No. 3

FEASIBILITY STUDY REPORT

FOR

THE ESTABLISHMENT OF A PHOSPHATE FERTILIZER PLANT

IN

THE ARGENTINE REPUBLIC

(SUMMARY)

AUGUST 1984

JAPAN INTERNATIONAL COOPERATION AGENCY

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JAPAN INTERNATIONAL COOPERATION AGENCY

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GENERAL MAP OF ARGENTINE AND SITE FOR PROPOSED PROJECT

ABBREVIATIONS AND CONVERSION FACTORS

for The Feasibility Study on the Establishment of a Phosphate Fertilizer Plant in the Argentine Republic

General

BPC	Base Project Cost which is estimated as of June 1, 1983
C & F	Cost & Freight
CIF	Cost, Insurance and Freight
ERR	Economic Internal Rate of Return
ENPV	Economic Net Present Value
FRR	Financial International Rate of Return
FNPV	Financial Net Present Value
Fiscal Year	From January 1 to December 31 in Argentine
FOB	Free on Board
GDP	Gross Domestic Product
GNP	Gross National Product
IDC	Interest during Construction
IWC	Initial Working Capital
IRR	Internal Rate of Return
NPV	Net Present Value
NA	Not Available
$a	Pesos Argentinos, Currency Unit in Argentine
ROI	Return on Investment
ROE	Return on Equity
S/W	Scope of Work
TCR	Total Capital Required at Commencement Date for Commercial Production
USD	U.S Dollar
Exchange Rate (Effective June 1, 1983)	USD1.00 = $a 8.86 (Mercado Oficial), USD1.00 = $a 11.30 (Mercado Libre) $a 1.00 = USD 0.1129 (Mercado Oficial), $a 1.00 = USD 0.0885 (Mercado Libre) Denomination of Pesos (Ley 18,188) $10,000 to Pesos Argentinos $a 1.00 has been effected on June 1, 1983

Organization

AAN	Armada Argentina Servicio de Hidrografia Naval
AAT	Armada Argentina Servicio de Transportes Navales
ACINDAR	Acindar SA
AGTF	Administración general de transporte fluvial
JICA	Agencia de Cooperación Internacional del Japón
AyE	Agua y Energía Eléctrica
AGROMAX	Agromax SAIC
ALECY	Alecy SA
BNA	Banco de la Nación Argentina
BGA	Banco Ganadero Argentino
BND	Banco Nacional de Deserrollo Caprolactama SA
CAC	Camara Argentina de la Construccion
CIS	Centro de la Industria Siderurgica
CNT	Centro de Navegación Transatlantica
CTI	Consejo Técnico de Inversiones SA
CIADE	Compaia Italo-Argentina de Electricidad
CF Río Chubut	Corporación de Formento del Rsio Chubut
CF Río Colorada	Corporación de Formento del Río Colorada
CORCEMAR	Corporación Cementera Argentina
DALMINE	Dálmine Siderca SA
DGCEE	Dirección General de Centrales Electricas del Estado
DGFM	Dirección General de Fabricaciones Militares
DNEM	Dirección Nacional de Economic Minera
DNFCA	Dirección Nacional de Fiscalizacion y Comercializatisón Agrícola
DNRO	Direccion Nacional del Registro Oficial de la Secretaria de Informacion Publica de la Presidencia de la Nacion
DOW	Dow Química Argentine
DUPERIAL	Duperial SAIC
EFEA	Empresa de Ferrocarriles Nacionales
EFFDEA	Empresa Flota Fluvial del Estado Argentino
ELMA	Empresa Lineas Maritimas Argentinas
EPEC	Empresa Provincial de Energía de Córdoba
FERTILIZAR	Fertilizar SA
FANF	Flota Argentina de Navegación
GAS DEL ESTADO	Gas del Estado
GURMENDI	Gurmendi SA
HINODE	Hinode Kagaku Kogyo KK, Japan
HIPASAM	Hierro Petagónico de Sierra Grande Sociedad Anónima Minera
IDS	Ingenieria del Suelo SRL
IPAKO	Industrias Petroquímicas Argentinas
IMPAGRO	Industras Petroquímica Palalelagro
INDQUICAS	Industrial Químicas SAIC

IRAM	Instituto Argentino de Racionalización de Materiales
IDEVI	Instituto de Dessarrollo del Valle Interior del Rio Negro
INDEC	Instituto Nacional de Estadistica y Censos
INTA	Instituto Nacional de Tecnologia Agropecuaria
INTI	Instituto Nacional de Tecnologia Industrial
ICC	International Chamber of Commerce
INVAP	INVAP SE
NIKKO	Nippon Mining Co., Ltd., Japan
NISSAN	Nissan Chemical Industries Ltd., Japan
NORSK HYDRO	Norsk Hydro sa, Norway
PASA	Petro Quimica Argentina SA
PETROSUR	Petrosur SA
PQBB	Petroquímica Bahía Blanca SAIC
MOSCONI	Petroquimica General Mosconi SAIC
HOECHST	Quimica Hoechst SA
SDM	Subsecretaria de Mineria
SEAGN	Secretaria de Estado de Agricultura y Ganadersia de la Nacison
SEDI	Secretaria de Estado de Desarrollo Industrial
SEGBA	Servicios Eléctricos del Gran Buenos Aires
STN	Servicios de Transportes Navales
SIDERSUR	Siderurgica del Sur SA
SOMISA	Sociedad Mixta Siderurgia Argentina
SUDAMFOS	Sudamfos SA
SULFACID	Sulfacid SA
YCF	Yacimientos Carboniferos Fiscales
YPF	Yacimientos Petroliferos Fiscales
ZARATE	Zárate Sulfurico

Units

Acre, A	1.0 Acre = 4,047 m^2
BBL	Barrel, 1.0 BBL = 42.0 US Gallon
	= 34.97 Imperial Gallons
BSCF, BCF	Billion SCF
BSCFD	Billion SCF per Day
BTU	British Thermal Unit,
	1.0 BTU = 0.252 kcal
Bushel	1.0 Bushel = 34.25 Liters
DWT	Dead Weight Ton
EL	Elevation Level
Fanga	Unit of Volume in Argentine
	1.0 Fanga = 1.57 US Bushels
	= 1.52 Imperial Bushels
	= 55.4 Liter
ha	Hectare, 1.0 ha = 10,000 m^2
	= 2,471 Acres (A)
HHV	High Heating Value
Gallon	1.0 US Gallon = 0.003785 m^3
kVA	Kilovolt-Ampere
kW	Kilowatt
kWh	Kilowatt-Hour = 3.413 BTU
LHV	Low Heating Value
MW	Megawatt, Million Watt
MMBTU	Million BTU
MMSCF	Million SCF
MMSCFD	Million SCF per Day
MSCF	Thousand SCF
MSL	Mean Sea Level
Nm^3	Normal Cubic Meter measured at 0°C and 1.0 ata
psi	Pound per Square Inch
	1.0 psi = 0.07031 kg/cm^2
Quintal	1.0 Quintal = 100 kg
SCF, CF	Standard Cubic Feet measured at 60°F and 14.7 lb/in^2
	1.0 SCF = 0.0283 Nm^3
SCFD, CFD	Standard Cubic Feet per Day
STB	Standard Tankage Barrel
	1.0 STB = 159 Litre (60°F)
TSCF, TCF	Trillion SCF
TPH	Ton per Hour
TPD	Ton per Day
TPY	Ton per Year
Ton, ton	Metric Ton

K, K_2O	1.0% K	= 1.2046% K_2O
	1.0% K_2O	= 0.8302% K
P, P_2O_5, BPL	1.0% P	= 2.2914% P_2O_5,
		= 5.0073% BPL
	1.0% P_2O_5,	= 0.4364% P
		= 2.1853% BPL
	1.0% BPL	= 0.1997% P
		= 0.4576% P_2O_5,
Fe, FeO, Fe_3O_4, Fe_2O_3	1.0% Fe	= 1.2865% FeO
		= 1.3820% Fe_3O_4
		= 1.4297% Fe_2O_3

Fertilizer

Apatite	Major Calcium Phosphate Mineral of $Ca_{10}(PO_4, CO_3, OH)_{18}(OH,F,Cl)_2$ in General Formula
AN	Ammonium Nitrate Fertilizer
AP	Ammonium Phosphates (MAP and/or DAP) Fertilizer
AS	Ammonium Sulfate Fertilizer
BPL	Bone Phosphate of Lime in Terms of $Ca_3(PO_4)_2$, BPL/ P_2O_5 = 2.1853
CAN	Calcium Ammonium Nitrate Fertilizer
CN	Calcium Nitrate Fertilizer
DAP	Diammonium Phosphate Fertilizer
FMP	Fused Magnesium Phosphate Fertilizer
GGPR	Granulated Ground Phosphate Rock Fertilizer
K_2O	Potash Nutrient Expressed in Terms of K_2O 1.0% K_2O = 0.8302% K
N	Nitrogen Nutrient Expressed in Terms of N
NP	Nitrophosphate Fertilizer (Specifically Compound Fertilizer by Nitric Acid Decomposition Process)
NP/NPK	Compound Fertilizer or Complex Fertilizer
MAP	Monoammonium Phosphate Fertilizer
MOP	Muriate of Potash, Potassium Chloride Fertilizer
P_2O_5	Phosphate Nutrient Expressed in Terms of P_2O_5, 1.0% P_2O_5 = 0.4364% P
SOP	Sulfate of Potash, Potassium Sulfate Fertilizer
SSP	Single Superphosphate Fertilizer
TCP	Tri-Calcium Phosphate; $Ca_3(PO_4)_2$
TPL	Tri-Phosphate of Lime; $Ca_3(PO_4)_2$
TSP	Triple Superphosphate Fertilizer
Urea	Urea Fertilizer

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Preface

This report is a summary of the Feasibility Study Report on the Establishment of a Phosphate Fertilizer Plant in the Argentine Republic, performed by the Japan International Cooperation Agency in 1983 to 1984.

The objective of the study is to concentrate phosphate rock from tails of the iron ore concentration plant, HIPASAM, Sierra Grande, Río Negro and then to produce phosphate fertilizer, by utilizing the phosphate rock as major raw material and reacting with other supplementary raw materials, having optimal fertilizer characteristics to the soils and agricultural environments of the Argentine Republic.

A local study in Argentine to investigate the raw material supply conditions, proposed plant locations, agriculture and the terms and conditions for investment was made in May, 1983 as well as the sampling of a 700 kg representative tails of HPASAM, Sierra Grande was made for analysis, testing and study.

The tails were utilized to perform phosphate rock concentration tests, mineralogical studies and preparation of a 15 kg representative phosphate rock sample for the evaluation tests and studies for seven phosphate fertilizer alternatives.

The test results show that phosphate rock with apatite minerals are produced from the tails but because of the specific nature of Sierra Grande ore, the quality and recovery of phosphate rock are both low which would increase the production cost of phosphate rock and that some technical and economic constraints would be encountered in the production of phosphate fertilizers.

The phosphate rock contains high iron as impurity, however the evaluation tests revealed that the production of fused magnesium phosphate, monoammonium phosphate and nitrophosphate among seven alternatives are technically feasible and the product quality are high and acceptable as fertilizer evaluation.

Two integrated project plans for the establishment of phosphate concentration plant and phosphate fertilizer plant to produce monoammonium phosphate or nitrophosphate fertilizer were selected to perform the financial analysis and economic evaluation, but the result was that it was not possible to identify a feasible phosphate fertilizer plant project under the present conditions.

During the course of the study the mineralogical characteristics of the Sierra Grande ore were determined and valuable technical informations were obtained regarding to the production of phosphate fertilizers from the specific phosphate rock. Some suggestions and recommendations for the promotion of the fertilizer projects in the Argentine Republic are also made in the main report, to which attention is invited.

CHAPTER 1. OUTLINE OF THE PROJECT

1-1 Outline of the Project

Among the seven product alternatives, the nitrophosphate production project was selected as the most highly technical viable project, but it was found that the product as well as by-product nitrogen fertilizer would lack marketability in the domestic market and the capacity utilization of the plant would be constrained. The financial analysis and economic evaluation led to be the conclusion that the project is not feasible under present conditions.

In the case when a sufficiently high capacity utilization can be assured, it is judged that financially there is marginal feasibility, and therefore the basic nature of the selected project is outlined under such assumption as follows.

A phosphate rock concentration plant to produce phosphate rock (P_2O_5, 35.65% and Fe, 5.80%; production capacity, 100,000 TPY) which would use as raw material non-magnetic tails (P_2O_5, 7.08% and Fe, 27.53%; Supply of 921,620 TPY in 1990) from the iron ore concentration plant in Sierra Grande, Rio Negro would be built in Sierra Grande. The tails is the only commercially available phosphate resource in the Argentine Republic.

The intermediate product phosphate rock would be transported on road from Sierra Grande to Bahia Blanca (528km) where a nitrophosphate fertilizer plant would be built. The final product of nitrophosphate [fertilizer nutrients, (20.80-20.80-0.0); production capacity, 163,677 TPY] would be accompanied by the co-product nitrogen fertilizer [fertilizer nutrients, (26.00-0.0-0.0); production capacity, 139,709 TPY], both of which would be bagged and sold in the domestic market in Argentine.

1-2 Outline of the Project Facility

	Phosphate Fertilizer Plant Project	
	Phosphate Rock Concentration Plant	Phosphate Fertilizer Plant
- Proposed Plant Site :	Sierra Grande, Rio Negro	Bahia Blanca, Buenos Aires
- Raw Material :	Non-Magnetic Tails of HIPASAM	Phosphate Rock, Natural Gas
- Product :	Phosphate Rock	Nitrophosphate, Calcium Ammonium Nitrate
- Plant Capacity :	336.7 TPD 100,000 TPY	1,021.5 TPD 303,385.5 TPY
- Major Process Plant :	Phosphate Rock Concentration (Grinding, flotation, filtration, drying)	Ammonia, Nitrophosphate
- Major Off-Site Facility :	Product Storage, Utility, Plant Management, Maintenance	Raw Material and Product Storage, Utility, Plant Management, Maintenance
- Plant Site Area :	40,000 m^2	135,000 m^2
- Construction Schedule :		
- Construction Start ;	1987	1987
- Construction Completion ;	1989	1989
- Commercial Production ;	1990	1990
- Plant Cost (Excluding duties), Base Project Cost - 1983 :	USD 33.65 MM	USD 180.63 MM
- Total Financing Required - 1990 :	USD 421.79 MM for the Integrated Plant Project	

1-3 Financial Analysis and Economic Evaluation

- Management Entity : Independent management under HIPASAM leadership

- Personnel :

Executives	6
Head Office	13
Plants	640
Total	659

- Required Capital :

- Foreign Currency Portion	; USD 193.3 MM	(45.8%)
- Local Currency Portion	; 228.5	(54.2%)
	USD 421.8 MM	(100.0%)

- Financing Plan :

- Equity	; USD 126.5 MM	(30.0%)
- Long-Term Loan	; 295.3	(70.0%)
	USD 421.8 MM	(100.0%)

- Internal Rate of Return :

	FIRROI-DCF, %		EIRROI-DCF, %
	Before Tax	After Tax	
- Current Price Basis	15.7	14.0	9.6
- Real Price Basis (Constant Price - 1987)	8.9	7.4	3.2

CHAPTER 2. SUMMARY OF THE STUDY RESULTS

2-1 General Features of Agriculture and the Fertilizer Market

The output of the agricultural sector of the Argentine Republic contributed a 13% of the gross domestic production in 1980, while the share of agricultural product and primary commodities in total exports was 75%. Agriculture thus is a key industry of the national economy.

Although the agricultural productivity is high, the long distance to export markets is disadvantageous in terms of competitiveness of exports and the agricultural production is constrained.

It is characteristic of the country's agriculture that there is coexistance of extensivo and intensivo farmings. Extensivo farming is typified grain production such as wheat and maize as export commodity as is mostly observed in the Pampeana region.

The intensivo farming produces vegetables, fruits and other crops in the Mendoza and other regions. Much of the country's fruit and wine export products are obtained from the intensivo farming.

The use of fertilizer was at first introduced for intensivo farming, where the use of fertilizer has reached a high level at present. For extensivo agriculture, the use of fertilizer was begun in recent years and spread particularly among wheat farmers. Fertilizer demand fluctuates greatly depending on farm product prices, and as shown in Table 1, the demand has grown from the 1965/75 levels of 40,000 TPY-N of nitrogen, 24,000 TPY-P_2O_5 of phosphate and 6,000 TPY-K_2O of potash fertilizer to the recent levels of 50,000 TPY-N, 50,000 TPY-P_2O_5 and 6,000 TPY-K_2O.

In intensivo farming phosphate is applied together with nitrogen fertilizer, while there is strong tendency in extensivo farming that either phosphate or nitrogen is applied as straight fertilizer.

Demand of phosphate fertilizer is estimated to be 50,000 TPY-P_2O_5 at present time, the consumption by region and by crops is shown in Table 2, from which it is evident that the Pampeana region around Bahia Blanca area is the major consuming of phosphate which accounts for 70% of total demand. It is estimated that 30% of demand is the use for wheat, 25% is for pasture crops, 15% is for vegetables and 10% is for fruits.

The future phosphate fertilizer demand is projected and shown in Table 2 which indicates 78,400 in 1990 and 106,700 TPY-P_2O_5 in 1995. Assumption used to make the projection are as follows.

(1) There will be no rapid change in cultivating area for the most crops, except of the increasing trend observed for the soybean area.

(2) In intensivo farming, in the future there will not be a rapid increase in consumption because already consumption level reached a high level.

(3) In extensivo farming, especially regarding wheat, it is excepted that phosphate consumption will increase in the phosphate deficit soil area in the southern part of Buenos Aires near Bahía Blanca, where the fertilized area rises to 40%. The fertilized area in nation wide is 6% in 1982 and is expected to increase to 14% in the future.

(4) In extensivo farming, regarding maize and pasture crops even in the phosphate deficit soil area, there will be not a rapid increase in fertilizer demand unless the price level for these agricultural products rise substantially.

Regarding the relative evaluation among potential phosphate fertilizer product alternatives from Sierra Grande tails, following judgements have been made mostly from soil and agricultural aspects in the country.

(1) In general, phosphate fertilizer with high water soluble phosphate (W-P_2O_5 and Av-P_2O_5) is the most suitable. Marketability of acid soluble phosphate (C-P_2O_5, F-P_2O_5 and T-P_2O_5) is limited to either for the Mesopotamia region in the north where acidic soils are common or for the pasture crops in general.

(2) Compound fertilizer, and nitrogen and phosphate fertilizer mixed are applied in intensivo farming, while nitrogen or phosphate fertilizer is applied as straight fertilizer in extensivo farming.

(3) Among the alternative phosphate fertilizers, water soluble phosphate such as ammonium phosphate and triple super phosphate are the most suitable. Fused magnesium phosphate and granular ground phosphate rock fertilizer are not suitable because of low water solubility.

(4) The production of monoammonium phosphate from Sierra Grande tails would be able to satisfy only a third of domestic demand in 1990, so that it would still be necessary to import ammonium phosphate continuously.

(5) Although nitrophosphate has not be used widely in Argentine to date, it is judged to be possible that a market can be developed, especially in the intensivo farming sectors. However, judging from the fact that in wheat and potato growing area of Pampeana, farmers have applied phosphate fertilizer as straight fertilizer, there is some doubt for rapid switch could be attained from the traditionally used phosphate to nitrophosphate fertilizer.

(6) Regarding co-product nitrogen fertilizer from the production of nitrophosphate, if the use of nitrogen fertilizer is increased among wheat growers in southern Pampeana, it is judged to be possible for a market development to some extent, but since the existing nitrogen fertilizer plant of PETROSUR (Campana, ammonia capacity of 190 TPD, completed in 1968) will continue production, the marketability of such new type nitrogen fertilizer would be limited causing low capacity utilization of the plant during initial years of operation.

(7) For the development of a market for nitrophosphate and its co-product nitrogen fertilizer, it is judged that it would be necessary to undertake promotional efforts as well as premarketing activities using imported products.

2-2 Fertilizer Industry and Raw Materials

Regarding nitrogen fertilizer, the Argentine Republic has ammonia, urea and ammonium sulfate plant of PETROSUR based on natural gas, the DGFM has small scale ammonia, nitric acid and ammonium nitrate plant which products are mostly sold as industrial chemicals as well as an ammonium sulfate plant based on ammonia recovery from the coke oven gas, but their combined output is not sufficient to cover domestic demand for nitrogen fertilizer. As a result it is necessary to rely on imports, primarily of urea. Ample domestic natural gas resources exist and studies are being made regarding possible construction of large export oriented and also small domestic market oriented nitrogen fertilizer plants, but no project has reached the construction stage. Therefore, there is no existing domestic supply potential to provide ammonia and/or nitric acid for use by the phosphate fertilizer plant under consideration in the present study. The ELECTROCLOR has a small ammonia plant for supplying mostly for industrial uses of ammonia.

The phosphate rock resources of commercial scale has not been confirmed. In the past, both Thomas phosphate and hyperphosphate were produced by DGFM and by the AGROMAX, respectively, but such production has been stopped.

Virtually all requirements are being satisfied by imports, mostly of ammonium phosphates. The only known source of phosphate rock in the country is the tails of HIPASAM, Sierra Grande. Potash resources do not exist and a small quantities are being imported.

Compound fertilizer is being produced at PETROSUR, Bahia Blanca, using domestic and imported raw materials, but the production at present is at an extremely low level.

Sulfuric acid is produced using imported sulfur and metal smelting off-gas, but existing plants can not provide enough sulfuric acid to meet the requirement of the studied phosphate fertilizer plant project.

There are adequate resources of serpentine for the production of fused magnesium phosphate.

The qualities of fertilizers in the country are determined according to the IRAM standards and the official analytical methods are also stipulated at the IRAM. In conformity with the quality of the phosphate fertilizer product alternatives, one or two types of five quality guarantees (T-P_2O_5, Av-P_2O_5, C-P_2O_5, F-P_2O_5 and W-P_2O_5 would be applicable. Product quality evaluation of the studied alternatives were made in accordance with the IRAM standards.

2-3 Concentration of Phosphate Rock and Supply

Existence of the commercial scale phosphate rock resources capable of being developed has not been comfirmed in the Argentine Republic. The only possible source would be apatite phosphate rock from tails of the iron ore concentration plant (capacity 2,000,000 TPY) operated by HIPASAM in Sierra Grande, Río Negro.

The iron ore is mostly magnetite having the composition of Fe, 54.8% and P_2O_5, 3.28% and because of its high P_2O_5content, the iron ore should be concentrated to yields an iron ore with the composition of Fe, 68.5% and P_2O_5, 0.32% as steel making raw materials, at a same time non-magnetic tails of Fe, 27.53% and P_2O_5, 7.08% are produced and discarded. The phosphate rock is equivalent to 65,250 TPY-P_2O_5in the non-magnetic tails.

It is reported that there are two plants in Sweden and one small plant in the USA which concentrate phosphate rock from tails of the iron ore concentration plants. Production capacity at the SSAB, Grängesberg and LKAB, Kiruna, both in Sweden are 75,000 and 200,000 TPY, respectively to produce a high quality phosphate rock and a part of the product is exported.

As a part of the study, representative sample of 700kg tails were collected at the HIPASAM in June and October, 1983 and used for laboratory-scale experimental test for the concentration of phosphate rock as well as mineralogical studies and for the production of a 15kg of representative sample of phosphate rock to be used for the evaluation tests and the conceptual design of the seven alternatives of phosphate fetilizer production plant.

Results of the phosphate rock concentration tests were as follows:

(1) Phosphate minerals in the tails are mostly fluorapatite and hydroxyapatite, and apatite crystals are in locked form with iron minerals and chlorite.

(2) Minor phosphate minerals are also identified other than the apatites which are blue colored and brown colored and contain iron as constituent.

(3) There are inclusion of iron minerals in apatite crystals and the iron minerals seem partly fused in the apatite crystals.

(4) A small amount of iron is homogeneously dispersed over the entire surface of the apatite crystals as detected by X-ray observation.

(5) Even if the tails are ground to the average diameter of 0.02mm or less, it is impossible to achieve crystal grain isolation or liberation of iron minerals, chlorite and apatites.

(6) Chlorite which contains iron have similar Zeta potentials to that of apatite, the concentration of phosphate rock from chlorite would be difficult by flotation separation.

(7) As the results of the concentration test, it was found to be possible to produce phosphate rock of P_2O_5, 35.65% and Fe, 5.8% grade with the P_2O_5 recovery of 55.5% in the tails, by grinding the tails, rougher flotation and five stage cleaner flotation.

(8) With the purpose of determining the lower limit of the residual iron in the phosphate rock, HGMS (high gradient magnetic separation) was performed to obtain highly purified phosphate rock of P_2O_5, 39.55% and Fe, 1.84% grade. Although the product grade is improved, the P_2O_5 recovery is only 22.1% and judged to be not suitable for the industrial application.

(9) Phosphate rock concentration would be by flotation but because the specific characteristics of the Sierra Grande ore, the consumption of electric power for extensive grinding and flotation collector are higher, and also the P_2O_5 recovery is lower.

Regarding the conceptual design of the phosphate rock concentration plant based on the study results, it was confirmed that the following design would be rational.

(1)	Phosphate Rock Quality	:	
	- P_2O_5		35.65%
	- Fe		5.80
(2)	Recovery of P_2O_5	:	55.50%
(3)	Concentration Process	:	Grinding, Rougher Flotation, Cleaner Flotation (5 stages), Sedimentation, Filtration and Drying
(4)	Production Capacity	:	
	- Phosphate Rock		100,000 TPY (336.7TPD×297DRY)
	- P_2O_5		35,650 TPY - P_2O_5
(5)	Plant Location	:	Sierra Grande, Río Negro

The grade of the P_2O_5in the product phosphate rock is sufficiently high but the residual iron is higher and the recovery of $P_2O_5$is lower compared to the performance in Sweden. Reasons for those differences are believed to be due to the mineralogical nature.

The quality of phosphate rock commonly stipulated for the international trade is of P_2O_5, 30% or higher and Fe, 0.6% or lower, and the total impurities (Fe_2O_3+ Al_2O_3+ MgO), 3.0% or lower. The impurities in the product is exceeding 10.0% and would not be accepted as commercial commodity in general.

Moreover, the production cost would be higher than the imported product price and further the process applicable to the tails of Sierra Grande is not adequately commercially proven.

No precedent exists in the world for the production of phosphate fertilizer from the phosphate rock of this quality, making it necessary to undertake evaluation and trial tests for the seven phosphate fertilizer alternative production, and to prepare the conceptual design of the plant on the basis of the results thereby obtained.

Not only are there technical problems in using the phosphate rock but there are problems in the raw material and utility consumption, product quality and production cost. The process applicable to the phosphate rock for the production of phosphate fertilizer have not been commercial proven to an adequate extent.

The quality of the sample phosphate rock obtained are given in Table 4.

2-4 Technical Study on the Phosphate Concentration Plant and Phosphate Fertilizer Plants

The three site locations were compared to select the best plant location for the phosphate rock concentration and phosphate fertilizer plants, on the basis of comparative study of raw material and ancillary material availability, utility supply, transport costs of raw materials and product to the final fertilizer market and also the available infrastructures.

Site Location Alternatives	Code
- Sierra Grande, Rio Negro	PS-1, SG
- San Antonio Oeste, Rio Negro	PS-2, SAO
- Bahia Blanca, Buenos Aires	PS-3, BB

A summary outline of the site conditions are given in Table 5 and Table 6.

Concerning the alternative phosphate fertilizer products, following seven schemes were studied, especially on the supply conditions of ancillary raw materials and utility, product quality, suitability to the soils and agricultural conditions to select the best alternative process and product.

Phosphate Fertilizer Alternatives	Code
- Granular Ground Phosphate Rock	PF-1, GGPR
- Fused Magnesium Phosphate	PF-2, FMP
- Single Superphosphate	PF-3, SSP
- Triple Superphosphate	PF-4, TSP
- Monoammonium Phosphate	PF-5, MAP
- Nitrophosphate and Calcium Ammonium Nitrate (Ammonia Import)	PF-6, NP/CAN
- Nitrophosphate and Calcium Ammonium Nitrate (Ammonia Production)	PF-7, NP/CAN

The integration scheme of the phosphate rock concentration plant and the phosphate fertilizer plant is shown in Figure 1.

The evaluation test of the phosphate rock and phosphate fertilizer production tests were commissioned at the following firms which have long and extensive experiences for the specific fertilizer process know-how and process research and developments, and based upon the test results the conceptual design were prepared.

- Hinode Kagaku Kogyo K.K. (Japan)
- Nissan Chemical Industries, Ltd. (Japan)
- Norsk Hydro as (Norway)

As the result of the tests, following specific characteristics of the phosphate rock extracted from the non-magnetic tails of Sierra Grande were clarified.

(1) The concentration of P_2O_5 is sufficiently high.

(2) Iron content is high in phosphate rock and the product quality of phosphate fertilizer made from it is low, in particular the water solubility of phosphate.

(3) Most of the iron is in ferrous iron, Fe (II).

(4) Although the phosphate rock is of finely ground, the reactivity with acid is very low.

(5) The content of organic matter and carbonate are low and no foaming is observed at acid digestion.

The evaluation result of phosphate fertilizer production is as follows:

Phosphate Fertilizer Alternative	Production Technology	Process Consumption	Product Quality Evaluation
· GGPR, PF-1.	Applicable	Applicable	Low, especially low in C-P_2O_5/T-P_2O_5 and F-P_2O_5/T-P_2O_5
· FMP, PF-2	Applicable	Applicable (Open Hearth Furnace)	Excellent in C-P_2O_5/$_2O_5$
· Phosphoric Acid (P_2O_5), PF-4, and PF-5	Applicable, limited in concentration, Evolution of SO_2	Applicable, H_2SO_4 consumption is high and residual SO_3 is high	High in viscosity and sludge forming, concentration upto 40% of P_2O_5 (in general 54%)
· SSP, PF-3	Not applicable, low reactivity with sulfuric acid	Sulfuric acid consumption is high	Low, low in Av-P_2O_5/T-P_2O_5, W-P_2O_5/T-P_2O_5, high in free acid
· TSP, PF-4	Not applicable, low reactivity with phosphoric acid	Sulfuric acid consumption is high	Low, low in Av-P_2O_5/T-P_2O_5, W-P_2O_5/T-P_2O_5, high in free acid
· MAP, PF-5	Applicable, iron is transfered in fertilizer	Applicable	A little low but satisfactory for domestic market, low in Av-P_2O_5/T-P_2O_5, W-P_2O_5/T-P_2O_5 and W-N/T-N
· NP/CAN, PF-6 and PF-7	Applicable, partially iron is removed	Applicable	Excellent in Av-P_2O_5/T-P_2O_5, W-P_2O_5/T-P_2O_5

As the comparison study result, it was determined that the site location for the phosphate rock concentration plant is suitable in Sierra Grande and for the phosphate fertilizer plant, in case GGPR and TSP production the site in Sierra Grande is the best and in case FMP, SSP, MAP and NP/CAN the site in Bahia Blanca is the best suited.

The results of technical studies of the seven alternatives, with the production amount, product quality, effective utilization of P_2O_5, availability of ancillary raw material in the country, evaluation comparison is given in Table 7, Table 8, Table 9 and Table 10.

The alternative selected according to the comparative evaluation are monoammonium phosphate (MAP, PF-5) and nitrophosphate (NP/CAN, PF-7). The integrated project of phosphate rock concentration and such phosphate fertilizer plant are illustrated in Figure 2 and Table 11.

Their feasibility as an industrial project was investigated by the financial analysis and economic evaluation method.

2-5 Financial Analysis and Economic Evaluation

The two projects were selected in accordance with the market study and technical study and the projects were analyzed and evaluated in financial and economic feasibility calculations.

The Case I for the production of MAP is not feasible in financial and also in economical evaluation. The reasons for such low feasibility are;

(1) In spite of the high residual iron content in phosphate rock, the production of phosphoric acid is proved technically feasible. However the product quality of monoammonium phosphate as final product is a little less than traditional product in other countries.

(2) The cost for ammonia and sulfur as ancillary raw materials are higher because of a small lot import from overseas.

(3) The production capacity of phosphate rock concentration plant (336.7 TPD) and monoammonium phosphate plant (243.8 TPD) are both small in scale due to the limited availability of non-magnetic tails at Sierra Grande, therefore the fixed cost burden is higher in comparison with the world scale phosphate rock plants (10,000 to 20,000 TPD) and ammonium phosphate plants (1,000 to 2,000 TPD) located in North Africa or in the USA with export oriented nature.

(4) The monoammonium phosphate plant would have limited suppliabity to the domestic market up to a third and importation of phosphate fertilizer should be continued.

The Case II for the production of nitrophosphate has also technical viability and beneficial to rely on only to the domestic resources, however the financial feasibility is found also low because of the low capacity utilization. The major reasons for such low feasibility are as follows,

(1) Nitrogen content is higher in comparison with phosphate nutrients in nitrophosphate, and replacement of traditional phosphate fertilizer (DAP and TSP) by nitrophosphate would not proceed with at a high rate.

(2) A half of nitrogen in nitrophosphate and co-product nitrogen fertilizer is nitrate nitrogen and replacement of traditional nitrogen fertilizer (Urea and Ammonium Sulfate) would not proceed with at a high rate.

(3) The production capacity of an ammonia plant incorporated in the project is a 303 TPD. The scale is rather small but if it is assumed that the existing ammonia plant in Argentine would be continuously operational, the combined nitrogen capacity would be larger than the low growing nitrogen domestic market. The nitrogen fertilizer surplus would not be competitive for export market because there are world scale ammonia plants (1,000 to 1,500 TPD) in natural gas producing countries in export oriented nature.

However, if it is assumed that the capacity utilization is higher in Case II, the project has technical viability, the product quality is in conformity with the IRAM standard and also the marginal feasibility in financial and economic analysis are expected. Therefore the analytical data are presented in the report under such assumption and preconditions, and recommendations of project promotion on fertilizer (phosphate and nitrogen) in Argentine in the future are also presented as reference.

CHAPTER 3. CONCLUSION AND RECOMMENDATIONS

3-1 Conclusion

In connection with the proposed project which would utilize tails from the iron ore concentration plant, HIPASAM in Sierra Grande, Río Negro, which is the only phosphate rock source known to exist in the Argentine Republic, to concentrate the phosphate rock as an intermediate and to produce phosphate fertilizer, a wide range of tests and studies as well as evaluation research were performed for seven phosphate fertilizer alternatives. However, the results obtained did not permit the judgement that the plan to construct an integrated phosphate rock concentration plant and phosphate fertilizer plant under present condition is highly feasible.

Reasons for the low feasibility are (1) because of characteristics of the Sierra Grande ore, the cost of concentrating the phosphate rock would be high, (2) product quality would be low (i.e., there would be a high level of impurities especially iron), (3) the product quality of some of the phosphate fertilizer products would be low.

While there would be viable regarding technological aspects of production of monoammonium phosphate fertilizer and also in marketing, the production scale would be small and it would be necessary to rely on imports of ammonia and sulfur, the production cost would be high and inevitably low feasibility would be obtained when the project is subjected to the financial evaluation.

Study was also made for nitrophosphate fertilizer project, utilizing the Argentine Republic's abundant natural gas reserves to produce nitrogen fertilizer which could be combined with phosphate fertilizer production. In this case, because domestic demand for the by-product nitrogen fertilizer is low, and also the product would lack export competitiveness, the production scale would be excessive to the domestic market and the utilization of capacity would be low. This project thus would not have high feasibility, too.

A feasibility study was nevertheless performed for this project, because if it is assumed that a satisfactorily high degree of utilization of capacity can be obtained, it would be judged that technologically the project had viability and was marginally feasible. Problems in implementing the project in this case, and the working assumptions, were given. It is suggested hereafter to monitor the trend of the demand of nitrogen and phosphate fertilizer, and the possibility for the improvement of production technology, which could provide an opportunity to restudy the project as an alternatives for production of nitrogen and phosphate fertilizer as integrated project in the Argentine Republic in a future.

3-2 Recommendations

It did not prove possible to conclude that as a result of the study, the project was feasible and therefore preparations should be made to construct the proposed plant. Nevertheless, the following recommendations can be made as a result of the study.

(1) Effort should be continued for the improvements at the iron ore concentration plant as planned, and to obtain the production quantity and quality of tails which is beneficial for phosphate concentration. Moreover, the plan presently being made by HIPASAM to improve the quality of the iron ore should be implemented, as part of the effort to obtain tails quality which is advantageous for phosphate rock concentration.

(2) Tests and studies on concentrating phosphate rock from tails should be continued and improvements should be sought regarding quality, yield, and concentration cost.

(3) Study should be made of a phosphate fertilizer project to be integrated with a nitrogen fertilizer project. Consideration should also be given to importation of some phosphate rock in order to attain a higher level of production scale. The nitrogen fertilizer plant should be export oriented to enjoy the economies of scale.

Table 1 FERTILIZER SUPPLY/DEMAND SITUATION IN ARGENTINE

(Unit: TPY)

	Yearly Average			Yearly				
	1964/1966	1969/1971	1974/1976	1978	1979	1980	1981	1982
Nitrogen Fertilizer (N)								
Production (A)	-	-	-	30,652	27,305	30,437	25,124	30,596
Consumption (B)	27,321	40,445	39,043	44,412	60,576	65,355	51,173	50,926
Balance (A)-(B)	-	-	-	-13,760	-33,271	-34,918	-26,049	-20,330
Phosphate Fertilizer (P_2O_5)								
Production (A)	-	-	-	1,121	1,541	498	89	0
Consumption (B)	14,010	24,816	23,068	32,551	64,660	50,013	28,885	45,719
Balance (A)-(B)	-	-	-	-31,430	-63,119	-49,515	-28,796	-45,719
Potash Fertilizer (K_2O)								
Production (A)	0	0	0	0	0	0	0	0
Consumption (B)	6,231	7,687	5,233	5,694	12,261	8,752	5,301	5,660
Balance (A)-(B)	-6,231	-7,687	-5,233	-5,694	-12,261	-8,752	-5,301	-5,660

Table 2 ESTIMATED CONSUMPTION OF PHOSPHATE FERTILIZER IN ARGENTINE

(Unit: TPY-P_2O_5)

	Phosphate Fertilizer Consumption			
	1972 (Estimate)	1982 (Estimate)	1990 (Projection)	1995 (Projection)
By region				
Pampeana	25,600	34,900	59,300	85,600
Andina	5,300	5,300	6,300	7,200
Noroeste	2,900	2,700	2,600	2,700
Mesopotamia	4,600	5,600	6,100	6,500
Patagonia	2,100	2,600	4,100	4,700
Chaquena	0	0	0	0
Total	40,500	51,100	78,400	106,700
By Crop				
Wheat	5,800	15,900	39,900	65,900
Other cereals	800	700	700	700
Pasture	13,300	13,300	13,300	13,300
Fruits	4,600	5,000	6,700	7,500
Vegetables and Potato	8,500	8,100	10,200	11,700
Grapes	3,400	3,400	3,400	3,400
Others	4,100	4,700	4,200	4,200
Total	40,500	51,100	78,400	106,700
Average Annual Growth Rate, %/Year	2.35	5.50	6.36	

Table 3 SALES PLAN FOR DOMESTIC MARKET

Phosphate Rock Concentration and Phosphate Fertilizer Plant Project	1990 Sales Volume Product ton	1990 Sales Volume N	1990 Sales Volume P_2O_5	1990 Total Demand '000 N	1990 Total Demand '000 P_2O_5	1990 Sales Potential '000 N	1990 Sales Potential '000 P_2O_5	1995 Sales Volume Product ton	1995 Sales Volume N	1995 Sales Volume P_2O_5	1995 Total Demand '000 N	1995 Total Demand '000 P_2O_5	1995 Sales Potential '000 N	1995 Sales Potential '000 P_2O_5
Case I (PC-1/PF-5)														
MAP														
Pampeana	64,400	6,400	29,000	53.0	59.3	13.1	58.9	66,700	6,700	30,000	68.8	85.6	18.9	85.1
Mesopotamia	1,800	200	800	3.5	6.1	1.2	5.6	1,400	100	650	3.9	6.5	1.3	5.9
Noroeste	1,400	100	650	15.9	2.6	0.5	2.3	1,200	100	550	16.2	2.7	0.5	2.4
Andina	7,900	800	3,550	10.2	6.3	1.3	6.0	6,400	600	2,900	11.2	7.2	1.5	6.8
Patagonia	4,900	500	2,200	6,5	4.1	0.8	3.7	4,700	500	2,100	7.6	5.5	1.1	4.9
Total	80,400	8,000	36,200	89.1	78.4	16.9	76.5	80,400	8,000	36,200	107.7	106.7	23.3	105.1
(Production capacity)	(72,409)	(7,386)	(33,243)					(72,409)	(7,386)	(33,243)				
Case II (PC-1/PF-7)														
NP														
Pampeana	37,000	7,400	7,400	53.0	59.3	11.1	11.1	51,500	10,300	10,300	68.8	85.6	16.0	16.0
Mesopotamia	3,500	700	700	3.5	6.1	3.5	3.5	4,000	800	800	3.9	6.5	3.9	3.9
Noroeste	4,500	900	900	15.9	2.6	2.3	2.3	5,000	1,000	1,000	16.2	2.7	2.4	2.4
Andina	25,000	5,000	5,000	10.2	6.3	6.2	6.2	28,500	5,700	5,700	11.2	7.2	7.1	7.1
Patagonia	16,500	3,300	3,300	6.5	4.1	4.1	4.1	22,000	4,400	4,400	7.6	5.5	5.5	5.5
Total	86,500	17,300	17,300	89.1	78.4	27.2	27.2	111,000	22,200	22,200	107.7	106.7	34.9	34.9
(Production capacity)	(163,677)	(34,045)	(34,045)					(163,677)	(34,045)	(34,045)				
CAN														
Pampeana	17,600	6,000	-			23.7	-	20,000	6,800	-			28.1	-
Mesopotamia	0	0	-			0	-	0	0	-			0	-
Noroeste	0	0	-			13.6	-	0	0	-			13.8	-
Andina	8,200	2,800	-			4.0	-	8,500	2,900	-			4.1	-
Patagonia	5,000	1,700	-			2.4	-	4,400	1,500	-			2.1	-
Total	30,800	10,500	-			43.7	-	32,900	11,200	-			48.1	-
(Production capacity)	(139,709)	(36,324)	(-)					(139,708)	(36,324)	(-)				

Table 4 ANALYSIS OF PHOSPHATE ROCK EXTRACTED FROM IRON ORE CONCENTRATION NON-MAGNETIC TAILS OF HIPASAM, SIERRA GRANDE, ARGENTINE

(1) CHEMICAL ANALYSIS

As Element	Weight Percent	As Oxide	Weight Percent	Equivalency for 100g Sample
P	15.56%	P_2O_5	35.65%	(-) 1.507
C (Carbonate)	0.09	CO_2	0.33	(-) 0.015
F	1.50	F	1.50	(-) 0.079
Cl	0.01	Cl	0.01	(-) 0.0005
OH	-	OH	(3.88)	(-) (0.2285)
S (Total)	-	S and Oxides	-	(-) -
S (Sulfide)	0.48	S	0.48	(-) 0.030
S (Sulfate)	-	SO_3	-	(-) -
Si	1.98	SiO_2	4.24	(-) 0.141
Fe (Total)	5.80	Fe Oxides	7.67	(+) 0.233
Fe (II)	4.36	FeO	(5.61)	(+) (0.156)
Fe (III)	1.44	Fe_2O_3	(2.06)	(+) (0.077)
Al	1.46	Al_2O_3	2.06	(+) 0.162
Mn	-	MnO	-	(+) -
Ca	31.66	CaO	44.30	(+) 1.580
Mg	0.22	MgO	0.36	(+) 0.018
Na	0.15	Na_2O	0.20	(+) 0.006
K	0.07	K_2O	0.08	(+) 0.002
Others	-	Others	-	-
Free Moisture	0.14	Free Moisture	0.14	-
Organics	-	Organics	-	-
Ignition Loss	1.68	Ignition Loss	1.68	
Total	65.95	Sub-total	102.58	(-) 2.001
		Adjustment for F	(-) 0.63	(+) 2.001
		Total	101.95	(+) 0.000

(2) PHYSICAL PROPERTY

Color		Gray
Size Distribution (Tyler Mesh and Millimeter)		
(+) 400 Mesh	(0.0370 mm)	15.9%
(+) 468.4	(0.0316)	18.4
(+) 677.8	(0.0219)	36.1
(+) 993.3	(0.0149)	52.5
(+) 1,309.7	(0.0113)	64.5
(-) 1,309.7	(0.0113)	35.4
		100.0
Density		3.27
Bulk Density - Packed		1.67
- Loose		1.27
Angle of Reponse		43.0°
Free Moisture of Filter Cake, %		13.0
Specific Surface Area, cm^2/gr		2,770

(3) FERTILIZER PROPERTY

	Weight Percent	Solubility Percent
Total P_2O_5	35.65%	100.0%
Nitric Acid Soluble P_2O_5	35.60	99.9
Hydrocholoric Acid Soluble P_2O_5	35.11	98.5
Citric Acid Soluble P_2O_5	7.96	22.3
Formic Acid Soluble P_2O_5	5.69	16.0
Ammonium Citrate Soluble (AV) P_2O_5 (Neutral)	0.00	0.0
Water Soluble P_2O_5	0.00	0.0

Notes:
- Sample tails (Fe=27.53%, P_2O_5=7.08%) were taken on October 6, 1983 at HIPA and concentration test and analysis were made at NIKKO Consulting and Engineering Co. Ltd., Japan in January, 1984. Recovery of P_2O_5 is 55.5%. Fertilizer property was determined at Nissan Chemical Industries, Ltd., Japan in March, 1984.
- Ignition loss is measured by heating at 900°C for 0.5 hours.
- Free moisture is measured by heating at 105°C for 5.0 hours.
- (OH) is estimated to keep balanced equivalency.

Table 5 (1) SITE CONDITIONS FOR PHOSPHATE ROCK CONCENTRATION AND PHOSPHATE FERTILIZER PLANT PROJECT, HIPASAM, ARGENTINE

Items	Project Site Alternatives		
	(PS-1) Sierra Grande, Río Negro	(PS-2) San Antonio Oeste, Río Negro	(PS-3) Bahía Blanca, Buenos Aires
GENERAL DESCRIPTION	Within the Iron Ore Concentration Plant of HIPASAM	Close to Muell Este-Puerto San Antonio and proposed site for SIDERSUR	Close to the Puertos de Bahia Blanca and Parque Industrial
LOCATION			
Longitude, West, Degree	65°20'	64°45'	62°15'
Latitude, South, Degree	41°30'	40°45'	38°45'
Height, Meter abbove Sea Level	268.0	10.0	10.0
CLIMATIC CONDITIONS			
Temperature, °C			
Absolute Maximum	37.0 (Feb)	41.7 (Jan)	41.9 (Jan)
Absolute Minimum	(-) 5.2 (Jun)	(-) 7.5 (Jun)	(-) 8.5 (Jun)
Average	13.5	-	14.8
Design, Maximum/Minimum	42.0 / (-) 10.0	42.0 / (-) 10.0	42.0 / (-) 10.0
Rain Fall, mm			
Annual	258.0	245.0	604.0
Monthly Maximum	44.7 (Dec)	29.0 (Oct)	88.0 (Mar)
Daily Maximum	54.5	-	-
Design, Daily	60.0	60.0	60.0
Relative Humidity, %			
Monthly Maximum	85.0 (Jun)	-	-
Monthly Maximum	60.0 (Jan)	-	-
Design	75.0 (35°C)	75.0 (35°C)	75.0 (35°C)
Wind			
Velocity, km/hour			
Absolute Maximum	147.0	-	-
Average of Daily Maximum	32.0	28.0	26.0
Design	120.0	120.0	120.0
Direction	SW	NWW	NNE
Atomospheric Pressure, ata	0.968 ± 0.003	1.999 ± 0.003	1.001 ± 0.003
Annual Evaporation, mm	750.0	750.0	750.0

Table 5 (2) SITE CONDITIONS FOR PHOSPHATE ROCK CONCENTRATION AND PHOSPHATE FERTILIZER PLANT PROJECT, HIPASAM, ARGENTINE

Items	Project Site Alternatives		
	(PS-1) Sierra Grande, Río Negro	(PS-2) San Antonio Oeste, Río Negro	(PS-3) Bahía Blanca, Buenos Aires
SOIL CONDITION			
General Conditions	Flat (Not Developed)	Flat (Not Developed)	Flat (Developed)
Soil Structure	Silty (0.5-1.0m) Sand Stone (3.0m-)	Silty Sand	Sandy Soil
Soil Bearing Capacity, Ton/m^2 Surface Ground Rock	 20.0 100.0 (3.0m)	 15.0 (Estimate) -	 15.0 (Estimate) -
Vegetation	None	None	None
Seismic Zone and Coefficient	0.013 (Zone VI: Minor)	0.013 (Zone VI: Minor)	0.013 (Zone VI: Minor)
UTILITY SUPPLY AND PRICE			
Water, Existing	A Pipeline from Arroyo de los Berros and Arroyo de la Ventana: 486m^3/h(120km)	Canal Pomona (37km) from from Río Negro: 1,100m^3/h	DOSBA
Water, Potential	A Pipeline from Arroyo de los Berros: 79m^3/h(120km)	-	-
Electric Power	AyE: 50 MW, 132 KV, 50 Hz	AyE: 12 MW, US$0.015/kWh 132 KV, 50 Hz	DEBA: 132 KV, 50 Hz
Natural Gas	Gas del Estado: US$0.045/$Nm^3$, 25 atg, 8 Inch Diameter	Gas del Estado: 2.5 MMm^3/day US$0.045/$Nm^3$	Gas del Estado: US$0.045/$Nm^3$
Fuel Oil	Lorry Supply	Lorry Supply	Lorry Supply
Waste Water Treatment	None	Yes: 800m^3/hr	Yes:
INFRASTRUCTURES			
Access Road	Paved Road with 7 meter Width	Paved Road with 7 meter Width	Paved Road with 7 meter Width

Table 5 (3) SITE CONDITIONS FOR PHOSPHATE ROCK CONCENTRATION AND PHOSPHATE FERTILIZER PLANT PROJECT, HIPASAM, ARGENTINE

Items	Project Site Alternatives		
	(PS-1) Sierra Grande, Río Negro	(PS-2) San Antonio Oeste, Río Negro	(PS-3) Bahía Blanca, Buenos Aires
State High Way Connection	A 3km for Ruta 3	A 38km for Ruta 3, Ruta 251, Ruta 308 and Ruta 23	A 5km for Ruta 3, Ruta 33, Ruta 35 and A 35km for Ruta 22
Rail Road Connection	A 134km for San Antonio Oeste of EFEA	A 25km for San Antonio Oeste of EFEA	A 5km for Bahía Blanca of EFEA
Ocean Port Connection, km			
Punta Colorada (27ft, No Crane)	32.0	166.0	528.0
San Antonio Oeste (40ft, 45 Ton Crane)	134.0	2.0	394.0
Puerto Madryn (30ft, 12 Ton Crane)	144.0	278.0	672.0
Bahía Blanca (36ft, 50 Ton Crane)	528.0	394.0	10.0
Buenos Aires (27ft, 150 Ton Crane)	1,213.0	1,079.0	685.0
Air Port Connection, km	A 208km for Trelew	A 160km for Viedma (Heliport at San Antonio Este)	A 10km for Bahía Blanca
ACCOMMODATIONS			
Community	Sierra Grande	San Antonio Oeste	Bahía Blanca
Population	10,000	9,000	180,000
Hotel	Yes	Yes	Yes
School	Yes	Yes	Yes
Hospital	Yes	Yes	Yes
GroceryYes	Yes	Yes	Yes
Telecommunication	Yes	Yes	Yes
Construction Camp	(Yes)	(None)	(Yes)
INVESTMENT INCENTIVES			
Provincial Incentives			
Equity Participation	Yes	Yes	(None)
Loan Financing	Yes	Yes	(None)
Industrial Park	(None)	(None)	Yes
Utility Supply	Yes	Yes	Yes
Training Subsidy	Yes	Yes	Yes
Housing Subsidy	Yes	Yes	(None)
Research Assistance	Yes	Yes	(Yes)
Local Tax, %	-	-	-
Local Tax Holiday, year	-	-	-

Table 6 BRIEF DESIGN CONDITIONS FOR PHOSPHATE ROCK CONCENTRATION AND PHOSPHATE FERTILIZER PLANT, ARGENTINE

	Project Site Alternatives		
	PS-1 Sierra Grande, Rio Negro	PS-2 San Antonio Oeste, Rio Negro	PS-3 Bahia Blanca, Buencs Aires
Location			
Longitude, West/ Latitude, South	65°20'/41°30'	64°45'/40°45'	62°15'/38°45'
Height, Meter above Sea Level	268.0	10.0	10.0
Climatic Conditions			
Temperature, °C			
- Maximum	42.0	42.0	42.0
- Minimum	(-)10.0	(-)10.0	(-)10.0
Humidity, %	75.0	75.0	75.0
(Temperature, °C)	(30.0)	(30.0)	(30.0)
Rainfall, mm			
- Daily Maximum	60.0	60.0	60.0
Wind Velocity, km/hour	120.0	120.0	120.0
(Direction)	(SW)	(NWW)	(NNE)
Atmospheric Pressure, ata	0.968 (±)0.003	0.999 (±)0.003	1.001 (±)0.003
Soil Conditions			
Bearing Capacity, Ton/m^2	20.0	15.0 (Estimate)	15.0 (Estimate)
Seismic Coefficient	0.013	0.013	0.013
(Zone, Magnitude)	(VI, Minor)	(VI, Minor)	(VI, Minor)
Utility Supply Conditions			
Raw Water			
- Analysis, ppm			
Total Hardness, $CaCO_3$	125.0	119.0	-
SO_4,	88.0	18.0	-
Cl,	-	23.0	-
pH	-	7.5	-
- Source	Arroyo de los Berros, Arroyo de la Ventana	Canal Pomona from Rio Negro	Pipeline from Rio Colorada
- Supply Location	Battery Limit	Battery Limit	Battery Limit
Electric Power			
- Conditions	132 KV, 50 Hz 3 Phase, 3 Wire	132 KV, 50 Hz 3 Phase, 3 Wire	132 KV, 50 Hz 3 Phase, 3 Wire
- Source	Aye	Aye	Beba
- Supply Location	Battery Limit	Battery Limit	Battery Limit
Natural Gas			
- Heating Value, Cal/Nm^3, LHV/HHV	9,012/9,970	9,012/9,970	9,012/9,990
- Pressure, ata	25.0	25.0	25.0
- Source	Gas del Estado	Gas del Estado	Gas del Estado
- Supply Location	Battery Limit	Battery Limit	Battery Limit

Table 7 ALTERNATIVES OF PHOSPHATE FERTILIZER PRODUCTION IN ARGENTINE

Product	Daily Production (TPD)	T-N	A-N	N-N	T-P_2O_5	Av-P_2O_5	C-P_2O_5	F-P_2O_5	W-P_2O_5	W-K_2O	Free Moisture	Free Acid	Other Major Raw Material and Utility Daily Consumption	
		Production Specification, %												
PF-1, GGPR, Granular, Bagged	347.4	0.0	0.0	0.0	33.87 (24.0)	0.0	7.60	5.40 (14.4)	0.0	3.00	0.70 (4.0)	0.0	MOP	17.9 TPD
PF-2, FMP, Sandy, Bagged	569.0	0.0	0.0	0.0	20.68	13.40	20.30 (11.9) for Escorias Thomas	9.27	0.0	0.0	0.30	0.0	Serpentine	289.1 TPD
PF-3, SSP, Granular, Bagged	572.0	0.0	0.0	0.0	20.57 (19.5)	16.04	-	-	10.70 (18.0)	0.0	3.00 (4.0)	4.0 (3.7)	Sulfur	66.0 TPD
PF-4, TSP, Granular, Bagged	243.3	0.0	0.0	0.0	47.33 (45.0)	35.50	-	-	31.00 (40.0)	0.0	3.0 (4.0)	7.0 (4.0)	Sulfur	63.3 TPD
PF-5, MAP, Granular, Bagged	243.8	10.20 (11.4)	10.20	0.0	46.80	45.91 (48.0)	-	-	30.42	0.0	0.9	0.0	Ammonia, Sulfur	31.2 TPD 90.2 TPD
PF-6, NP, Granular, Bagged	551.1	20.80 (20.0)	11.40	9.40	21.10	20.80 (19.0)	-	-	15.83	0.0	0.60	0.0	Ammonia,	306.0 TPD
/CAN, Granular, Bagged	470.4	26.00 (20.50)	13.00	13.00	0.0	0.0	-	-	0.0	0.0	0.40	0.0	Natural Gas	2,788 MMBTU -LHV/D
Averaged Total	1,021.5	23.19	12.14	11.05	11.38	11.22	-	-	8.54	0.0	0.51	0.0		
PF-7, NP, Granular, Bagged	551.1	20.80 (20.0)	11.40	9.40	21.10	20.80 (19.0)	-	-	15.83	0.0	0.60	0.0	Natural Gas	10,025 MMBTU -LHV/D
/CAN, Granular, Bagged	470.4	26.00 (20.50)	13.00	13.00	0.0	0.0	0.0	-	0.0	0.0	0.40	0.0		
Averaged Total	1,021.5	23.19	12.14	11.05	11.38	11.22	-	-	8.54	0.0	0.51	0.0		

Notes: 1) Production is designed to consume 336.7 TPD (100,000 TPY/297 DPY) of phosphate rock (P_2O_5; 35.65%, Fe; 5.8%) which is recovered from non-magnetic tails at phosphate rock concentration plant, Sierra Grande, Argentine.

2) Requirement at fertilizer control order in Argentine (IRAM) is referred by underlined analysis and its figure is indicated in parenthesis.

Table 8 PROJECT ALTERNATIVES FOR PHOSPHATE ROCK CONCENTRATION AND PHOSPHATE FERTILIZER PRODUCTION IN ARGENTINE

Project	Plant and Product	Site	Daily Production and P_2O_5 Efficiency			Annual Production			
		Location	Material	Total P_2O_5	Effective P_2O_5	Material	N	Effective P_2O_5	K_2O
			TPD	TPD (Efficiency, %)	TPD (Efficiency, %)	TPY	TPY	TPY	TPY
Phosphate	Rock Concentration Plant								
PC-1, PR	Phosphate Rock Concentration, Bulk	PS-1, Sierra Grande	336.7	120.0 (100.0)	$F-P_2O_5$; 19.2 (16.0)	100,000	0.0	5,690.0	0.0
Phosphate	Fertilizer Plant								
PF-1, GGPR	Granular Ground Phosphate Rock, Bagged	PS-3, Bahia Blanca	347.4	117.7 (98.1)	$F-P_2O_5$; 18.8 (15.6)	103,178	0.0	5,571.6	3,095.3
PF-2, FMP	Fused Magnesium Phosphate, Bagged	PS-3, Bahia Blanca	569.0	117.7 (98.1)	$C-P_2O_5$; 115.5 (96.3)	168,993	0.0	34,305.5	0.0
PF-3, SSP	Single Super Phosphate, Bagged	PS-3, Bahia Blanca	572.0	117.7 (98.1)	$W-P_2O_5$; 61.2 (51.0) $T-P_2O_5$; 117.7 (98.1)	169,884	0.0	18,177.6 34,945.1	0.0
PF-4, TSP	Triple Super Phosphate, Bagged	PS-1, Sierra Grande	243.3	115.2 (96.0)	$W-P_2O_5$; 75.4 (62.9) $T-P_2O_5$; 115.2 (96.0)	72,260	0.0	22,400.6 34,200.7	0.0
PF-5, MAP	Monoammonium Phosphate, Bagged	PS-3, Bahia Blanca	243.8	114.1 (95.1)	$Av-P_2O_5$; 111.9 (93.3)	72,409	7,385.7	33,242.8	0.0
PF-6, NP/CAN	Nitrophosphate and Calcium Ammonium Nitrate by Ammonia Import	PS-3, Bahia Blanca	1,021.5	116.2 (96.8)	$Av-P_2O_5$; 114.6 (95.5)	303,386	70,355.1	34,039.9	0.0
PF-7, NP/CAN	Nitrophosphate and Calcium Ammonium Nitrate by Ammonia Production	PS-3, Bahia Blanca	1,021.5	116.2 (96.8)	$Av-P_2O_5$; 114.6 (95.5)	303,386	70,355.1	34,039.9	0.0

Table 9 BASIS FOR FINANCIAL ANALYSIS OF PHOSPHATE FERTILIZER PRODUCTION

Product and Production			Consumption/Ton of Product, Bagged									
Product Sepcification (Fertilizer Nutrients, %)		Daily Production (TPD)	Liquid Ammonia	Phos-phate Rock	Potassium Chloride	Sulfur	Ser-pentine	Natural Gas (MMBTU-LHV)	Electric Power (kWh)	Raw Water	Chemicals and Catalysts (USD)	Fertilizer Bag, (Sheet)
	N P2O5 K2O											
PF-1, GGPR	0.0 -33.87 (5.40) -3.0 T- F- W-	347.4	-	0.9692	0.0515	-	-	0.555	55.50	0.25	-	20.20
PF-2, FMP	0.0 -20.30 -0.0 C-	569.0	-	0.5917	-	-	0.5080	6.050	155.50	5.60	1.250	20.20
PF-3, SSP	0.0 -20.57 (10.70) -0.0 T- W-	572.0	-	0.5886	-	0.1154	-	-	69.23	4.40	0.275	20.20
PF-4, TSP	0.0 -47.33 (31.00) -0.0 T- W-	243.3	-	1.3839	-	0.2602	-	-	139.74	7.37	0.271	20.20
PF-5, MAP	10.2 -45.91 -0.0 T- Av-	243.8	0.1279	1.3687	-	0.3698	-	-	180.49	7.38	0.373	20.20
PF-6, NP/ CAN	20.80-20.80 -0.0 26.00- 0.0 -0.0 23.19-11.20 -0.0 T- Av-	551.1 470.4 1,021.5	0.2996	0.3296	-	-	-	2.730	171.1	5.47	0.984	20.20
PF-7, NP/ CAN	20.80-20.80 -0.0 26.00- 0.0 -0.0 23.19-11.20 -0.0 T- Av-	551.1 470.4 1,021.5	-	0.3296	-	-	-	9.815	419.7	7.06	1.525	20.20

Table 10 EVALUATION AND SELECTION OF ALTERNATIVES FOR PHOSPHATE FERTILIZER PRODUCTION IN ARGENTINE

Alternatives	Evaluation and Selection Items and Criteria								Overall Evaluation
	Raw Materials Availability in Argentine, Foreign Currency Saving	Utility Consumption (Low)	Product P_2O_5 Evaluation in Argentine (IRAM)	Product P_2O_5 Water Solubility (High)	Product Physical Property	Product Market Development	Phosphate Rock Applicability to Conventional Production Process	Plant Investment Costs (Low)	
PF-1, GGPR	B	A	D (Formic)	D	A	C	A	A	C
PF-2, FMP	A	B	A (Citric)	D	B	D	A	A	B
PF-3, SSP	C	A	C (Total/Water)	C	C	C	C	A	C
PF-4, TSP	C	A	C (Total/Water)	C	C	B	C	B	B
PF-5, MAP	D	A	B (Citrate)	B	A	A	B	B	A
PF-6, NP/CAN -Ammonia Import	D	B	A (Citrate)	A	A	A	A	C	B
PF-7, NP/CAN -Ammonia Production	A	B	A (Citrate)	A	A	A	A	C	A

Table 11 SUMMARY OF SELECTED PHOSPHATE ROCK CONCENTRATION AND PHOSPHATE FERTILIZER PLANT PROJECT IN ARGENTINE

Product	Phosphate Rock Concentration Plant	Phosphate Fertilizer Plant		Integrated Plants Project	
				Case I	Case II
	PC-1	PF-5	PF-7	PC-1/PF-5	PC-1/PF-7
	Phospahte Rock, PR	Monoammonium Phosphate, MAP	Nitrophosphate/ Calcium Ammonium Nitrate, NP/CAN	Monoammonium Phosphate, MAP	Nitrophosphate/ Calcium Ammonium Nitrate, NP/CAN
Product Grade, % (T-N, T-P_2O_5(AV-P_2O_5), W-K_2O 23.19-11.38(11.22)-0.0		0.0-35.65(0.0)-0.0	10.20-46.8(45.91)-0.0	23.19-11.38(11.22)-0.0	10.20-46.8(45.91)-0.0
Product, TPD TPY	336.7 100,000	243.8 72,409	1,021.5 303,386	243.8 72,409	1,021.5 303,386
Plant Location	Sierra Grande, PS-1	Bahía Blanca, PS-3	Bahía Blanca, PS-3	Sierra Grande/Bahía Blanca, PS-1/PS-3	Sierra Grande/Bahía Blanca, PS-1/PS-3
Site Area, m^2	40,000	97,500	135,000	137,560	175,000
Production Start Year	1990	1990	1990	1990	1990
Total Number of Employee	238	298	440	517	659
Base Project Cost, USD, MM - 1983, Without Taxes	33.65	46.44	180.63	80.09	214.28
Consumption, TPT of Product					
- Liquid Ammonia	0.00	0.1279	0.00	0.1279	0.00
- Phosphate Rock (P_2O_5; 35.65%)	(1.00)	1.3687	0.3296	0.00	0.00
- Transport of Phos Rock (528km)	0.00	0.00	0.00	USD 10.2653	USD 2.4720
- Sulfur	0.00	0.3698	0.00	0.3698	0.00
- Non-Magnetic Tails (P_2O_5; 7.08%)	9.2163	0.00	0.00	12.614	3.0377
- Natural Gas, MMBTU-LHV	0.55	0.00	9.815	0.7527	9.9963
- Electric Power, kWh	338.58	180.49	419.70	643.90	531.30
- Raw Water,	0.784	7.38	7.06	8.453	7.318
- Chemical and Catalysts	USD 12.50	0.373	1.525	17.482	5.645
- Fertilizer Bag, Sheet	0.00	20.20	20.20	20.20	20.20

Notes; 1) Production of NP/CAN is weighted average for the 551.1 TPD of NP(20.80-20.80-0.0) and 470.4 TPD of CAN(26.0-0.0-0.0).
2) Cost for the transport of phosphate rock and chemicals and catalysts in USD-1983 and taxes are not included.

FIGURE 1 OVERALL FLOW SCHEME FOR PHOSPHATE FERTILIZER PRODUCTION IN ARGENTINE

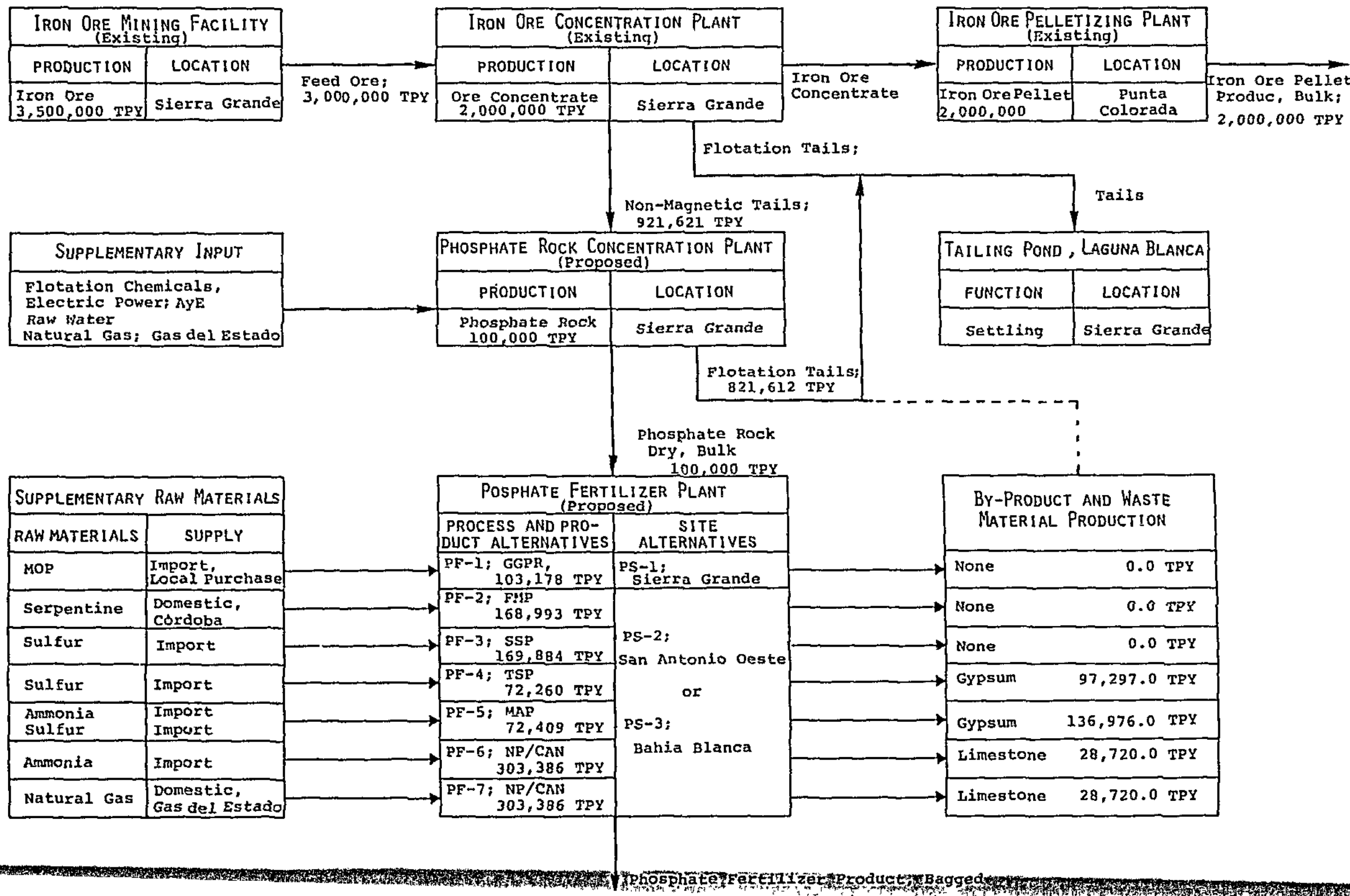

Figure 2 PROPOSED INTEGRATED PROJECTS FOR PHOSPHATE ROCK CONCENTRATION PLANT AND PHOSPHATE FERTILIZER PLANT IN ARGENTINE