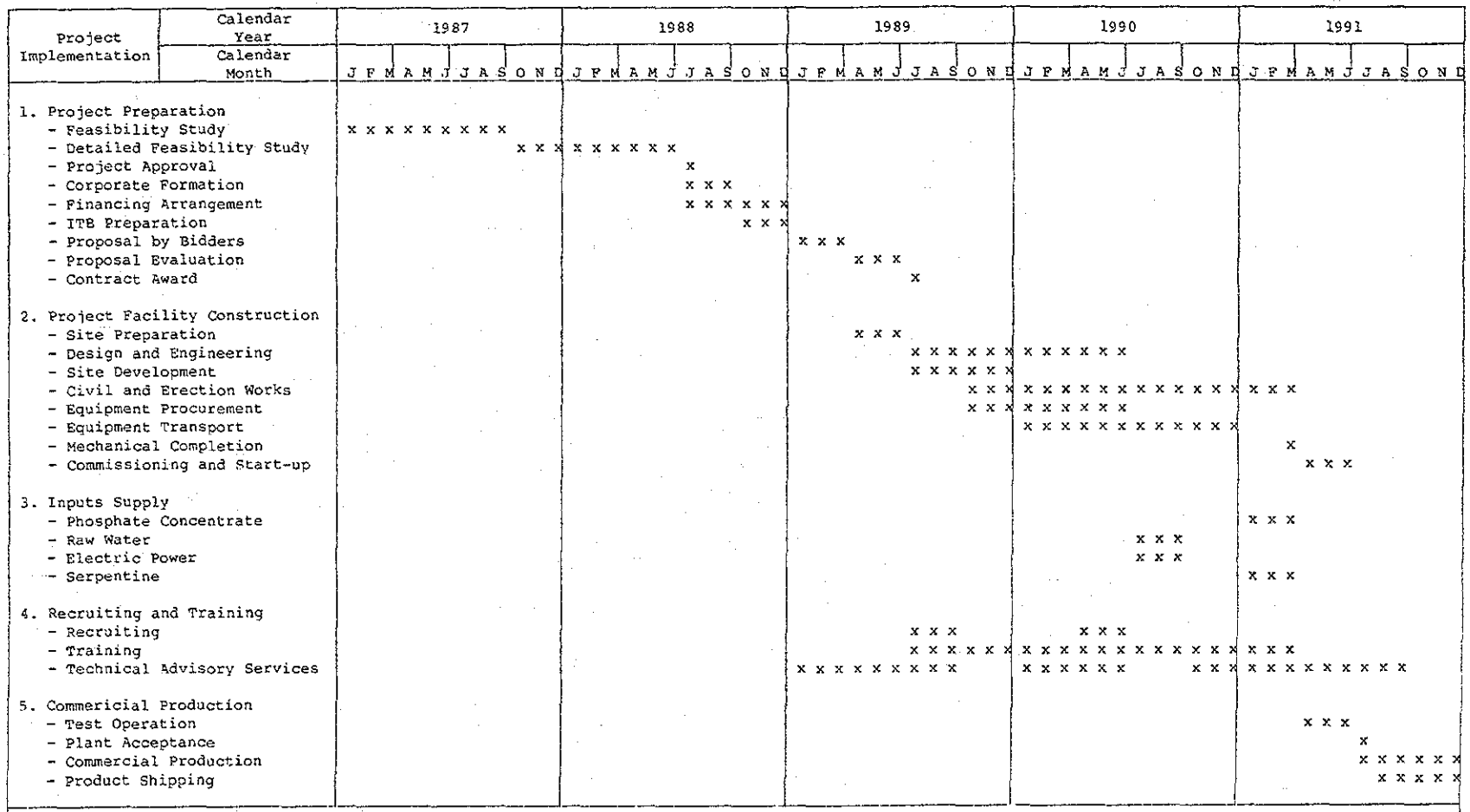
Figure III-17 PROCESS CONFIGURATION FOR THE FUSED MAGNESIUM PHOSPHATE PROJECT

Product : Fused Magnesium Phosphate, Bags
Capacity : 50,400 TPY
Location : Kafue, Zambia



Notes: 1) Material flow under normal operating conditions at design capacity for 300 DPY of annual operable days is illustrated.
2) Normal flow and facility design capacity with allowance for utility and offsite are shown in normal flow/design capacity, respectively.

Figure III-18 IMPLEMENTATION SCHEDULE FOR THE FUSED MAGNESIUM PHOSPHATE PROJECT



Project:
- Location : Kafue, Zambia
- Product/Capacity: Fused Magnesium Phosphate/50,400 TPY-Bags
- Project Life : July 1, 1991 to June 30, 2006 for 15 years

Estimate Date

Contract Award
Foundation Works Start
Foundation Works Completion
Mechanical Completion
Acceptance/ Commercial Production

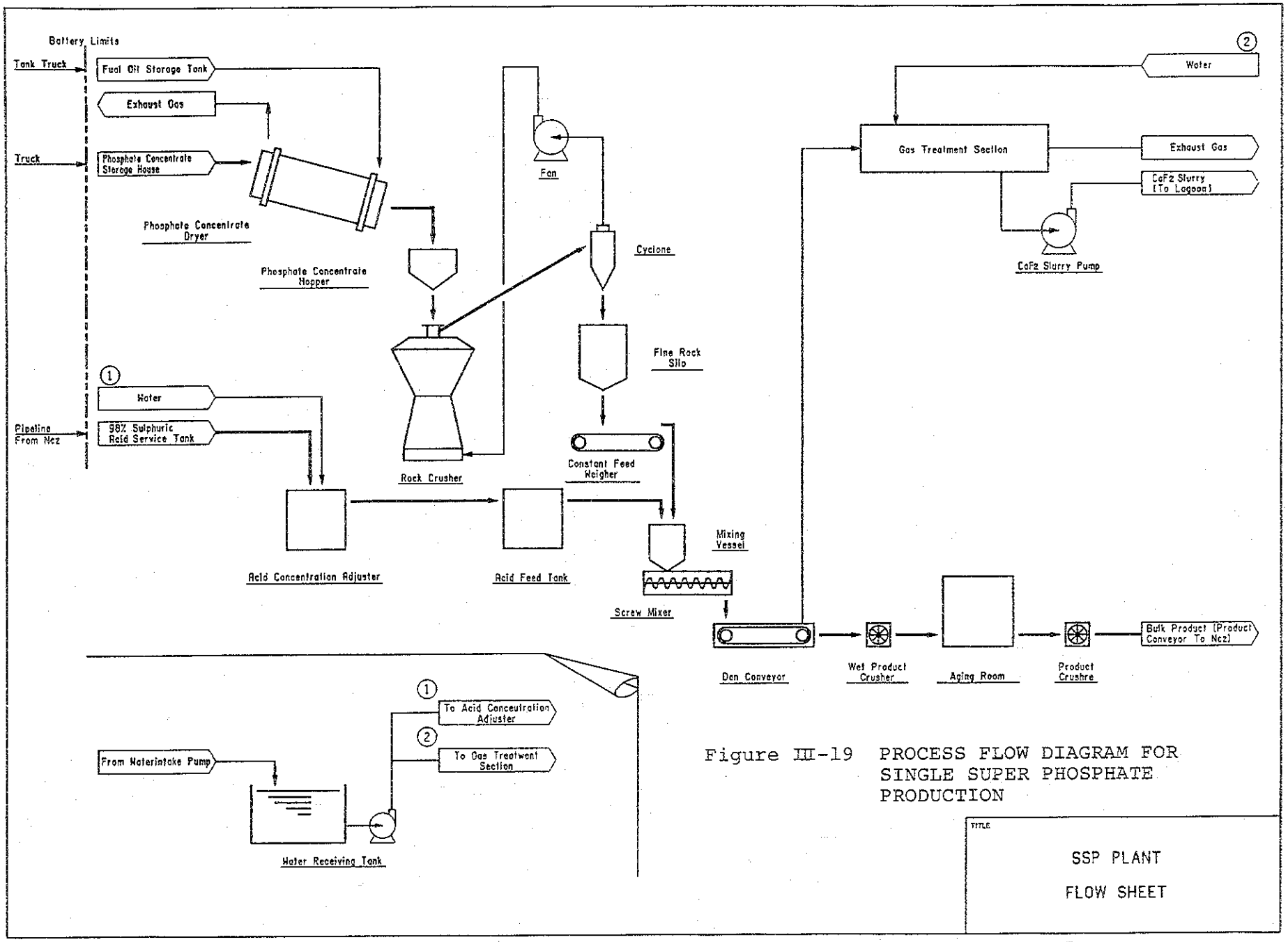
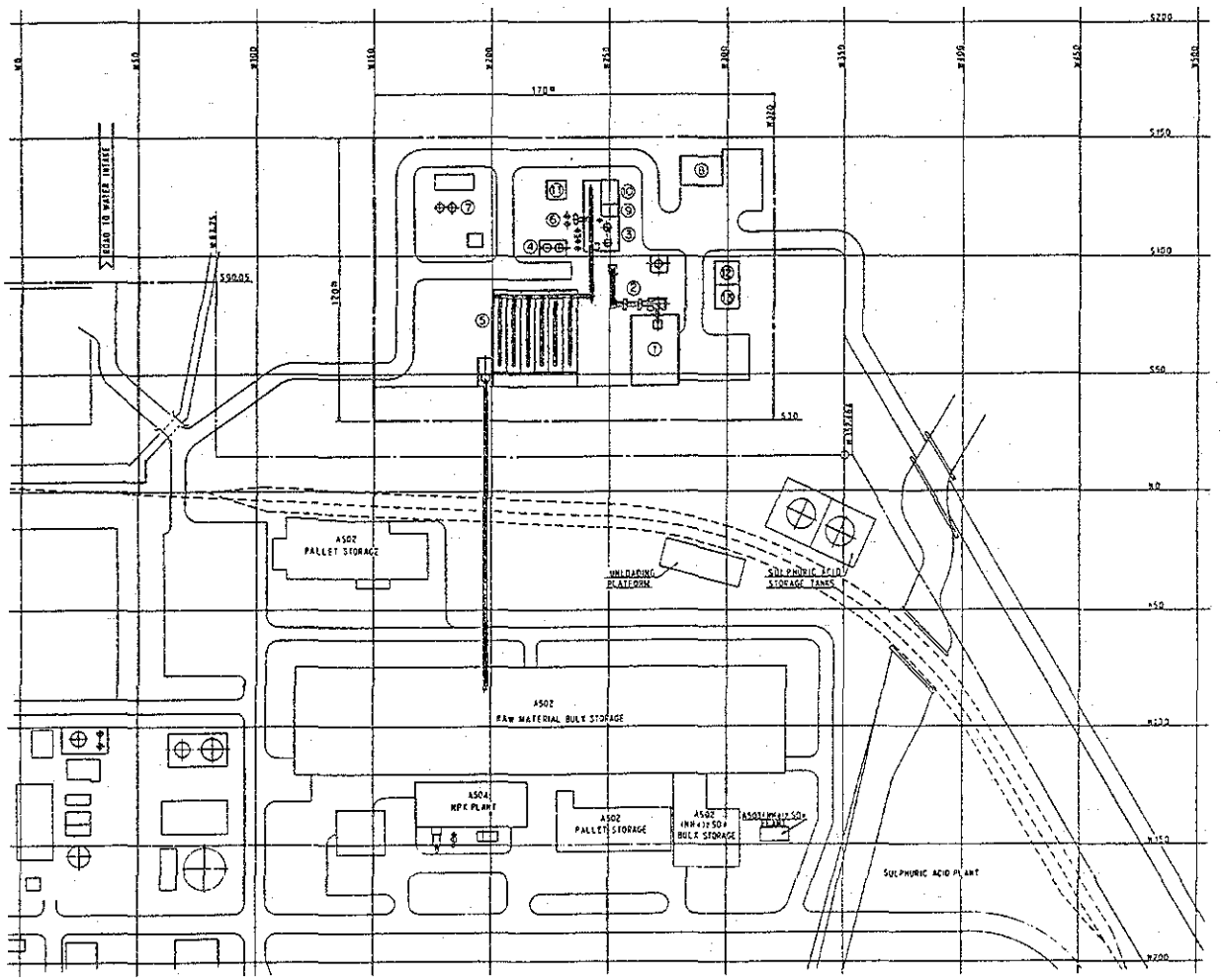


Figure III-19 PROCESS FLOW DIAGRAM FOR SINGLE SUPER PHOSPHATE PRODUCTION



NOTE

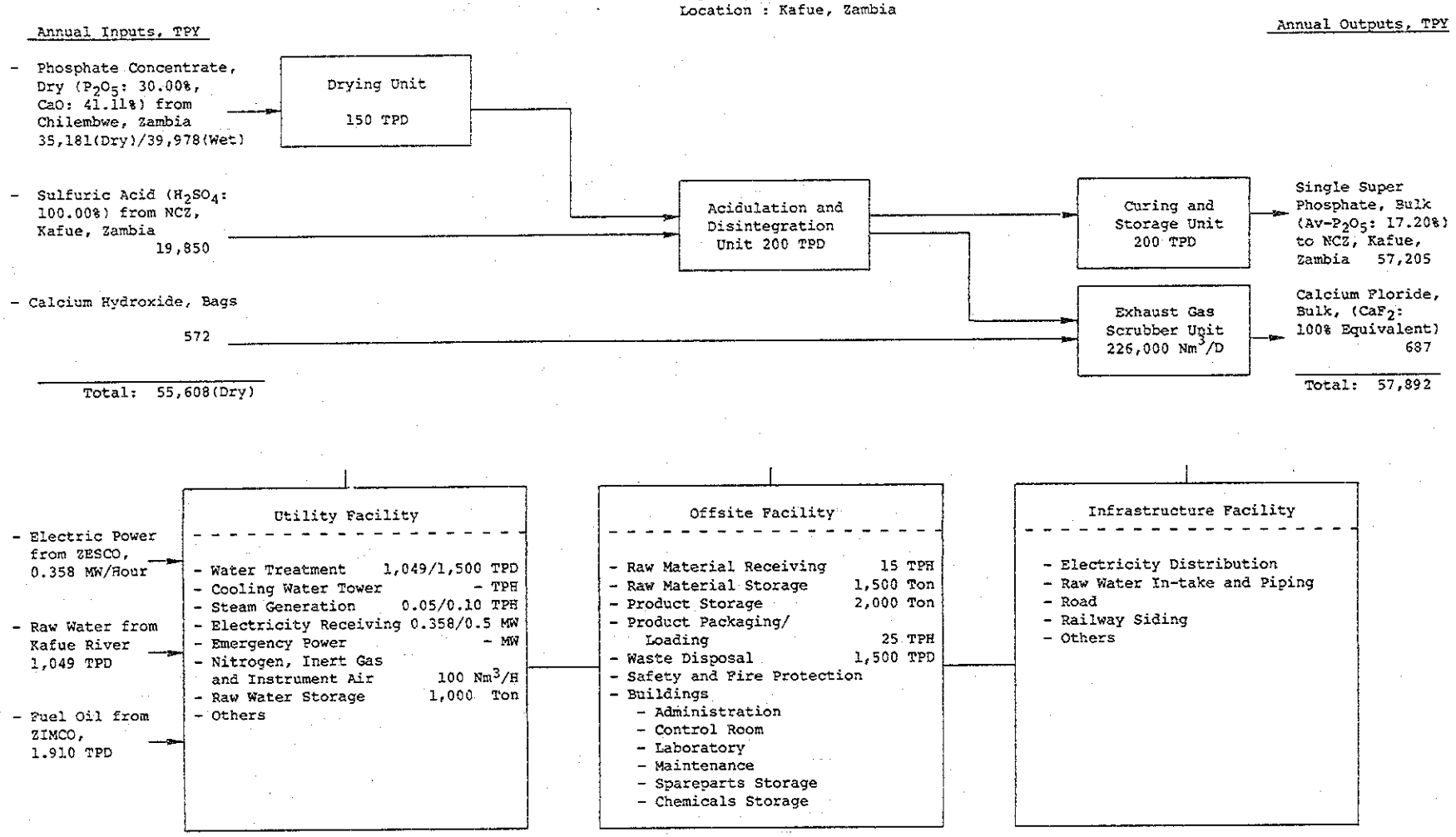
① Phosphate Concentrate Storage Yard
② Phosphate Concentrate Dryer
③ Phosphate Concentrate Grinding & Acidulation
④ Sulphuric Acid Storage
⑤ Product Aging and Storage House
⑥ Gas Treatment
⑦ Waste Water Treatment
⑧ Office Building
⑨ Control Room
⑩ Electrical Room
⑪ Laboratory
⑫ Spare Parts Storage House
⑬ Maintenance House

Figure III-20 GENERAL PLOT PLAN OF SINGLE SUPER PHOSPHATE PROJECT

ZAMBIA SSP PLANT
GENERAL LAYOUT

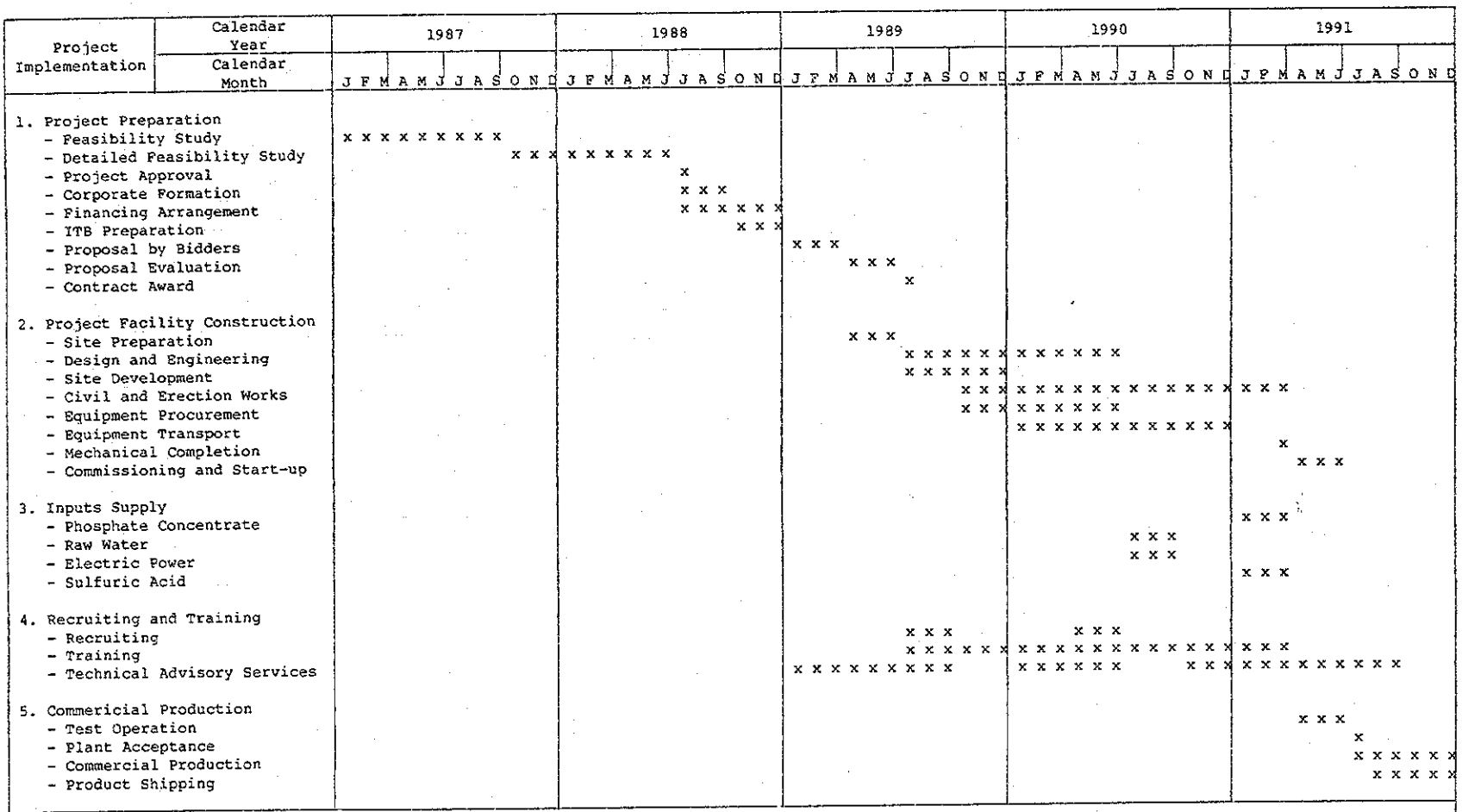
Figure III-21 PROCESS CONFIGURATION FOR THE SINGLE SUPER PHOSPHATE PROJECT

Product : Single Super Phosphate, Bulk
Capacity : 57,205 TPY
Location : Kafue, Zambia



Notes: 1) Material flow under normal operating conditions at design capacity for 300 DPY of annual operable days is illustrated.
2) Normal flow and facility design capacity with allowance for utility and offsite are shown in normal flow/design capacity, respectively.

Figure III-22 IMPLEMENTATION SCHEDULE FOR THE SINGLE SUPER PHOSPHATE PROJECT



PART Ⅳ
FINANCIAL ANALYSIS AND ECONOMIC EVALUATION OF THE PROJECT

Part IV FINANCIAL ANALYSIS AND ECONOMIC EVALUATION OF THE PROJECT

Chapter 1 FINANCIAL ANALYSIS

1.1 Assumption for Financial Analysis

Proposed alternative projects: the fused magnesium phosphate project or the single super phosphate project in Kafue which will captively consume phosphate concentrate from the phosphate mining and concentrate project in Chilembwe, Zambia, are concluded technically feasible according to the analysis, experiments and study in Japan, and the conceptual design of these projects are formulated and summarized in Part III of the Report.

Therefore, based on the conceptual design and assumed implementation organization and schedule, the proposed projects are analyzed financially as well as from national economy of Zambia for the final comparison and selection of the alternative projects.

In principle, as the feasibility study for the up-stream project of the phosphate mining and concentrate project was completed in 1985 and analysis itself is not required for the present study. However, in practice the product from the up-stream project is non-traded and non-tradable commodity without the realization of down-stream project in Zambia. Therefore, the financial analysis should be undertaken on the integrated projects of the up-stream and down-stream projects as a whole to examine the project viability and to estimate the fair and reasonable transfer pricing of up-stream product. If the integrated project is financially viable, it is possible to formulate the up-stream and down-stream projects financially viable, simultaneously. But, if the integrated project is found financially not viable, then it is impossible to formulate the both projects financially viable, simultaneously.

It was felt during the technical and marketing studies of the projects, the financial return for the proposed projects were low, therefore the favorable terms as far as possible were formulted in the analysis.

Some of them might be a little unrealistic under present conditions in Zambia, therefore further review and revision works might be required, if the project is proved viable. The major assumptions and basis for the financial analysis applied for the project evaluation are explained hereunder.

1.1.1 Foreign Currency Exchange Rate

The investment cost for the proposed projects are estimated using the prevailing pricings on the cost estimate date: January 1, 1987. The currency unit in terms of the US Dollar (US$) is exclusively used for the calculation. The locally procurable items in terms of Zambian Kwacha (ZK) are converted into the equivalent of the US$.

The foreign exchange rate of ZK had gone through an extensive fluctuation with associated institutional changes during the study period of 1986/7 in Zambia. Historial rates are documented in Table IV-1 which illustrates a high devaluation in accordance with the introduction of weekly auction system in October, 1985 (ZK2.20/US$ to ZK5.01/US$) and system modifications of marginal rate, Dutch rate (Multi rates), controlled auction within a range, two rate system with ranged official and auctioned private rates, and the phasing out of auction system and the re-introduction of fixed foreign currency rate system in May 01, 1987 (ZK21.01/US$ to ZK8.00/US$).

Under the fluid situation in Zambia, a reasonable exchange rate should be formulated in accordance with the expected escalation rate in Zambia in terms of US$. The observed effective weighted average rate by the consultant on the cost estimate date of January 01, 1987 was ZK8.00/US$, while the official auction rate of the date was ZK12.71/US$. Therefore, the rate of ZK8.00/US$ is applied for the feasibility study, which coincides with the re-introduced fixed rate on May 01, 1987 in Zambia. It is understood that the escalation in Zambia during the period has been far below the foreign exchange rate devaluation.

1.1.2 Escalation Rates

The commencement date of commercial production for the proposed project is scheduled on July 01, 1991. Therefore, escalation of domestic and foreign procurement prices should be adjusted according to the projected future inflation rate in the world.

As approximately two third of investment requirements of project is coming from the industrialized countries, a projected inflation rate in terms of US$ of 3.0%/year from 1987 to 1991 is assumed (OECD Economic Outlook, Number 40, December, 1986 is estimating 3.0%/year in 1987 and 1988 for the total OECD countries) for the project analysis.

It is also assumed that the difference between the domestic and international inflation rates will be reflected in the exchange rate of ZK even under fixed rate system as a long term projection. Therefore, the domestic inflation rate in Zambia is projected 3.0%/year in terms of US$ up to 1991.

1.1.3 Interest Rates

For the financing of the project, a reasonable and practical allocation of equity subscription, long term and short term loans should be formulated.

In view of expected high priority of the proposed project in Zambia, the most concessional financing is assumed. The base cases financing is formulated with a long term loan of 12.0%/year interest rate through relending at the BOZ and a low interest rate case of 4.0%/year under direct financing to the project.

The grace period and repayment terms of these loans are as follows:

Loan Financing Terms

Loans	Interest Rate %/Year	Grace Period Year	Repayment Year
Long Term Loan in Foreign Currency			
- Base Case	12.0	2.5	15.0
- Low Interest Rate Case	4.0	7.5	20.0
Short Term Loan in Zambian Currency			
- Base Case	20.0	0.0	1.0
- Low Interest Rate Case	20.0	0.0	1.0

1.1.4 Equity/Loan Ratio and Ownership

The equity is assumed to subscribe 25% of the total financing required, the rest is financed by long term loan basically and short term loan is allocated when the annual cash position is negative.

The proposed project is assumed that INDECO will implement the project as a state owned corporation (parastatal sector under ZIMCO) for the production and marketing of phosphate fertilizer in Zambia.

1.1.5 Capital Allowance and Income Tax

The Chapter 668 of the Law of Zambia is stipulating the capital allowance for corporate income tax calculation: initial allowance as well as annual wear and tear allowance. The initial allowance and annual allowance for the project implements, machinery and plant are 20% and 20%, respectively. The tax rate is defined 35% for manufacturing. The details of allowance and depreciation practice at major corporations in Zambia are summarized in Table IV-2.

For the analysis of proposed project, annual capital allowance (depreciation) of 6.67% and five years of tax grace period are assumed because of expected low return on the project.

1.1.6 Implementation and Operation Schedule

The project implementation schedule is as discussed in Part III: the construction contract award is assumed on July 01, 1989, the mechanical completion on March 01, 1991 and the commencement of commercial product on July 01, 1991. The operation schedule, capacity utilization, product sales and increase of inventory are assumed from technical operability and product marketability considerations as follows:

Production and Product Sales Schedule for the Project, %

Year	Production Capacity Utilization	Annual Sales	Inventory
1991 (1/2 Year)	35	30	5
2	80	75	10
3	90	90	10
4	100	100	10
.	.	.	.
.	.	.	.
.	.	.	.
2005 (1/2 Year)	50	60	0
Project Life Average	97	97	9.7

1.1.7 Financial Viability

The financial viability of the project is analyzed in terms of financial internal rate of return on investment in constant price by the discounted cash flow method. In addition to the internal rate of return on investment, the cash flow during the project life is also carefully examined in terms of debt service ratio and annual requirements of short term loan. A complete financial analysis, profitability and financial indicators and sensitivity analysis are presented in Annex IV-1 of the Report.

1.2 Project Cost and Financing Plan

Total financing required for the proposed projects are estimated using the prevailing prices in Zambia as well as the international market. The costs at the estimate date are escalated to the total financing required on the commencement date of the commercial production for the projects.

Basic prevailing prices for the construction and erection works in Zambia during the study period are summarized in Table IV-3. The capital cost estimates for the proposed projects are computed in Table IV-4 and summarized as follows:

Financing Required and Financing Plan for the Projects, $,MM

Proposed Project	Financing Required			Financing Plan			Annual Sales
	Foreign Currency	Local Currency	Total	Equity	Long Term Loan	Total	
Individual Projects							
- Phosphate Mining and Concentrate, I	10.11	4.45	14.56	3.64	10.92	14.56	4.57
- Fused Magnesium Phosphate, II	16.66	4.86	21.52	5.38	16.14	21.52	9.07
- Single Super Phosphate, III	14.58	5.21	19.79	4.95	14.84	19.79	8.58
Integrated Projects							
- Phosphate Mining and Concentrate, and Fused Magnesium Phosphate, I + II	26.77	9.31	36.08	9.02	27.06	36.08	9.07
- Phosphate Mining and Concentrate, and Single Super Phosphate, I + III	24.69	9.67	34.36	8.59	25.77	34.36	8.58

Base Case: Interest Rate of Long Term Loan; 12.0%/year

1.3 Operating Cost and Financial Analysis

1.3.1 Operating Cost

Projection of major operating costs as of July 01, 1991 for the proposed projects are summarized in Table IV-5. As the expected return on investment is low, favorable variable costs are also assumed for the project as follows:

(1) Electricity Cost

Pricings of electricity is fixed by ZESCO according to the tariff and additional government sales tax of 15% on the tariff is charged. The tariff is classified into four sectors: Industrial Bulk, Industrial, Commercial and Household.

Industrial class is further classified according to the contract volume of electricity purchase. The larger the volume, the lower the tariff, in general. The annual average pricings are determined by the contractual terms on power, load and diversity factors for the project. Individual pricings are calculated in Table III-11 and III-12 in Part III.

It is also understood that the present tariff at ZESCO is fixed at low rates and to keep financial viability of ZESCO, an annual escalation of 80.0% of tariff for at least three years from 1987 is required (5.83 times in three years).

For the projection of electricity cost, a modest annual escalation of 16.65% is assumed while general price increase in Zambia is assumed 3.00% from 1987 to 1991. The electricity cost is assumed also at Kafue to make integrated contract with the existing NCZ purchase to save operating cost.

The difference between independent and integrated purchase of electricity in Kafue is ZK0.0462/kWh and 0.0423 for the production of fused magnesium phosphate and ZK0.0644/kWh and 0.0423 for the production of single super phosphate, respectively. Integrated purchase is beneficial for the projects, if approved and realized.

(2) Sulfuric Acid Cost

At present, the availability of sulfuric acid is limited only at NCZ, Kafue. Sulfuric acid is an objective product to produce ammonium sulfate, therefore the cost is projected as a simple average of present selling price and production cost under improved capacity utilization with from present 42% to 90% in 1991 at NCZ.

(3) Products Price

Marketing study stipulates the products selling pricing in 1991 as is discussed in Part II and as shown below:

Product Alternatives	Product Selling Price, $/Ton-1991	Rated Production Capacity, TPY
Fused Magnesium Phosphate, Ex-Plant, Kafue, Zambia	180.0 - Bags	50,400
Single Super Phosphate, Ex-Plant, Kafue, Zambia	150.0 - Bulk	57,205

It may be noted, however, that the two proposed products are low analysis in fertilizer nutrients, lower than even phosphate concentrate, and are not and will not be imported into Zambia as leading phosphate fertilizers. High analysis phosphates are advantageous for long distance transport to Zambia. The proposed products might be only viable as domestic production from domestic raw materials and for domestic consumption in Zambia.

Principal phosphate fertilizers for production and international transaction at present in the world are diammonium phosphate, DAP (18.2-46.4-0) and triple super phosphate, TSP (0-46.4-0). Zambia's phosphate fertilizer supply is mostly fulfilled by the importation of these two phosphates and their derivative compound fertilizers at present. Therefore, approximate matching prices of the proposed products in terms of phosphate are calculated in Table IV-6 and a simple mathematical matching calculation which is neglecting domestic transport burden for low analysis fertilizer and nutrients adjustment for sulfur and magnesium is shown as follows:

Matching Product Price of Proposed Projects (Unit: -)

Triple Super Phosphate, (0-46.4-0)	Fused Magnesium Phosphate, (0-20.11-0)	Single Super Phosphate, (0-17.20-0)
100	43.2	37.1
200	86.3	71.4
300	129.5	111.2
400	172.7	148.3
500	215.8	185.3

Simple P_2O_5 matching price ratio assuming Av-P_2O_5 = C-P_2O_5

1.3.2 Financial Analysis

Calculation results on the financial analysis, assuming two cases for long term interest rates: 4.0% and 12.0% for the proposed projects are presented in Annex IV-1, illustrated in Table IV-7 and IV-8, and summarized as follows:

Project Financial Analysis Summary

	FIRROI, DCF, After Tax, %		Project Life Avarage Debt Service Ratio		Transfer Price of Phosphate Concentrate	
Long Term Interest Rate	4.0%	12.0%	4.0%	12.0%	4.0% $/Ton	12.0% $/Ton
Individual Projects						
- Phosphate Mining and Concentrate, I	(-)4.29	(-)4.27	0.35	(-)2.76	(130.0)	(130.0)
- Fused Magnesium Phosphate, II	(-)10.11	(-)10.06	(-)1.27	(-)3.50	(130.0)	(130.0)
- Single Super Phosphate, III	(-)3.53	(-)3.52	0.64	(-)2.18	(130.0)	(130.0)
Integrated Projects						
- Phosphate Mining and Concentrate, and Fused Magnesium Phosphate, I + II	(-)8.04	(-)8.00	(-)0.51	(-)3.12	120.3	120.3
- Phosphate Mining and Concentrate, and Single Super Phosphate, I + III	(-)3.85	(-)3.84	0.63	(-)2.27	131.3	131.3

The calculations reveal that the five projects: one up-stream and two down-stream alternative projects as well as the two integrated projects are financially not viable. Not only the FIRROI, after tax by DCF method are negative but also the cash flow in terms of debt service ratio and short term loan requirements are not sustainable for the industrial projects. In view of the cut-off rate of 12.0% at INDECO for financial analysis criteria and assumed interest rate of 4.0% or 12.0%, the proposed projects are not acceptable and not recommendable for INDECO in financial viability.

The project life average production costs are higher than the projected price as are cited below:

Project Life Average Production Cost, US$/Ton-1998

Project	Production Cost					Projected Price
	Variable/ Transport	Direct Fixed	Depreciation	Sales/ Interest	Total	
Individual Projects						
- Phosphate Mining and Concentrate, I	98.5	14.5	25.8	111.4	250.2	130.0 - Bulk
- Fused Magnesium Phosphate, II	162.3	9.9	25.8	128.1	326.1	180.0 - Bags
- Single Super Phosphate, III	127.4	7.7	19.9	79.2	234.2	150.0 - Bulk
Integrated Projects						
- Phosphate Mining and Concentrate, and Fused Magnesium Phosphate, I + II	141.4	19.7	43.8	200.9	405.8	180.0 - Bags
- Phosphate Mining and Concentrate, and Single Super Phosphate, I + III	108.0	16.3	35.8	141.2	301.3	150.0 - Bulk

Base Case: Interest Rate of Long Term Loan; 12.0%/year

Although the low financial return for the projects are attributable to the high production cost of domestic phosphate mining and concentration at Chilembwe, the project return will not be improved by switching from domestic phosphate concentrate to imported one, because the financial analysis is assuming fair and even transfer price of phosphate concentrate at Kafue at approximately US$130/Ton which gives negative return on investments for up-stream and down-stream projects while the landed cost of imported phosphate concentrate from North Africa is projected approximately US$180.0/Ton in 1991 as is shown in Table IV-6. Complete financial analysis for the proposed projects are given in Annex I-1 of the Report and summarized in Table IV-8.

The both alternative projects are financially not viable: it may be noted, however, that the return is a little higher for single super phosphate production. The sensitivity analysis reveals that the product price is the most sensitive for project return and to realize financially viable return for the base case project, the product price should be more than 60.0% higher than the projected price. The degree of sensitivities for raw material cost, investment cost, and utility and transport cost are modest and almost equivalent in degree. To realize financially viable project, the investment cost should be reduced to less than a third of projected investment cost. Such extreme deviations are considered not likely under present conditions and assumed near future projections.

Chapter 2 ECONOMIC AND SOCIAL EVALUATION

2.1 Assumption for Economic Evaluation

The financial analysis for the proposed projects concludes that under assumed conditions, the projects are not financially viable and give negative returns as well as negative net present values regardless to the interest rate of long term loan within the range of 4.0% to 12.0% annually.

In this Chapter, however, economic and social evaluation for the proposed projects are undertaken to examine the economic and social benefits of the projects for the Republic of Zambia. Quantitative assessment of the benefits or effects is calculated in economic internal rate of return on investment, economic net present value using cut-off rate criteria of 12.0%, if it gives positive value, and net foreign currency savings derived from the projects.

Additional qualitative benefits for the projects: creation of employment opportunities, technology transfer, regional development as well as the contribution of stable supply of phosphate fertilizer to Zambian agriculture are also considered.

The economic return is calculated in four steps: estimate of economic project cost, economic annual cost, economic benefits and computation of the return using converted economic data over the financial basic data of the proposed projects. Major assumptions and conversion factors referred to are summarized and presented in Table IV-9 which also shows the general practices applied at INDECO, Zambia.

The economic evaluation are undertaken for the two integrated projects of up-stream and down-stream alternative projects in view of project features in Zambia.

2.2 Economic Evaluation

The economic project costs derived from the assumed conversion factors on the financial project costs are summarized as follows:

Financial and Economic Project Costs

Projects	Financial Project Cost US$, MM	Economic Project Cost US$, MM	Overall Conversion, %
Integrated Projects			
- Phosphate Mining and Concentrate, and Fused Magnesium Phosphate, I + II	36.08	29.47	82.0
- Phosphate Mining and Concentrate, and Single Super Phosphate, I + III	34.36	28.16	82.0

Major issues for the economic annual operating cost estimate are pricing of electricity cost and product alternatives price. Although the opportunity cost of electricity for exporting to Zimbabwe is lower than domestic tariff at present but the exporting of electricity will be phased out in 1990's according to the domestic consumption increases in Zambia. It is also understood that the long run marginal cost is much higher than present tariff and if such highly priced marginal cost is applied, the project economic return will be further deteriorated. Therefore, the economic cost of electricity is projected simply deducting the government sales tax of 15% over the tariff.

The conversion factor for product pricing is assumed 80% of financial price because the projection of financial price of the products are based on the existing systems for compound fertilizer production at NCZ as well as the distribution and marketing of fertilizers by NAMBOARD in Zambia. To match the direct border cost and landed cost of imported fertilizer at farm gate in Zambia, the economic price might be much lower than the financial price. Calculated economic return on investments are again negative as are summarized belows:

Economic Internal Rate of Return on Investment, %

Integrated Projects	EIRROI, DCF, % Low Interest Rate Case, 4.0%/Year	 Base Interest Rate Case, 12.0%/Year
- Phosphate Mining and Concentrate, and Fused Magnesium Phosphate, I + II	(-) 10.07	(-) 10.07
- Phosphate Mining and Concentrate, and Single Super Phosphate, I + III	(-) 5.02	(-) 5.02

The net present value, if using cut-off rate of 12%, is negative, too. Although the proposed project will create approximately 200 employment opportunities and will be contributable to technology transfer as well as the regional development in Zambia, the proposed and studied projects will not be contributable for the national economy in Zambia as a whole. Again the return is a little higher for the single super phosphate than fused magnesium phosphate projects.

2.3 Foreign Exchange Savings and Other Benefits

Net foreign exchange savings for the production of domestic phosphate fertilizers are estimated which may be accrued by the import substitution of principal phosphate fertilizers to Zambia: triple super phosphate, TSP (0-46.4-0) minus the outlays of foreign currency: payment of interest and repayment of principal of foreign long term loan, and payment for annual foreign procurement for chemicals, electrode, fuel oil, spare parts and technical services which may be incurred for the domestic production of fused magnesium phosphate or single super phosphate at Kafue, Zambia. It is assumed that the long term loan allocated for the projects is foreign currency borrowing for the project entity. The calculated project life foreign exchange savings are $1.22 MM for fused magnesium phosphate and $23.63 MM for single super phosphate project as is summarized belows:

Project Life Foreign Exchange Savings, US$, MM/Year - Net Present Value - 1991

	Foreign Exchange for Import of Phosphate Fertilizer	Foreign Exchange Outlays from the Project		Net Foreign Exchange Saving
		Debt Service of Foreign Loan	Foreign Procurement	
Integrated Projects				
- Phosphate Mining and Concentrate Project, and Fused Magnesium Phosphate Project, I + II	87.46	28.49	57.75	1.22
- Phosphate Mining and Concentrate Project, and Single Super Phosphate Project, I + III	84.91	26.91	34.37	26.63

Notes:
- Interest rate for long term loan : 4.0%/Year
- Assumed import price of triple super phosphate : US$286/Ton at Kafue in 1991
- Escalation rate : 3.0%/Year
- Deflator : 3.0%/year

If the project is implemented, additional economic and social benefits such as more secure supply of fertilizer will be realized which will allow Zambia to pursue the development of its agricultural sector: increase of agricultural production and decrease of import requirement of agricultural products in Zambia.

The proposed projects are evaluated and might be concluded that the economic return is not enough for project justification for the economy of the Republic of Zambia under present and assumed near future conditions of the phosphate fertilizer industries in the world. The studied projects are technically feasible but financially not viable and economically not justifiable as an immediate industrial and commercial project in the Republic of Zambia under assumed conditions.

Table and Figure

for

Part IV

FINANCIAL ANALYSIS AND ECONOMIC EVALUATION OF THE PROJECT

Table IV-1 to Table IV-9

Table IV-1 FOREIGN CURRENCY EXCHANGE RATE TREND IN ZAMBIA

Effective Date	Auction Week	Set Rate	Foreign Currency Fund	Foreign Currency Demand	Bids Range Low	Bids Range High	Bids Number Successful	Bids Number Total	Note
		ZK/US$	US$,MM	US$,MM	ZK/US$	ZK/US$			
End, 1980	-	0.80	-	-	-	-	-	-	Monthly Bulletion of
End, 1981	-	0.88	-	-	-	-	-	-	Statistics, United
End, 1982	-	0.93	-	-	-	-	-	-	Nations
End, 1983	-	1.51	-	-	-	-	-	-	
End, 1984	-	2.20	-	-	-	-	-	-	
October, 1985									
11	1	5.01							Weekly Auction
									- Marginal Rate
End, 1985	12	5.70							
August, 1986									
02	43	5.00							Weekly Auction
									- Dutch Rates
September, 1986									
06	48	7.00	15.0	24.3	5.00	7.99	571	674	
October, 1986									
04	52	7.64	7.1	23.8	5.04	8.11	172	712	
11	53	8.30	6.5	24.3	5.00	8.56	128	769	
18	54	9.20?	-	-	-	-	-	-	
25	55	10.32	5.5	16.5	5.50	11.51	84	493	
		(Av. 8.87)							
November, 1986									
01	56	11.51			6.00	12.50	119	421	
08	57	12.30		14.2	6.00	13.15	111	439	
15	58	13.48		11.3	6.00	14.41	383	407	
25	59	14.48	5.5	9.9	6.00	15.15	123	324	
29	60	15.25		7.2	6.00	16.52	140	273	
		(Av. 13.40)							
December, 1986									
06	61	12.10		5.0	6.00	18.00	130	221	
13	62	11.90	5.5	12.4	6.00	16.00	280	333	
20	63	12.50	5.5	9.9	6.00	13.77	116	310	
27	64	12.71	5.6	8.0	6.00	14.20	141	285	
		(Av. 12.30)							
End, 1986	-	12.71	-	-	-	-	-	-	
January, 1987									
03	65	12.97	5.6	7.3	6.00	13.76	118	192	
10	66	13.51	5.5	11.4	6.00	13.98	55	232	
17	67	14.12	5.5	9.4	6.00	15.00	111	257	
24	68	14.92	-	-	6.00	15.31	109	250	Controlled Auction
31	69	9.00/12.50	-	-	-	-	-	-	- Re-peg within Range
		(Av. 13.25)							
March 27, 1987	-	15.17	-	-	-	-	-	-	Ranged Official and
		(9.00/12.50)							Auction Private Rates
April 4, 1987	-	16.99	-	-	-	-	-	-	
11	-	18.75	6.0	-	13.00	20.75	135	370	
25	-	21.01	-	-	-	-	-	-	
May 01, 1987	-	8.00	-	-	-	-	-	-	Fixed Rate System

Notes:
1) January 31, 1974; ZK0.714/US$ (ZK1.0/Sterling Shillings 10)
2) March, 1978 ; ZK1.024/SDR (IMF Agreement)
3) January 06, 1983; ZK1.280/SDR
4) July, 1983 ; ZK1.1/US$, Managed floating (crawling) and currency basket (US$, Sterling Pound, Mark, Franc and Yen) system
5) January, 1985 ; ZK2.25/US$, Free exchange policy
6) October 09, 1985; ZK5.01/US$, Weekly Auction - Marginal rate system
7) August 02, 1986 ; ZK5.00/US$, Weekly Auction - Dutch rates system
8) January 28, 1987; ZK9.00 (Floor)/12.50 (Ceiling)/US$, Re-pegged to currency basket within a range and allocated by auction. Interest rate at the BOZ and maximum lending rate are reduced to 15.00 (from 30.00) and to 20.00 (from 32.00)%, respectively.
9) March 27, 1987 ; ZK15.17 (Auction)/9.00-12.50 (Official)/US$, Re-opened the auction and the official rate is applied governmental transaction and repayment
10) May 01, 1987 ; ZK8.00/US$, Re-introduction of fixed foreign exchange rate. Interest rate at BOZ and maximum lending rate are reduced to 15.00 (from 20.00) and to 20.00 (from 25.00)%, respectively. Interest for State Bond is reduced to 15.50% from 18.00%.

Table IV-2 CORPORATE INCOME TAX LAW AND DEPRECIATION PRACTICE IN ZAMBIA

1. Income Tax Law (Chapter 668 of the Laws of Zambia, May 26, 1967)

1) Capital Allowance

Items	Capital Allowance for Income Tax Calculation	
	Initial Allowance, %	Wear and Tear Allowance, %/Year
Buildings		
- Low Cost Industrial Housing	-	10.0
- Industrial Building	10.0	5.0
- Commercial Building	-	2.0
Implements, Machinery and Plant	20.0	20.0
- Prime Moving Machinery	20.0	30.0

2) Tax Rates

Items	Annexure	Allowance, ZK	Tax Rate, %, (Income in ZK)
Individuals who do not remit	A, B	Single : 1,800	5.0 (2,000)
		Married : 4,600	11.0 (5,000)
		Child : 330	17.5 (10,000)
		Life Insurance	28.5 (20,000)
		Premiums: 800	42.5 (40,000)
Other than Individuals	C		
- Farming		-	15.0
- Manufacturing		-	35.0
- Other Sources		-	45.0
Trusts	D	-	35.0
Entertainment Fee	E	-	15.0
Management and Consultant Fee	F	-	15.0
Royalties	G	-	10.0
Dividends	H	-	15.0

2. General Depreciation Practise in Zambia

Items	Major Corporations				
	NCZ	ZSCL	NAMBOARD	ZIMCO	INDECO
Year of Annual Report	1986	1985/6	1984	1985	1985
Method	Straight Line	Straight Line	Straight Line	Straight Line	Straight Line
Depreciation Rate, %/Year					
- Land and Buildings					
- Freehold	-	-	-	2.5	-
- Leasehold					
- Industrial	2.5	2.5	2.0	1.0/ 2.5	2.0
- Commercial	2.0	2.0	-	2.0/ 2.5	-
- Residential	-	2.0	-	2.0/ 2.5	-
- Plant and Machinery	7.5	10.0	10/20	10.0/33.3	7.2/10.0
- Furnace and Relining	-	-	-	-	25.0
- Vehicles	25.0	25.0	25.0	10.0/33.3	25.0
- Furniture	25.0	25.0	-	-	10.0/25.0
- Water System	-	7.5	-	-	-
- Mining Assets	-	-	-	4.0(-)	-
- Capital Work in Progress	0.0	-	0.0	0.0	0.0

Notes: Tax law in Zambia is under reforming processes in 1987

Table IV-3 MAJOR UNIT PRICES IN ZAMBIA (1/6)

1. Construction Machine and Equipment

Machine/ Equipment	Availability in Zambia	Specification/ Model	Hourly Rental ZK/Hr	Remarks
1.1 Earth Works				
Power Shovel	No	-	-	-
Bulldozer	Yes	200 HP CAT D7	500	Excluding Fuel
Back Hoe	Yes	70 HP JCB 3D	140	Excluding Fuel
Scraper	Yes	300 HP 621 CAT	600	Excluding Fuel
1.2 Loading Equipment				
Truck Crane	Yes	3 Ton HIAB	110	Excluding Fuel
Clawler Crane	Yes	-	-	-
Tower Crane	Yes	3 Ton LIEBHERR	125	Excluding Electricity
Folk Lift	No	-	-	-
1.3 Transportation Equipment				
Dump Truck	Yes	40 CWT WINGET	40	Including Fuel
Trailer	Yes	5 Ton LENCO	10	Including Fuel
Truck	Yes	10 Ton FUSO LEYLAND	125	Including Fuel
Truck with Crane	Yes	3 Ton HIAB	125	Including Fuel
1.4 Concrete Equipment				
Mixer	Yes	10/7 WINGET	20	Including Fuel
Mixer	Yes	14/10 WINGET	28	Including Fuel
Agitater Truck	No	-	-	-
Pumping Car	No	-	-	-
Batcher Plant	No	-	-	-

Notes: Pricings are as of January 01, 1987 and exchange rate is assumed ZK8.00/US$ for financial and economic calculation

Table IV-3 MAJOR UNIT PRICES IN ZAMBIA (2/6)

Machine/ Equipment	Availability in Zambia	Specification/ Model	Hourly Rental ZK/Hr	Remarks
1.5 Others				
Pilling Machine	No	-	-	-
Ashalt Paving Finisher	No	-	-	-
Tyre Roller	No	-	-	-
Macadam Roller	No	-	-	-
Grader	Yes	170 HP CAT 14/E	200	Excluding Fuel
Rammer	No	-	-	-
Generator	Yes	62.5 kVA CAT	40	Excluding Fuel
Welder	Yes	400 AMP LINCOLN	20	Excluding Fuel
Compressor	Yes	250 CFM Ingersol Rand	70	Including Fuel
Bar Cutter	Yes	Electrical	10	
Bar Bender	Yes	Electrical	10	
Passenger Car	Yes	1,800 cc PUEGOT 504	55	Including Fuel
Jeep	Yes	3,000 cc TOYOTA	88	Including Fuel
Mini Bus	Yes	28 Seat MITSUBISHI	100	Including Fuel
Wagon	No	-	-	-

Table IV-3 MAJOR UNIT PRICES IN ZAMBIA (3/6)

2. Labour Salary and Wage

Categories	ZK/Man·Day
2.1 Staff	
Pit Shop Foreman	65
Plant Maintenance Foreman	65
Welder Foreman	65
2.2 Worker	
Head Coolie	19
Coolie	19
Head Porter	19
Porter	19
Mason, Carpenter, Painter, Plumber, Blacksmith	22
Plumber Foreman	24
Truck Driver Cum Mechanics, Heavy Machine Operator	35
Truck Driver	30
Driver	26
Electrician, Mechanics	26
Timber Sawer	26
Wood Carvener, Stone Carvener	26
Helper	20
Sequrity Guard	20
Casual Worker	19

Table IV-3 MAJOR UNIT PRICES IN ZAMBIA (4/6)

3. Construction Works (Including Material and Equipment)

Items		Unit	Price, ZK
Surface Clearing and Grabbing		m^2	1
Excavation	- Common Soil	m^3	26
	- By Blasting	m^3	140
Back-Fill		m^3	5
Concrete Works	- Common Type	m^3	320
	- Mass Type	m^3	295
Concrete Molding Work	- Simple	m^2	350
	- Complicated	m^2	400
Placing of Reinforcement		Ton	450
Form Works		m2	46
Asbesto Cement Sheet Rooting		m^2	28
Asphalting Works		Ton	
Processing Works of Iron Material		Ton	16,000
Installation of Machinery		Ton	
Piping (Steel Pipe, Depth 0.5-1.5 m)		m	160
Building Works - Concrete Block, Asbestos Roof		m^2	2,300
Overhead of Contractor		-	18 - 30%
Profit to Contractor		-	12.5 - 15%
Inland Transportation on Road		Ton-km	0.8
Concrete Piling Works (65 Ton x 0.45 mD)		m	850
Brick Works (Concrete)		m^3	520

Table IV-3 MAJOR UNIT PRICES IN ZAMBIA (5/6)

4. Material

Items		Unit	Price, ZK
4.1 Fuel and Electricity for Construction Works			
Gasoline		m^3	2,850
Fuel Oil for Diesel Engine		m^3	1,900
Lubricant		m^3	21,000
Electricity; ZESCO D2 Tariff (500 kVA, 300 kW)		kWh	0.07
4.2 Aggregate			
Gravel		m^3	125
Sand		m^3	80
4.3 Cement (Ex-Works, Chilanga, Copperbelt)		Ton	285
4.4 Steel Material			
Reinforce Rod (including cut, bend)		Ton	7,150
Angle, T-beam, Channel, Plate		Ton	16,000
Steel Pipe	- 25A	m	30
	- 50A	m	56
	- 100A	m	114
	- 150A	m	170
	- 200A	m	
4.5 Valve			
Sluice Valve	- 25A	pc	
	- 50A	pc	440
	- 100A	pc	615
	- 150A	pc	825
	- 200A	pc	1,735
Brass Gate Valve	- 25A	pc	88
	- 50A	pc	176
	- 100A	pc	3,788
4.6 Molding Material			
Plywood	- 12 mm	m^2	46
4.7 Glass	- 3 mm	m^2	110
	- 6 mm	m^2	184
4.8 Concrete Block			
20 x 20 x 40 cm		100 pc	200
10 x 10 x 40 cm		100 pc	150
4.9 Brick			
Clay		1,000 pc	625
Concrete		1,000 pc	700
4.10 Paint		liter	33

Table IV-3 MAJOR UNIT PRICES IN ZAMBIA (6/6)

	Unit	Price, ZK
4.11 Timber		
Bolt Wood	m^3	1,500
Ordinary Plywood	m^3	2,800
Plane Plank (Hard Wood)	m	3,500
4.12 Electric Cable Armored (Ex-Works, Zamefa)		
- 25 mm^2	km	33,796
- 35 mm^2	km	45,887
- 50 mm^2	km	57,789
- 70 mm^2	km	73,681
- 95 mm^2	km	98,380
- 120 mm^2	km	121,074
- 150 mm^2	km	146,760
- 185 mm^2	km	174,481
4.13 Insulator (Ex-Works, Behrens)		
11 kV Pin Type	pc	147
11 kV Suspension Type	pc	147
4.14 Oxygen (150 atg) and Acetylene (15.5 atg) - 40 liter cylinder	cylinder	160

Table IV-4 CAPITAL COST ESTIMATE FOR PROJECT (1/5)

Project : Phosphate Mining and Concentrate Project
Product : Phosphate Concentrate, Bulk, Wet
Capacity: 35,181 TPY as Dry
Location: Chilembwe, Zambia

Unit: US$, Millions

	Foreign Currency	Local Currency	Total Project Cost
1. Site Acquisition/Preparation (779,000 m^2)	0.000	0.189	0.189
2. Plant Direct Cost			
- Equipment, Materials and Spare Parts (2 years)	5.096	0.000	5.096
- Civil and Erection Works	0.000	2.073	2.073
3. Construction Equipment	0.149	0.018	0.167
4. Freight, Insurance and Local Handlings (3,000 Freight Ton)	1.529	0.000	1.529
5. Know How/Engineering Services (48 Man·Months)	0.481	0.000	0.481
6. Project Management (20 Man·Months)	0.000	0.178	0.178
Plant Cost - Estimate Date	7.255	2.458	9.713
7. Contingencies			
- Physical Contingency	0.363	0.246	0.609
- Price Contingency (Foreign: 14.23%, Local: 14.23% from Estimate to Production Dates)	1.032	0.350	1.382
Plant Cost - Commercial Production Date	8.650	3.054	11.704
8. Taxes and Duties (5%)	0.000	0.585	0.585
9. Pre-operational Expenses	0.216	0.076	0.292
10. Working Capital	0.000	0.739	0.739
11. Interest during Construction (12%/Year)	1.244	0.000	1.244
Total Financing Required - Commercial Production Date, (Ratio, %)	10.110 (69.41)	4.454 (30.58)	14.564 (100.00)

Notes: 1) Equity + Loan = Total, $,MM (%) : 3.641 (25) + 10.923 (75) = 14.564 (100)
2) Annual Escalation, %/Year : Foreign Currency; 3.0, Local Currency; 3.0
3) Interest for Long Term Loan : 12.0%/Year
4) Estimate Date : January 01, 1987
5) Plant Construction Contract : July 01, 1989
6) Commercial Production Date : July 01, 1991
7) Exchange Rate at Estimate Date : ZK8.00/US$

Table IV-4 CAPITAL COST ESTIMATE FOR PROJECT (2/5)

Project : Fused Magnesium Phosphate Project
Product : Fused Magnesium Phosphate, Bags
Capacity: 50,400 TPY
Location: Kafue, Zambia

Unit: US$, Millions

	Foreign Currency	Local Currency	Total Project Cost
1. Site Acquisition/Preparation (27,000 m^2)	0.000	0.136	0.136
2. Plant Direct Cost			
- Equipment, Materials and Spare Parts (2 years in general, 0.5 years for electrode)	5.233	0.000	5.233
- Civil and Erection Works	3.387	1.537	4.924
3. Construction Equipment	0.400	0.058	0.458
4. Freight, Insurance and Local Handlings (5,000 Freight Ton)	0.820	0.136	0.956
5. Know How/Engineering Services (130 Man·Months)	1.867	0.051	1.918
6. Project Management (40 Man·Months)	0.533	0.058	0.591
Plant Cost - Estimate Date	12.240	1.976	14.216
7. Contingencies			
- Physical Contingency	0.612	0.198	0.810
- Price Contingency (Foreign: 14.23%, Local: 14.23% from Estimate to Production Dates)	1.741	0.281	2.022
Plant Cost - Commercial Production Date	14.593	2.455	17.048
8. Taxes and Duties (5%)	0.000	0.426	0.426
9. Pre-operational Expenses	0.306	0.061	0.367
10. Working Capital	0.000	1.915	1.915
11. Interest during Construction (12%/Year)	1.764	0.000	1.764
Total Financing Required - Commercial Production Date, (Ratio, %)	16.663 (77.43)	4.857 (22.57)	21.520 (100.00)

Notes: 1) Equity + Loan = Total, $,MM (%) : 5.380 (25) + 16.140 (75) = 21.520 (100)
2) Annual Escalation, %/Year : Foreign Currency; 3.0, Local Currency; 3.0
3) Interest for Long Term Loan : 12.0%/Year
4) Estimate Date : January 01, 1987
5) Plant Construction Contract : July 01, 1989
6) Commercial Production Date : July 01, 1991
7) Exchange Rate at Estimate Date : ZK8.00/US$

Table IV-4 CAPITAL COST ESTIMATE FOR PROJECT (3/5)

Project : Single Super Phosphate Project
Product : Single Super Phosphate, Bulk
Capacity: 57,205 TPY
Location: Kafue, Zambia

Unit: US$, Millions

	Foreign Currency	Local Currency	Total Project Cost
1. Site Acquisition/Preparation (20,800 m^2)	0.000	0.098	0.098
2. Plant Direct Cost			
- Equipment, Materials and Spare Parts (2 years)	4.160	0.000	4.160
- Civil and Erection Works	3.020	1.373	4.393
3. Construction Equipment	0.400	0.058	0.458
4. Freight, Insurance and Local Handlings (4,000 Freight Ton)	0.740	0.127	0.867
5. Know How/Engineering Services (121 Man·Months)	1.613	0.048	1.661
6. Project Management (36 Man·Months)	0.480	0.058	0.538
Plant Cost - Estimate Date	10.413	1.762	12.175
7. Contingencies			
- Physical Contingency	0.521	0.176	0.697
- Price Contingency (Foreign: 14.23%, Local: 14.23% from Estimate to Production Dates)	1.481	0.251	1.732
Plant Cost - Commercial Production Date	12.415	2.189	14.604
8. Taxes and Duties (5%)	0.000	0.365	0.365
9. Pre-operational Expenses	0.620	0.030	0.650
10. Working Capital	0.000	2.631	2.631
11. Interest during Construction (12%/Year)	1.544	0.000	1.544
Total Financing Required - Commercial Production Date, (Ratio, %)	14.579 (73.65)	5.215 (26.35)	19.794 (100.00)

Notes: 1) Equity + Loan = Total, $,MM (%) : 4.949 (25) + 14.845 (75) = 19.794 (100)
2) Annual Escalation, %/Year : Foreign Currency; 3.0, Local Currency; 3.0
3) Interest for Long Term Loan : 12.0%/Year
4) Estimate Date : January 01, 1987
5) Plant Construction Contract : July 01, 1989
6) Commercial Production Date : July 01, 1991
7) Exchange Rate at Estimate Date : ZK8.00/US$

Table IV-4 CAPITAL COST ESTIMATE FOR PROJECT (4/5)

Project : Phosphate Mining and Concentrate Project and
Fused Magnesium Phosphate Project
Product : Fused Magnesium Phosphate, Bags
Capacity: 50,400 TPY
Location: Chilembwe and Kafue, Zambia

Unit: US$, Millions

	Foreign Currency	Local Currency	Total Project Cost
1. Site Acquisition/Preparation (806,000 m^2)	0.000	0.325	0.325
2. Plant Direct Cost			
- Equipment, Materials and Spare Parts (2 years in general, 0.5 years for electrode)	10.329	0.000	10.329
- Civil and Erection Works	3.387	3.610	6.997
3. Construction Equipment	0.549	0.076	0.625
4. Freight, Insurance and Local Handlings (8,000 Freight Ton)	2.349	0.136	2.485
5. Know How/Engineering Services (178 Man·Months)	2.348	0.051	2.399
6. Project Management (60 Man·Months)	0.533	0.236	0.769
Plant Cost - Estimate Date	19.495	4.434	23.929
7. Contingencies			
- Physical Contingency	0.975	0.444	1.419
- Price Contingency (Foreign: 14.23%, Local: 14.23% from Estimate to Production Dates)	2.773	0.631	3.404
Plant Cost - Commercial Production Date	23.243	5.509	28.752
8. Taxes and Duties (5%)	0.000	1.011	1.011
9. Pre-operational Expenses	0.522	0.137	0.659
10. Working Capital	0.000	2.654	2.654
11. Interest during Construction (12%/Year)	3.008	0.000	3.008
Total Financing Required - Commercial Production Date, (Ratio, %)	26.773 (74.20)	9.311 (25.80)	36.084 (100.00)

Notes: 1) Equity + Loan = Total, $,MM (%) : 9.021 (25) + 27.063 (75) = 36.084 (100)
2) Annual Escalation, %/Year : Foreign Currency; 3.0, Local Currency; 3.0
3) Interest for Long Term Loan : 12.0%/Year
4) Estimate Date : January 01, 1987
5) Plant Construction Contract : July 01, 1989
6) Commercial Production Date : July 01, 1991
7) Exchange Rate at Estimate Date : ZK8.00/US$

Table IV-4 CAPITAL COST ESTIMATE FOR PROJECT (5/5)

Project : Phosphate Mining and Concentrate Project and Single Super Phosphate Project
Product : Single Super Phosphate, Bulk
Capacity: 57,205 TPY
Location: Chilembwe and Kafue, Zambia

Unit: US$, Millions

	Foreign Currency	Local Currency	Total Project Cost
1. Site Acquisition/Preparation (799,800 m^2)	0.000	0.287	0.287
2. Plant Direct Cost			
- Equipment, Materials and Spare Parts (2 years)	9.256	0.000	9.256
- Civil and Erection Works	3.020	3.446	6.466
3. Construction Equipment	0.549	0.076	0.625
4. Freight, Insurance and Local Handlings (7,000 Freight Ton)	2.269	0.127	2.396
5. Know How/Engineering Services (169 Man·Months)	2.094	0.048	2.142
6. Project Management (56 Man·Months)	0.480	0.236	0.716
Plant Cost - Estimate Date	17.668	4.220	21.888
7. Contingencies			
- Physical Contingency	0.884	0.422	1.306
- Price Contingency (Foreign: 14.23%, Local: 14.23% from Estimate to Production Dates)	2.513	0.601	3.114
Plant Cost - Commercial Production Date	21.065	5.243	26.308
8. Taxes and Duties (5%)	0.000	0.950	0.950
9. Pre-operational Expenses	0.836	0.106	0.942
10. Working Capital	0.000	3.370	3.370
11. Interest during Construction (12%/Year)	2.788	0.000	2.788
Total Financing Required - Commercial Production Date, (Ratio, %)	24.689 (71.86)	9.669 (28.14)	34.358 (100.00)

Notes: 1) Equity + Loan = Total, $,MM (%) : 8.590 (25) + 25.768 (75) = 34.358 (100)
2) Annual Escalation, %/Year : Foreign Currency; 3.0, Local Currency; 3.0
3) Interest for Long Term Loan : 12.0%/Year
4) Estimate Date : January 01, 1987
5) Plant Construction Contract : July 01, 1989
6) Commercial Production Date : July 01, 1991
7) Exchange Rate at Estimate Date : ZK8.00/US$

Table IV-5 OPERATING COST ESTIMATE AND PROJECTION FOR THE PROJECTS

Itmes	Basic Data for Estimate January 01, 1987		Base Estimate January 01, 1987		Projection July 01, 1991	
	Unit Cost ZK/Ton	Annual Throughput TPY	Unit Cost $/Ton	Annual Cost $, MM/Year	Unit Cost $/Ton	Annual Cost $, MM/Year
0. Basis of Projection						
- Foreign Currency Exchange Rate, ZK/$	12.00		8.00		8.00	
- Escalation, 1991/1987						
- Foreign Currency Portion	-		-		1.1423	
- Local Currency Portion	-		-		1.1423	
- Electricity	-		-		2.0000	
1. Transport Cost of Phosphate Concentrate on Road	453	39,978-Wet	56.63	2.264	64.68	2.586
- Chilembwe/Kafue: 541 km	-	35,181-Dry	64.35		73.50	
2. Serpentine Mining Cost, Mkushi	136.1	20,023-Wet	17.01	0.340	19.41	0.389
- Project Capital Cost: $0.960 MM	-	19,103-Dry	17.83		20.34	
- Personel : ZK10,489 x 20/MY						
- Consumable : $0.088 MM/Year						
3. Transport Cost of Serpentine on Road and Railway	173.0	20,023-Wet	21.63	0.433	24.70	0.495
- Mkushi/Kafue: 297 km	-	19,103-Dry	22.67		25.89	
4. Sulfuric Acid from NCZ, Kafue by Pipeline	901	19,850-Dry	112.63	2.236	128.64	2.554
- Kafue/Kafue: 1 km						
- Selling Price of NCZ	1,130					
- Handling Cost	10					
	1,140					
- Production Cost, September,1986						
- Capacity Utilization: 42%	944					
: 90%	652					
- Assumed Price for Project	(1,130+652)/2+10=901					
5. Electricity,	ZK/kWh	kWh, MM/Year	$/kWh		$/kWh	
- ZESCO Tariff plus 15% Sales Tax	0.0657x1.15	3.318	0.00944	0.0313	0.0189	0.063
- Phosphate Mining and Concentrate Project, Chilembwe						
- Phosphate Fertilizer Projects, Jointly with NCZ Contract						
- FMP Project, Kafue	0.0423x1.15	45.870	0.00608	0.2789	0.0122	0.558
- SSP Project, Kafue	0.0423x1.15	2.575	0.00608	0.0157	0.0122	0.031
6. Fuel						
- ZIMCO						
- Diesel Oil, kl	1,900	-	237.50	-	271.27	-
- Fuel Oil, Ton	1,300	-	162.50	-	185.61	-
7. Electrode for FMP Production	Import	252	3,500	0.882	3,988.00	1.008
8. Calcium Hydroxide, Ton	223	-	27.88	-	31.83	-
9. Fertilizer Bag, Bag (50 kg Net)	6	-	0.75	-	0.86	-
10. Personnel	ZK/Man-Year	Man-Year	$/Man-Year		$/Man-Year	
- Phosphate Mining and Concentrate Project, Chilembwe	11,726	117	1,465.75	0.171	1,674.19	0.195
- FMP Project, Kafue	10,072	83	1,259.00	0.1045	1,438.02	0.120
- SSP Project, Kafue	10,324	74	1,290.50	0.0955	1,474.00	0.110

Table IV-6 RAW MATERIAL AND PRODUCT IMPORT SUBSTYITUTE PRICE ESTIMATE AND PROJECTION

Items	Escalation for 1987/1991, %	Importing Raw Material and Product Prices: Phosphate Rock (0-33.4-0)		Triple Super Phosphate (0-46.4-0)		Diammonium Phosphate (18.2-46.4-0)	
1. Historical Export Price Trend[1], 1974/1987							
Price Standard Location		FOB, Bulk, USA		FOB, Bulk, USA		FOB, Bulk, USA	
Price, $/Ton							
- Highest		50.0 - 1980		370.0 - 1974		410.0 - 1974	
- Lowest		25.0 - 1977		80.0 - 1976		100.0 - 1976	
- Average		35.0 - 1974/87		150.0 - 1974/87		185.0 - 1974/87	
- Price Estimate Date, January 01,1987		35.0 - 1987		105.0 - 1987		145.0 - 1987	
- The Latest, March 01, 1987		35.0 - 1987		135.0 - 1987		165.0 - 1987	
2. Realization Price[2], $/Ton-1982							
- FAO/UNIDO/World Bank:		40.4 - High Grade Ore		236.7		340.2	
New Developing Site (Capacity)		48.5 - Low Grade Ore (3,000,000 TPY)		(356,400 TPY)		(356,400 TPY)	
3. Present Price for Export to Zambia[1]							
Price Standard Location		FOB, Bulk, North Africa		FOB, Bulk, North Africa		FOB, Bulk, North Africa	
Price, $/Ton							
- Price Estimate Date, January,01,1987		35.0		125.0		160.0	
- The latest, March 01, 1987		35.0		145.0		180.0	
- Assumed Price for Financial Analysis		35.0		150.0		185.0	
- Unit Nutrient (N + P_2O_5)		104.8		323.3		286.4	
- Nutrient Price Ratio		1.000		3.085		2.733	
4. Price Projection, CIF, Kafue, Zambia, $/Ton		January 01, 1987	July 01, 1991	January 01, 1987	July 01, 1991	January 01, 1987	July 01, 1991
FOB, Bulk, North Africa	14.23	35.0	40.0	150.0	171.3	185.0	211.3
Packaging and Loading	14.23	20.0	22.8	20.0	22.8	20.0	22.8
Ocean Freight to Dar-es -Salaam, 5,000 Tonner	14.23	35.0	40.0	35.0	40.0	35.0	40.0
Unloading/Transshipment	14.23	20.0	22.8	20.0	22.8	20.0	22.8
Railway to Kafue	14.23	55.0	62.8	55.0	62.8	55.0	62.8
Interest/Insurance/Shrinkage	14.23	12.4	14.2	21.0	24.0	23.6	27.0
Import Tax	14.23	-	-	-	-	-	-
Sales Tax	14.23	-	-	-	-	-	-
CIF, Before Tax and Duty, Bags, Kafue, Zambia		177.4	202.8	301.0	343.7	338.6	386.7
- Unit Nutrient (N + P_2O_5)		531.1	606.6	648.7	740.7	524.2	598.6
- Nutrient Price Ratio		1.000	1.000	1.221	1.221	0.987	0.987
5. Import Substitute Pricing for Zambian Product, $/Ton		Chilembwe Phosphate Concentrate, Bulk/Bags (0-30.00-0)		Fused Magnesium Phosphate, Bulk/Bags (0-20.03-0-0-14.1)		Single Super Phosphate, Bulk/Bags (0-17.20-0-11.1-0)	
Price Standard Specification							
Annual Production, TPY		35,188-Dry		50,400-Bulk/Bags		57,205-Bulk/Bags	
Ex-Factory Price, Kafue							
- P_2O_5 Equivalent[3]		159.3	182.0	129.9	148.4	111.6	127.4
- Sulfur Credit, (Gypsum-15% S, $40/Ton-1987)		-	-	-	-	29.6	33.8
- Magnesia Credit, (Dolomite-20% MgO, $30/Ton-1987)		-	-	21.2	24.2	-	-
- Alkaline and Others Credit (Lime -53%, $20/Ton-1987)		-	-	18.9	21.6	-	-
		159.3	182.0	170.0	194.2	141.2	161.2
- Unit Nutrient Price, $/Ton-$P_2O_5$		531.1	606.6	848.7	969.5	820.9	937.2
- Nutrient Price Ratio		1.000	1.000	1.598	1.598	1.546	1.546
Farmer's Gate Price, Zambia as Average							
- Transport Cost Adjustment[4]		-	-	(-)22.5	(-)25.7	(-)32.9	(-)37.6
- Inventory Time Cost Adjustment[5]		-	-	(-)12.1	(-)13.8	(-)10.0	(-)11.4
		-	-	135.4	154.7	98.3	112.2
- Unit Nutrient Price, $/Ton-$P_2O_5$		-	-	676.0	772.3	571.5	652.3
- Nutrient Price Ratio		-	-	1.182	1.107	1.000	1.000

Notes: 1) Fertilizer International, The British Sulfur Corp. Ltd., England
2) Current World Fertilizer Situation and Outlook, 1980/81 - 1986/87, FAO/UNIDO/World Bank Working Group on Fertilizer, FAO, Italy, September, 1982
3) Pricing assumption: Av-P_2O_5 in SSP = Av-P_2O_5 in TSP and C-P_2O_5 in FMP = Av-P_2O_5 in TSP
4) Domestic average transport cost of ZK155.2-1987 ($19.40-1987/$22.16-1991)/Ton is assumed for TSP from Kafue
5) Inventory average time factor between domestic production and import of 4.0 months at annual interest rate of 20% is assumed: $1 - (1-0.20)^{4/12} = 7.10\%$

Table IV-7 FINANCIAL ANALYSIS SUMMARY FOR PROJECT INTEGRATION

		Individual Projects						Integrated Projects			
		Phosphate Mining and Concentrate Project, Chilembwe, Zambia [I]		Fused Magnesium Phosphate Project, Kafue, Zambia [II]		Single Super Phosphate Project, Kafue, Zambia [III]		Phosphate Mining and Concentrate Project and Fused Magnesium Phosphate Project, Chilembwe/Kafue, Zambia [I] + [II]		Phosphate Mining and Concentrate Project and Single Super Phosphate Project, Chilembwe/Kafue, Zambia [I] + [III]	
1.	Long Term Loan Interest Rate. %/Year	Low Case 4.0	Base Case 12.0	Low Case 4.0	Base Case 12.0	Low Case 4.0	Base Case 12.0	Low Case 4.0	Base Case 12.0	Low Case 4.0	Base Case 12.0
2.	Project Cost, $, MM - 1991	13.71	14.56	20.31	21.52	18.73	19.79	34.02	36.08	32.44	34.36
3.	Transfer Price of Phosphate Concentrate, $/Ton, Bulk, Dry, Kafue	130	130	130	130	130	130	120.3	120.3	131.3	131.3
4.	Product Price, $/Ton, Kafue, (Nutrient Price, $/Ton-$P_2O_5$)-Packaging	[130] (433) - Bulk	[130] (433) - Bulk	180 (899) - Bags	180 (899) - Bags	150 (872) - Bulk	150 (872) - Bulk	180 (899) - Bags	180 (899) - Bags	150 (872) - Bulk	150 (872) - Bulk
5.	ROI, DCF, Constant Price, After Tax, %	(-)4.29	(-)4.27	(-)10.11	(-)10.06	(-)3.53	(-)3.52	(-)8.04	(-)8.00	(-)3.85	(-)3.84
6.	Debt Service Ratio										
	- 1991	0.85	0.16	0.32	0.06	0.93	0.18	0.50	0.10	0.90	0.17
	- 3	0.94	(-)0.05	0.21	0.19	1.00	0.09	0.48	(-)0.12	1.00	0.06
	- 5	1.26	(-)0.46	0.13	(-)0.73	1.26	(-)0.26	0.68	(-)0.59	1.29	(-)0.29
	- 7	0.58	(-)1.21	(-)0.16	(-)1.63	0.58	(-)0.89	0.20	(-)1.42	0.59	(-)0.94
	- 9	0.44	(-)2.44	(-)0.68	(-)3.13	0.61	(-)1.91	(-)0.15	(-)2.78	0.62	(-)1.99
	Project Life Average	0.35	(-)2.76	(-)1.27	(-)3.50	0.64	(-)2.18	(-)0.51	(-)3.12	0.63	(-)2.27
7.	Short Term Loan, $, MM (Interest Rate; 20%/Year)										
	- 1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	- 3	0.01	2.42	0.00	3.33	0.00	1.65	0.00	5.16	0.00	3.41
	- 5	0.00	6.59	0.78	10.47	0.00	6.57	0.16	16.28	0.00	12.16
	- 7	0.00	12.08	2.32	20.05	0.00	12.97	1.50	31.08	0.00	23.54
	- 9	0.76	19.58	5.73	33.26	0.00	21.63	5.46	51.39	0.00	38.99
	- 2005, Project Life	5.14	65.07	26.64	114.37	2.49	73.56	29.02	175.45	4.97	131.80

Notes: 1) Equity/Long Term Loan = 25/75

2) Project Life/Depreciation = 15 years/15 years (1991 to 2005)

3) Loans :

	Interest Rate	Grace Period	Repayment
- Long Term - Base Case	12.0%	2.5 years	15 years
- Low Case	4.0	7.5	20
- Short Term	20.0	0.0	1

4) Cut-Off Rate for Project Evaluation at INDECO, Zambia
- Financial Analysis : 12%
- Economic Analysis : 18%

Table IV-8-1 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY (1/5)

1. Project

Title	:	Phosphate Mining and Concentrate Project
Location	:	Chilembwe, Zambia
Executing Agency	:	State Owned Corporation
Project Case	:	Base
Product	:	Phosphate Concentrate, Bulk, Wet
Maximum Operable Days	:	290 DPY
Rated Capacity (100%)	:	121.31 TPD x 290 DPY = 35,181 TPY as Dry
Production Start Year	:	July 01, 1991
Monetary Unit	:	US$ in terms of current price at the commercial production start date

2. Schedule

Pricing Estimate	:	January 01, 1987
Project Approval	:	July 01, 1988
Contract Award	:	July 01, 1989
Mechanical Completion	:	March 31, 1991
Commercial Production	:	July 01, 1991
Project Phase Out	:	June 30, 2006
Project Life	:	15 Years (Effective Production for 14.6 Years)
Construction and Commissioning	:	2 Years

3. Financing Required and Financing Plan on Commercial Production Date

Financing Required	$, MM	Financing Plan	$, MM
Land/Site Preparation	0.189	Equity : 25%	3.641
Erected Plant Cost	12.100	Long Term Loan: 75%	10.923
Pre-Operational Expense	0.292	- Interest 12.0%	
Interest during Construction	1.244	Short Term Loan/Local	Balanced
		- Interest 20.0%	
Fixed Capital Cost	13.825		
Initial Working Capital	0.739	Financing Plan	14.564
Financing Required	14.564		

Table IV-8-1 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY (2/5)

4. Inputs and Pricing (CIF at the Plant in Chilembwe on Commercial Production Date)

Inputs	Unit		Per Product Mix		Annual	
	Unit	Cost	Consumption	Cost	Consumption	Cost
		$/Unit	Unit	$	Unit	$, MM
Raw Material						
- Raw Ore	Ton	0.000	2.956	0.000	104,000	0.000
- Chemicals/Catalysts/ Consumables	$	-	-	21.347	-	0.751
	-	-	2.956	(21.347)	104,000	(0.751)
Utility and Transport						
- Transport	Ton	73.50	1.000	73.500	35,181	2.586
- Raw Water	Ton	0.00	8.871	0.000	312,075	0.000
- Diesel Oil	kl	271.27	0.007	1.876	244	0.066
- Electricity	kWh	0.0189	94.293	1.782	3.318MM	0.0627
	-	-	-	(77.172)	-	(2.715)
Personnel	Man·Year	1,674	-	5.571	117	0.196
Overhead	Man·Year x 30%		-	1.677	-	0.059
Maintenance	Plant Cost x 2.00%		-	6.907	-	0.243
Insurance/ Local Tax	Plant Cost x 0.50%		-	1.734	-	0.061
Sales Expense/ Administration	Annual Sales x 1.50%		-	1.961	-	0.069
	-	-	-	(17.851)	-	(0.628)
Total/Average	-	-	-	116.369	-	4.094

5. Outputs and Pricing (CIF at the Plant in Kafue on Commercial Production Date)

Outputs	Unit		Per Product Mix		Annual	
	Unit	Price	Production	Price	Production	Sales
		$/Unit	Unit	$	Unit	$, MM
Product Mix						
- Phosphate Concentrate, Dry, Bulk	Ton	130.00	1.000	130.00	35,181	4.574
Total/Average	-	130.00	1.000	130.00	35,181	4.574

Note: Assumed Transfer Price of Phosphate Concentrate Price-Dry;

$56.50/Ton	- FOB, Chilembwe
73.50	- Transport Cost
130.00	- CIF, Kafue

Table IV-8-1 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY (3/5)

6. Operation Schedule

	Year							(Unit: %)
	(-)2	(-)1	1	2	3	4	5 ... 16	Average
	89	90	91	92	93	94	95 2006	
- Financing Disbursement	15	70	15					
- Production								
- Capacity Utilization			35	80	90	100	100 50	1,460
- Inventory Increase			5	5	0	0	0 (-)10	0
- Inventory			5	10	10	10	10 0	0
- Sales			30	75	90	100	100 60	1,460

- Depreciation/Salvage Value: 15 years straight line/Zero salvage value

- Debt Service

Loan Type	Maximum Grace plus Maturity Year	Annual Interest Rate %
- Development/Foreign		
- Base Case (Relending)	2.5 + 15.0	12.0
- Low Interest Rate Case	7.5 + 20.0	4.0
- Development/Local	0 + 1	20.0

- Corporate Income Tax, %/Tax Holiday, Year: 35.0/5.0
- Minimum Cash Reserve: $0.10 MM
- Escalation/Deflator Rate, %/Year: 0.0/0.0

7. Financial Analysis by Discounted Cash Flow Method

	Constant Price	
	Before Tax %	After Tax %
- Return on Investment, FIRROI-DCF		
- Base Case	(-)4.27	(-)4.27
- Sensitivity Analysis		
- Product Price (+20%)	5.74	5.74
- Raw Material Cost (-20%)	(-)2.24	(-)2.24
- Investment Cost (-20%)	(-)1.68	(-)1.68
- Utility and Transport Cost (-20%)	2.29	2.29

- Cash Flow

Year	Debt Service Ratio	Short Term Loan, $, MM
1991	0.16	0.00
1993	(-)0.05	2.42
1995	(-)0.46	6.60
1997	(-)1.21	12.08
1999	(-)2.44	19.58
Project Life Averate	(-)2.76	65.07-2005

Table IV-8-1 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY (4/5)

8. Sensitivity Analysis

Sensitivity Analysis		FIRROI-DCF, Constant Price Before Tax	After Tax
- Base Case		(-) 4.27%	(-) 4.27%
- Product Price	(+)40%	12.91	11.76
	(+)20	5.74	5.74
	(±)0	(-) 4.27	(-) 4.27
	(-)20	-	-
	(-)40	-	-
- Raw Material Cost	(+)40%	(-) 9.18	(-) 9.18
	(+)20	(-) 6.56	(-) 6.56
	(±)0	(-) 4.27	(-) 4.27
	(-)20	(-) 2.24	(-) 2.24
	(-)40	(-) 0.39	(-) 0.39
- Investment Cost	(+)40%	(-) 7.95	(-) 7.95
	(+)20	(-) 6.30	(-) 6.30
	(±)0	(-) 4.27	(-) 4.27
	(-)20	(-) 1.68	(-) 1.68
	(-)40	1.89	1.89
- Utility and Transport Cost	(+)40%	-	-
	(+)20	(-)14.57	(-)14.57
	(±)0	(-) 4.27	(-) 4.27
	(-)20	2.29	2.29
	(-)40	7.42	7.42

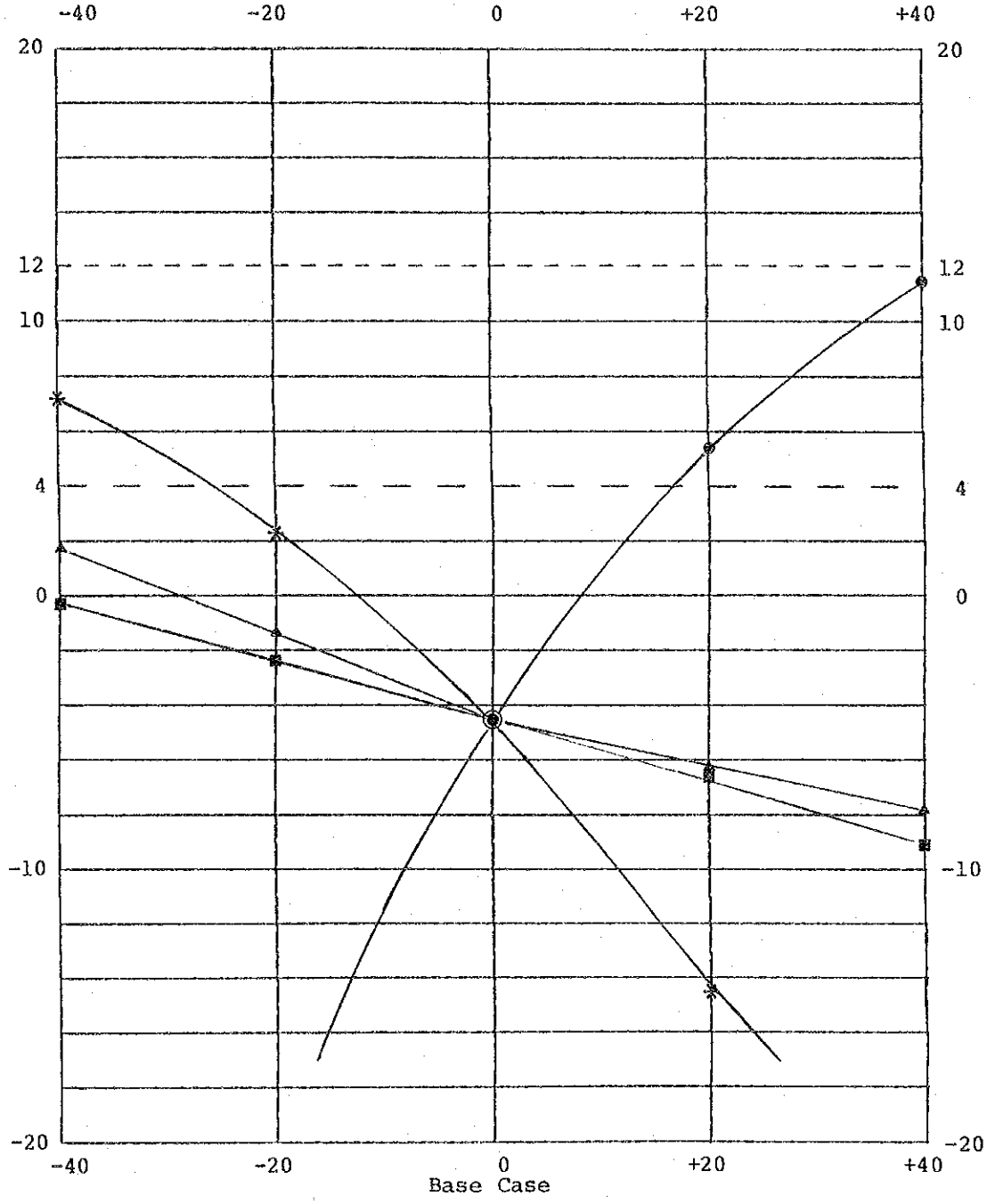
Notes:

- Long Term Loan/Equity, % = 75/25
- Interest Rate; Long/Short Term Loan, % = 12.0/20.0
- Annual Escalation/Deflator Rate, % = 0.0/0.0
- Corporate Income Tax Rate, % = 35.0

Table IV-8-1 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY (5/5)

9. Sensitivity Analysis Figure

Return on Investment
- FIRROI/After Tax/Constant Price/DCF, %/Year



Legend:

- ● - Product Price
- ■ - Raw Material Cost
- ▲ - Investment Cost
- ✱ - Utility and Transport Cost
- ○ - ROI, Before Tax for Base Case
- – – – Long Term Loan Interest Rate (Base Case: 12%/Year)
- — — — Long Term Loan Interest Rate (Low Interest Rate Case: 4%/Year)

Variant from Base Case, %

Table IV-8-2 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY (1/5)

1. Project

Title	:	Fused Magnesium Phosphate Project
Location	:	Kafue, Zambia
Executing Agency	:	State Owned Corporation
Project Case	:	Base
Product	:	Fused Magnesium Phosphate, Bags
Maximum Operable Days	:	300 DPY
Rated Capacity (100%)	:	168.0 TPD x 300 DPY = 50,400 TPY
Production Start Year	:	July 01, 1991
Monetary Unit	:	US$ in terms of current price at the commercial production start date

2. Schedule

Pricing Estimate	:	January 01, 1987
Project Approval	:	July 01, 1988
Contract Award	:	July 01, 1989
Mechanical Completion	:	March 31, 1991
Commercial Production	:	July 01, 1991
Project Phase Out	:	June 30, 2006
Project Life	:	15 Years (Effective Production for 14.6 Years)
Construction and Commissioning	:	2 Years

3. Financing Required and Financing Plan on Commercial Production Date

Financing Required	$, MM
Land/Site Preparation	0.136
Erected Plant Cost	17.338
Pre-Operational Expense	0.367
Interest during Construction	1.764
Fixed Capital Cost	19.605
Initial Working Capital	1.915
Financing Required	21.520

Financing Plan		$, MM
Equity	: 25%	5.380
Long Term Loan:	75%	16.140
- Interest	12.0%	
Short Term Loan/Local		Balanced
- Interest	20.0%	
Financing Plan		21.520

Table IV-8-2 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY (2/5)

4. Inputs and Pricing (CIF at the Plant on Commercial Production Date)

Inputs	Unit		Per Product Mix		Annual	
	Unit	Cost	Consumption	Cost	Consumption	Cost
		$/Unit	Unit	$	Unit	$, MM
Raw Material						
- Phosphate Concentrate, Dry	Ton	130.00	0.698	90.754	35,181	4.574
- Serpentine, Dry	Ton	46.23	0.379	17.520	19,103	0.883
- Calcium Hydroxide	Ton	32.00	0.010	0.317	504	0.016
- Electrode	Ton	3,998	0.005	19.980	252	1.007
- Chemicals/Catalysts/ Consumables	$	-	-	0.100	-	0.005
- Packaging	Bags	0.86	20.20	17.380	1.018MM	0.876
	-	-	-	(146.05)	-	(7.361)
Utility and Transport						
- Transport	Ton	.	.	.	,	-
- Raw Water	Ton	0.00	6.250	0.000	0.315MM	0.000
- Fuel Oil	Ton	185.61	0.028	5.198	1,411	0.262
- Electricity	kWh	0.0122	910.000	11.111	45.87MM	0.560
	-	-	-	(15.222)	-	(0.822)
Personnel	Man·Year	1,438	-	2.381	83	0.119
Overhead	Man·Year x 30%		-	0.714	-	0.036
Maintenance	Plant Cost x 2.00%		-	6.905	-	0.348
Insurance/ Local Tax	Plant Cost x 0.50%		-	1.726	-	0.087
Sales Expense/ Administration	Annual Sales x 1.50%		-	2.857	-	0.144
	-	-	-	(14.583)	-	(0.734)
Total/Average	-	-	-	165.148	-	8.917

5. Outputs and Pricing (FOB at the Plant on Commercial Production Date)

Outputs	Unit		Per Product Mix		Annual	
	Unit	Price	Production	Price	Production	Sales
		$/Unit	Unit	$	Unit	$, MM
Product Mix						
- Fused Magnesium Phosphate, Bags	Ton	180.00	1.000	180.00	50,400	9.072
- Calcium Fluoride	Ton	0.00	(0.015)	(0.00)	(756)	0.000
Total/Average	-	180.00	1.000	180.00	50,400	9.072

Note: Serpentine Price-Dry;

$20.34/Ton	- FOB, Mkushi
25.89	- Transport Cost
46.23	- CIF, Kafue

Table IV-8-2 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY (3/5)

6. Operation Schedule

	Year								(Unit: %)
	(-)2	(-)1	1	2	3	4	5	... 16	Average
	89	90	91	92	93	94	95	2006	
- Financing Disbursement	15	70	15						
- Production									
- Capacity Utilization			35	80	90	100	100	50	1,460
- Inventory Increase			5	5	0	0	0	(-)10	0
- Inventory			5	10	10	10	10	0	0
- Sales			30	75	90	100	100	60	1,460

- Depreciation/Salvage Value: 15 years straight line/Zero salvage value

- Debt Service

Loan Type	Maximum Grace plus Maturity Year	Annual Interest Rate %
- Development/Foreign		
- Base Case (Relending)	2.5 + 15.0	12.0
- Low Interest Rate Case	7.5 + 20.0	4.0
- Development/Local	0 + 1	20.0

- Corporate Income Tax, %/Tax Holiday, Year: 35.0/5.0
- Minimum Cash Reserve: $0.10 MM
- Escalation/Deflator Rate, %/Year: 0.0/0.0

7. Financial Analysis by Discounted Cash Flow Method

	Constant Price	
	Before Tax %	After Tax %
- Return on Investment, FIRROI-DCF		
- Base Case	(-)10.06	(-)10.06
- Sensitivity Analysis		
- Product Price (+20%)	5.74	5.74
- Raw Material Cost (-20%)	3.71	3.71
- Investment Cost (-20%)	(-)7.87	(-)7.87
- Utility and Transport Cost (-20%)	(-)7.92	(-)7.92

- Cash Flow

Year	Debt Service Ratio	Short Term Loan, $, MM
1991	0.06	0.00
1993	(-)0.19	3.33
1995	(-)0.73	10.47
1997	(-)1.63	20.05
1999	(-)3.13	33.26
Project Life Averate	(-)3.50	114.37-2005

Table IV-8-2 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY (4/5)

8. Sensitivity Analysis

Sensitivity Analysis		FIRROI-DCF, Constant Price Before Tax	After Tax
- Base Case		(-)10.06%	(-)10.06%
- Product Price	(+)40%	15.35	13.94
	(+)20	5.74	5.74
	(±)0	(-)10.06	(-)10.06
	(-)20	-	-
	(-)40	-	-
- Raw Material Cost	(+)40%	-	-
	(+)20	-	-
	(±)0	(-)10.06	(-)10.06
	(-)20	3.71	3.71
	(-)40	12.44	11.41
- Investment Cost	(+)40%	(-)13.23	(-)13.23
	(+)20	(-)11.79	(-)11.79
	(±)0	(-)10.06	(-)10.06
	(-)20	(-) 7.87	(-) 7.87
	(-)40	(-) 4.96	(-) 4.96
- Utility and Transport Cost	(+)40%	(-)15.40	(-)15.40
	(+)20	(-)12.51	(-)12.51
	(±)0	(-)10.06	(-)10.06
	(-)20	(-) 7.92	(-) 7.92
	(-)40	(-) 6.02	(-) 6.02

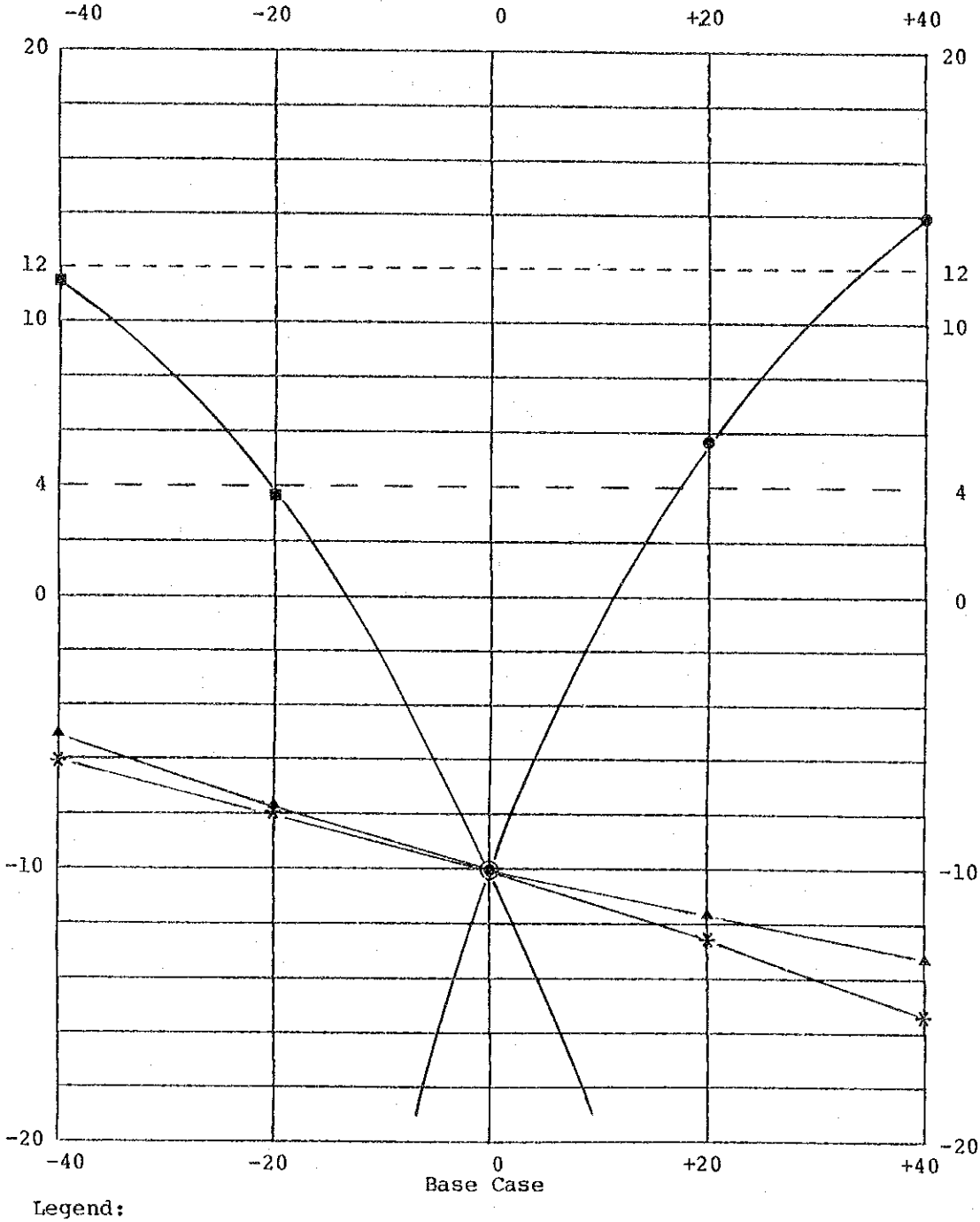
Notes:

- Long Term Loan/Equity, % = 75/25
- Interest Rate; Long/Short Term Loan, % = 12.0/20.0
- Annual Escalation/Deflator Rate, % = 0.0/0.0
- Corporate Income Tax Rate, % = 35.0

Table IV-8-2 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY (5/5)

9. Sensitivity Analysis Figure

Return on Investment
- FIRROI/After Tax/Constant Price/DCF, %/Year



Legend:

- ● - Product Price
- ■ - Raw Material Cost
- ▲ - Investment Cost
- ✻ - Utility and Transport Cost
- ○ - ROI, Before Tax for Base Case
- — — — - Long Term Loan Interest Rate (Base Case: 12%/Year)
- —— —— - Long Term Loan Interest Rate (Low Interest Rate Case: 4%/Year)

Variant from Base Case, %

Table IV-8-3 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY (1/5)

1. Project

Title	:	Single Super Phosphate Project
Location	:	Kafue, Zambia
Executing Agency	:	State Owned Corporation
Project Case	:	Base
Product	:	Single Super Phosphate, Bulk
Maximum Operable Days	:	300 DPY
Rated Capacity (100%)	:	190.68 TPD x 300 DPY = 57,205 TPY
Production Start Year	:	July 01, 1991
Monetary Unit	:	US$ in terms of current price at the commercial production start date

2. Schedule

Pricing Estimate	:	January 01, 1987
Project Approval	:	July 01, 1988
Contract Award	:	July 01, 1989
Mechanical Completion	:	March 31, 1991
Commercial Production	:	July 01, 1991
Project Phase Out	:	June 30, 2006
Project Life	:	15 Years (Effective Production for 14.6 Years)
Construction and Commissioning	:	2 Years

3. Financing Required and Financing Plan on Commercial Production Date

Financing Required	$, MM
Land/Site Preparation	0.098
Erected Plant Cost	14.871
Pre-Operational Expense	0.650
Interest during Construction	1.544
Fixed Capital Cost	17.163
Initial Working Capital	2.631
Financing Required	19.794

Financing Plan		$, MM
Equity	: 25%	4.949
Long Term Loan:	75%	14.845
- Interest 12.0%		
Short Term Loan/Local		Balanced
- Interest 20.0%		
Financing Plan		19.794

Table IV-8-3 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY (2/5)

4. Inputs and Pricing (CIF at the Plant on Commercial Production Date)

Inputs	Unit		Per Product Mix		Annual	
	Unit	Cost	Consumption	Cost	Consumption	Cost
		$/Unit	Unit	$	Unit	$, MM
Raw Material						
- Phosphate Concentrate, Dry	Ton	130.00	0.615	79.958	35,181	4.574
- Sulfuric Acid, 100% H_2SO_4	Ton	128.64	0.347	44.646	19,850	2.554
- Calcium Hydroxide	Ton	32.00	0.010	0.315	572	0.018
- Chemicals/Catalysts/ Consumables	$	-	-	0.105	-	0.006
	-	-	-	(125.024)	-	(7.152)
Utility and Transport						
- Raw Water	Ton	0.00	5.500	0.000	314,628	0.000
- Fuel Oil	Ton	185.61	0.010	1.853	572	0.106
- Electricity	kWh	0.0122	45.000	0.549	2.575MM	0.0314
	-	-	-	(2.402)	-	(0.1374)
Personnel	Man·Year	1,474	-	1.923	74	0.110
Overhead	Man·Year x 30%		-	0.559	-	0.032
Maintenance	Plant Cost x 2.00%		-	5.209	-	0.298
Insurance/ Local Tax	Plant Cost x 0.50%		-	1.294	-	0.074
Sales Expense/ Administration	Annual Sales x 1.50%		-	2.552	-	0.146
	-	-	-	(11.537)	-	(0.660)
Total/Average	-	-	-	156.339	-	8.9434

5. Outputs and Pricing (FOB at the Plant on Commercial Production Date)

Outputs	Unit		Per Product Mix		Annual	
	Unit	Price	Production	Price	Production	Sales
		$/Unit	Unit	$	Unit	$, MM
Product Mix						
- Single Super Phosphate, Bulk	Ton	150.00	1.000	150.00	57,205	8.581
- Calcium Fluoride, Bulk	Ton	0.00	(0.012)	(0.00)	(687)	(0.000)
Total/Average	-	150.00	1.000	150.00	57,205	8.581

Table IV-8-3 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY (3/5)

6. Operation Schedule

	Year								(Unit: %)
	(-)2	(-)1	1	2	3	4	5	... 16	
	89	90	91	92	93	94	95	2006	Average
- Financing Disbursement	15	70	15						
- Production									
- Capacity Utilization			35	80	90	100	100	50	1,460
- Inventory Increase			5	5	0	0	0	(-)10	0
- Inventory			5	10	10	10	10	0	0
- Sales			30	75	90	100	100	60	1,460

- Depreciation/Salvage Value: 15 years straight line/Zero salvage value

- Debt Service

Loan Type	Maximum Grace plus Maturity Year	Annual Interest Rate %
- Development/Foreign		
- Base Case (Relending)	2.5 + 15.0	12.0
- Low Interest Rate Case	7.5 + 20.0	4.0
- Development/Local	0 + 1	20.0

- Corporate Income Tax, %/Tax Holiday, Year: 35.0/5.0
- Minimum Cash Reserve: $0.10 MM
- Escalation/Deflator Rate, %/Year: 0.0/0.0

7. Financial Analysis by Discounted Cash Flow Method

	Constant Price	
	Before Tax %	After Tax %
- Return on Investment, FIRROI-DCF		
- Base Case	(-)3.52	(-)3.52
- Sensitivity Analysis		
- Product Price (+20%)	9.92	9.33
- Raw Material Cost (-20%)	8.32	8.30
- Investment Cost (-20%)	(-)0.91	(-)0.91
- Utility and Transport Cost (-20%)	(-)3.22	(-)3.22

- Cash Flow

Year	Debt Service Ratio	Short Term Loan, $, MM
1991	0.18	0.00
1993	0.09	1.65
1995	(-)0.26	6.57
1997	(-)0.89	12.97
1999	(-)1.91	21.63
Project Life Averate	(-)2.18	73.56-2005

Table IV-8-3 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY (4/5)

8. Sensitivity Analysis

Sensitivity Analysis		FIRROI-DCF, Constant Price Before Tax	After Tax
- Base Case		(-)3.52%	(-)3.52%
- Product Price	(+)40%	19.20	17.46
	(+)20	9.92	9.33
	(±)0	(-)3.52	(-)3.52
	(-)20	-	-
	(-)40	-	-
- Raw Material Cost	(+)40%	-	-
	(+)20	-	-
	(±)0	(-)3.52	(-)3.52
	(-)20	8.32	8.30
	(-)40	16.79	15.29
- Investment Cost	(+)40%	(-)7.23	(-)7.23
	(+)20	(-)5.56	(-)5.56
	(±)0	(-)3.52	(-)3.52
	(-)20	(-)0.91	(-)0.91
	(-)40	2.66	2.66
- Utility and Transport Cost	(+)40%	(-)4.13	(-)4.13
	(+)20	(-)3.82	(-)3.82
	(±)0	(-)3.52	(-)3.52
	(-)20	(-)3.22	(-)3.22
	(-)40	(-)2.93	(-)2.93

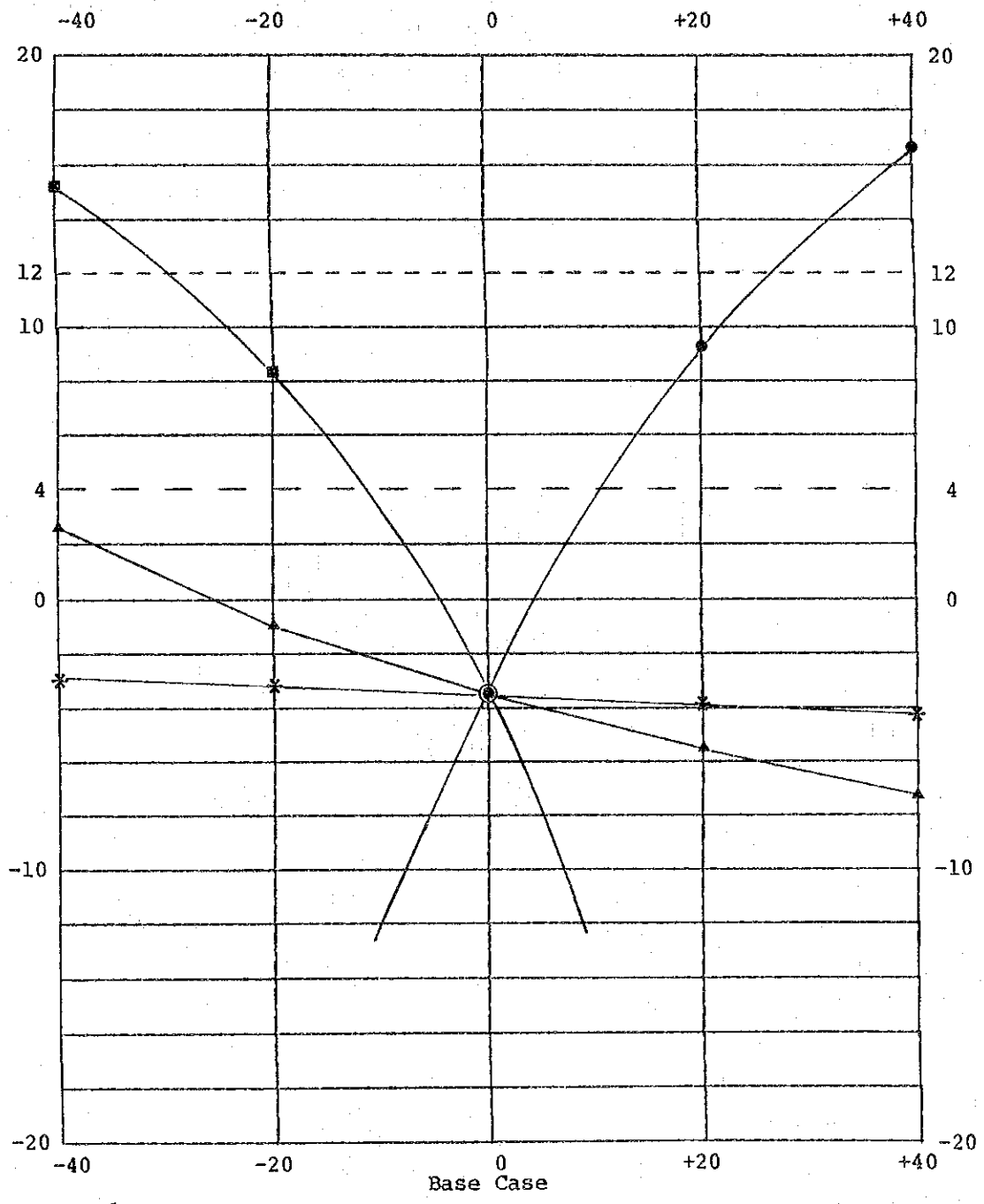
Notes:

- Long Term Loan/Equity, % = 75/25
- Interest Rate; Long/Short Term Loan, % = 12.0/20.0
- Annual Escalation/Deflator Rate, % = 0.0/0.0
- Corporate Income Tax Rate, % = 35.0

Table IV-8-3 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY (5/5)

9. Sensitivity Analysis Figure

Return on Investment
- FIRROI/After Tax/Constant Price/DCF, %/Year



Legend:

● - Product Price
■ - Raw Material Cost
▲ - Investment Cost
✻ - Utility and Transport Cost
○ - ROI, Before Tax for Base Case
– – – – Long Term Loan Interest Rate (Base Case: 12%/Year)
—— —— Long Term Loan Interest Rate (Low Interest Rate Case: 4%/Year)

Variant from Base Case, %

Table IV-8-4 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY (1/5)

1. Project

Title	:	Phosphate Mining and Concentrate Project and Fused Magnesium Phosphate Project
Location	:	Chilembwe and Kafue, Zambia
Executing Agency	:	State Owned Corporation
Project Case	:	Base
Product	:	Fused Magnesium Phosphate, Bags
Maximum Operable Days	:	300 DPY
Rated Capacity (100%)	:	168.0 TPD x 300 DPY = 50,400 TPY
Production Start Year	:	July 01, 1991
Monetary Unit	:	US$ in terms of current price at the commercial production start date

2. Schedule

Pricing Estimate	:	January 01, 1987
Project Approval	:	July 01, 1988
Contract Award	:	July 01, 1989
Mechanical Completion	:	March 31, 1991
Commercial Production	:	July 01, 1991
Project Phase Out	:	June 30, 2006
Project Life	:	15 Years (Effective Production for 14.6 Years)
Construction and Commissioning	:	2 Years

3. Financing Required and Financing Plan on Commercial Production Date

Financing Required	$, MM	Financing Plan	$, MM
Land/Site Preparation	0.325	Equity : 25%	9.021
Erected Plant Cost	29.438	Long Term Loan: 75%	27.063
Pre-Operational Expense	0.659	- Interest 12.0%	
Interest during Construction	3.008	Short Term Loan/Local	Balanced
		- Interest 20.0%	
Fixed Capital Cost	33.430		
Initial Working Capital	2.654	Financing Plan	36.084
Financing Required	36.084		

Table IV-8-4 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY (2/5)

4. Inputs and Pricing (CIF at the Plant on Commercial Production Date)

Inputs	Unit		Per Product Mix		Annual	
	Unit	Cost	Consumption	Cost	Consumption	Cost
		$/Unit	Unit	$	Unit	$, MM
Raw Material						
- Raw Ore, Dry	Ton	0.00	2.063	0.000	104,000	0.000
- Serpentine, Dry	Ton	46.23	0.379	17.520	19,103	0.883
- Calcium Hydroxide	Ton	32.00	0.010	0.317	504	0.016
- Electrode	Ton	3,998.00	0.005	19.980	252	1.007
- Chemicals/Catalysts/ Consumables	$	-	-	15.000	-	0.756
- Packaging	Bags	0.86	20.20	17.381	1.018MM	0.876
	-	-	-	(70.198)	-	(3.538)
Utility and Transport						
- Transport	$	73.480	0.698	51.310	35,181	2.586
- Raw Water	Ton	0.000	12.440	0.000	0.627MM	0.000
- Fuel/Diesel Oil	kl/Ton	231.420	0.033	7.508	1,655	0.328
- Electricity	kWh	0.01266	975.952	12.355	49.188MM	0.623
	-	-	-	(70.179)	-	(3.537)
Personnel	Man·Year	1,575	-	6.269	200	0.315
Overhead	Man·Year x 30%		-	1.885	-	0.095
Maintenance	Plant Cost x 2.00%		-	11.706	-	0.590
Insurance/ Local Tax	Plant Cost x 0.50%		-	2.936	-	0.148
Sales Expense/ Administration	Annual Sales x 2.22%		-	4.841	-	0.213
	-	-	-	(27.004)	-	(1.361)
Total/Average	-	-	-	167.381	-	8.436

5. Outputs and Pricing (FOB at the Plant on Commercial Production Date)

Outputs	Unit		Per Product Mix		Annual	
	Unit	Price	Production	Price	Production	Sales
Product Mix		$/Unit	Unit	$	Unit	$, MM
- Fused Magnesium Phosphate, Bags	Ton	180.00	1.000	180.00	50,400	9.072
- Calcium Fluoride	Ton	0.00	(0.015)	0.00	(756)	(0.000)
Total/Average	-	180.00	1.000	180.00	50,400	9.072

Table IV-8-4 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY (3/5)

6. Operation Schedule

	Year								(Unit: %)
	(-)2	(-)1	1	2	3	4	5	... 16	
	89	90	91	92	93	94	95	2006	Average
- Financing Disbursement	15	70	15						
- Production									
- Capacity Utilization			35	80	90	100	100	50	1,460
- Inventory Increase			5	5	0	0	0	(-)10	0
- Inventory			5	10	10	10	10	0	0
- Sales			30	75	90	100	100	60	1,460

- Depreciation/Salvage Value: 15 years straight line/Zero salvage value

- Debt Service

Loan Type	Maximum Grace plus Maturity Year	Annual Interest Rate %
- Development/Foreign		
- Base Case (Relending)	2.5 + 15.0	12.0
- Low Interest Rate Case	7.5 + 20.0	4.0
- Development/Local	0 + 1	20.0

- Corporate Income Tax, %/Tax Holiday, Year: 35.0/5.0
- Minimum Cash Reserve: $0.10 MM
- Escalation/Deflator Rate, %/Year: 0.0/0.0

7. Financial Analysis by Discounted Cash Flow Method

	Constant Price	
	Before Tax %	After Tax %
- Return on Investment, FIRROI-DCF		
- Base Case	(-)8.00	(-)8.00
- Sensitivity Analysis		
- Product Price (+20%)	2.00	2.00
- Raw Material Cost (-20%)	(-)3.36	(-)3.36
- Investment Cost (-20%)	(-)5.58	(-)5.58
- Utility and Transport Cost (-20%)	(-)3.30	(-)3.30

- Cash Flow

Year	Debt Service Ratio	Short Term Loan, $, MM
1991	0.10	0.00
1993	(-)0.12	5.16
1995	(-)0.59	16.28
1997	(-)1.42	31.08
1999	(-)2.78	51.39
Project Life Averate	(-)3.12	175.45-2005

Table IV-8-4 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY (4/5)

8. Sensitivity Analysis

Sensitivity Analysis		FIRROI-DCF, Constant Price Before Tax	After Tax
- Base Case		(-) 8.00%	(-) 8.00%
- Product Price	(+)40%	8.80	8.72
	(+)20	2.00	2.00
	(±)0	(-) 8.00	(-) 8.00
	(-)20	-	-
	(-)40	-	-
- Raw Material Cost	(+)40%	-	-
	(+)20	(-)14.51	(-)14.51
	(±)0	(-) 8.00	(-) 8.00
	(-)20	(-) 3.36	(-) 3.36
	(-)40	0.36	0.36
- Investment Cost	(+)40%	(-)11.45	(-)11.45
	(+)20	(-) 9.90	(-) 9.90
	(±)0	(-) 8.00	(-) 8.00
	(-)20	(-) 5.58	(-) 5.58
	(-)40	(-) 2.29	(-) 2.29
- Utility and Transport Cost	(+)40%	-	-
	(+)20	(-)14.62	(-)14.62
	(±)0	(-) 8.00	(-) 8.00
	(-)20	(-) 3.30	(-) 3.30
	(-)40	0.45	0.45

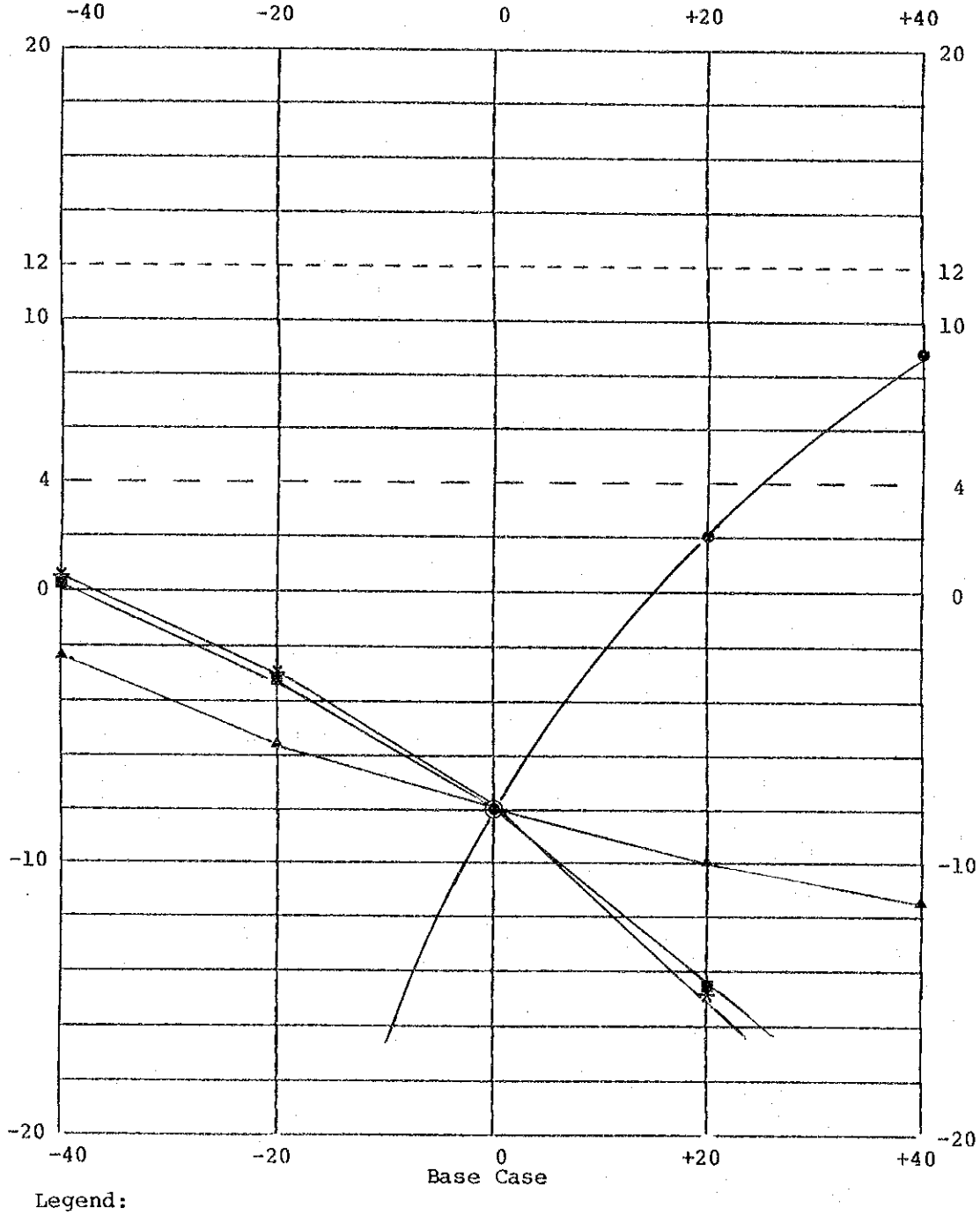
Notes:

- Long Term Loan/Equity, % = 75/25
- Interest Rate; Long/Short Term Loan, % = 12.0/20.0
- Annual Escalation/Deflator Rate, % = 0.0/0.0
- Corporate Income Tax Rate, % = 35.0

Table IV-8-4 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY (5/5)

9. Sensitivity Analysis Figure

Return on Investment
- FIRROI/After Tax/Constant Price/DCF, %/Year



Legend:

- ● - Product Price
- ■ - Raw Material Cost
- ▲ - Investment Cost
- ✻ - Utility and Transport Cost
- ○ - ROI, Before Tax for Base Case
- – – – - Long Term Loan Interest Rate (Base Case: 12%/Year)
- —— —— - Long Term Loan Interest Rate (Low Interest Rate Case: 4%/Year)

Variant from Base Case, %

Table IV-8-5 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY (1/5)

1. Project

Title	:	Phosphate Mining and Concentrate Project and Single Super Phosphate Project
Location	:	Chilembwe and Kafue, Zambia
Executing Agency	:	State Owned Corporation
Project Case	:	Base
Product	:	Single Super Phosphate, Bulk
Maximum Operable Days	:	300 DPY
Rated Capacity (100%)	:	190.68 TPD x 300 DPY = 57,205 TPY
Production Start Year	:	July 01, 1991
Monetary Unit	:	US$ in terms of current price at the commercial production start date

2. Schedule

Pricing Estimate	:	January 01, 1987
Project Approval	:	July 01, 1988
Contract Award	:	July 01, 1989
Mechanical Completion	:	March 31, 1991
Commercial Production	:	July 01, 1991
Project Phase Out	:	June 30, 2006
Project Life	:	15 Years (Effective Production for 14.6 Years)
Construction and Commissioning	:	2 Years

3. Financing Required and Financing Plan on Commercial Production Date

Financing Required	$, MM	Financing Plan	$, MM
Land/Site Preparation	0.287	Equity : 25%	8.590
Erected Plant Cost	26.971	Long Term Loan: 75%	25.768
Pre-Operational Expense	0.942	- Interest 12.0%	
Interest during Construction	2.788	Short Term Loan/Local	Balanced
		- Interest 20.0%	
Fixed Capital Cost	30.988		
Initial Working Capital	3.370	Financing Plan	34.358
Financing Required	34.358		

Table IV-8-5 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY (2/5)

4. Inputs and Pricing (CIF at the Plant on Commercial Production Date)

Inputs	Unit		Per Product Mix		Annual	
	Unit	Cost	Consumption	Cost	Consumption	Cost
		$/Unit	Unit	$	Unit	$, MM
Raw Material						
- Raw Ore	Ton	0.00	1.818	0.000	104,000	0.000
- Sulfuric Acid	Ton	128.64	0.347	44.646	19,850	2.554
- Calcium Hydroxide	Ton	31.83	0.010	0.315	572	0.018
- Chemicals/Catalysts/ Consumables	$	-	-	13.233	-	0.757
	-	-	-	(58.194)	-	(3.329)
Utility and Transport						
- Transport	$	73.50	0.615	45.206	35,181	2.586
- Raw Water	Ton	0.00	10.955	0.000	626,703	0.000
- Fuel/Diesel Oil	kl/Ton	210.78	0.0143	3.007	816	0.172
- Electricity	kWh	0.0160	103.015	1.645	5.893MM	0.0941
	-	-	-	(49.856)	-	(2.852)
Personnel	Man·Year	1,597	-	5.332	191	0.305
Overhead	Man·Year x 30%		-	1.608	-	0.092
Maintenance	Plant Cost x 2.00%		-	9.457	-	0.541
Insurance/ Local Tax	Plant Cost x 0.50%		-	2.360	-	0.135
Sales Expense/ Administration	Annual Sales x 2.21%		-	3.758	-	0.215
	-	-	-	(22.516)	-	(1.288)
Total/Average	-	-	-	147.942	-	8.463

5. Outputs and Pricing (FOB at the Plant on Commercial Production Date)

Outputs	Unit		Per Product Mix		Annual	
	Unit	Price	Production	Price	Production	Sales
		$/Unit	Unit	$	Unit	$, MM
Product Mix						
- Single Super Phosphate, Bulk	Ton	150.00	1.000	150.00	57,205	8.581
- Calcium Fluoride, Bulk	Ton	0.00	(0.012)	(0.00)	(687)	(0.000)
Total/Average	-	150.00	1.000	150.00	57,205	8.581

Table IV-8-5 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY (3/5)

6. Operation Schedule

	Year								(Unit: %)
	(-)2	(-)1	1	2	3	4	5	... 16	
	89	90	91	92	93	94	95	2006	Average
- Financing Disbursement	15	70	15						
- Production									
- Capacity Utilization			35	80	90	100	100	50	1,460
- Inventory Increase			5	5	0	0	0	(-)10	0
- Inventory			5	10	10	10	10	0	0
- Sales			30	75	90	100	100	60	1,460

- Depreciation/Salvage Value: 15 years straight line/Zero salvage value
- Debt Service

Loan Type	Maximum Grace plus Maturity Year	Annual Interest Rate %
- Development/Foreign		
- Base Case (Relending)	2.5 + 15.0	12.0
- Low Interest Rate Case	7.5 + 20.0	4.0
- Development/Local	0 + 1	20.0

- Corporate Income Tax, %/Tax Holiday, Year: 35.0/5.0
- Minimum Cash Reserve: $0.10 MM
- Escalation/Deflator Rate, %/Year: 0.0/0.0

7. Financial Analysis by Discounted Cash Flow Method

	Constant Price	
	Before Tax %	After Tax %
- Return on Investment, FIRROI-DCF		
- Base Case	(-)3.84	(-)3.84
- Sensitivity Analysis		
- Product Price (+20%)	4.76	4.76
- Raw Material Cost (-20%)	0.01	0.01
- Investment Cost (-20%)	(-)1.14	(-)1.14
- Utility and Transport Cost (-20%)	(-)0.50	(-)0.50

- Cash Flow

Year	Debt Service Ratio	Short Term Loan, $, MM
1991	0.17	0.00
1993	0.06	3.41
1995	(-)0.29	12.16
1997	(-)0.94	23.54
1999	(-)1.99	38.99
Project Life Averate	(-)2.27	131.80-2005

Table IV-8-5 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY (4/5)

8. Sensitivity Analysis

Sensitivity Analysis		FIRROI-DCF, Constant Price Before Tax	After Tax
- Base Case		(-) 3.84%	(-) 3.84%
- Product Price	(+)40%	11.10	10.27
	(+)20	4.76	4.76
	(±)0	(-) 3.84	(-) 3.84
	(-)20	(-)22.00	(-)22.00
	(-)40	-	-
- Raw Material Cost	(+)40%	(-)15.72	(-)15.72
	(+)20	(-) 8.70	(-) 8.70
	(±)0	(-) 3.84	(-) 3.84
	(-)20	0.01	0.01
	(-)40	3.26	3.26
- Investment Cost	(+)40%	(-) 7.64	(-) 7.64
	(+)20	(-) 5.93	(-) 5.93
	(±)0	(-) 3.84	(-) 3.84
	(-)20	(-) 1.14	(-) 1.14
	(-)40	2.58	2.58
- Utility and Transport Cost	(+)40%	(-)13.36	(-)13.36
	(+)20	(-) 7.91	(-) 7.91
	(±)0	(-) 3.84	(-) 3.84
	(-)20	(-) 0.50	(-) 0.50
	(-)40	2.38	2.38

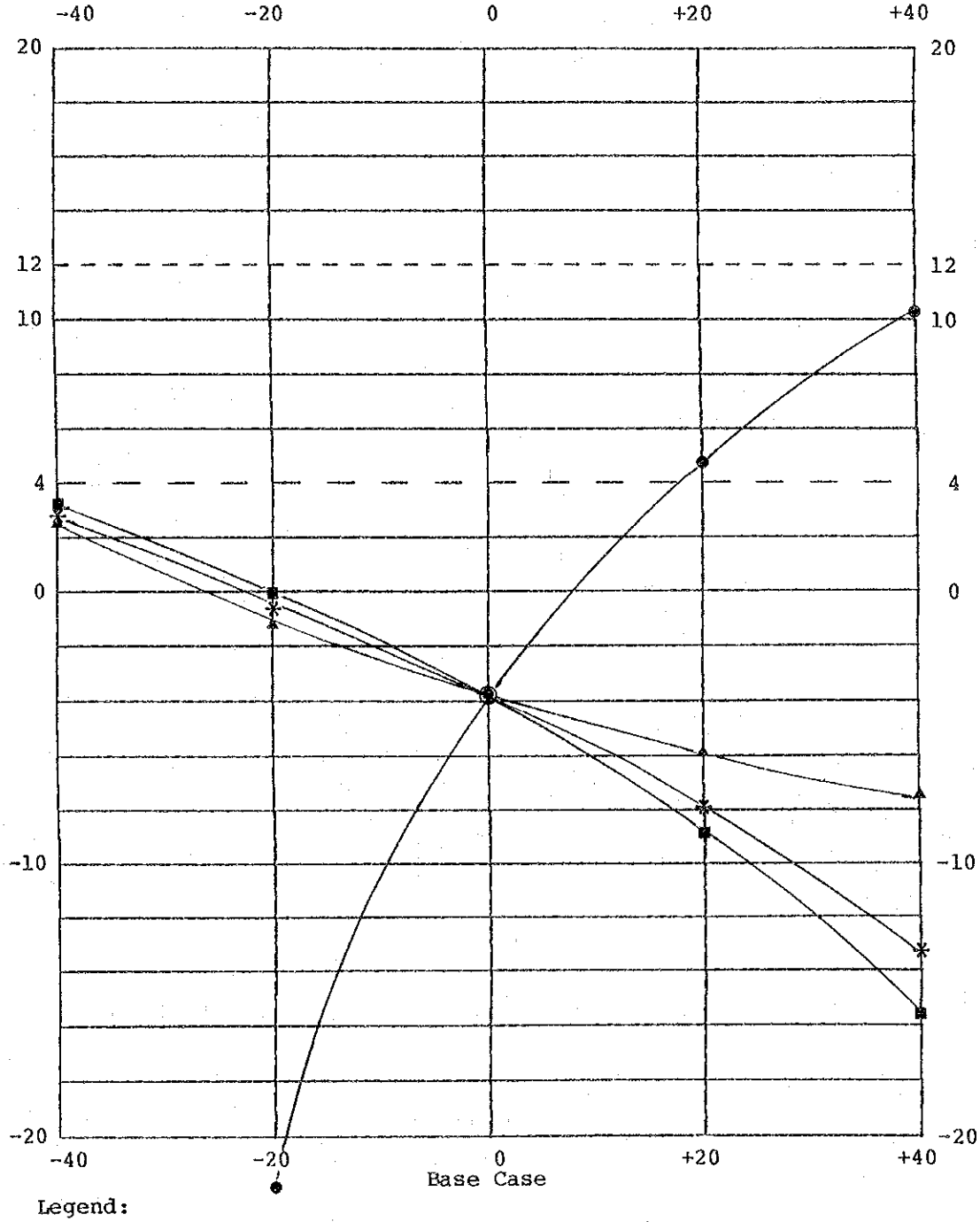
Notes:

- Long Term Loan/Equity, % = 75/25
- Interest Rate; Long/Short Term Loan, % = 12.0/20.0
- Annual Escalation/Deflator Rate, % = 0.0/0.0
- Corporate Income Tax Rate, % = 35.0

Table IV-8-5 PROJECT PROFILE AND FINANCIAL ANALYSIS SUMMARY (5/5)

9. Sensitivity Analysis Figure

Return on Investment
- FIRROI/After Tax/Constant Price/DCF, %/Year



Legend:

● - Product Price
■ - Raw Material Cost
▲ - Investment Cost
✱ - Utility and Transport Cost
○ - ROI, Before Tax for Base Case
– – – – Long Term Loan Interest Rate (Base Case: 12%/Year)
— — — — Long Term Loan Interest Rate (Low Interest Rate Case: 4%/Year)

Variant from Base Case, %

Table IV-9 CONVERSION FACTORS FOR ECONOMIC ANALYSIS OF PROJECT IN ZAMBIA

1. Tradeable Items : International prices to prevail during the economic life of the project (15 years) with no salvage value at the end.

2. Non-Tradeable Items :

	Conversion Factor			
	Fertilizer Industry Restructuring Project, The World Bank Feb 4, 1986	Economic Evaluation Unit, INDECO, 1986	This Study JICA, 1987	
Standard Conversion Factor	0.96	-	-	
Exchange Rate	-	0.80	1.00	
Land	-	1.00	1.00	
Site Preparation	-	0.81	1.00	
			Foreign	Local
Equipment and Materials	-	0.91	0.95	0.80
Field Expenses	-	0.80	0.95	0.80
Engineering Services	-	0.80	0.95	0.80
Imported Material/Services	-	0.80	0.95	-
Transport	0.76	-	-	0.76
Raw Materials	0.86	-	1.00	0.80
Intermediate Goods	0.95	-	1.00	0.80
Electricity	0.97*	0.85	-	0.87**
Fuel	-	0.85	-	1.00
Raw Water	-	0.90	-	0.80
Labor				
- Skilled	0.85	0.96	-	0.85
- Semiskilled	0.67	0.67	-	-
- Unskilled	0.54	0.52	-	0.54
3. Cut-Off Rate, %				
- Financial Analysis	12.00	12.00	12.00	
- Economic Analysis	12.00	18.00	12.00	
4. Exchange Rate, ZK/US$	2.1-1984	-	8.00-1987	
	3.1-1985	-	-	
	6.0-1986+	-	8.00-1991	
5. Inflation Rate, %/Year***	7.2-1986	-	-	
	6.8-1987	-	3.00-1987	
	6.8-1988	-	-	
	7.0-1989	-	-	
	7.1-1990	-	-	
	4.0-1991+	-	3.00-1991	

* Up to year 1996, the economic cost of electricity is opportunity cost of exporting to Zimbabwe as surplus, and after 1996 it is taken 30% higher than the financial cost.

** Tariff without sales tax is applied in due consideration of long run marginal cost and export price of electricity.

*** Assuming the difference between domestic and international inflation rates will be reflected in the foreign exchange rate.

PART V
CONCLUSION AND RECOMMENDATIONS

Part V CONCLUSION AND RECOMMENDATIONS

Chapter 1 CONCLUSION AND RECOMMENDATIONS

1.1 Conclusion

The Feasibility Study on the Establishment of a Fused Magnesium Phosphate Fertilizer Plant in the Republic of Zambia concludes that the proposed projects are technically feasible to recover phosphate concentrate (35,181 TPY, P_2O_5: 30.00%, CaO: 41.11%) in Chilembwe and to produce fused magnesium phosphate [50,400 TPY, (0-20.11-0), P_2O_5 in citric acid soluble] or single super phosphate [57,205 TPY, (0-17.20-0), P_2O_5 in ammonium citrate soluble] by using Chilembwe phosphate concentrate as major inputs in Kafue, Zambia.

However, the financial analysis illustrates that the proposed projects are not financially viable in terms of return on investment as well as cash flow during project life assuming the long term loan interest rates of 4.0 and 12.0%/year, respectively. The return on investments are negative in figure for the proposed projects, and far lower than the pre-determined cut-off rate of project evaluation criteria observed in Zambia at present.

Economic returns on investment are also negative. The net foreign exchange savings as import substition of phosphate fertilizer are fairly large positive value for the single super phosphate project while marginal for the fused magnesium phosphate project. However it is anticipated that the savings for the fused magnesium phosphate project might be improved if the higher effectiveness of fused magnesium phosphate fertilizer is confirmed at the agronomical testings in Zambia.

The major reasons behind the conclusion are summarized as follows:

- The phosphate reserves in Chilembwe are of small scale and one can not expect the economy of scale for mining and concentration cost saving

- The origin of phosphate reserves in Chilembwe is igneous and low in P_2O_5 analysis, and intensive beneficiation and concentration processes are required to produce phosphate concentrate

- The location of phosphate reserves in Chilembwe is sited in a remote area where transport infrastructure, especially the railways system is not developed and the transport cost by road to the phosphate fertilizer plant in Kafue is excessive

- In addition to the above reasons, due to the depressed international market of phosphate concentrate at present, the domestic cost of phosphate concentrate from Chilembwe is higher than the landed cost of imported phosphate concentrate from overseas where a large scale and high quality reserves are mined at large scale operation

- The production costs of fused magnesium phosphate and single super phosphate are higher than the import substitute price of phosphate fertilizers, because of the small scale production, high costs of phosphate concentrate from Chilembwe as well as high costs of supplementary inputs such as serpentine and sulfuric acid in Zambia, and because of the depressed international market of high concentrated phosphate fertilizers such as triple super phosphate and diammonium phosphate throughout the world at present and in near future

- It should be noted that the project feasibility will not be positive in return on investment even using imported phosphate concentrate as raw material instead of domestic material from Chilembwe

- The sulfur content in single super phosphate is evaluated in product pricing as a fertilizer nutrient for sulfur deficit soil in Zambia, however effectiveness of soluble magnesia, silica and alkali in fused magnesium phosphate is not counted in product pricing because no verifiable experimental data has been developed in Zambia, so far. Therefore, the return on investment for the fused magnesium phosphate project is a little lower

- Among various product alternatives, the feasibility will be higher for the production of nitric phosphate intermediate if the modification of compound fertilizer plant at NCZ in Kafue is technically and financially possible

The proposed and studied projects are technically feasible but financially not viable and economically not justifiable as an immediate industrial and commercial project for import substitution of phosphate fertilizers in Zambia

1.2 Recommendations

Because of the low financial and economic return on investment for the proposed projects mostly due to the depressed international market of phosphate concentrate as well as phosphate fertilizers at present and near future, the following recommendations are made:

- To wait, for the time being, the project promotion and preparation activities as an immediate industrial and commercial project in Zambia

- To continue survey and study work for the improvement of the project's potential: the discovery of larger and higher quality reserves of phosphate minerals in Zambia and the study on the production of nitric phosphate at NCZ in Kafue

- To promote the agronomical research programs in Zambia for the verification of effectiveness of not only water soluble phosphate as is stipulated in the Agriculture Act of Zambia but also citrate and citric acid soluble phosphate, soluble magnesia, silica and alkali in fertilizer to utilize various kinds of phosphate fertilizer for the diversifying and intensifying agriculture in Zambia

- To promote the efficient procurement and distribution system of fertilizer in Zambia for the agricultural development of Zambia