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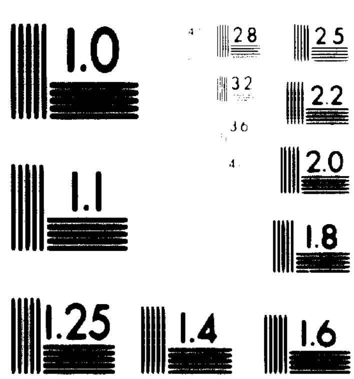

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HUMPHREYS & GLASGOW LIMITED

PRE INVESTMENT STUDIES FOR THE PROMOTION OF THE FERTILIZER AND PETROCHEMICAL INDUSTRIES IN PAKISTAN

for

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION

VOLUME I

Study Introduction, Scope & Conclusions with Summary of Interim Report

22, Carlisle Place, London S.W.1. England

PRE-INVESTMENT STUDIES FOR THE PROMOTION OF THE FERTILIZER AND PETROCHEMICAL INDUSTRIES IN PAKISTAN

02583

for

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION

VOLUME 1
STUDY INTRODUCTION, SCOPE AND CONCLUSIONS
WITH
SUMMARY OF INTERIM REPORT

July 1970

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Rathausplatz 2,
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AUSTRIA.

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JRP/CS/C.1669

17th July, 1970.

The United Nations Industrial
Development Organisation,
Attention: Chief TEPCO
P.O. Box 707,
A-1011 VIENNA,
Austria.

Gentlemen,

Pre-Investment Studies for the Promotion of the
Fertilizer and Petrochemical Industries in Pakistan
UNIDO Contract 69/9
Humphreys & Glasgow Contract C.1669

Humphreys & Glasgow Limited are pleased to submit herewith their report of work undertaken for the above project. This work has been carried out in collaboration with Chemical Consultants Limited, Lahore, West Pakistan.

The project was carried out in two phases and the first phase culminated in an Interim Report which was presented to you at the end of November, 1969. This final report is presented in five volumes, the first of which summarises and updates the Interim Report. Following presentation and study of the Interim Report, four projects were selected for study in the second phase. These are discussed in Volumes II to V now presented.

We should like to emphasise that, apart from the contribution of Chemical Consultants Limited and ourselves to this project, a large proportion of the work has been undertaken in collaboration with the U.N.I.D.O. staff resident in Pakistan and the staff of the Planning Commission of the Pakistan Government concerned with the Project. We have also been very grateful for the assistance which we have received from the many organisations in Pakistan whom we have consulted during the course of our studies.

We trust that the information which we have prepared will prove useful to the Pakistan authorities in developing the Fertilizer and Petrochemical industries, and we thank both them and yourselves for the opportunity of participating in this important work.

Yours faithfully,
HUMPHREYS & GLASGOW LIMITED,
per:

J. R. Potter

J. R. Potter
Project Manager

VOLUME TITLES

1.6.5 General Conclusions

The general development of the fertilizer industry in West Pakistan should be based on straight N and NP fertilizers; NPK will be required in minor proportions. In East Pakistan the current developments based on the use of N, P and K fertilizer all in straight form is endorsed.

The price of sulphur is a very important factor in plans for development of the fertilizer industry. Longer term forcasts for sulphur price are important in determing the viability of the project at Chittagong for the utilisation of by-product gypsum.

More detailed agronomic data are required for East and West Pakistan. Tests are at present in hand as a part of the UNDP project.

In planning petrochemicals projects, account should be taken of the consumption forecasts of East and West Pakistan as a whole. The savings resulting from location of all production at one site usually over-ride the cost of interwing transport of petrochemicals.

A study of the viability of exporting fertilizer and petrochemical products from Pakistan should be undertaken. This should investigate the relationship between production cost, both total and marginal, in Pakistan and world prices. This analysis could include the following products starting from Synthesis gas, which could be produced from the resources of natural gas in East Pakistan:-

Melamine
Methanol
Formaldehyde
Resins based on urea, formaldehyde, melamine, cotton.
Ethylene glycol

The petrochemical and aromatics plants which have been proposed in this study are small in relation to units typically being constructed in developed countries. The present economic structure in Pakistan will, however, protect local products against severe competition from equivalent imported materials produced in these larger units.

VOLUME I

STUDY INTRODUCTION, SCOPE AND CONCLUSIONS WITH SUMMARY OF INTERIM REPORT

VOLUME 1

STUDY INTRODUCTION, SCOPE AND CONCLUSIONS

WITH

SUMMARY OF INTERIM REPORT

SECTION 1

STUDY INTRODUCTION, SCOPE AND CONCLUSIONS

1.1 Introduction

This is a report on pre-investment studies for the Fertilizer and Petrochemicals Industries in Pakistan carried out by Humphreys & Glasgow Limited in association with Chemical Consultants (Pakistan)Limited.

The studies were defined by UNIDO at the beginning of the study as follows.

> "Specific feasibility studies comprising the review of economic, technical and commercial aspects of the planned production, in particular the determination of such factors as the type of plant and kind and quality of commodities to be produced, plant location, raw materials needed, and a study of the financial aspects to determine capital requirements in both local and foreign currency."

The study was carried out in two phases. Phase I involved the analysis of information already available in a number of reports and the preparation of preliminary feasibility studies for a number of projects which were selected as being viable for Pakistan. At the end of Phase I an Interim Report was presented and, following a review period, four projects were then selected for more detailed analysis in Phase II.

It was intended that these four projects would be selected from among those recommended and analysed in a preliminary way in Phase I. On completion of Phase I, however, it was apparent that new projects must be selected. This was because a number of the projects proposed in Phase I had been analysed by independent consultants and others were no longer able to meet Pakistan's production needs because of certain projects which had received outline government approval during the course of Phase I. For this reason four new projects were selected for study in Phase II with the approval of the Pakistan Government, UNIDO and UNDP. The projects selected were now mainly concerned with the longer term planning of the Pakistan petrochemicals and fertilizer industry rather than feasibility studies of projects for immediate implementation.

1.1 Introduction - Continued

This report covers the whole study and is divided into five volumes. Volume I provides an introduction to the whole study and the conclusions arising from it, together with a summary of the Interim Report. Volumes II to V inclusive each cover one of the four projects studied in Phase II.

1.2 Scope of Phase I

The scope of Phase I may be summarised as follows:-

(a) Consideration of the documentation made available to H & G. This is listed in Appendix 1 of this Report.

(b) Identification and selection of promising petrochemical end-products and investigation of their production cost in the light of available raw materials and possible process routes.

(c) With the above information in hand, a minimum of two alternative processing schemes for petrochemical production units with utility plants and off site installations in East and West Pakistan respectively were to be compiled and submitted to a detailed economical analysis.

(d) Similarly, as outlined in (b) and (c) above, preliminary feasibility studies for fertilizer production units with utility plants and off site installations in East and West Pakistan respectively were to be prepared of which two for each wing were a minimum requirement.

(e) Preparatory survey of sites which appear practical for the execution of the proposed facilities and an evaluation of their respective merits and recommendations for the selection of the most appropriate ones.

(f) Preparation of a report (this is referred to as the Interim Report) covering the findings and conclusions in this part of the study, and recommendations for the selection of the cases to be closer studied under Phase II of the Contract.

1.3 Scope of Phase II

At the end of the project review stage, which came following the submission of the Interim Report (described in Section 2.7), the following four projects were selected for study in Phase II of the contract, and a technical and economic appraisal was carried out on each project.

Project No.1 - The further development of the petrochemicals complexes currently planned for East and West Pakistan.

Project No.2 - Proposals for the development of the aromatics, synthetic rubber and fibres industries in Pakistan in association with refinery and petrochemicals operations.

1.3 Scope of Phase II - Continued

Project No.3 - The utilisation of by-product gypsum from the TSP plants at Chittagong in East Pakistan.

Project No.4 - The development of the existing fertilizer factory at Multan in the context of future fertilizer requirements.

The work in Phase II was concluded by the preparation of a Final Report of which this volume forms a part.

1.4 Phase I-Implementation

The first step in Phase I was to review documentation made available by U.N.I.D.O. (Appendix I) and analyse the market data; projections of fertilizer and petrochemicals market data for the period 1970/80 were made. In the case of petrochemicals, those materials whose production in Pakistan was considered viable, were then selected. For both fertilizer and petrochemicals, a number of possible processing schemes were prepared and the schemes were evaluated economically. From these, schemes were selected for detailed analysis.

In matching the production capacity of the plants proposed to the market for the products, the problem of partition of the country into two Wings immediately arises. In the case of fertilizers the only indigenous raw material is natural gas and this is available in both Wings. Market requirements are sufficient in each Wing to consume the output from a modern, large-scale plant. It is therefore logical, and indeed economic, to satisfy the requirements of West Pakistan from plants in that Wing and those of East Pakistan from plants in the East. For petrochemicals, however, the situation is different. The market in one Wing, even in 1980, may not be large enough for a viable plant. In addition, petrochemical products are mainly higher value materials and inter-Wing transport costs are not so high in relation to total product value. Petrochemical processing schemes were therefore considered in sets of pairs of complementary plants in East and West Pakistan. Each pair of plants considered was designed to match the total market in East and West Pakistan for each viable petrochemical product.

The second factor which had to be decided at the start of the study was the treatment of production from:

(i) existing plants,
(ii) those under construction,
(iii) sanctioned new plants not yet under construction and
(iv) those merely planned.

The principle adopted for Phase I only was that, in deciding capacities for plants proposed in the study, the production from existing plants and those under construction would be taken into account while that from the other two categories would not. The study would then tend to confirm

1.4 Phase I - Implementation - Continued

or oppose those projects in categories (iii) or (iv) on which construction work had not been started. In principle it would be possible to modify or abandon projects in categories (iii) and (iv), if the study showed them to be unsuitable. In practice, this is what happened as will be seen from Section 2.7 of this volume of the report.

Finally in this general introduction, there is the question of exporting petrochemicals and fertilizers produced in Pakistan. It would always be possible for Pakistan to export its products at or about the World Market price. The question is whether the long-term World prices will be high enough to recompense Pakistan for the marginal costs of production and transport (foreign exchange and Rupee). The international trend is towards the construction of large merchant plants on the site of low-cost raw materials. Thus, for example, in considering the export of urea the production costs must be compared with those in other areas of the World which might compete for the same export market. Such a wide-ranging, multi-product study of the export potential of Pakistan's fertilizers and petrochemicals is not within the scope of the current study. Consideration was therefore concentrated on the home market and the agreed import requirements of other RCD Group countries.

1.5 Phase II - Implementation

Following the review of the Interim Report, the projects listed in Section 1.3 were selected. Projects which had received outline Governmental approval were now taken as the starting point for Phase II even though construction of the projects had not started. Thus Project No.1 (Volume II) assumed that Fauji's project at Korangi and EPIDC's petrochemical project at Ashuganj would proceed as envisaged at the start of Phase II of Humphreys & Glasgow's study. A similar assumption was made in respect of Punjab Fertilizers and Hyeson's projects in West Pakistan when carrying out Project No.4 (Volume V).

1.6 Conclusions

1.6.1 Project No.1 - The further development of planned petrochemical complexes

The Fauji Foundation Complex at Korangi is already planned for an expansion of the ethylene cracker to 60,000 MTPA ethylene in Phase II of the complex. H & G recommend that the expended capacity is used for the production of:-

23,600 MTPA polyethylene (additional)
10,000 MTPA dodecyl benzene

Phase I of EPIDC's complex at Ashuganj has not yet been finalised in all details. Based on latest information available to H & G, it is proposed that Phase II of the complex provides for additional acetylene production of 19,150 MTPA. Phase II products should be:-

1.6 Conclusions

1.6.1 Project No.1 - The further development of planned petrochemicals complexes - continued

16,000 MTPA dioctyl phthalate
8,400 MTPA vinyl acetate
1,650 MTPA acetic acid for sale

1.6.2 Project No.2 - The development of the aromatics, synthetic rubber and fibres industries

Expansion of nylon polyester fibres industry based on imported caprolactam and polyester chip should be initiated at once. Single sites in East and West Pakistan are recommended and Karachi and Chittagong are proposed. Production at the sites would be built up by stagewise construction of units of about 2500 MTPA capacity. Total production would reach about 17,500 MTPA of polyester and 17,000 MTPA nylon by 1980.

The rate of growth of synthetic fibre use in Pakistan cannot be predicted with certainty. The rate will be affected by the degree of technical service provided by producers and the readiness of the textile industry to incorporate synthetic fibre.

The production of SBR synthetic rubber will be attractive by the late 1970's. It is proposed that butadiene be extracted from pyrolysis gasoline and the small amount of styrene required would be imported, for an SBR plant of 10,000 MTPA capacity.

It is anticipated that the growing consumption of fibres and other aromatics will justify the start-up in 1976, or shortly after, of an aromatics extraction unit with associated 15,000 MTPA caprolactam and 13,500 MTPA terephthalic acid units. In principle either the refinery at Chittagong or the refinery complex at Karachi is a suitable location. There are considerable cost advantages in selecting the Karachi site, arising from the larger scale of refinery operations there, and the local availability of pyrolysis gasoline with a high benzene content.

1.6.3 Project No.3 - Utilisation of By-Product gypsum at Chittagong

A scheme to manufacture sulphuric acid and cement clinker from the by-product gypsum leaving the phosphoric acid plant is considered to be the only alternative to dumping the gypsum. The project is considered to be technically viable. Economic viability is dependent on forecasts of sulphur price during the life of the project. Two sulphur price levels have been considered - the current figure quoted by EPIDC ($ 57.8/MT) and a probable lower limit of $ 40/MT. Even at $ 40/MT, there is a net foreign exchange saving resulting from the project. At the upper level of sulphur

1.6.3 Project No.3 - Utilisation of By-Product gypsum at Chittagong - continued

price, the Rupees expenditure per $ saved is acceptable and the DCF rate of return to EPIDC is estimated at 22% before tax. At the lower sulphur price, DCF return on the project falls to 5% and Rupee expenditure per $ saved may well be considered excessive.

Although no full-scale plant based on by-product gypsum is yet in operation, the licensors of the process are considered to have taken adequate steps to confirm the technical viability of using by-product gypsum in a process which is otherwise well-known and well established.

1.6.4 Project No.4 - Future development of WPIDC's Multan Fertilizer Plant

Because of the unsatisfactory economic position of the current ammonia units, development of the site must be based on the erection of a modern ammonia unit with capacity of at leat 600 MTPD.

Humphreys & Glasgow have examined the combination of such an ammonia plant in two alternative schemes. The schemes are a 1000 MTPD urea project and a nitrophosphate project. In either of the schemes the major part of the existing plant units and off-site facilities would continue to be utilised.

The opportunity to undertake such a project at present is related to the N fertilizer consumption forecasts for West Pakistan and progress of projects currently sanctioned.

The projected consumption figures would not allow for a new ammonia plant of 600 MTPD capacity to be started up by WPIDC before 1977/78 assuming that both of the other sanctioned projects go ahead.

Significant savings in foreign exchange and Rupee capital expenditure would result from the inclusion of WPIDC's existing facilities in a development project of the type outlined.

If the development of WPIDC's Multan site is delayed until 1977/78, then there will be two major consequences. Firstly, by the time a development does take place, considerably less of the existing facilities at the site will have sufficient further life to justify their re-use in a new project. Secondly, it will be necessary to modify the urea plant now and revise the financial structure of the site. Possibilities for obtaining a cheaper source of ammonia should be examined.

VOLUME I

SECTION 2.

SUMMARY OF INTERIM REPORT

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CONTENTS - CONTINUED

CONTENTS - CONTINUED

CONTENTS - CONTINUED

SECTION 2

SUMMARY OF INTERIM REPORT

2.0 Introduction

Phase I of the study commenced at the beginning of August 1969 and was completed with the submission of an Interim Report to UNIDO at the end of November 1969.

The Interim Report consisted of one volume of approximately 200 pages made up of the following Sections, together with a covering Letter and Synopsis.

Section 1 - Basis of Study

Section 2 - Market Analysis

Section 3 - Site Evaluation

Section 4 - Raw Materials and Utilities

Section 5 - Process and Product Scheme Evaluation

Section 6 - Schemes Proposed

Section 7 - Conclusions and Recommendations

Section 8 - Appendices

Following discussions with U.N.I.D.O. in Vienna in December 1969 and in Pakistan in January 1970 a number of additions and modifications were made to the Interim Report as submitted - primarily to make the Report easier to follow, and revised and additional pages were submitted to U.N.I.D.O. in January 1970.

In the following pages a summary of the main information, conclusions and recommendations of the Interim Report has been made. This has been presented under the following headings, which, it is felt, will make the summary easier to read:-

2.1 Basis of Work

2.2 Market Analysis

2.3 Site Data

2.4 Fertilizer Scheme Studies

2.5 Petrochemical Scheme Studies

2.6 Conclusions and Recommendations

2.1 Basis of Work

This has already been outlined in Section 1 of this volume. It is necessary, however, to state the basis of the financial analysis and the basis of assessment of viability of the project schemes, carried out in Phase 1 of this Study.

2.1.1 Method of Financial Analysis

There have been two stages of financial analysis in Phase I:

(i) Analysis of the various process routes.

(ii) Analysis of projects based on process routes which appear most attractive.

The technique adopted was different for the above two stages. Since it was necessary to analyse a large number of routes in the first stage, a less detailed financial analysis was possible. The technique adopted was to work out the production costs (both total and foreign exchange element) for each product when the plant is operating at its intended production capacity. This technique gave a common basis for all processing schemes. In the case of fertiliser plants the schemes were then compared with one another on the basis of total and foreign exchange costs. For petrochemicals, the costs resulting from different schemes were compared with each other and with the costs of imported materials.

In carrying out costing for stage (i), only capital costs of "battery limits" plants were considered and utilities were charged at typical costs from utilities plants, these costs including the capital and foreign exchange elements. The cost data used in this stage are listed in Sections 4 and 5 respectively of the Interim Report, and are given in Sections 2.3 to 2.5 of this summary. A number of points about the cost analysis need to be made for clarification:-

(a) The level of capital charges in such a process scheme analysis is always a matter for some debate. In our studies the figure of 21% has been used made up from 8% interest (or return on capital) with depreciation over 10 years (non-linear) and maintenance at 5 - 6% annually of capital invested. The same percentage has been used for both foreign exchange and rupee elements.

2.1.1 Method of Financial Analysis - continued

(b) In such an analysis of many process routes, it is not possible to make detailed allowance for all of the charges associated with start-up and commissioning. Such charges include interest during construction and commissioning, start-up costs and provision of working capital, failure to reach full capacity in initial years, etc. To allow for such costs 15% was added to the battery limits capital costs of plants.

(c) As in (b) above, it is not feasible to assess accurately all "overheads" costs associated with each production unit. Again a flat rate of 10% was added to thecost of each end product to cover such overheads as administrative, planning, selling costs, etc.

(d) In estimating battery limits capital costs, it was assumed that during the life of the plant annual production would average about 90% of what would be achieved in a similar facility in a European location. This appears to be a reasonable assumption on the basis of past experience in Pakistan, and is in line with the recommendations of UNIDO staff.

For stage (ii) analysis of the projects- the steps undertaken were as follows:-

A Select process schemes for project proposal.

B Use market data (period 1973 - 80) together with data on existing plants to decide :

(i) capacity, and
(ii)stages of construction for project.

C Prepare block diagram of project showing plants with capacities and inter-plant material transfers.

D Estimate total utility requirement for project and specify all facilities outside Battery Limits.

E Select site. Outline work requirements - filling, wharfs, roads, etc. Specify raw material and product handling, storage, loading/off-loading facilities.

F Estimate capital costs of plant units and total site facilities.

G Estimate production costs of each product from the project (including all handling costs, etc. up to departure of products from site).

H Estimate cost of products in the market including average costs of transport from plant site to point of sale.

2.1.1 Method of Financial Analysis - continued

I Prepare financial analysis of project. In preparing the financial analysis it will be necessary to assume output for initial years after start up. For the first two years, 30% and 70% of planned capacity respectively was assumed, in subsequent years 100%. (These figures, however, must not be in excess of market requirements).

An analysis of the product costs was made for the initial period of the life of the complex. The utility costs have, however, been estimated separately for the utility facilities associated with each project.

2.1.2 Assessment of Viability

The basis for assessment of viability is different for fertilizers and petrochemicals. In the case of fertilizers it is necessary to compare the different process routes, which can be adopted to satisfy the market requirements, with one another. The comparison is based primarily on the difference in the foreign exchange components of operating costs. At the same time it is necessary that foreign exchange is not saved at the expense of excessive additional Rupee costs.

For petrochemicals the problem of viability is rather different. The first step was to assess those products for which the market in the 1970's would result in a production unit of viable size. A unit would not be viable if it were very small by current international standards; apart from production costs being high, it would be difficult to interest process licensors in the construction of a very small unit. The second step is to calculate production costs in Pakistan for those products required in sufficient quantities. The foreign exchange element of these costs can then be compared with the C & F price of imports. The final step is to compare process routes which can be adopted for products whose internal production will result in a foreign exchange saving.

2.1.3 Taxes and Duties in Pakistan

The financial evaluation work in Phase I of this study has been based on cost data which includes local taxes, duties and bonus voucher regulations applicable to imported materials. Changes in these provisions or in their levels will, of course, affect the Rupee element of the study. They do not, however, have any impact on the foreign exchange element.

The application of subsidies to fertilizers does, of course, offset the application of charges on phosphate rock and potash which increase their cost to the fertilizer manufacturer by a factor of two.

2.2 Market Analysis

2.2.1 Introduction

2.2.1.1 General

The object of the Phase I part of the Pre-Investment Study for Pakistan was to put forward specific projects based on the needs for petrochemicals and fertilizers where there is an economic justification. The Reports from earlier parts of the Pre-Investment Study and other sources gave the actual consumptions and the probable future needs for the products. The Reports also cover problems in distribution and marketing.

Humphreys & Glasgow were asked by U.N.I.D.O. to start by reviewing the available documentation critically so as to extract the information on which to base the current study-notably, the proposing of specific plants and processes and making economic studies of these.

2.2.1.2 Bibliography

For convenience, Appendix I lists the reports and papers which have been made available. The reference numbers in that Appendix apply throughout this report.

2.2.2 Presentation of Information

The Phase I study was concerned with many products, a wide range of quantities and span of 15-20 years. In many cases there are estimates for different periods within the overall span.

From the documentation made available to H&G, a study of the present and future fertilizer and petrochemical markets and production in both East and West Pakistan was made and, from the various estimates and predictions, H&G formed their own opinion of the fertilizer nutrient and petrochemical products required for the period under review. These are given in summary tabular form below.

2.2.3 Fertilizers

2.2.3.1 Table of Fertilizer Consumptions in Pakistan

The estimated fertilizer nutrient consumptions for both West and East Pakistan and totals for Pakistan in terms of N, P_2O_5 or K_2O are given below. (Note that for both wings the fertilizer usage, which would be needed to achieve self-sufficiency in the production of balanced dietary requirements in Pakistan, is higher than the consumption figures quoted.)

A. Nitrogen (.000 tons)

	73/74	74/75	75/76	76/77	77/78	78/79	79/80	80/81
EAST	260	320	375	430	485	528	560	590
* WEST	478	536	570	600	620	630	635	640
Total	738	856	945	1030	1105	1158	1195	1230

B. Phosphate (.000 tons)

	73/74	74/75	75/76	76/77	77/78	78/79	79/80	80/81
EAST	120	160	215	270	335	395	442	480
* WEST	183	214	225	235	245	260	270	280
Total	303	374	440	505	580	655	712	760

C. Potash (.000 tons)

	73/74	74/75	75/76	76/77	77/78	78/79	79/80	80/81
EAST	60	90	120	156	190	235	275	320
WEST	35	50	63	76	90	103	116	128
Total	95	140	183	232	280	338	391	448

Notes:

* 1. The Nitrogen and Phosphate fertilizer consumption data for West Pakistan were slightly different in the Interim Report. During the discussion with UNIDO/Pakistan Government representatives in Jan./Feb.1970, they were increased and aligned with the projections for 1973/74 and 1974/75 which have been made by the Sectoral Working Group following detailed analysis.

2. The N : P_2O_5 ratios in the above table are 2.6 : 1 and 2.2 : 1 for West and East Pakistan respectively for 1973/74, whereas present sales are running at about 6 : 1.

2.2.3 Fertilizers

2.2.3.1 Table of Fertilizer Consumptions in Pakistan - continued

Humphreys & Glasgow consider, therefore, that if the lower ratios are to be achieved, considerable attention will need to be given to agricultural extension services, including means of making phosphate fertilizers more attractive to the farmers, possibly by appropriate adjustments to the fertilizer subsidies.

2.2.3.2 Table of Existing Fertilizer Capacity

A summary table of fertilizer production from existing plants and plants under construction in West Pakistan is given on Page 2.8 . For East Pakistan this is given on Page 2.9.

WEST PAKISTAN

Estimates of Fertilizer Production from existing plants and plants under Construction during Fourth Plan Period (1970-75) (i.e. plants existing, under construction or for which contracts have been placed) - As at 30.11.1969

FACTORY	Type of Fertilizer	Capacity (000 Tons) Fertilizer	Nutrient	1969-1970	70-71	71-72	72-73	73-74	74-75	REMARKS
				Thousand Nutrient Tons						
. NITROGENEOUS	N									
1. Pak-American Fertilizer Factory, Daudkhel.	Ammonium Sulphate	95	20	13.5	15.5	18	18	18	18	Extension in Operation since Mid 1969.
2. Natural Gas Fertilizer Factory, Multan.	i) Ammonium Nitrate	120	32	27	29	29	29	29	29	- do -
	ii) Urea	67	31	26	28	28	28	28	28	- do -
3. Esso Pakistan Urea Fertilizer Factory, Dharki.	Urea	170	78	63	70	70	70	70	70	In Operation since Nov. 68
4. Dawood Hercules Chichoki Malian/ Sheikhupura	Urea	340	156	-	-	78	110	141	141	Mid 1971
	TOTAL N			129.5	142.5	223	225	286	286	
PHOSPHATIC	P_2O_5									
1. Lyallpur Chemical Fertilizer Factory Ltd., Lyallpur & Jaranwalla	S.S.P.	54	10	7	9	9	9	9	9	
2. Jaffa Brothers, Karachi.	T.S.P.	150	69	-	-	35	48	62	62	Mid 1971 start-up
	TOTAL P_2O_5			7	9	44	57	71	71	

NOTE: Maximum production from existing and projected plants has been estimated on the basis of 90% of their rated capacity.

NOTE: Between 30.11.69 and July 1970, a project sponsored by Hyesons was sanctioned for 340,000 MTPA urea. The Jaffa project was revised for the production of 120,000 MTPA mono-ammonium phosphate.

EAST PAKISTAN

Estimates of Fertilizer Production from existing plants and plants under construction during Fourth Plan Period(1970-75) - As at 30.11.1969

FACTORY	Type of Fertilizer	Capacity (000 tons) Fertilizer	Nutrient	1969-1970	70-71	71-72	72-73	73-74	74-75	REMARKS
					Thousand Nutrient Tons					
NITROGENEOUS										
1. Natural Gas Fertilizer Factory - Fenchuganj (E.P.I.D.C.)	i) Urea	114	52.5	40	45	47	47	47	47	
	ii) Ammonium Sulphate	12	2.5	1	2	2.3	2.3	2.3	2.3	
2. Natural Gas Fertilizer Factory - Ghorasal (E.P.I.D.C.)	Urea	340	156	-	62	110	141	141	141	Start-up Mid 1971
	TOTAL N			41	109	159.3	190.3	190.3	190.3	
PHOSPHATIC										
1. Triple Superphosphate Factory I - Chittagong (E.P.I.D.C.)	T.S.P.	32	15	5	10.5	13.5	13.5	13.5	13.5	
2. Triple Superphosphate Factory II - Chittagong (E.P.I.D.C.)	T.S.P.	120	55	-	14	38.5	50	50	50	Start-up Mid 1971
	TOTAL P_2O_5			5	24.5	52	63.5	63.5	63.5	

NOTE: Maximum production from existing and projected plants has been estimated on the basis of 90% of their rated capacity.

NOTE: Between 30.11.69 and July 1970, three further projects were sanctioned but construction has not yet started.

1. EPIDC project at Ashuganj for 320,000 MTPA urea.
2. IML project at Ashuganj for 340,000 MTPA urea.
3. Bengal Heavy Chemicals project at Khulna for 120,000 MTPA TSP.

2.2.4 Petrochemicals

2.2.4.1 General

As noted elsewhere in this report, a study of Pakistan's domestic requirements for petrochemical products should be developed considering the total national needs as well as the separate demands in each wing, if the results of such a survey are to lead to an optimum solution incorporating such conflicting requirements of a minimum economic plant size, the most suitable feedstock, and the need to proceed with a balanced industrial development in both wings. For this reason the market demand predictions are dealt with firstly on a commodity basis rather than a geographical one.

The scope of the present section is strictly limited to the Pakistan domestic market. At least one project currently under consideration is based on the development of an export market to achieve production units of sufficient size to yield products at prices similar to those prevailing in the world markets. However, the market surveys available to Humphreys & Glasgow have been limited to the Pakistan domestic market and in some cases in R.C.D. countries; no surveys of any significance covering potential export markets have been made available for study by Humphreys & Glasgow and the capability of offering commodities for export at competitive prices does not of itself insure that an outlet for these exports in bulk exists. In the absence of data on potential export markets (other than the R.C.D., countries), petrochemical exports have been excluded from this report.

The project of the Fauji Foundation for a petrochemical complex in West Pakistan based on surplus naphtha from the Pakistan refinery was not included in the market analysis as a sanctioned project. At the date of writing this Final Report, the project is sanctioned and contracts for construction are under negotiation. A summary table of existing and sanctioned petrochemical operations is given on pages 2.17 and 2.18.

2.2.4.2 Projected Demands for Petrochemicals

In the following tables and notes the estimated demands for petrochemicals in Pakistan are given:-

(a) Polyethylene (Low Density)

Table of Projected Demand - PE (low density)

Quantities given in 1000 tons.

Year	1972	1974	1976	1978	1980
West	8	13	18.5	27	40
East	7	8.5	11.5	16	22
Total	15	21.5	30.0	43	62

2.2.4.2 Projected Demands for Petrochemicals - continued

(b) Polyethylene (High Density)

The total Pakistan high density polyethylene demand as predicted by the Battelle Institute rises from 1100 tons in 1972 to 4100 tons in 1980. The demand in East Pakistan is not expected to be more than 320 tons in 1975.

The market figures given do not justify consideration of domestic production in the period under review.

(c) Polyvinyl Chloride (PVC)

Quantities given in 1000 tons.

Year	1972	1974	1976	1978	1980
West	9	12	15.5	21	28
East	8	13	17.5	24	32
Total	17	25	33.0	45	60

A feature of the future market for PVC productions in East Pakistan is that it will contain in addition to rigid pipes and sections a significant proportion of footware and waterproof clothing which should be reflected in a higher consumption of plasticisers per ton of polymer than will be found in the West.

(d) Polypropylene (PP)

Table of Projected Demand - Polypropylene

Year	1972	1974	1976	1978	1980
West	2.0	2.5	4.2	6.4	9.7
East	0.4	0.9	2.9	3.8	5.2
Total	2.4	3.4	7.1	10.2	14.9

Quantities given in 1000 tons.

2.2.4.2 Projected Demands for Petrochemicals - continued

(e) Projected Demand for Dioctylphthalate (DOP)

The consumption of Dioctylphthalate in Pakistan is derived directly from the prediction of PVC consumption and the ratio of rigid and plasticised applications foreseen, on the basis of the data available to Humphreys & Glasgow. It has been estimated that the domestic market will consume 8,000 tons of DOP in 1975 and this will increase to 16,000 tons in 1980, the split of consumption between the two wings being 56% in the East and 44% in the West reflecting the larger consumption of plasticised products in the East.

At the present time there is no domestic production of DOP and the forecast demands will need to be supplied from new manufacturing facilities.

(f) Demand for Dodecyl Benzene

Predictions for the demand for Dodecyl Benzene for the production of non-biodegradable detergents amount to 6,850 tons per year in 1975 rising to 13,700 tons/year in 1980 according to the long range predictions of the Battelle Institute, 60% of these demands occurring in the Western wing.

(g) Demands for Other Products

In addition to the products referred to in the previous paragraphs, market data for a number of other products was examined and the conclusions are summarised briefly below:

(i) Polyvinyl Acetate

The total Pakistan market is estimated to be 1,700 tons per year in 1975 rising to 3,400 tons in 1980. Existing and sanctioned manufacturing capacity is in excess of 2,000 tons/annum so that no additional capacity is required for the present.

(ii) Urea Formaldehyde

The estimated domestic market demands for 1975 and 1980 are forecast as 5,600 and 12,800 tons respectively with an additional export commitment of 900 tons/year to Iran. Existing production capacity is 6,750 tons so that there is no necessity to establish additional capacity in the immediate future.

2.2.4.2 Projected Demands for Petrochemicals- continued

(g) Demands for Other Projects - continued

(iii) Phenol Formaldehyde

The estimated domestic consumption of Phenol Formaldehyde for all its applications is approximately 900 tons in 1975 rising to 2,300 tons in 1980, existing and sanctioned production being 1,100 tons per year. In addition to the domestic demand there is a reported export commitment of 2,000 tons/year to Iran which, although agreed in principle, has not yet been implemented and the need for additional production capacity will be strongly influenced by the ratification of this export.

(iv) Methanol

Pakistan's domestic consumption of Methanol is predicted as 4,300 tons in 1975 rising to 9,400 tons in 1980 with a provisional export of 900 tons per year to Iran. Domestic production is presently at the rate of 3,000 tons/annum so that there is an impending need to increase domestic production if imports are to be avoided.

(v) Acetic Acid

Domestic consumption predictions are 600 tons for 1975 increasing to 1,650 tons in 1980, these capabilitities do not justify production as part of a new petrochemicals operation.

(vi) Acetone

The Acetone consumption of Pakistan excluding defence requirements is below 1,000 tons per year on the available predictions for 1980 and current domestic production is able to satisfy this demand. The quantity produced by the ordnance factories is probably considerably in excess of this figure but exact data is not available.

(vii) Methyl Ethyl Keytone

The consumption of this material is on a very small scale (below 500 tons/year for 1980) and is not considered for domestic production.

(viii) Ethylene Glycol

Predictions of domestic consumption give figures of 1,640 tons for 1975 increasing to 3,200 tons in 1980.

2.2.4.2 Projected Demands for Petrochemicals - continued

(g) Demands for Other Projects - continued

(ix) Alkyd Resins

Predictions for Alkyd resins consumptions in 1975 and 1980 are 5,800 tons and 8,500 tons respectively. Existing and sanctioned capacity amounts to approximately 3,700 tons/year so that further increase in production capacity is justified.

2.2.4.3 Feedstocks for Established Plants

The problems of existing petrochemical plants operating at small capacities with expensive feedstocks must be considered as they will have to operate in competition with the proposed new facilities.

The plant of Arokey Chemicals Limited located in Karachi, is reported to be in operation with a design capacity of 5,000 tons/year of PVC from VCM produced by the carbide acetylene route. The new production facilities for PVC in West Pakistan have therefore been designed with the capability of exporting 5,500 tons/year of VCM to Arokey to enable them to produce PVC at competitive production costs.

The production of Polyethylene at Valika Chemical Industries plant in Karachi is at present of the order of 5,000 tons/year with sanctioned extensions subject to the availability of ethylene from a new petrochemicals operation. Therefore an export of 10,500 tons/year of ethylene to Valika has been allowed for in the studies involving naphtha cracking in the Karachi area. It has been assumed in assessing the make up of existing and sanctioned polyethylene production in Pakistan that Valika will base their whole operation on ethylene from the new cracker, giving them a total production capability of 10,000 tons/year of polyethylene.*

By-product caustic soda from the operation of chloralkali cells would seem to have a satisfactory domestic outlet in West Pakistan, but the potential market in East Pakistan is much more uncertain and it is therefore concluded that the production of chlorine for manufacture of chlorinated hydrocarbons in East Pakistan may prove to be more expensive than a similar operation in the West due to the inability to obtain a satisfactory price for the byproduct caustic.

* Valika's sanctioned capacity is actually 15,000 tons/year including 5,000 tons/year based on ethylene from ethanol (see also volume II).

2.2.4.3 Feedstocks for Established Plants - continued

Pyrolysis Gasoline produced as a by-product of ethylene and propylene production is a suitable feedstock for a future aromatics operation. However, its utilisation as a fuel must be foreseen until such time as an aromatics project becomes financially attractive.

2.2.4.4 Fibres

The collation of market predictions of artificial fibre consumption in Pakistan presents some difficulties since different researchers have disagreed on which are the most suitable fibres for the domestic market, and in some cases the emphasis has been given to one type of fibre because its production is conveniently incorporated within a particular development project.

To enable some conclusions to be drawn from the available data, two criteria have to be examined in selecting the leading fibres:

(a) To choose a fibre which can be blended with cotton to upgrade the quality of textiles and release cotton for export.

(b) Take guidance from the established trends in comparable developing countries.

Using this approach, it is concluded that Nylon and Polyester fibres in that order will become established as the principal fibres in the period under review and that Polypropylene and PVC fibres can be ignored.

Acrylic fibres would seem to have a lower value in the Pakistan market as their capability of blending with the more important natural fibres in textile production is inferior to nylon.

Current and sanctioned nylon production totals 4,000 tons/year, there is no current production of polyester fibre.

Forecasts for domestic consumption for 1975 are of the following order:

Nylon : 11,000 to 15,000 tons/year

Polyester : 5,000 to 7,000 tons/year

2.2.4.4 Fibres - continued

The lower predictions are based on the present price level and the demand is held to be strongly price elastic in the present decade.

On the basis of these predictions an extension to the nylon industry and the establishment of polyester production based on imported feedstocks is justified.

Capacity of Existing and Sanctioned Petrochemical Operations - W and E Pakistan
(not including the Fauji Foundation Complex)

Material	Company	Place	Nominal Capacity tons per annum	REMARKS
Polyethylene (existing)	Valika Chemical Industries Ltd.	Karachi	5000	Started 1967 Capacity 1967 - 1,000 Tons Capacity 1968 - 3,000 Tons Full production not yet achieved.
Polyethylene (sanctioned)	Valika Chemical Industries Ltd.	Karachi	10,000	Polyethylene from ethylene.
Polypropylene	-	-	-	No existing production
Polyvinyl Chloride	Arokey Chemicals Ltd.	Karachi	5000	Started Mid 1969
Polyvinyl Acetate (existing)	Futehilly Chemicals Ltd.	Karachi	600	Started 1967
Polyvinyl Acetate (sanctioned)	Hoechst Pharmaceuticals Ltd.	Karachi	1000	
" "	Pakbay Co.	Dacca	500	
Polystyrene	-	-	-	No existing production or sanctions
Polyacrylates	-	-	-	No existing production or sanctions
Phenolic Resins (existing)	Allied Industries Azmat Industries Zaheer Industries	Wazirabad Gujranwala Sialkot	10 280 600	Started production 1958 Under Construction 1968
Phenolic Resins (sanctioned)	M.M. Industries	Gujranwala	210	Due for erection 1970-71

Continued...

Capacity of Existing and Sanctioned Petrochemical Operations (not including the Fauji Foundation Complex - cont.

Material	Company	Place	Nominal Capacity tons per annum	REMARKS
Urea Formaldehyde (existing)	Valika Chemical Industries Ltd.	Karachi	2700 and 1000	
	Eastern Chemical Industries Ltd.	Chittagong	1300 and 350	
	Synthetic Resin Products Ltd.	Chittagong	1300	
Urea Formaldehyde (sanctioned)	Kahmir Development Corporation	Jhelum	4400	
Polyurethane	-	-	-	No domestic production
Alkyd Resins	Jenson and Nicholson of Pakistan Ltd.	Karachi	600	Started 1966

2.2.5 Pesticides

2.2.5.1 Forecast

A forecast of the 1980 requirements was prepared by Chemical Consultants Limited following detailed analysis, and assuming the same general pattern as at present. This is given below:

Forecast 1980 Pesticide Requirements

Pesticides (in terms of active ingredient)	Quantity (tons)
West Pakistan	
DDT	736
BHC	1,535
Malathion	2,224
Diptrex	447
Methyl Parathion	1.69
Endrin	2,127
Metasystax	1,235
Dimecron	763
Sevin	1,715
Diazinon	346
Toxaphene	3,430
Aldrin	826
DDVP	181
East Pakistan	
Carbicron/Dimecron	2,000
Diazinon	1,300
Metasystax	1,140
Nogos/DDVP	771
Malathion	2,696
DDT	240
Sevin	2,891
Methyl Parathion	250
Endrin	132
Others	
Organic Fungicides (Dithane, Antrocol, Zerate & Mercurials)	800 - 1,000
Rodenticides (Zinc Phosphide & Cyn gas)	700 - 800
Weedicides	500 - 600

These quantities are considerably less than those forecast for 1969-70 in Reference 54 but specifically relate to the active ingredient alone.

2.2.5.2 The General Situation

There are many and rapid changes in the practice of using insecticides: technical development is fast and the public attitude towards specific insecticides undergoes changes as some unexpected consequences come to light. The manufacture of many of the compounds is complex and requires stringent safety precautions so that effort devoted to these would detract from other production of greater importance to the country.

In these circumstances Humphreys & Glasgow are unable to recommend a policy of local production in terms of varieties and quantities to which a government should commit itself because of the costs and likelihood of changes. The list above is sufficient to indicate that the international pesticide industry is extremely complex in terms of marketing and production strategies, while capacities are relatively small. A separate detailed study is necessary. Meanwhile, approval on an ad hoc basis of small projects (in the private sector) for which there is an economic case appears to be the most satisfactory way or proceeding.

2.2.6 The Market Situation - Elastomers, Detergents and Carbon Black

2.2.6.1 Forecast Demands

Three possible end-products from a petrochemical complex which are known to be required in Pakistan, with the estimated demands (Reference 16) are:-

	1967/8	1972/3
	Tons	
Synthetic Rubber	3,000	6,000
Carbon Black	1,300	3,000
Detergents	2,500	14,000

2.2.6.2 Detergents

Detergents are the key to higher standards of hygiene, less effort in laundering and greater durability of fabrics. They have also extensive uses in industry. The forecast of a rapid rise in consumption if therefore expected, and any economic production unit will quickly become loaded as the demand rises. A policy decision will be required on the extent to which non-biodegradable detergents should be manufactured, or even imported, since there are alternatives.

2.2.6.3 Synthetic Rubber and Carbon Black

Forecast demands were considered to be too small to justify local manufacture in the near future .

2.2.7 "World Prices" for Key Materials

2.2.7.1 General

For the economic calculations and comparisons in Phase I of this study it is frequently necessary to have a base price at which a material could be supplied from a hypothetical free world market to Pakistan. This is defined as the probable cost (C&F in Karachi) in quantities of the order of one-tenth of the estimated annual consumption or more.

For convenience the base prices (World Prices) used for petrochemical materials are set out below:

World Prices of Petrochemicals

	US Dollars/ton
Polyethylene LD	300
PVC powder	250
Dioctylphthalate	450
Polypropylene	340
Polystyrene	275
Polyvinylacetate	320
Urea Formaldehyde	420
Acetic Acid	220
Ethylene Glycol	220
Vinylchloride monomer	175
Ethylene	N.A.
Acetone	150
MEK	200
Methanol	80
DDB	300
Phthalic Anhydride	280
Alkyd Resin	450
2-Ethyl Hexanol	300

2.3 Site Data

In this section the sections on "Site Evaluation" and "Raw Materials and Utilities" - Sections 3 and 4 of the Interim Report are summarised.

2.3.1 Site Evaluation

2.3.1.1 Maps

On page 2.25 a map of West Pakistan is included which shows the location of the sites of the projects studied.

On page 2.28 a similar map of East Pakistan is included.

2.3.1.2 Site Availability - West Pakistan

(a) General Description of West Pakistan

West Pakistan may be divided basically into three regions:-

1. The mountainous North and North West.
2. The table land of Baluchistan to the West of the mountain wall and,
3. The basin of the Indus river including the Punjab area, right down to the port of Karachi.

The third of the above regions is the most important from the point of view of agriculture and it is also in this region that industries have mainly been, and are being established.

Due to low rainfall, about 66 per cent of the total cropped areas in West Pakistan depends on irrigation. This has been achieved largely by harnessing the major rivers Indus, Chenab, Jhelum, Ravia and Sutlej and providing an extensive system of irrigation canals.

2.3.1.2 Site Availability - West Pakistan

(b) Location of Basic Raw Materials

Basic raw materials for ammonia-based fertilizer plants and for petrochemicals are natural gas and naphtha. As described in Section 2.3.2, the natural gas fields of particular interest to this study are the Sui and Mari gas fields. The Sui field is situated about 190 miles south west of Multan, the Mari field is about 50 miles south of the Sui field.

The Mari gasfield supplies gas by pipeline to the Esso Pakistan Fertilizer Co. at Daharki. From the Sui gasfield however, a gas transmission system is in existance to Karachi in the south and as far north as Islamabad.

Further extensions of the system are also planned to Peshawar and Gujranwala in the north and there are future plans (after 1972 but before 1975) to supply gas to the Industrial area of Daudkhel by laying a new line from Dulian, a gas field itself but connected to the Sui Northern Gas Companies system.

(c) Choice of Sites - West - Fertilizers

From a preliminary selection of twenty possible sites for fertilizer plants in West Pakistan and taking into acoount such factors as gas availability and the location of markets five sites were selected as being of particular interest. These are:

1. Daharki

   Located about ten miles west of the Mari gas field adjacent to the existing Esso natural gas fertilizer factory.

2. Multan

   Located about four miles south west of Multan city, a most important town on the gas pipeline with good water and other facilities.

3. Sidhnai

   Located about two miles south west of the Sidhnai barrage in District Multan, also on the gas pipe line with good water and rail facilities.

4. Chiniot

   Located near the centre of the marketing belt for fertilizers, in District Jhang about eight miles from Chiniot city, with good water facilities.

2.3.1.2 Site Availability - West Pakistan - continued

(c) 5. Ismailwal

Located at the foot of the West Pakistan Salt Range in District Jhelum, near gypsum and shale deposits and the existing cement works of the Ismail Cement Co. Ltd.

Preliminary site data was obtained for these five sites. This information has been presented in tabular form on page 2.29

As described in Section 2.4 two alternative fertilizer plants have been proposed to meet the nitrogen and phosphate shortfall requirements of the West Wing.

A. A complex comprising the following plants: ammonia, nitric acid, nitrophosphate fertilizer and ammonium nitrate limestone fertilizer.

B. A complex comprising the following plants: sulphuric acid from gypsum, phosphoric acid, ammonia and urea/diammonium phosphate fertilizer.

Giving due weight to fertilizer markets and the availability of raw materials such as sulphur, gypsum, phosphate rock and also natural gas, water and communications, it was concluded that the ammonia/nitrophosphate complex should be located at Multan and the ammonia/sulphuric acid plant be located at or near Ismailwal.

(d) Choice of Sites - West - Petrochemicals

For petrochemicals, two alternative sites have been considered:-

1. Karachi

Located at the Karachi Petrochemical centre at Korangi near the sea coast about three miles south east of Karachi. This site is considered for a naphtha based complex.

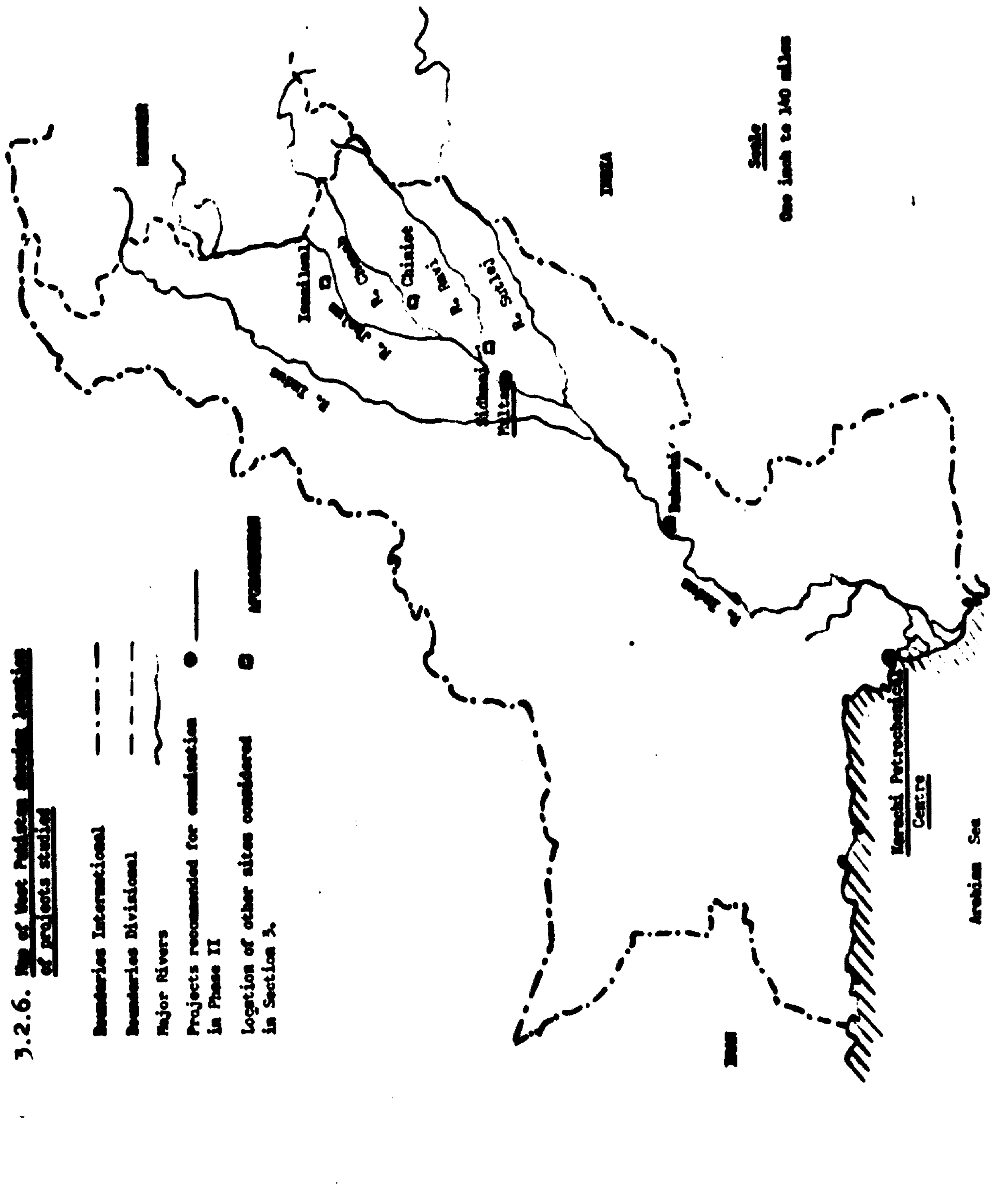
2. Multan

Located adjacent to the fertilizer factory site mentioned above. This site being considered for a petrochemical complex based on natural gas.

Preliminary site data was obtained for these sites and is presented in tabular form on page 2.29.

From an analysis of the two alternative sites it was concluded that Korangi - Karachi is the best site for the first petrochemical complex in West Pakistan.

3.2.6. Map of West Pakistan showing location of projects studied



2.3.1.3 Site Availability - East Pakistan

(a) General Description of East Pakistan

East Pakistan can be basically divided into three areas:-

1. The main populated area, representing the Mymensingh-Dacca-Chittagong area, lying in the North-East, Central and South-East area of the province.
2. The Khulna area lying to the South West.
3. The North Bengal Area lying in the North and North West of the province.

These three areas are separated from each other by big rivers (the Ganges, Jamuna and the Teesta) and communications across these rivers are limited. Thus from the consumption angle, the regions are somewhat isolated and well-defined from each other. However, the presence of large rivers permits easy water transport not only between the zones, but within the zone itself, except possibly in North Bengal.

(b) Location of Basic Raw Materials

In East Pakistan basic raw materials for ammonia based fertilizer plants and for petrochemical plants are largely confined to the first of the three zones mentioned above. The natural gas fields are in the North East, and naphtha, when available, in the South East at Chittagong. Therefore, pending the establishment of a second refinery in the Khulna Area, all projects based on gas or on naphtha, must, of necessity be located in the Centre or North East Area (between Dacca and Sylhet) or in the South East (Chittagong area).

(c) Choice of Sites - East - Fertilizers

As outlined in section 2.4 two plants have been proposed to meet the requirements of the East Wing.

Those are:-

1. A complex comprising the following plants: sulphuric acid from sulphur, phosphoric acid and triple super phosphate fertilizer.
2. An ammonia plant and a urea fertilizer plant.

Possible sites at Chittagong and Khulna were considered for the TSP Complex and Ashuganj or Ghorasal or Chittagong for the ammonia/urea plant.

2.3.1.3 Site Availability - East Pakistan - continued

It was concluded that the TSP plant (the third one to be built in East Pakistan) should be located in the Khulna/Chalna area, and the ammonia/urea plant located at Ashuganj adjacent to the proposed petrochemical complex.

Preliminary site data was obtained for these sites and is presented in tabular form on page 2.29.

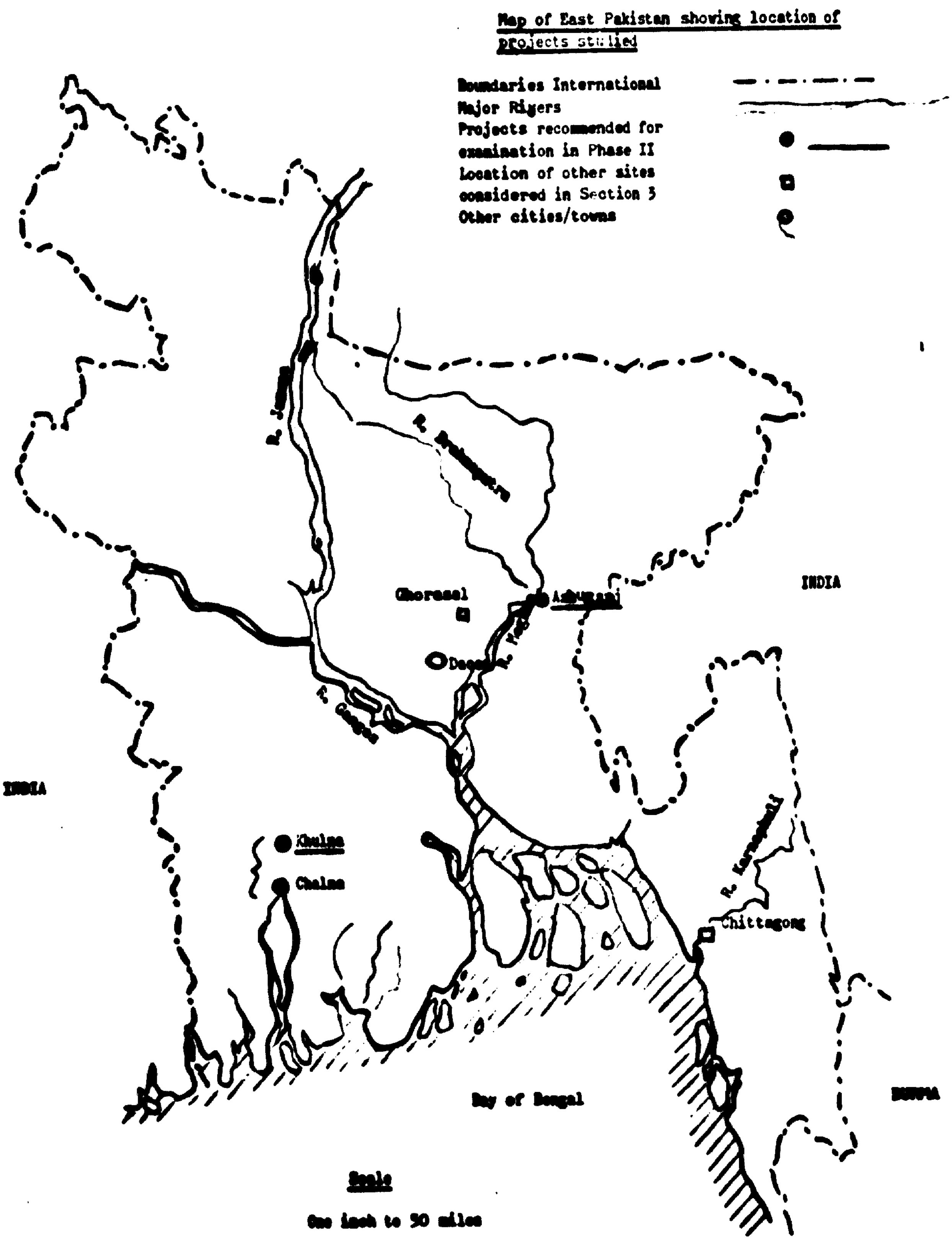
(d) Choice of Sites - East - Petrochemicals

Possible sites at Chittagong and Ashuganj were considered for a petrochemical plant in East Pakistan. Ashuganj for a complex based on natural gas - being situated only ten miles from the Titas Gas Field, and Chittagong for a complex based on the use of naphtha as basic raw material.

It was concluded that Ashuganj was a suitable site for a natural gas petrochemical plant.

With regard to Chittagong, there are a number of possible sites which have been investigated with a view to siting a natural gas based urea plant of about 340,000 tons of urea product per annum. Then the Halda Industrial Estate on the west bank of the Karnaphuli river would appear to be most advantageous. As no firm date can be put on the availability of natural gas in Chittagong, Chittagong has to be considered as a possible site for a naphtha based petrochemical complex.

It is not known for certain at this stage, whether the required acreage of land would be available for such a complex at the Halda estate although this is believed to be the case. This point would require checking should this proposal be considered further.


Map of East Pakistan showing location of projects studied
Boundaries International
Major Rivers
Projects recommended for examination in Phase II
Location of other sites considered in Section 3
Other cities/towns
Ghorasal
Dacca
Khulna
Chalna
Chittagong
INDIA
INDIA
Bay of Bengal
Scale
One inch to 30 miles

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Preliminary Site Data

2.3 Site Data

Site	(1) Site Levelling and filling	(2) Land Cost	(3) Road Access	(4) Rail Access	(5) Wharf	(6) Drainage	(7) Water	(8) Power (Stand-by)
West Pakistan								
Ismailwal	Rs.7500/acre	Rs.2500/acre	Yes. To Gujarat Sargodha, Jhelum	Yes, across Jhelum river to Malakwal and beyond	None required	To nearby gorge	Water scarce - may be possible to take water from Jhelum river (9mls) (tube wells)	66 KV grid supplies to existing cement works
Chiniot	Rs.7500/acre	Rs.3000 /acre	Yes. 8mls by road to Chinot. 30 mls to Lyallpur	Yes. One ml from site. Lyallpur/ Sargodha branch line	None required	To Budh Nala 1½ mls away. Needs check	Considered sufficient. Tube wells	11 KV 66 KV & 132 KV grid supplies. Near site
Sidhnai	Rs.7500/acre	Rs.3000/acre	Yes. Road passes site. Connects Multan-Lahore-Jhang	Yes. Passes site Khanewal Wazirabad branch	None required	To main canals or Abdul Hakeem distributory	Quality good. Tube wells	11 KV sub 1.5 mls away. 66 KV line nearby
Multan	Assume included in (2)	Rs.9000/acre payable in 10 years includes estate roads &sewage	Yes. One ml from National Highway	Yes. Industrial estate station one ml from site	None required	Estate plans to treat plant industrial waste	Good quality. Tube wells. River also 4 mls away	Grid station 3mls away. Estate will have power
Daharki	Rs.7500/acre	Rs.2500/acre	Yes to Karachi Lahore Highway	Yes to main double track main line adj. to site	None required	A problem, soak pit evaporate or to river	Water scarce expensive	Work in progress on 132 KV line to Daharki
Karachi	Rs.4000/acre Assumed figures	Rs.4000/acre	Yes to Karachi	Yes to main PWR line	None required	To sea	Available	Available
East Pakistan								
Ashuganj	Rs.65000/acre	Rs.10000/acre	None at present National Highway projected	Yes Dacca-Chittagong line passes site	Required. site is by side of river Meghna	To river after suitable treatment	From Meghna river and tube well	Adj. EPWAPDA power station
Khulna	Rs.70000/acre	Rs.19000/acre	Not known	Khulna has rail connection	Required. Site must have waterway access	" "	River and tube well	Purchased from EPWAPDA
Chittagong	Rs.13000/acre	Rs.19000/acre	Yes. Chittagong Kaptai dam rd.	Yes near to site	Desirable should be possible to arrange	" "	Sub soil water scarce. River water	Nearby 132 KV grid station

SECTION 1

Preliminary Site Data

(6) Drainage	(7) Water	(8) Power (Stand-by)	(9) Natural Gas	Remarks
To nearby gorge	Water scarce - may be possible to take water from Jhelum river (9mls) (tube wells)	66 KV grid supplies to existing cement works	Sui gas available existing 8" line. Site 12miles from 12" line	Existing cement factory of Ismail Cement Industries Ltd. exists at Ismailwal
To Budh Nala 1½ mls away. Needs check	Considered sufficient. Tube wells	11 KV 66 KV & 132 KV grid supplies. Near site	Sui gas pipeline 6 mls from site	Site 30 mls by existing road from Lyallpur. Educational facilities in Lyallpur. Airport at Lyallpur
To main canals or Abdul Hakeem distributory	Quality good. Tube wells	11 KV sub 1.5 mls away. 66 KV line nearby	Sui gas pipeline 2 mls from site	Important Mandi town and agricultural production centres within radius of 65-110 mls. Schools and hospitals in Multan 50mls away
Estate plans to treat plant industrial waste	Good quality. Tube wells. River also 4 mls away	Grid station 3mls away. Estate will have power	Small existing pipeline nearby Sui gas will be available	Industrial Estate outside Multan. Good for labour. Smaller housing colony. Educational advantage. Airport at Multan
A problem, soak pit evaporate or to river	Water scarce expensive	Work in progress on 132 KV line to Daharki	Pipeline from Mari gasfield	Landing strip for aircraft. Adjacent to existing plant of Esso Pakistan
To sea	Available	Available	Available	Level site adjacent to National Refinery and about 1ml from Pakistan Refinery. Airport at Karachi
To river after suitable treatment	From Meghna river and tube well	Adj. EPWAPDA power station	Available at Titas gasfield 9-10 mls away	60 mls from Dacca. Labour from Dacca & Bhairab Bazar. Site subject to annual flooding. Requires 15/16 ft of fill
" "	River and tube well	Purchased from EPWAPDA	Not available furnace oil used as fuel	Site not investigated. Assumed similar fill to Ashuganj. Nearest airport Jessore.
" "	Sub soil water scarce. River water	Nearby 132 KV grid station	Not available yet	Halda Industrial Estate probably the best site. Assumed requires 3' fill. Airport at Chittagong

SECTION 2

2.3.2 Raw Materials and Utilities

2.3.2.1 General

In this section a note on the availability, location, assumed cost and analytical data for the various raw materials for fertilizers and petrochemicals production in both wings of Pakistan is given. For ease of reference this has been presented in tabular form:

Table 1 - Indigenous Materials (on pages 2.39 and 2.40)
Table 2 - Imported Materials (on pages 2.41 and 2.42)

A brief amplifying note on the major materials is also given in this section.

It is understood that at present, fertilizer raw material and imports are free of duty. The landed cost price for phosphate rock, phosphoric acid and raw sulphur given in Table 2 do not therefore include any customs duties. The sulphur landed cost does however, include a 20% sales tax.

The landed cost of Benzene and Phthalic Anhydride includes 50% duty but no sales tax.

It is assumed that coke fines are imported free of duty.

2.3.2.2 Indigenous Materials

(a) Oil

Crude oil is being produced only in West Pakistan as no oilfield has yet been discovered in East Pakistan. Production is obtained from a number of small oilfields lying in the Attock and Jhelum districts, in an area which is referred to by geologists as the "Potwar Basin".

The petroleum products obtained from the refining of these indigenous crudes at the Attock Oil Refinery (AOC) near Rawalpindi can meet only the partial requirements of the northern regions of West Pakistan.

A domestic refining industry based upon imported Middle East crude oils has, therefore, been established to obviate the necessity of importing finished petroleum products.

Three refineries have been established to operate on imported crude, the Pakistan Refinery Limited (PRL) and the National Refinery Limited (NRL) both located at Korangi near Karachi in the West Wing, and the Eastern Refinery Limited (ERL) located at Chittagong in the East Wing.

At the present time both PRL and NRL are operating at full capacity. ERL is operating at two-thirds capacity having recently completed its first year of operation.

2.3.2.2 Indigenous Materials - continued

(b) Naphtha

The Pakistan Refinery has a present capacity of about 50,000 bpsd (actually 2.5 million tons crude per year); the National Refinery, at present primarily a lube oil plant with a capacity of 550,000 tons per year, is being expanded into an integrated refinery with a capacity of 1.7 million tons per year. The availability of surplus naphtha is necessarily contingent upon the total capacity for petroleum products. At the date of writing this interim report, promised information on the availability of naphtha in Pakistan is not yet available from the Oil Companies Advisory Committee but is estimated in the West to be about 200,000 tons per annum in 1970, ie. about 5% of 4 million tons of crude oil input per annum, this figure must be considered as indicative until the O.C.A.C. data is made available.

The naphtha produced by the refineries which is surplus to present domestic requirements is disposed of in the following ways:

The Western refineries export the bulk of their surplus naphtha as part of the agreement under which they purchase their crude, they also use naphtha as a fuel within the refinery, and under certain adverse conditions naphtha is flared.

The above remarks apply to PRL and NRL only. All the naphtha produced by AOC is blended and sold as motor fuel.

The Eastern Refinery at present sells its surplus naptha as fuel for electric power generation as under the present circumstances naphtha is marginally cheaper than alternative fuels.

The availability of natural gas in Chittagong or any alternative fuel for power generation would release surplus naphtha for other use.

A typical Naphtha specification for Naphtha produced by Pakistan Refinery Limited Karachi is given on Page 2.37.

2.3.2.2 Indigenous Materials - continued

(c) Natural Gas

Natural gas has been found at a number of places in Pakistan. The reserves and relevant analyses of West and East Pakistan fields are given on page

1. Natural Gas - West Pakistan

The two major sources of natural gas in West Pakistan are: the Sui Gas field and the Mari Gas field. The remaining gasfields in the West have not been considered due either to the gas field having too small a reserve and/or too low a quantity of gas for the plants considered.

The Mari gasfield at present supplies gas to the Natural Gas Fertilizer Factory of Esso Pakistan Fertilizer Co. Ltd. at Daharki and a pipeline belonging to Esso carries the gas a distance of about seven miles to the factory. No up-to-date information on the reserves of gas at Mari are available except that Esso have guaranteed that in addition to their own requirements they will supply sufficient gas for the requirements of two additional Urea plants of a capacity of 1000 tons per day each.

As the fertilizer plants in West Pakistan considered in the Report are all well North of the Sui gasfield (Multan the nearest is about 190 miles north of Sui) there is no advantage to be gained from using Mari gas. This leaves only the Sui gas system for consideration.

2. Availability of Gas, North of Sui

The distribution from Sui gasfields is the responsibility of two companies, the Sui Northern Gas Company (SNGC) which takes care of gas distribution north of the Sui gasfield and the Indus Gas Company which controls the southern zone with a subsidiary at Karachi.

The Sui fields have a capability of continuous operation at 600 million scf per day on an average day basis and could take a peak of 700 million scf per day. Approximately half of this quantity can be considered as available to the Northern line.

2.3.2.2 Indigenous Materials - continued

(c) 2. Availability of Gas, North of Sui - continued

The deliverability of gas in SNGC pipelines, after looping of the Sui-Multan line to be completed by end 1972, is expected to reach 250 million scfd. These are peak figures and take care of the potential extension of lines to Daudkhel, Peshawar and Gujranwala. The average daily consumption, corresponding to this peak is about 180-190 million scf . Hence no difficulty should arise for supply from Sui even for two new large Ammonia plants. In the northern region the current flow on an average day is about 100 million scf .

3. Natural Gas - East Pakistan

Natural gas is produced from a number of fields in East Pakistan. The gases produced are purer than those of West Pakistan and the gross heating value is higher.

Gas from Sylhet is used exclusively for the fertilizer factory at Fenchuganj and its power plant. Gas from the small Chhatak reserves is used solely for cement manufacture by the Assam Bengal Cement Co. The gas from Kailash Tila will possibly supplement Sylhet (ref. 19).

Gas from Rashidpur is reported (ref. 19) to be not yet in production (in 1968). By virtue of the size of the gas reserves and the position of the gasfield, the Titas field is at present the most important gasfield in East Pakistan. A 50 mile long pipeline now connects the Titas field with the Dacca-Narayanganj area.

Recently a further major natural gasfield has been discovered at Bakhrabad due east of Dacca and about half way between Dacca and Comilla. The reserves and quality are as yet not proven but a preliminary representative gas analysis and an estimate of reserves (3.7 million million cubic feet) indicate a valuable and important addition to the total gas reserves if proven.

The projected gas pipeline from the Titas gasfield to serve the industrial commercial and domestic needs of Chittagong is still in the discussion stage, an economic feasibility study for the pipeline having been prepared and submitted to the Government by Pakistan Shell Oil Company Limited in mid 1969. (An estimate of the cost of a pipeline from Bakhrabad instead of Titas was submitted as an alternative).

It is concluded that ample reserves of gas appear to be available for the requirements of a petrochemical complex and nitrogenous fertilizer plant in East Pakistan.

2.3.2.2 Indigenous Materials - continued

(c) 4. Price of Gas - West and East Pakistan

This is given in Table 1 on page 2.39 and 2.40.

(d) Gypsum and Anhydrite

High grade gypsum deposits are available in West Pakistan of which the most important are at Dandkhel, Dandot and Ismailwal at the foot of the Salt Range.

Natural gypsum is not available in East Pakistan.

An analysis of Gypsum from Ismailwal is as follows:

Ignition Loss	21.78%
SiO_2	1.70
Al_2O_3	0.65
Fe_2O_3	0.20
CaO	33.15
MgO	1.95
Na_2O + K_2O	1.02
SO_3	40.57
Chlorides	0.37
$CaSO_4 2H_2O$	87.2

(e) Salt - Rock Salt

Very large deposits of rock salt are present in the West Pakistan Salt Range. The most important deposit being mined at Khewra in District Jhelum. There is no rock salt at present available in East Pakistan.

A typical analysis of Khewra rock salt is given below:-

Analysis reported by Khewra Salt Mines	
Moisture	0.15%
Insolubles	0.11%
Sodium Chloride	95-98%
Calcium Sulphate	0.72%
Magnesium Chloride	0.12%
Magnesium Sulphate	0.48%
Sodium Sulphate	0.48%
Undetermined	0.12%

2.3.2.2 Indigenous Materials - continued

(e) Salt - Rock Salt - continued

All salt produced from the Khewra mines is sold as "run of mine" product to the present consumers.

(f) Salt - Sea Salt

Sea salt is available just outside of Karachi - the salt is evaporated from sea water. A proportion of which is normally exported to East Pakistan.

The sea salt quality assumed is equivalent to a yield of Sodium Chloride to the Chlorine plant of 92% of the sea salt supplied.

(g) Brine - Dhariala Project

Drilling for brine is at present proceeding at Dhariala about 20 miles North West of Khewra in the Pakistan Salt Range, under the jurisdiction of West Pakistan Industrial Development Corporation.

On successful completion of the drilling of this main well, tests will be carried out to determine the quality and reserves of the brine. Whilst it is hoped that this well may yield a brine rich in potash which may be of future use in Pakistan as a fertilizer, no account has been taken, at this stage, of any future production of potash from this source.

RESERVES AND QUALITY OF NATURAL GAS IN WEST PAKISTAN *

	Sui	Zin	Uch	Khair-pur	Khandh-kot	Maza-rani	Mari	Sari
Methane %	88.52	46.1	27.3	12.2	79.2	87.0	66.2	78.92
Ethane %	0.89	0.4	0.7	0.2	1.1	2.5	0.2	2.18
Propane %	0.26	0.15	0.3	0.1	0.2	0.1	-	0.81
Butane & higher %	0.37	0.15	0.3	-	0.4	1.2	-	0.14
Nitrogen %	2.46	8.5	25.2	16.9	16.6	8.0	19.5	15.96
Hydrogen sulphide grains/100 cu.ft.	92.2	13.3	33.5	2.0	30.8	10.7	-	-
Mercaptan sulphur grains/100 cu.ft.	3.8	2.3	10.2	46	1.2	2.2	-	-
Gross heating Value BTU/cu.ft.	993	484	308	130	842	976	674	856
Reserves 10^{12} cu.ft. (balance as at 1 July 1968)	5.86	0.10	2.50	1.00	0.20	0.03	3.90	0.02

RESERVES AND QUALITY OF NATURAL GAS IN EAST PAKISTAN *

	Sylhet	Chhatak	Rasidpur	Kailas Tila	Titas	Habi ganj
Methane %	95.4	99.05	98.2	95.7	97.2	97.8
Ethane %	2.67	0.24	1.20	2.6	1.8	1.5
Propane %	0.3	-	0.2	0.9	0.5	-
Butane & higher %	0.78	-	0.1	0.4	0.5	-
Nitrogen %	0.37	0.67	0.3	0.2	-	0.7
Carbon dioxide %	0.48	0.04	-	0.2	-	-
Hydrogen sulphide grains/100 cu.ft.	-	-	-	-	-	-
Mercaptan sulphur grains/100 cu.ft.	0.29	0.08	-	-	-	-
Gross heating value BTU/cu.ft.	1,052	1,007	1,014	1,050	1,039	1,020
Reserves 10^{12} cu.ft. (balance as at 1 July 68)	0.24	0.02	1.06	0.6	2.25	1.28

* Chemical Consultants (Pakistan) Limited

The following typical Naphtha specification was given for Naphtha produced by Pakistan Refinery Limited, Karachi:

	TYPICAL FIGURES		EXPORT NAPHTHA SPECIFICATION
	LIGHT NAPHTHA	HEAVY NAPHTHA	
S.G. at 60/60°F	0.6880	0.743	min. 0.68 max. 0.71
Distillation:			
I.B.P.°C	40	100	min. 40
10% vol. rec. at °C	58		min. 45 max. 70
50% vol. rec. at °C	74	114	min. 65 max. 90
90% vol. rec. at °C	92		min. 90 max. 110
F.B.P. °C	106	150	max. 150
Colour Saybolt	+30	+30	+30
Doctor Test	Negative	Negative	Negative
Sulphur content ppm	8	12	max. 50
Lead content ppb	Nil	Nil	max. 50
PONA Analysis:			
Aromatics % vol.	5	15	max. 10
Naphthenes% vol.	5	25	max. 10
Paraffines% vol.	90	76	min. 80
Olefines % vol.	Nil	Nil	Nil

2.3.2.3 Imported Materials

(a) Phosphate Rock

Whilst deposits of phosphate rock have been reported in West Pakistan at various times in the Pakistani Salt Range and in the Kalachitta Hills in the Campbellpur and Kohat districts in the vicinity of the Indus River, reports indicate that reserves are too small for commercial exploitation.

It is therefore necessary that phosphate rock be imported for fertilizer manufacture (or alternatively phosphoric acid).

Since the Suez Canal closure, phosphate rock from Jordan would represent the best source of rock phosphate for Pakistan. The phosphate rock considered in this report would have a P_2O_5 content of 32.7%.

Phosphoric Acid has not previously been imported into Pakistan.

(b) Raw Sulphur

Raw sulphur of the quality required for H_2SO4 manufacture is required for fertilizer manufacture. In Pakistan this raw material is imported exclusively by the Trading Corporation of Pakistan.

2.3.2.4 Utilities

For preliminary costing purposes the following utilities costs were used:

	Unit	Rs. Total per unit	Rs. Foreign Exchange per unit
Electricity	KWH $x10^3$	47.7	19.1
HP Steam	MT	8.6	1.7
Cooling Water	m^3 x 10^3	31.5	6.3
Demineralised Water	m^3	1.54	0.15

For the economic analyses of the proposed fertilizer and petrochemical complexes, capital and operating costs of the facilities to produce these utilities were estimated directly for each case as described in Sections 2.4 and 2.5.

TABLE 1

INDIGENOUS MATERIALS - WEST PAKISTAN

Material	Source	Specification	Quantity Available 1970	1975	1980	Unit	Price ex-works Rs/Unit	Foreign Exchange Component Rs/Unit
1. Gypsum - Rock	Daudkhel			Any Quantity		Ton	12	-
Gypsum - Rock	Ismailwal	See Section 2.3		Any Quantity		Ton	15	-
Gypsum - By-product	TSP plant of Jaffer Bros. Karachi			210,000		Ton		-
2. Shale	Ismailwal (also available at many places)			Large Quantity		Ton	5	-
3. Salt - Rocksalt	Khewra	96% NaCl average		Any Quantity		Ton	33	-
- Sea Salt	Karachi			Any Quantity		Ton	16	-
4. Natural Gas								
- Sui field	Along pipeline	See Section 2.3		See Section 2.3		1000 scf	1.77 plus 0.4 excise tax.*(At Multan, Lyallpur, Ismailwal, Lahore sites)	0.22
- Mari field	Wellhead	See Section 2.3		See Section 2.3		1000 scf	0.50 at wellhead plus 0.4 excise duty	0.09
5. Naphtha	Karachi Refineries	See Section 2.3	200×10^3	250×10^3	350×10^3	Ton	82	68

* Rate of Rs.1.77 + 0.4 = Rs.2.17 Sui gas price assumed uniform for Fertilizer and Petrochemical Industries

TABLE 1 - continued

INDIGENOUS MATERIALS - EAST PAKISTAN

Material	Source	Specification	Quantity Available 1970	1975	1980	Unit	Price ex-works Rs/Unit	Foreign Exchange Component Rs/Unit
1. Gypsum - by-product	TSP Plant Chittagong		40,000	200,000	200,000	Metric Ton		-
Gypsum - Rock	Not available in East Pakistan							
2. Salt - Rock	Not available in East Pakistan							
Salt - Sea	Karachi			Any Quantity				
3. Natural Gas	Titas	See Section 2.3		Large reserves (See Sect 2.3)		1000 scf	**0.5 plus 0.4 excise duty at wellhead	0.09
	Bakhrabad	See Section 2.3		Not yet known but expected to be similar to Titas		1000 sch	Not known	
4. Naphtha	Eastern Refinery Chittagong		None	56,000	80,000***		82	68

** At Ghorasal gas is expected to cost Rs.1.2 + 0.4 excise duty.

*** The surplus naphtha available from the Eastern Refinery is dependent upon natural gas or some alternative fuel being available at Chittagong.

TABLE 2

IMPORTED MATERIALS - WEST PAKISTAN

	Material	Source	Specification	Unit	C & F Rs/Unit	Landed Cost Rs/Unit at Karachi	FOR* Rs/Unit	Foreign Exchange Component Rs/Unit
1.	Phosphate Rock	Jordan	32.7% P_2O_5	Ton	93	100	186	93
**2.	Phosphoric Acid	International Market	54% P_2O_5	Ton	386	417	764	
3.	Raw Sulphur	International Market	Prime Quality for H_2SO_4 manufacture	Ton	288	349	662	288
4.	Coke		Fines	Metric Ton	246	253	475	246
5.	Benzene	International Market		Metric Ton	525	830	1303	525
6.	Phthalic Anhydride	International Market		Metric Ton	1320	2040	3230	1320

* All imported materials bought on Cash-cum-Bonus. The FOR price therefore includes a Cash-cum-Bonus premium calculated at $\frac{\text{C \& F value}}{2} \times 1.8$

** No phosphoric acid, coke fines and phthalic anhydride imported up to present.

Certain catalysts & chemicals required for petrochemical & plastics processes will also have to be imported, the cost of these are included in the operating costs of the plants concerned.

TABLE 2 - continued

IMPORTED MATERIALS - EAST PAKISTAN

Material	Source	Specification	Unit	C & F Rs/Unit	Landed Cost Rs/Unit at Port of Chittagong or Khulna	FOR Rs/Unit	Foreign Exchange Component Rs/Unit
1. Phosphate Rock	Jordan	32.7% P_2O_5	Ton	143	150	280	143
2. Phosphoric Acid	International Market	54% P_2O_5 W/W	Ton	386	417	764	
3. Raw Sulphur	International Market	Prime Quality for H_2SO4	Ton	288	349	662	288
4. Coke	"	Fines	Metric Ton	246	253	475	246
5. Benzene	"		" "	525	830	1303	525
6. Phthalic Anhydride	"		" "	1320	2040	3230	1320

*All imported materials bought on Cash-cum-Bonus. The FOR price therefore includes a Cash-cum-Bonus premium calculated at $\frac{\text{C \& F value} \times 1.8}{2}$

Certain catalysts & chemicals required for petrochemical & plastics processes will also have to be imported, the cost of these are included in the operating costs of the plants concerned.

2.4 Fertiliser Scheme Studies

In this section the Sections on "Process and Product Scheme Evaluation" and "Schemes Proposed" for fertilizers - Sections 5 and 6 of the Interim Report-are summarised.

2.4.1 Summary of Product Market Data

Based on a preliminary analysis of the fertilizer market in East and West Pakistan together with output data for existing plants, the following market data were used as the basis for initial comparison of a number of schemes:

	West Pakistan	East Pakistan
N	240,000 MTPA	150,000 MTPA
P_2O_5	140,000 MTPA	100,000 MTPA
K_2O	-	50,000 MTPA

The consensus of expert opinion, with which H&G concur, is that expansion of P_2O_5 production in West Pakistan should be based on NP fertilizer production. The plants which produce NP fertilizer are able to make a range of formulations, but for the Phase I study a mean product $N:P_2O_5$ ratio of 1:1 was adopted. In East Pakistan with its predominant rice crop grown on paddy, the obvious choice of nitrogen fertilizer is urea. There is strong agronomic evidence that, for East Pakistan soils, direct application of soft rock phosphate is an adequate method of P_2O_5 fertilisation in many areas. If this fact is accepted, then the policy of using "straight" fertilizers in East Pakistan which has already been implemented is correct. For those parts of East Pakistan where a water-soluble P_2O_5 fertilizer is required, TSP is the logical choice since its production cost is lower than fertilizer P_2O_5 derived entirely from phosphoric acid and its P_2O_5 concentration is high enough to prevent transport costs being excessive. In those sectors of the country where K_2O is also deficient, potash can be applied as a straight fertilizer.

2.4.2 Preliminary Analysis of Processing Schemes - West Pakistan

An analysis of processing schemes must be made with due consideration to raw material transport and product distribution problems. In Pakistan conditions the cheapest route to a 1:1 fertilizer is the nitrophosphate process provided that:

(a) the plant is sited adjacent to ammonia and nitric acid units;

(b) an overall ratio of $N:P_2O_5$ of about 2 is acceptable and there is a market for by-product ammonium nitrate;

(c) mean product distribution distances are not excessive

2.4.2 Preliminary Analysis of Processing Schemes - West Pakistan - continued

The three basic processing schemes which were studied are:

I Ammonia, Urea, Sulphuric Acid, Phosphoric Acid with Urea/DAP N:P fertilizer

II Ammonia, Nitric Acid, Ammonium Nitrate Limestone, Sulphuric Acid, Phosphoric Acid with AN/DAP fertilizer

III Ammonia, Nitric Acid, Nitrophosphate NP fertilizer with by-product ammonium nitrate limestone.

A brief review of potential fertilizer plant sites indicates that sites are available in the main agricultural zones of the country. The fertilizer raw materials which are available internally are:

Gypsum - Daudkhel and Ismailwal

Natural Gas - Along the SUI pipeline and at Mari.

Phosphate rock, sulphur and potash must be imported.

For the three basic processing schemes, sites in the central/northern regions of the country were considered.

Costs of sulphuric acid from imported sulphur and local gypsum were compared.

These schemes were analysed and are summarised in Section 2.4.4.

In addition to the three basic processing schemes analysed, the following alternative P_2O_5 schemes - all based on the production or import of P_2O_5 at Karachi, were considered, and are commented on below. Reasons are given why a detailed analysis was not proceeded with.

2.4.2.1 Thermal Phosphoric Acid

It has not been possible up to the present to produce thermal phosphoric acid at a cost low enough for it to compete with wet process acid for fertiliser purposes. The maximum furnace size is about 50 MW (i.e. 200 MTPD P_2O_5). If hydro electric power is used, then of course, the thermal process can be considered. Taking hydro electric power in the north of West Pakistan at Rs 0.02/Kwh, it was calculated that thermal acid is 20% more expensive per MT P_2O_5 than wet process acid based on gypsum in both total and foreign exchange costs. A major problem and cost in thermal acid is the need to import coke for the process. Even with free power the thermal acid would not become competitive unless an indigenous source of coke were available.

2.4.2.2 Imported Phosphorus

A recent TVA paper (Economic and Technical Evaluation of Overseas Shipment and Utilisation of Elemental Phosphorus for Fertiliser Production, January 1968 - Ref. 32) indicates that DAP can be produced in India from elemental phosphorus imported from a large U.S. plant at a cost competitive with DAP made from wet process acid based on sulphur. H&G do not consider this a viable proposition for Pakistan, mainly because of the high Foreign exchange element in the cost of imported Phosphorus.

2.4.2.3 Import of Phosphoric Acid at Karachi

P_2O_5 could be imported as either 54% P_2O_5 acid (wet process) or as phosphorus (thermal process). Although the price of 54% acid (C&F) imported under a bulk contract might be similar to its cost of production, the cost of such acid would be entirely in foreign exchange. Phosphorus has already been discussed above. Import of acid or phosphorus is not attractive in view of the foreign exchange requirement.

2.4.2.4 Production of 54% Phosphoric Acid at Karachi and Bulk Shipment of Acid inland

Given that this is not based on imported acid or phosphorus, then sulphuric acid must be produced at Karachi from either gypsum or sulphur. It is cheaper to transport phosphate rock north than to bring gypsum from Daudkhel or Ismailwal to Karachi. It is therefore logical to site a plant based on gypsum in the north. The sulphuric acid/phosphoric acid unit at Karachi would be based on sulphur.

Two further points may be mentioned concerning such a scheme. Firstly there is no suitable rolling stock available for transport. Secondly, the scheme would involve setting up separate production facilities at Karachi and in the centre or north of the country with duplication of off-site facilities etc.

2.4.2.5 MAP or DAP Production at Karachi

For reasons discussed above such production should be based on sulphuric acid from sulphur. The P_2O_5 capacity is not large enough to support economic ammonia production at Karachi. It would be necessary, therefore, to bring ammonia from plants on the natural gas fields in the SUI area down to Karachi. Again no suitable rolling stock exists. In addition, the majority of the ammonia would simply be transported north again along the same track.

2.4.2.5 MAP or DAP Production at Karachi - continued

The only advantages in producing MAP or DAP at Karachi are:-

(i) the weight of material to be taken north by rail is reduced by approximately one-third.

(ii) the DAP or MAP may be bulk-blended or granulated in mixing plants to produce a wide range of formulations.

Such an operation would be typical of a large section of the phosphate fertilizer industry in the USA, which is concerned with the traffic of P_2O_5 from Florida to theMid-West. There are many factors in the USA, however, which have encouraged this traffic and which do not pertain in West Pakistan.

2.4.2.6 TSP Production at Karachi

This could be produced at the coast, transported inland and then bulk-blended with Urea to produce the NP fertiliser. This route suffers from the fact that bulk blends tend to segregate during transportation in bags. Also it would have to be transported north as a bagged product.

Furthermore, it will be seen that sulphuric acid from gypsum is preferred and gypsum is not available at Karachi.

The advantage of TSP is that no ammonia transport is involved.

In the above it is theoretically possible to reduce P_2O_5 transport costs north from Karachi, but the reduction is small compared to the savings which will be made in production by integrating P_2O_5 and nitrogen production at a single site in the centre or north of the country.

A TSP plant which will serve the local market around Karachi is already under construction at Karachi.

2.4.3 Preliminary Analysis of Processing Schemes - East Pakistan

Following the discussion in Section 2.4.1 the only schemes examined in East Pakistan were

IV Ammonia, Urea plant

V Sulphuric Acid, Phosphoric Acid, TSP plant

In V, gypsum-based and sulphur-based sulphuric acid were again compared, and imported phosphoric acid was considered. This scheme was also analysed for the case where all P_2O_5 was in form of TSP and, as an alternative, where half was applied in the form of soft rock phosphate. See Section 2.4.5.

2.4.4 Operating and Product Cost Data - West Pakistan (Schemes 1, 11 and 111)

Because the nitrophosphate scheme normally produces N and P_2O_5 in a total ratio slightly greater than two, the comparison of the three schemes was finally based on production rates of

N 241,000 MTPA
P_2O_5 115,000 MTPA

The first step was to compare the production cost of Sulphuric Acid from Sulphur and Gypsum. This was done for a plant capacity of 400,000 MTPA at a site such as Daudkhel where gypsum is available. The results were

	Total Rs/MT	Foreign Exchange Rs/MT
H_2SO_4 from gypsum	170	69
H_2SO_4 from sulphur	236	105

In calculating these figures, cement clinker was credited at Rs 45/MT (Rs 10 for foreign exchange). This credit was considered to represent the basic cost of manufacture by the normal cement process. In fact there is currently a cement production deficit in Pakistan and higher foreign exchange credit may well be justifiable. A further point affecting the results is that the cost of transport of sulphur from Karachi was not included. This would inflate the total cost of sulphuric acid from sulphur produced at Daudkhel or Ismailwal by about Rs 25.

Sulphur cost used in the study is $ 60/MT (C & F). It is noted that other recent studies have used $ 70/MT. Sulphur is a commodity whose longer term price fluctuations are difficult to predict. The sulphur price, however, is an important determining factor in selecting process routes. UNIDO have commissioned a study of future prices by the British Sulphur Corporation, but the results of this are not yet available.

On page 2.50 is shown the production cost of sulphuric acid from sulphur and gypsum. This indicates that sulphur must be available at less than $ 40/MT before the sulphur route is competitive in West Pakistan with the route from gypsum. Subsequent to the presentation of the Interim Report in November 1969, sulphur price has continued to decline. It will be seen from Section 3 of this Volume, that further work on new Projects in West Pakistan was not called for by UNIDO

2.4.4 Operating and Product Cost Data - West Pakistan - continued

Basic Production Costs were estimated for intermediates and fertilisers. The results were as follows:

	Total Rs/MT	Foreign Exchange Rs/MT
Sulphuric Acid (from gypsum)	170	69
Phosphoric Acid (MT P_2O_5)	1159	527
Ammonia	166	59
Urea	137	55
Nitric Acid	81	36
Urea/DAP fertiliser	440	196
ANL (26% N)	99	43
AN/DAP fertiliser	366	164
Nitrophosphate NP fertiliser	258	119
Byproduct ANL (26% N)	73	32

(Notes: 1. Cost of Phosphoric Acid imported at Karachi is 715 Rs (C & F) or Rs 1415 (Duties and Bonus paid) per MT P_2O_5).

2. Costs here do not include any "overheads" allowance and are for products in bulk at plant).

Three possible sites were now selected DAHARKI, MULTAN and DAUDKHEL. Costs of transport of raw materials to these sites were estimated. Costs of bagging and mean distribution and transport costs from the site to market were evaluated. Results are tabulated on page 2.51.

Finally, a comparison was made between the costs of producing and distributing ammonium nitrate as a pure material and in the form of ANL (26 % N). The costs are summarised below for 128,000 MTPA of Nitrogen.

	ANL Rs x 10^6	AN Rs x 10^{-6}
Production	47.6 *	45.3
Bagging	10.8	7.5
Transport	14.3	10.7
	72.7	63.5

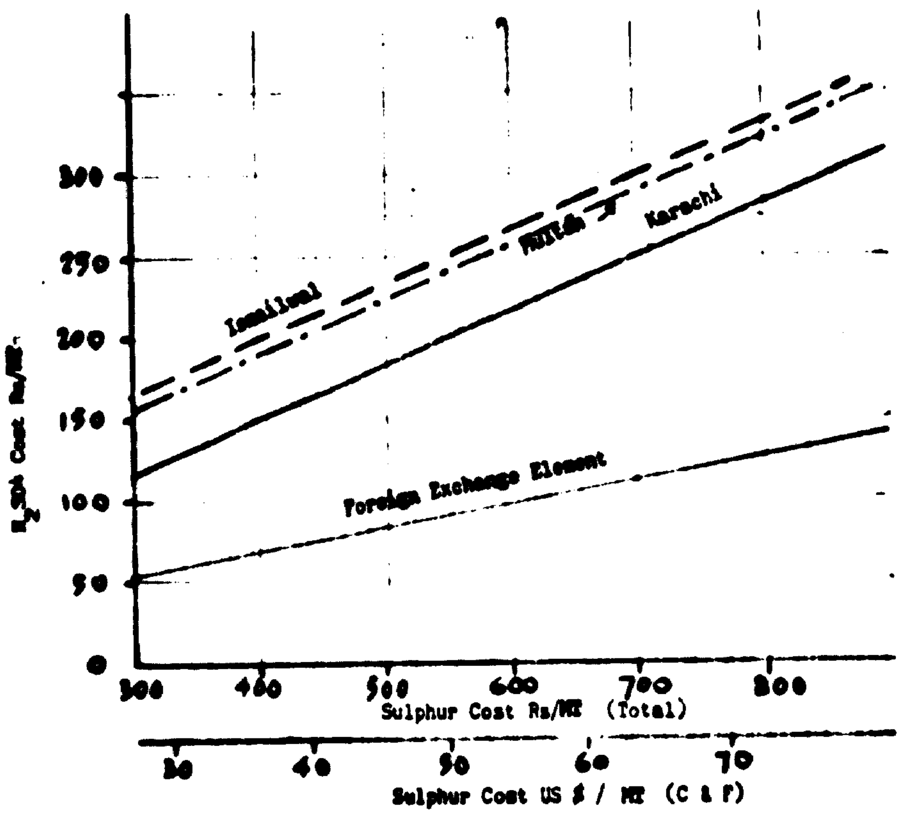
(* Note that chalk is not included as a cost for ANL - assumed available free).

2.4.4 Operating and Product Cost Data - West Pakistan - continued

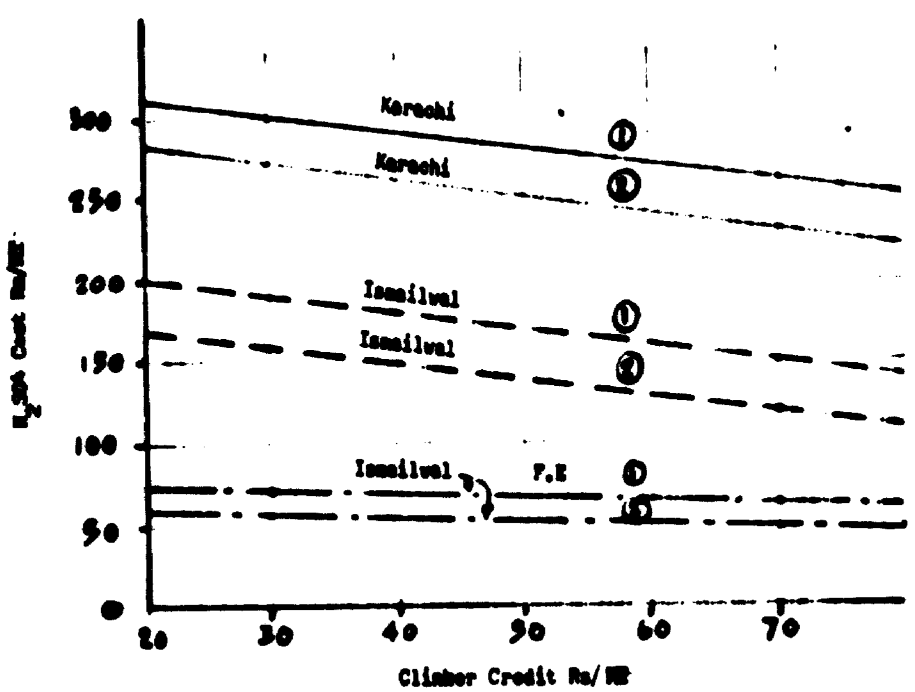
Thus ANL is more expensive by about 14% or Rs 84/MT nitrogen (~ Rs 25/MT fertiliser)

If chalk is not available as a by-product (nitrophosphate process), then the disadvantage of ammonium nitrate limestone is still greater.

2.4.4 Operating and Product Cost Data - West Pakistan



Production Cost of H_2SO_4 from Sulphur



Production Cost of H_2SO_4 from Gypsum

COKE PRICES

	Total	F.E
	Rs/MT	Rs/MT
1	475	246
2	250	130

F.E = Foreign Exchange Element

Comparison of Production Costs, Raw Material and Product Transport Costs and Bagging Costs at Various Sites.

Basis - Production of:
241,000 MTPA of N
115,000 MTPA of P_2O_5

SCHEME	I Urea/DAP (Sulphuric Acid			II Ammonium Nitrate/DAP from Gypsum)			III Nitrophosphate		
SITE	DAUDKHEL Rs/Yr	MULTAN Rs/Yr	DAHARKI Rs/Yr	DAUDKHEL Rs/Yr	MULTAN Rs/Yr	DAHARKI Rs/Yr	DAUDKHEL Rs/Yr	MULTAN Rs/Yr	DAHARKI Rs/Yr
	$(x10^6)$	$(x10^6)$	$(x10^6)$	$(x10^6)$	$(x10^6)$	$(x10^6)$	$(x10^6)$	$(x10^6)$	$(x10^6)$
Basic Production Cost	219.3	219.3	219.3	222.6	222.6	222.6	174.8	174.8	174.8
Raw Material Transport (Phosphate rock and gypsum)	17.4	24.7	27.7	17.4	24.6	27.7	16.3	11.0	8.7
Product Bagging	20.7	20.7	20.7	22.9	22.9	22.9	22.5	22.5	22.5
Product Distribution	20.2	16.4	19.9	28.6	24.3	28.5	29.3	24.8	29.0
Total Annual Costs	277.6	281.0	287.7	291.6	294.5	301.7	242.8	233.1	235.0
F.E. Element	102.3	102.3	102.3	106.7	106.7	106.7	86.3	86.3	86.3

2.4.5 Operating and Product Cost Data - East Pakistan

The schemes considered were IV and V in Section 2.4.3. The first analysis was again to compare gypsum and sulphur as raw materials for sulphuric acid at a coastal site. The results were as follows for a capacity of 700 MTPD:

	Total Rs/MT	Foreign Exchange Rs/MT
H_2SO_4 from gypsum	569	82
H_2SO_4 from sulphur	241	107

As expected the gypsum route still gives a smaller foreign exchange element. But the Rupee expenditure to achieve this saving is too high. This is because of the high cost of West-to-East gypsum and shale transport. Cement credit assumed was the same as for the West Pakistan case.

A question which immediately arises is the use of by-product gypsum from the phosphoric acid plant. This is an attractive proposition for East Pakistan since the cost of sulphuric acid would be reduced to a total of about Rs 190/MT with Foreign Exchange element of Rs 80/MT, and the acid would again be cheaper than that from sulphur with a foreign exchange saving. To date, however, there is no plant producing sulphuric acid from by-product gypsum; plants in East Germany and Austria have operated for periods of a few days on this material. A problem in using Jordan rock phosphate for the process is its high flourine content. At present it is not possible to recommend the process for East Pakistan although more serious consideration should be given to it in Phase II of this study. (The utilisation of by-product gypsum from the TSP plants at Chittagong has been elected for study in Phase II - See Volume IV.)

Costs of TSP production were calculated using sulphuric acid based on imported sulphur.

		Total Rupees	Foreign Exchange Rupees
Case (i)	50,000 MTPA P_2O_5 as TSP	64.3×10^6	30.2×10^6
	50,000 MTPA P_2O_5 as rock	28.7×10^6	14.3×10^6
	TOTAL	93.0×10^6	44.5×10^6
Case (ii)	100,000 MTPA P_2O_5 as TSP	125×10^6	58.2×10^6

In the case of a urea plant, no alternative process considerations are involved in Phase I and consideration of this plant is largely a question of the site to be selected. It was, therefore, passed forward to the detailed scheme analysis, (Section 2.4.8.4)

2.4.6 Conclusions reached on Fertilizer Schemes following Preliminary Analysis and Costing

West Pakistan

(i) Production scheme involving combined nitrogen and P_2O_5 complexes in the central and northern parts of the country are preferred to those in which phosphate rock is processed at Karachi or in which acid is imported.

(ii) Sulphuric acid for fertilizer processing can be made more economically in the north from gypsum than at Karachi from imported sulphur.

(iii) Of three schemes analysed in detail the nitrophosphate scheme for production of 1:1 NP fertilizer and by-product ammonium nitrate limestone gave lowest production costs. Its advantage is still greater if ammonium nitrate (34%N) is produced.

(iv) Schemes selected for more detailed analysis in the following section are:-

A. Nitrophosphate project at Multan.

B. Urea/DAP project based on gypsum at Ismailwal.

Ismailwal appeared to be a more suitable site than Daudkhel for detailed analysis of Scheme B since gypsum is more accessible and the natural gas has already reached Ismailwal. Also it is somewhat nearer to the centre of the fertilizer market.

East Pakistan

(i) The policy of further development of the industry on the basis of "straight" fertilizers is endorsed.

(ii) Urea is selected as the nitrogenous fertilizer.

(iii) Schemes selected for analysis in the following section are:-

A. Urea at Ashuganj

B. TSP at Khulna based on imported sulphur.

2.4.7 Selection of Plant Capacities for Schemes Selected for Further Study

2.4.7.1 Estimation of Future Demand

Having now selected the schemes for more detailed analysis, it is necessary to consider again the future demand for fertilisers. In the following paragraph is tabulated the estimated demand for Nitrogen, Phosphate and Potash for the years 73/74 to 80/81 and the expected production from the existing plants and plants under construction. These data have been extracted from that presented in Section 2.2.

(a) West Pakistan

Nitrogen (.000 MT of N)

	73/74	74/75	75/76	76/77	77/78	78/79	79/80	80/81
Estimated demand	478	536	570	600	620	630	635	640
Production	286	286	286	286	286	286	286	286
Shortfall	192	250	284	314	334	344	349	354

Phosphate (.000 MT of P_2O_5)

	73/74	74/75	75/76	76/77	77/78	78/79	79/80	80/81
Estimated demand	183	214	225	235	245	260	270	280
Production	71	71	71	71	71	71	71	71
Shortfall	112	143	154	164	174	189	199	209

Potash (.000 M of K_2O)

	73/74	74/75	75/76	76/77	77/78	78/79	79/80	80/81
Estimated demand	35	50	63	76	90	103	116	128
Production	-	-	-	-	-	-	-	-
Shortfall	35	50	63	76	90	103	116	128

2.4.7.1 Estimation of Future Demand - continued

(b) East Pakistan

Nitrogen (.000 MT of N)

	73/74	74/75	75/76	76/77	77/78	78/79	79/80	80/81
Estimated demand	260	320	375	430	485	528	560	590
Production	190.3	190.3	190.3	190.3	190.3	190.3	190.3	190.3
Shortfall	69.7	129.7	184.7	239.7	294.7	337.7	369.7	399.7

Phosphate (.000 MT of P_2O_5)

	73/74	74/75	75/76	76/77	77/78	78/79	79/80	80/81
Estimated demand	120	160	215	270	335	395	442	480
Production	63.5	63.5	63.5	63.5	63.5	63.5	63.5	63.5
Shortfall	56.5	96.5	151.5	206.5	271.5	331.5	378.5	416.5

Potash (.000 MT of K_2O)

	73/74	74/75	75/76	76/77	77/78	78/79	79/80	80/81
Estimated demand	60	90	120	156	190	235	275	320
Production	-	-	-	-	-	-	-	-
Shortfall	60	90	120	156	190	235	275	320

2.4.7.2 Determination of required Plant Capacities

The basis of these determinations was that, even if a project has approval and is well advanced in the planning stage, it will not be possible to start-up the plant before the fertilizer year'73/74.

A plant starting in that year is assumed to produce 30% of its Nominal design capacity in the first year, 70% in the second year and 90% in the third and subsequent years.

2.4.7.2 Determination of required Plant Capacities - continued

The only exception to this is the complex producing triple superphosphate in East Pakistan where, because no plants in the complex require the use of high pressure plant or advanced technology, it is assumed that initial production can start in the year '72/73 and build up to full capacity in '74/'75.

It has been decided previously that in West Pakistan mixed NP fertilizers will be produced and it is necessary therefore to consider the demands for the nitrogen and P_2O_5 in connection with one another.

(a) West Pakistan

Two types of Project were studied in detail for West Pakistan

(i) Nitrophosphate
(ii) Urea/DAP

(i) Nitrophosphate Scheme

Analysis of the data tabulated above resulted in a nitrophosphate project for the production of 240,000 MTPA of N and 115,000 MTPA of P_2O_5. This plant must come on-stream and reach full capacity by late 1974 in order that predicted consumptions are approached. In a nitrophosphate project of this type the minimum overall $N:P_2O_5$ ratio is approximately 2.1:1; for this reason an exact match between estimated production and forecast consumption cannot be achieved. Production at the levels quoted above would certainly ensure that total production figures in W. Pakistan meet consumption within the margin of accuracy of such forecasts.

(ii) Urea/DAP Scheme

For the Urea/DAP scheme the proposed production capacity is 240,000 MTPA of N and 140,000 MTPA of P_2O_5. In the case of this scheme no limitation in overall $N:P_2O_5$ ratio exists, and P_2O_5 production capacity was made slightly higher so that production approached the specific consumption forecast figures rather more closely. This plant must reach full production in about 1974/75.

(The upward revision of the consumption figures for West Pakistan mentioned in the notes on Page 2.7 has brought forward the start-up dates required for the proposed projects when compared with the dates quoted in the Interim Report).

2.4.7.2 Determination of Required Plant Capacities - continued

Potash Requirement

There are, at present, considerable uncertainties about the need for and future demand for potash fertilizer. It is clear from the References that it has often been difficult to demonstrate conclusively that this nutrient brings benefit to the farmer. The facility for K_2O, in West Pakistan, can quite easily be added to a nitrophosphate complex where the need is indicated. Space for such a facility should be allowed in planning such a complex. In the meantime, the application of a straight K_2O fertilizer where there are indications of potash deficiency can be implemented.

(b) East Pakistan

Two types of project were studied in detail for East Pakistan.

(i) Urea
(ii) Triple Super-phosphate (TSP)

(i) Urea Scheme

In the case of East Pakistan the earliest date for commissioning a nitrogenous fertilizer plant not already ordered would be in the fertilizer year 1973/74 with production building up to full capacity in 75/76.

The forecast of demand shows a requirement for about 200,000 MTPA of N in the year '75/'76. Agronomic considerations have led to the decision that the nitrogen requirements of East Pakistan will be met by the use of urea applied as a single nutrient fertilizer. To meet the forecast demand of 200,000 MTPA N would require a urea plant with a design capacity of 1450 MTD. This is greater than the currently available single stream capacity and it would, in H&G's opinion be inadvisable to build a plant of this capacity in East Pakistan until the design has been proven fully elsewhere. H&G's recommendation is to build a plant of 1100 MTD design capacity which will give a production of 150,000 MTPA of N. This output will fall short of demand by 35-50,000 MT in '75/'76 and initial commissioning of a second plant of similar capacity in that year will be required if demand increases at the rate shown by current forecasts.

2.4.7.2 Determination of Required Plant Capacities - continued

(b) East Pakistan - continued

(ii) TSP Scheme

In the case of phosphatic fertilizer there is a considerable body of agronomic opinion that, in those areas of East Pakistan where the soil is acid, soft ground phosphate rock is an effective and economical fertilizer. The reports show that approximately half the requirement can be met in this way. H & G concurred with this opinion, thus only 50% of the P_2O_5 shortfall needs to be met from processed P_2O_5.

Due to the fact that a proposed plant is in an advanced state of study for the Khulna/Chalna area and because start-up of such a complex is likely to be more rapid as outlined on page 2.56, H & G consider that a plant of 55,500 MTPA of P_2O_5 nominal capacity could reach full capacity operation in the fertilizer year '74/'75. Such a plant will meet the full forecast demand for P_2O_5 as TSP for that year. In order to meet the predicted increase in demand a second plant will require to be commissioned approximately two years after the first.

Potash Requirement

Similar remarks to those made with respect to West Pakistan also apply in East Pakistan, except that no nitrophosphate plants are planned in East Pakistan to which a K_2O facility can be added. H & G consider that for the immediate future straight K_2O fertilizer should be applied to the soil where there are indications of potash deficiency.

2.4.8 Description of the Selected Schemes

2.4.8.1 General

As previously outlined above a number of schemes were studied for both West and East Pakistan in relation to various sites. This study showed that in West Pakistan the most faviourable site for a project based on urea/DAP was at Ismailwal and for a project based on nitrophosphates was at Multan. For East Pakistan Ashuganj has been chosen for the ammonia/urea complex and Khulna for the phosphoric acid/TSP plants. Block flow diagrams were prepared for each of the four schemes.

2.4.8.2 Urea/Urea - DAP complex at Ismailwal

See block diagram on page 2.62.

This complex used indigenous supplies of gypsum and shale to manufacture sulphuric acid and cement clinker. Coke fines are brought to the site but gypsum is available from local quarries. The complex would be built next to the adjacent cement works which would take the cement clinker for further processing.

Phosphate would be brought in by rail from Karachi and reacted with sulphuric acid to form wet-process phosphoric acid. A conventional di-hydrate plant has been considered but a hemi-hydrate plant could be used if detailed study of the economics showed it to be advantageous.

Ammonia is produced in conventional plant based on reforming natural gas. Part of the ammonia goes to form urea in a total recycle plant while the remainder is used to form ammonium phosphate slurry in the granulation plant. In the granulation plant, ammonium phosphate slurry is granulated with part of the urea produced to form fertilizer granules with $N:P_2O_5$ ratio of 1:1. This plant could be readily adapted to allow potash either as chloride or sulphate to be incorporated if this was found desirable at a later date. Full solids handling equipment would be provided for the reception, handling, storage, reclamation, bagging, storage and dispatch of the products.

Due to the shortage of water in the area, raw waterwould be drawn from the River Jhelum and pumped to the site. All the water would be pre-treated to a standard suitable for use as process water or cooling tower make-up. Part of the process water would be further treated in a demineralisation plant to give high quality boiler feed water. The ammonia plant will be self supporting on steam with the main drives utilising steam turbines. Steam for the other process units will be raised in gas fired boilers and passed through a turbo-alternator set before passing out to the process plants. The turbo-alternator will be of sufficient rating to supply the whole power requirements of the complex and it will require more steam than is used in the processes. The extra steam will pass through the low pressure section of the turbine to condensers. The power supply will be inter-connected with the local power grid to give an alternative supply during start-up and emergency conditions.

Cooling water for the turbine condensers and the process units will be provided by induced draught cooling towers. A central plant will be installed for the supply of plant and instrument air.

2.4.8.3 Nitrophosphate Scheme at Multan

See block diagram on page 2.63.

This complex is based on the use of one of the advanced nitrophosphate processes capable of producing an NP fertilizer with a water-soluble P_2O_5 content of about 85%.

Ammonia is produced from natural gas by reforming and synthesis. Part of the ammonia formed goes to a medium pressure nitric acid plant with a single absorption tower containing sieve trays.

The nitric acid is used in the nitrophosphate plant to attack phosphate rock which is brought in by rail from Karachi. The remainder of the ammonia is used in the nitrophosphate plant, both for neutralisation of the nitrophosphate solution and for conversion of calcium nitrate to ammonium nitrate. The plant produces both a main product of NP fertilizer at a $N:P_2O_5$ ratio of 1:1 and a by-product of ammonium nitrate We have allowed for the production of ammonium nitrate lime stone at 26% N using part of the calcium carbonate from the conversion plant for dilution. The plant could produce straight ammonium nitrate if required. The plant could be readily modified to allow for the incorporation of potash if this proves desirable.

Besides the main by-product the plant will also produce surplus calcium carbonate. This can be either dumped, used as agricultural lime or used in the manufacture of cement. Full handling facilities will be provided for the reception, handling storage and reclaiming of phosphate rock and for the bulk storage, reclaiming, bagging, storage and dispatch of the NP fertilizer and ammonium nitrate limestone. Facilities for the storage and dispatch in bulk of surplus calcium carbonate will also be available.

Raw water will be drawn from tube wells close to the site. Other plant services and facilities will be as for the Ismailwal project.

2.4.8.4 Ammonia/Urea Project at Ashuganj

See block diagram on page 2.64.

This plant produces urea only as a single product. A conventional ammonia plant produces ammonia by reforming natural gas. The whole of the ammonia is fed to a urea plant using a total recycle process. Facilities are provided for the bagging, storage and dispatch of the urea.

Raw water will be drawn from the adjacent Meghna river and pre-treated to process water standards. The other plant service facilities will be similar to those for Ismailwal. At this stage no account has been taken in the assessment of utility plant costs of the fact that a petrochemical complex may be built on the same site as the fertilizer complex.

If both the ammonia/urea and the Petrochemical plant at Ashuganj are required to be studied in the final stage of the study then the economics obtained by the integration of services will be taken into account. Account will also be taken of the possible use of acetylene plant off-gas in the fertilizer plants.

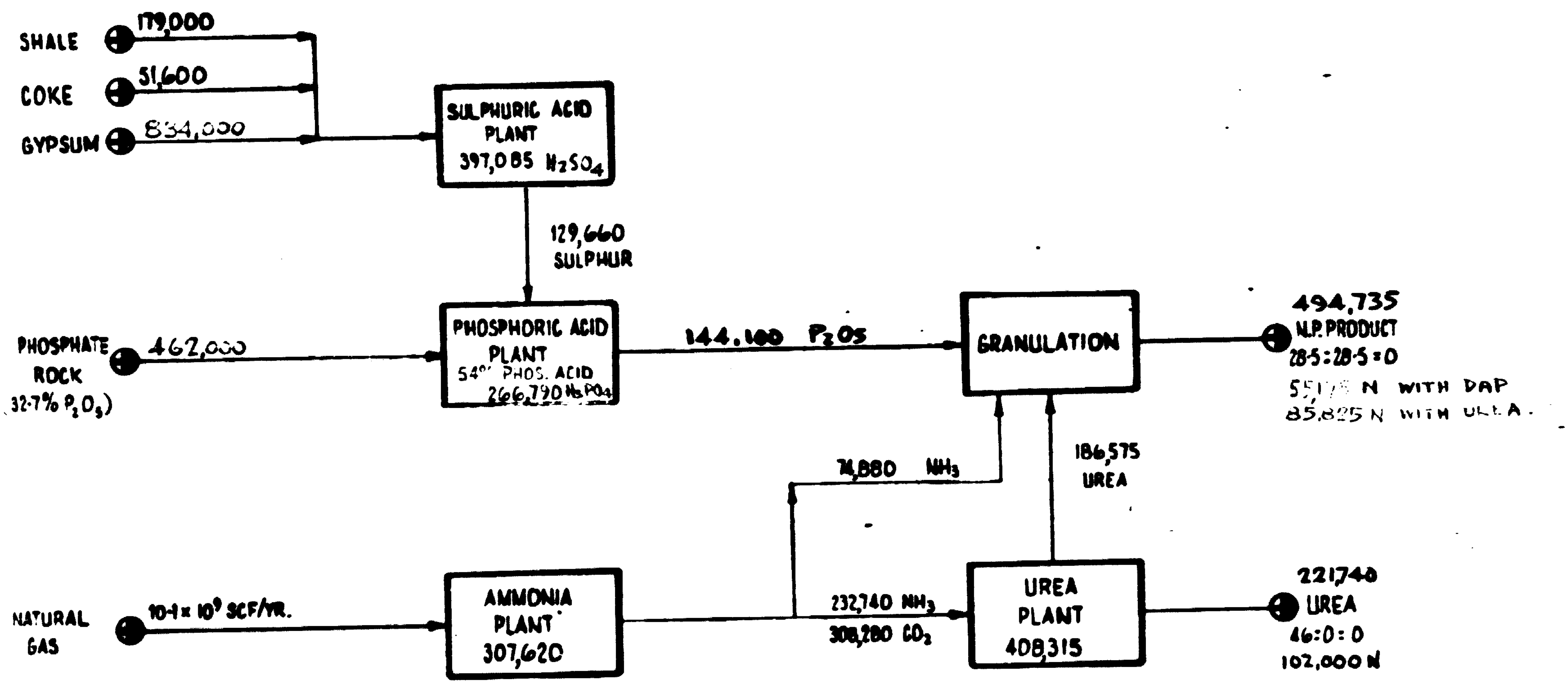
2.4.8.5 Triple Superphosphate Plant at Khulna

See block diagram on page 2.65.

This complex consists of a sulphuric acid plant, phosphoric acid plant and triple superphosphate plant. As discussed in Section 2.4., a conventional sulphur burning contact sulphuric acid plant for acid production has been chosen. The whole of the sulphuric acid will be fed to a conventional di-hydrate phosphoric acid plant where it will react with phosphate rock to produce wet process phosphoric acid.

The phosphoric acid will be evaporated to about 50% P_2O_5 before being fed to a slurry process triple superphosphate plant. The TSP plant will produce granular material directly. Full facilities will be provided for unloading phosphate rock and sulphur from barges or ships by crane, transport, storage and reclaiming of these materials. Bulk storage, bagging, storage and dispatch of TSP will also be provided.

Raw water will be drawn from the adjacent river and the service facilities will be similar to those provided at Ismailwal.



NOTE:
ALL QUANTITIES ARE IN METRIC TONS PER YEAR

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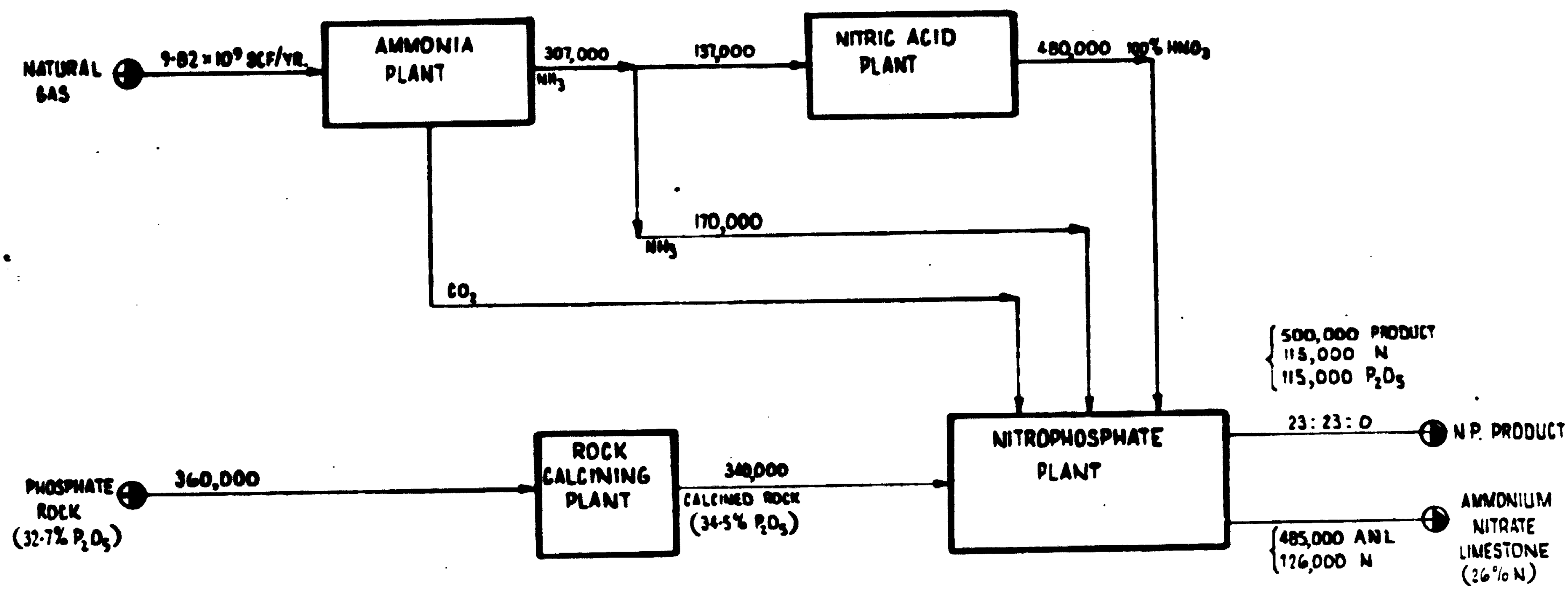
BLOCK DIAGRAM

HUMPHREYS & GLASGOW LIMITED | WEST PAKISTAN | UREA/UREA-DAP | VOLUME I 2.62



Note:

ALL QUANTITIES ARE IN METRIC TONS PER YEAR

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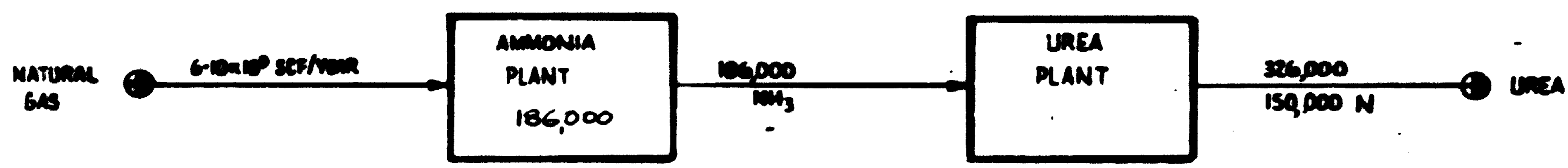
BLOCK DIAGRAM

HUMPHREYS & GLASGOW LIMITED — WEST PAKISTAN — NITROPHOSPHATE — VOLUME I 2.63



Note
ALL QUANTITIES ARE IN METRIC TONS PER YEAR.

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BLOCK DIAGRAM

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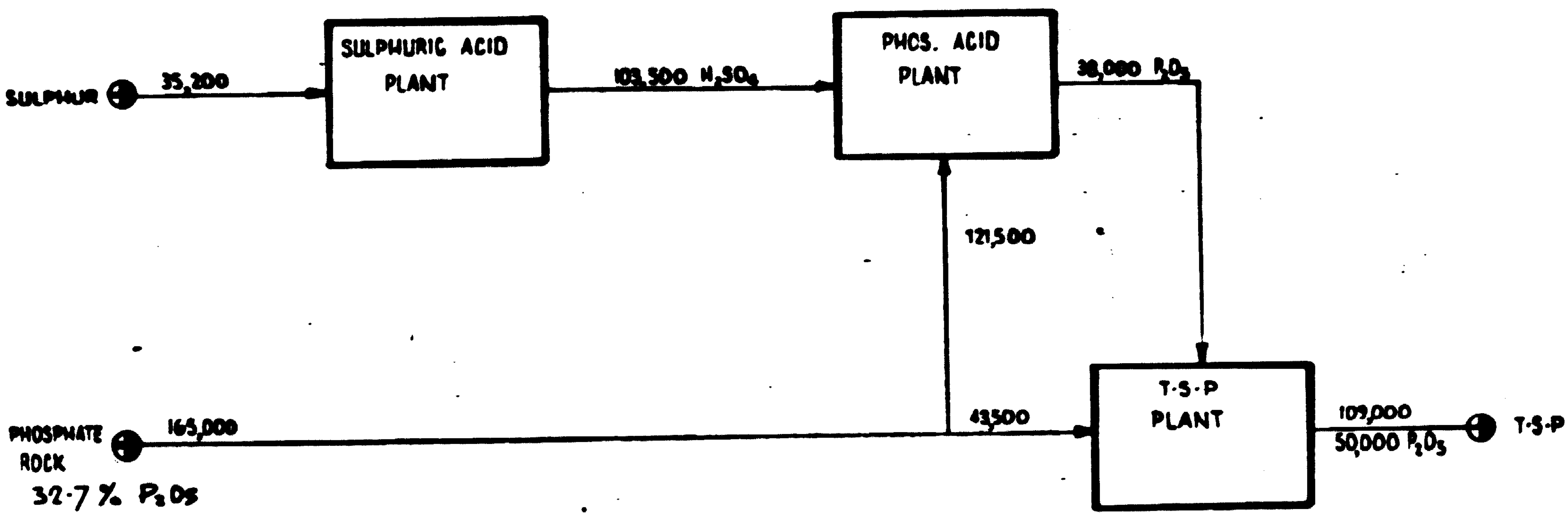
EAST PAKISTAN — UREA

VOLUME I
· 2.64



NOTE:

ALL QUANTITIES ARE IN METRIC TONS PER YEAR.

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BLOCK DIAGRAM

HUMPHREYS & GLASGOW LIMITED EAST PAKISTAN TRIPLE SUPERPHOSPHATE

VOLUME I
2.65

2.4.9 Financial Analysis of Selected Schemes

The following tables are presented showing the overall financial analysis of the schemes considered:

Page 2.67 Capital Costs of Schemes.

Page 2.68 Total annual cost - Urea + Urea/DAP - West Pakistan

Page 2.69 Total annual cost - Nitrophosphate - West Pakistan

Page 2.70 Total annual cost - Urea - East Pakistan

Page 2.71 Total annual cost - TSP - East Pakistan

2.4.10 Conclusions on Fertilizer Schemes Analysed

Two schemes have now been analysed in detail for each of East and West Pakistan.

From the earlier analysis the nitrophosphate scheme appeared more attractive for West Pakistan than the Urea/DAP project. Analysis in the preceeding pages has increased the advantage. It must also be remembered that, while the nitrogen capacity is the same for both projects, the P_2O_5 capacity of the Urea/DAP project is 20% higher.

In East Pakistan it is recommended that the proposed urea project is integrated with the petrochemicals project in the East. This can then be studied as a single project in Phase II.

As a result of this analysis the projects recommended for detailed study in Phase II of the Contract are:

The Nitrophosphate project at Multan - West Pakistan.

The TSP plant at Khulna - East Pakistan.

.4.9 Financial Analysis of Selected Schemes

Capital Costs of Schemes

Capital Costs

	WEST PAKISTAN				EAST PAKISTAN			
PLANT	UREA/UREA - DAP		NITROPHOSPHATE		AMMONIA/UREA		TSP	
CAPACITY MTPA (Fertiliser)	221,740/494,735		500,000		186,000/326,000		1[illegible],000	
LOCATION	Ismailwal		Multan		Ashuganj		Khulna	
PROCESS UNITS	Rs TOTAL	Rs FE	Rs TOTAL	Rs FE	Rs TOTAL	Rs FE	Rs TOTAL	Rs FE
Sulphuric acid	148×10^6	74×10^6	-	-	-	-	12.6×10^6	6.3×10^6
Phosphoric acid	44×10^6	22×10^6	-	-	-	-	19.2×10^6	9.6×10^6
Ammonia	121×10^6	73×10^6	121×10^6	73×10^6	91.4×10^6	54.8×10^6	-	-
Urea	85.5×10^6	51.3×10^6	-	-	68.5×10^6	41.1×10^6	-	-
Granulation Plant	37×10^6	19×10^6	-	-	-	-	-	-
TSP	-	-	-	-	-	-	10.9×10^6	5.5×10^6
Nitric acid	-	-	66×10^6	$40. \times 10^6$	-	-	-	-
Nitrophosphate	-	-	85×10^6	51×10^6	-	-	-	-
Rock Calcining	-	-	8×10^6	5×10^6	-	-	-	-
OFFSITE & UTILITIES FACILITIES								
Water treatment	19.00×10^6	11.61×10^6	12.2×10^6	7.3×10^6	19.76×10^6	5.86×10^6	1.62×10^6	0.97×10^6
Steam raising	11.62×10^6	6.4×10^6	3.1×10^6	1.9×10^6	3.98×10^6	2.39×10^6	7.02×10^6	4.22×10^6
Power Generation	15.00×10^6	8.76×10^6	7.7×10^6	4.6×10^6	3.33×10^6	2.0×10^6	1.00×10^6	0.60×10^6
Cooling towers etc.	14.00×10^6	8.19×10^6	16.5×10^6	9.9×10^6	8.20×10^6	4.92×10^6	0.25×10^6	0.15×10^6
Raw material handling	44.0×10^6	33.2×10^6	33.1×10^6	19.8×10^6	1.85×10^6	1.11×10^6	17.6×10^6	10.6×10^6
Product bagging, sotrage & dispatch, Laboratories offices & Social facilities	20.0×10^6	6.8×10^6	15.0×10^6	5.0×10^6	8.00×10^6	4.8×10^6	8.0×10^6	4.8×10^6
Site Development	1.5×10^6	0.9×10^6	0.9×10^6	0.3×10^6	1.0×10^6	0.6×10^6	0.64×10^6	0.38×10^6
Total Costs	560.62×10^6	315.16×10^6	368.5×10^6	217.8×10^6	206.02×10^6	117.58×10^6	78.83×10^6	43.12×10^6

2.4.9 Financial Analysis of Selected Schemes

Total Annual Cost-Urea + Urea/DAP Ismailwal, West Pakistan

UREA + UREA/DAP, ISMAILWAL, WEST PAKISTAN (221,740 MTPA UREA, 494,755 MTPA UREA/DAP) 28.5:28.5:0)

	Quantity at 100% Production	Unit Cost	74/75 yr at 30% capacity		75/76 at 70% capacity		76/77 at 100% capacity	
			Total	FE	Total	FE	Total	FE
			Rs/Year	Rs/Year	Rs/Year	Rs/Year	Rs/Year	Rs/Year
RAW MATERIALS								
Phosphate Rock	462,000 MTPA	222 RS/MT	30.7×10^6	$12.[illegible] \times 10^6$	71.6×10^6	30.1×10^6	102.5×10^6	43.0×10^6
Gypsum	834,000 MTPA	12.0 RS/MT	3.0×10^6	—	$[illegible].0 \times 10^6$	—	10.0×10^6	—
Shale	179,000 MTPA	12.0 RS/MT	0.6×10^6	—	1.4×10^6	—	2.0×10^6	—
Coke	51,600 MTPA	511.0 RS/MT	$[illegible].9 \times 10^6$	3.8×10^6	$1[illegible].4 \times 10^6$	8.86×10^6	26.3×10^6	12.7×10^6
Natural Gas	21.8×10^9 SCFPA	2.17 RS/ 1000SCF	14.26×10^6	$[illegible].44 \times 10^6$	33.26×10^6	3.35×10^6	47×10^6	4.79×10^6
Raw Water	$22.2 \times 10^6 M^3/YR$	0.441 RS/M^3	2.0×10^6	0.6×10^6	6.8×10^6	1.4×10^6	9.8×10^6	1.9×10^6
SUNDRY MATERIALS								
Bags	4.94×10^6	1.4 RS/BAG	6.9×10^6	2.07×10^6	16.1×10^6	4.84×10^6	20.7×10^6	6.22×10^6
Coating Agent	9900 MTPA		0.7×10^6	0.41×10^6	1.63×10^6	0.96×10^6	2.33×10^6	1.37×10^6
Chemicals and Sundry Materials			2.0×10^6	0.84×10^6	4.68×10^6	1.96×10^6	6.69×10^6	2.80×10^6
Raw Materials and Product Handling	160 Men	9000 RS/Man Year	0.72×10^6	—	1.15×10^6	—	1.44×10^6	—
Total Variable Cost			69.68×10^6	22.06×10^6	162.02×10^6	51.47×10^6	229.46×10^6	72.73×10^6
Plant Operating Labour	113 Men	9000 RS/Man Year	1.02×10^6	—	1.02×10^6	—	1.02×10^6	—
Maintenance	560.62×10^6 RS	6%	33.56×10^6	18.91×10^6	33.56×10^6	18.91×10^6	33.56×10^6	18.91×10^6
Interest Total Interest FE	560.62×10^6 RS) 315.16×10^6 RS)	8%	44.75×10^6	25.21×10^6	44.75×10^6	25.21×10^6	44.75×10^6	25.21×10^6
Depreciation Total Depreciation FE	560.62×10^6 RS) 315.16×10^6 RS)	10%	55.94×10^6	31.52×10^6	55.94×10^6	31.52×10^6	55.94×10^6	31.52×10^6
Net cost of Production			204.95×10^6	97.70×10^6	297.29×10^6	127.11×10^6	364.73×10^6	148.42×10^6
Overheads		10%	20.50×10^6	9.77×10^6	29.75×10^6	12.71×10^6	36.47×10^6	14.84×10^6
Product Transport and Distribution	20.3×10^6 RS		6.80×10^6	—	14.00×10^6	—	20.30×10^6	—
Total Cost			232.25×10^6	107.47×10^6	341.04×10^6	139.82×10^6	421.50×10^6	163.26×10^6

2.4.9 Financial Analysis of Selected Schemes

Total Annual Cost - Nitrophosphate - Multan, West Pakistan.

NITROPHOSPHATE - MULTAN, WEST PAKISTAN

500,000MTPA NP (23:23:0)
485,000MTPA AN (26:0:0)

	Quantity at 100% Production	Unit Cost	74/75 @ 30% Capacity Total	74/75 @ 30% Capacity F.E.	75/76 @ 70% Capacity Total	75/76 @ 70% Capacity F.E.	76/77 @ 100% Capacity Total	76/77 @ 100% Capacity F.E.
RAW MATERIALS			Rs/Year	Rs/Year	Rs/Year	Rs/Year	Rs/Year	Rs/Year
Phosphate Rock	360,000MTPA	217 Rs/MT	20.1×10^6	7.0×10^6	46.9×10^6	23.4×10^6	67.0×10^6	33.5×10^6
Natural Gas	14.58×10^6 SCFA	2.17 Rs/1000 SCF	12.1×10^6	1.0×10^6	23.7×10^6	2.2×10^6	31.6×10^6	3.2×10^6
Raw Water	$14.06 \times 10^6 M^3/A$	0.441 Rs/M^3	2.56×10^6	0.52×10^6	4.55×10^6	0.94×10^6	6.20×10^6	1.25×10^6
SUNDRY MATERIALS								
Bags	19.7×10^6	1.14 Rs/Bag	6.68×10^6	2.02×10^6	15.6×10^6	4.70×10^6	22.3×10^6	6.73×10^6
Coating Agent	20,000MT	228 Rs/MT	1.37×10^6	0.68×10^6	3.17×10^6	1.59×10^6	4.56×10^6	2.28×10^6
Chemicals & Cats.	—	—	0.99×10^6	0.48×10^6	2.24×10^6	1.12×10^6	3.20×10^6	1.60×10^6
Raw Material and Production Handling Labour	158 Men	9000 Rs/Man Year	0.71×10^6	—	1.14×10^6	—	1.42×10^6	—
TOTAL VARIABLE COST			44.51×10^6	11.70×10^6	97.3×10^6	33.95×10^6	136.28×10^6	48.56×10^6
Plant Operating Labour	122 Men	9000 Rs/Man Year	1.10×10^6	—	1.10×10^6	—	1.10×10^6	—
Maintenance	368.5×10^6 Rs	6%	22.11×10^6	13.07×10^6	22.11×10^6	13.07×10^6	22.11×10^6	13.07×10^6
Interest Total	368.5×10^6 Rs	8%	29.48×10^6	17.42×10^6	29.48×10^6	17.44×10^6	29.48×10^6	17.44×10^6
Interest F.E.	217.8×10^6 Rs	8%						
Depreciation Total	368.5×10^6 Rs	10%	36.85×10^6	21.78×10^6	36.85×10^6	21.78×10^6	36.85×10^6	21.78×10^6
Depreciation F.E.	217.8×10^6 Rs	10%						
NET COST OF PRODUCTION			134.05×10^6	63.97×10^6	186.84×10^6	86.24×10^6	225.82×10^6	100.85×10^6
Overheads	—	10%	13.40×10^6	6.40×10^6	18.68×10^6	8.62×10^6	*22.58×10^6	10.09×10^6
Produc Transport and distribution	24.8×10^6 Rs	—	7.44×10^6	—	17.4×10^6	—	24.8×10^6	—
TOTAL COST			154.89×10^6	70.37×10^6	222.92×10^6	94.86×10^6	273.20×10^6	110.94×10^6

2.4.9 Financial Analysis of Selected Schemes

Total Annual Cost - Ammonia Urea - East Pakistan

AMMONIA/UREA - EAST PAKISTAN   186,000 MTPA AMMONIA
326,000 MTPA UREA

	Quantity at 100% Production	Unit Cost	74/75 @ 30% Capacity Total	74/75 @ 30% Capacity F.E.	75/76 @ 70% Capacity Total	75/76 @ 70% Capacity F.E.	76/77 @ 100% Capacity Total	76/77 @ 100% Capacity F.E.
RAW MATERIALS			Rs/Year	Rs/Year	Rs/Year	Rs/Year	Rs/Year	Rs/Year
Natural Gas	9.81×10^9 SCF PA	0.9 Rs/1000 SCF	2.65×10^6	0.26×10^6	6.18×10^6	0.61×10^6	8.84×10^6	0.88×10^6
Raw Water	$7.30 \times 10^6 M^3/YR$	0.441 Rs/M^3	0.97×10^6	0.20×10^6	2.26×10^6	0.467×10^6	3.23×10^6	0.67×10^6
SUNDRY MATERIALS								
Bags	6.57×10^6	1.4 Rs/Bag	3.10×10^6	1.03×10^6	7.23×10^6	2.41×10^6	9.20×10^6	3.10×10^6
Chemicals			0.67×10^6	0.40×10^6	1.56×10^6	0.93×10^6	2.24×10^6	1.33×10^6
Raw Material and Product Handling Labour	133 Man	9000 Rs/Man Year	0.60×10^6	—	0.96×10^6	—	1.20×10^6	—
TOTAL VARIABLE COST			7.99×10^6	1.89×10^6	18.19×10^6	4.41×10^6	24.71×10^6	5.98×10^6
Plant Operating Labour	65 Man	9000 Rs/Man Year	0.59×10^6	—	0.59×10^6	—	0.59×10^6	—
Maintenance	206.00×10^6 Rs	6%	12.36×10^6	7.05×10^6	12.36×10^6	7.05×10^6	12.36×10^6	7.05×10^6
Interest Total	206.00×10^6 Rs	8%						
Interest F.E.	117.58×10^6 Rs	8%	16.48×10^6	9.41×10^6	16.48×10^6	9.41×10^6	16.48×10^6	9.41×10^6
Depreciation Total	206.00×10^6 Rs	10%						
Depreciation F.E.	117.58×10^6 Rs	10%	20.60×10^6	11.76×10^6	20.60×10^6	11.76×10^6	20.60×10^6	11.76×10^6
NET COST OF PRODUCTION			58.08×10^6	30.11×10^6	68.28×10^6	32.63×10^6	74.74×10^6	34.20×10^6
Overheads		10%	5.80×10^6	3.01×10^6	6.82×10^6	3.26×10^6	7.47×10^6	3.42×10^6
Product Transport and Distribution	2.42×10^6 Rs		0.81×10^6	—	1.89×10^6	—	2.42×10^6	—
TOTAL COST			64.63×10^6	33.12×10^6	76.95×10^6	35.89×10^6	84.63×10^6	37.62×10^6

2.4.9 Financial Analysis of Selected Schemes

Total Annual Cost - TSP - East Pakistan

EAST PAKISTAN — 109,000 MTPA TSP

	Quantity at 100% Production	Unit Cost	74/75 @ 30% Capacity Total	74/75 @ 30% Capacity F.E.	75/76 @ 70% Capacity Total	75/76 @ 70% Capacity F.E.	76/77 @ 100% Capacity Total	76/77 @ 100% Capacity F.E.
RAW MATERIALS			Rs/Year	Rs/Year	Rs/Year	Rs/Year	Rs/Year	Rs/Year
Sulphur	34,900 MTPA	662 Rs/MT	6.98×10^6	3.04×10^6	16.30×10^6	7.10×10^6	23.30×10^6	10.12×10^6
Phosphate Rock	165,000 MTPA	183 Rs/MT	9.1×10^6	4.6×10^6	21.1×10^6	10.6×10^6	30.2×10^6	15.1×10^6
Raw Water	2.22×10^6 M^3/YR	0.441 Rs/M^3	0.3×10^6	0.1×10^6	0.7×10^6	0.23×10^6	1.0×10^6	0.33×10^6
Fuel Oil	0.012×10^6 MTPA	82 Rs/MT	0.3×10^6	0.03×10^6	0.7×10^6	0.07×10^6	1.0×10^6	0.10×10^6
SUNDRY MATERIALS								
Bags	1.92×10^6	1.6 Rs/Bag	3.05×10^6	1.02×10^6	7.12×10^6	2.39×10^6	10.2×10^6	3.41×10^6
Chemicals			0.22×10^6	0.13×10^6	0.51×10^6	0.30×10^6	0.73×10^6	0.43×10^6
Raw Materials and Product Handling	80 Men	9000 Rs/Man Year	0.36×10^6	—	0.58×10^6	—	0.72×10^6	—
TOTAL VARIABLE COST			20.31×10^6	8.92×10^6	47.01×10^6	20.69×10^6	67.15×10^6	29.49×10^6
Plant Operating Labour	59 Men	9000 Rs/Man Year	0.53×10^6	—	0.53×10^6	—	0.53×10^6	—
Maintenance	78.8×10^6 Rs	6%	4.70×10^6	2.56×10^6	4.70×10^6	2.56×10^6	4.70×10^6	2.56×10^6
Interest Total	78.8×10^6 Rs	8%	5.30×10^6	3.45×10^6	5.30×10^6	3.45×10^6	5.30×10^6	3.45×10^6
Interest F.E.	43.1×10^6 Rs	8%						
Depreciation Total	78.8×10^6 Rs	10%	7.88×10^6	4.31×10^6	7.88×10^6	4.31×10^6	7.88×10^6	4.31×10^6
Depreciation F.E.	43.1×10^6 Rs	10%						
NET COST OF PRODUCTION			38.72×10^6	19.24×10^6	65.42×10^6	31.01×10^6	85.56×10^6	39.81×10^6
Overheads		10%	3.87×10^6	1.92×10^6	6.54×10^6	3.10×10^6	8.56×10^6	3.98×10^6
Product Transport and distribution	1.21×10^6 Rs		0.36×10^6	—	0.85×10^6	—	1.21×10^6	—
TOTAL COST			42.95×10^6	21.16×10^6	72.81×10^6	34.11×10^6	95.33×10^6	43.79×10^6

2.5 Petrochemicals Scheme Studies

2.5.1 Summary of Product Market Data

2.5.1.1 Preliminary Selection of Products to be Manufactured in Pakistan

It was decided to exclude from consideration in Phase I of this report any requirements for aromatics based chemicals and/or ethylene/glycol which could arise if synthetic fibre polymers are produced in Pakistan.

Following from this decision, and from the analysis of market data it was clear that for only five products - Polyethylene (PE), Polyvinyl Chloride (PVC), Dioctylphthalate (DOP), Polypropylene (PP) and Dodecyl Benzene (DDB) - were the predicted requirements large enough to merit further study of their manufacture in Pakistan. Requirements for the other petrochemicals were all relatively small so that it would be cheaper in foreign exchange to import them than to manufacture them in Pakistan. In the Interim Report, this was discussed in more detail and reasons were given why polystyrene, formaldehyde and its precursor - methanol, phenol formaldehyde resins, alkyd resins and monomers for synthetic fibres were eliminated from the list for further study.

2.5.1.2 Production Capacities

Because of the anticipated high rate of growth of the markets for the chosen five petrochemical products, and the substantial improvements of production costs with scale of manufacture, the optimum production capacities were judged to be in the range of 2 to 2½ times the 1975 requirements. The figures so obtained were close to the estimated requirements for 1980, which latter were therefore chosen as the selected production capacities.

Including the monomers required to supply the existing and sanctioned PVC and PE capacity, the selected production capacities are as follows, in thousands of metric tons/year:

	Total Pakistan	West	East
Polyethylene	52	30	22
Ethylene	10.5	10.5	-
Polyvinyl Chloride	55	23	32
Vinylchloride	5.6	5.6	-
Dioctylphthalate	16	7	9
Polypropylene	14.9	9.7	5.2
Dodecyl Benzene	13.7	8.2	5.5

2.5.1.2 Production Capacities - continued

Production of ethylene and vinylchloride for supply to the existing polymer producers in the West is included only if the proposed production capacity is situated in the West; transport of these monomers from East to West would be uneconomic.

DDB capacity is adjusted downward, if necessary, to match the propylene available from the naphtha cracker.

2.5.1.3 Prospects for Synthetic Fibre Production in Pakistan

The primary requirement for fibres in Pakistan is polyester and nylon for combination with or replacement of cotton, thus enabling cotton exports to be increased.
Production of these fibres from basic raw materials necessitates the availability of aromatics feedstock. The petrochemicals study does not provide for aromatics plant units because there is no suitable naphtha feedstock containing aromatics available in Pakistan. In addition it is known that Iran, which is a member of the RCD group, proposes to build a large aromatics unit.

In the Interim Report Humphreys and Glasgow recommended that polyester fibre plant in Pakistan is based on the import of DMT and comment on this proposal. Some relative advantages of using polyester or nylon were given and it was recommended that prior to final decisions being taken to produce fibre in Pakistan the choice between polyester and Nylon 6 should be thoroughly reviewed.

Amplification of the reasons for not making specific recommendations for synthetic fibre manufacture was also given.

2.5.2 Processing Schemes

2.5.2.1 Process Routes

Preference was given to processes which are thoroughly proved and for which good technical backing is believed to be available from a licensor who operates the process. At the same time it was necessary to investigate whether indigenous natural gas could be used with advantage for organic chemicals production.

From the analysis of the market and raw materials available, it was concluded that for the five end-products to be considered - Polyethylene, Polypropylene, Dodecyl Benzene, Polyvinyl Chloride and Dioctylphthalate, all can be made from ethylene or propylene, both derived from the available naphtha; the last two products can alternatively be made from acetylene derived

2.5.2.1 Process Routes - continued

from natural gas.

Potential sources of technology for the appropriate processes were contacted and in nearly every case it was confirmed that competitive and reliable technology is likely to be available from at least one licensor.

A summary of the process routes considered is given below. The process routes were then combined in a variety of ways to make the selected products, the result being a number of schemes which are detailed in section 2.5.2.2.

Summarising, the routes considered were:

Polythene - High pressure process (since low density polythene is expected to be in greater demand than high density).

Polypropylene - Particle-form polymerisation on a heterogenous catalyst (all available processes are believed to be similar in this respect).

Dodecyl Benzene - Propylene to propylene tetramer; propylene tetramer and benzene to dodecyl benzene.

Polyvinyl Chloride - Ethylene and chlorine to vinylchloride; alternatively acetylene, hydrogen and chlorine to vinylchloride. Electrolysis of sodium chloride brine to chlorine, hydrogen, and caustic soda. Suspension polymerisation of vinylchloride to PVC.

Dioctylphthalate - Partial oxidation of fuel oil by oxygen to give CO + H_2 mixture; high pressure catalytic reaction with propylene to give n-butyraldehyde and by-products; condensation and hydrogenation of n-butyraldehyde to give 2-ethylhexanol. Alternatively either hydration of acetylene to acetaldehyde or air oxidation of ethylene to acetaldehyde (two stage version of the Hoechst-Wacker process). From acetaldehyde through aldol to crotonaldehyde; hydrogenation to n-butyraldehyde; condensation and hydrogenation to 2-ethylhexanol.

From 2-ethylhexanol (by any of these three routes) and phthalic anhydride, to dioctylphthalate.

Ethylene and Propylene - From naphtha by pyrolysis of vapour, mixed with steam, in fired tubular furnaces, and subsequent cooling, compression and distillation of the furnace effluent. Gasoline, fuel oil, other hydrocarbons and hydrogen as by-products.

2.5.2.1 Process Routes - continued

Acetylene - From natural gas by partial combustion with oxygen, followed by rapid cooling, compression, and separation of acetylene from the burner gases. Hydrogen-rich tail gas as by-product.

Only one route is listed for each product from a given feedstock, except in the case of 2-ethylhexanol from naphtha, for which a choice of routes via ethylene or propylene exists. However, the propylene/ethylene ratio from the naphtha cracker is variable only between limits of about 0.44 and 0.50 by weight with the available naphthas. It was quite clear that to achieve reasonable production costs, a large unused surplus of either ethylene or propylene must be avoided. This requirement was found to determine the choice of route to 2-ethylhexanol from naphtha in every scheme considered.

In a majority of schemes, the propylene demand, based on the 1980 requirements, tended slightly to exceed 0.50 times the ethylene demand. In all these cases, the dodecyl benzene production capacity was reduced to match the availability of propylene, because this was believed to be the most economical way of balancing the propylene and ethylene demands.

2.5.2.2 Possible Schemes for Analysis

The four sites considered for the schemes - one for each feedstock, in each of East and West Pakistan - were:

Site	Feedstock	East or West
Korangi-Karachi	Naphtha	West
Multan	Natural Gas	West
Chittagong	Naphtha	East
Ashuganj	Natural Gas	East

A list of 22 schemes was drawn up using these sites, the selected routes, and the selected production capacities. This list is set out in the table on pages 2.76 & 2.77 and is believed to include all combinations of these sites and process routes which are of interest. Not more than two sites were used in any one scheme, because to split these production capacities between more than two sites would certainly be uneconomic.

The total investment cost in process plants was estimated for each of the 22 schemes, using consistent methods. From an initial analysis of the 22 posibilities, seven schemes were selected for detailed calculations of costs of production of individual materials. These are scheme numbers 1, 8, 21, 23, 24, 26 and 27.

2.5.2 Processing Schemes - continued

Summary of Schemes Examined

Quantities: 1,000 metric tons/year

Market Basis (Ethylene, DDB, VCM and NaOH vary between schemes)

	E	PE	PP	PVC	DOP	DDB	VCM	NaOH
West	10.5	30	9.7	23	7.0	8.2	5.6	30.0
East	-	22	5.2	32	9.0	5.5	-	10.0
	10.5	52	15.0	55	16.0	13.7	5.6	40.0

Scheme	No.	Feedstock	E	PE	PP	PVC	*DOP	DDB	VCM	NaOH
1	W	Naphtha	10.5	52.0	14.9	55.0	(P)16.0	11.4	5.6	45.2
	E	"	-	-	-	-	-	-	-	-
2	W	"	-	-	-	-	-	-	-	-
	E	"	-	52.0	14.9	55.0	(P)16.0	6.6	-	41.2
3	W	"	10.5	30.0	9.7	23.0	(P) 7.0	7.7	5.6	21.1
	E	"	-	22.0	5.2	32.0	(P) 9.0	3.7	-	24.1
4	W	"	10.5	52.0	14.9	-	-	11.8	-	-
	E	"	-	-	-	55.0	(P)16.0	-	-	41.2
5	W	"	10.5	52.0	-	-	(P)16.0	12.3	-	-
	E	"	-	-	14.9	55.0	-	-	-	41.2
6	W	"	10.5	-	-	55.0	(P)16.0	-	5.6	45.2
	E	"	-	52.0	14.9	55.0	-	7.9	-	-
7	W	"	10.5	-	14.9	55.0	-	-	5.6	45.2
	E	"	-	52.0	-	-	(P)16.0	8.5	-	-
8	W	"	10.5	52.0	14.9	23.0	(P)16.0	-	5.6	21.1
	E	"	-	-	-	32.0	-	6.1	-	24.1
9	W	"	10.5	20.5	-	55.0	(P)16.0	11.4	5.6	45.2
	E	"	-	31.5	14.9	-	-	-	-	-
10	W	"	10.5	20.6	14.9	-	-	-	-	-
	E	"	-	31.4	-	55.0	(P)16.0	10.9	-	41.2
11	W	"	10.5	37.4	14.9	23.0	-	11.4	5.6	21.1
	E	"	-	14.0	-	32.0	(P)16.0	-	-	24.1
12	W	"	10.5	36.4	-	23.0	(P)16.0	11.4	5.6	21.1
	E	"	-	15.9	14.9	32.0	-	-	-	24.1
13	W	"	10.5.	11.8	-	13.6	(P)16.0	11.1	5.6	12.8
	E	"	-	40.2	14.9	41.4	-	-	-	32.4
14	W	"	10.5	22.5	14.9	55.0	(P)16.0	-	5.6	45.2
	E	"	-	29.5	-	-	-	11.4	-	-
21	W	"	10.5	52.0	14.9	-	-	11.7	-	-
	E	Nat. Gas	-	-	-	55.0	(A)16.0	-	-	39.0
22	W	Nat. Gas	-	-	-	55.0	(A)16.0	-	5.6	43.9
	E	Naphtha	-	52.0	14.9	-	-	11.7	-	-

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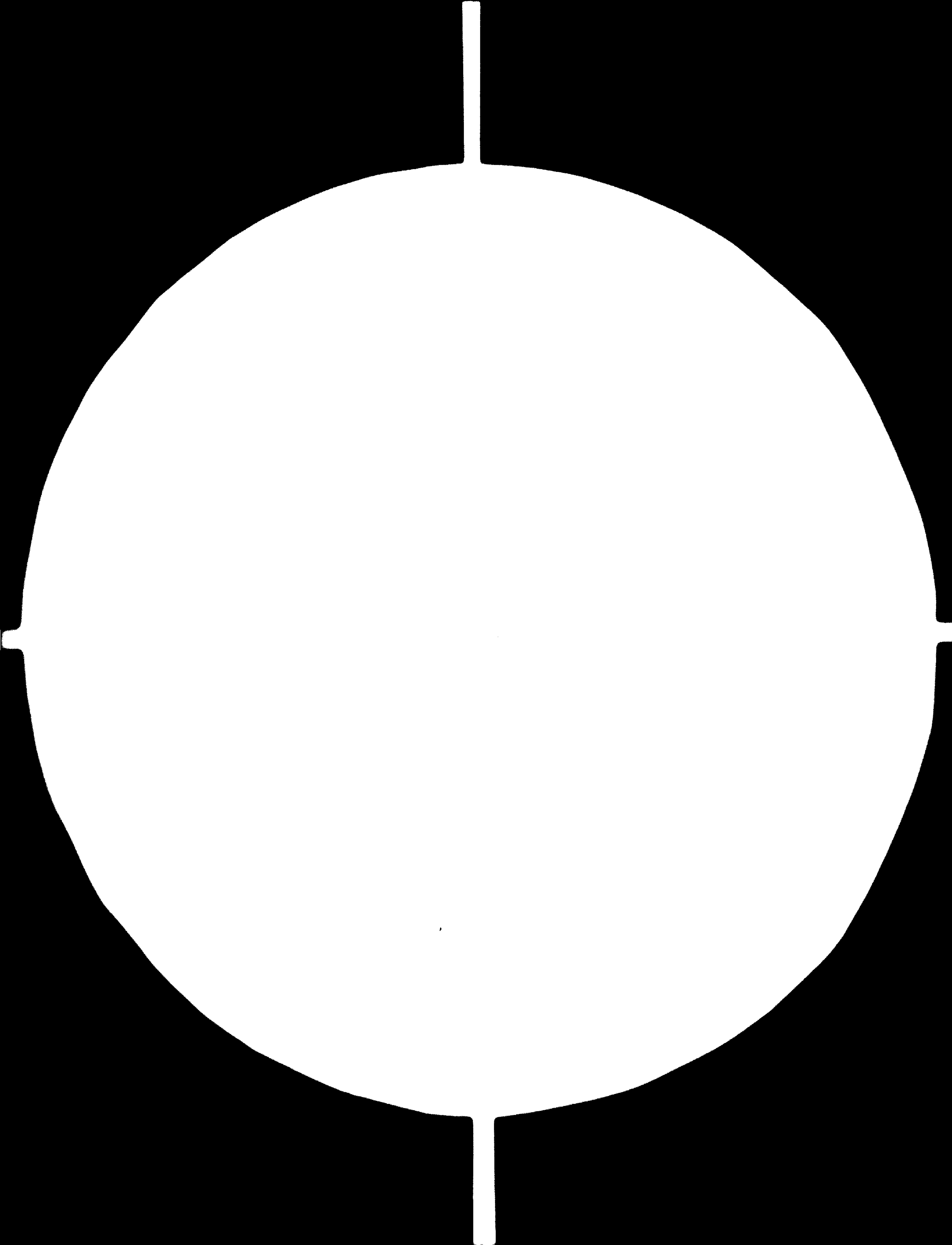

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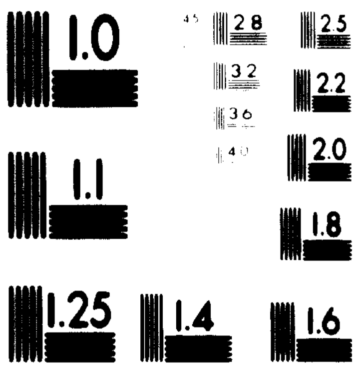

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS
STANDARD REFERENCE MATERIAL 1010a
(ANSI and ISO TEST CHART No 2)

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2.5.2 Processing Schemes - continued

Summary of Schemes Examined - continued

Scheme No.		Feedstock	E	PE	PP	PVC	*DOP	DDB	VCM	NaOH
23	W	Naphtha	10.5	52.0	14.9	-	-	11.7	-	-
	W	Nat. Gas	-	-	-	55.0	(A)16.0	-	5.6	43.9
24	W	Naphtha	10.5	52.0	14.9	-	(E)16.0	13.7	-	-
	E	Nat. Gas	-	-	-	55.0	-	-	-	39.0
25	W	Naphtha	10.5	52.0	14.9	55.0	-	13.7	5.6	43.9
	E	Nat. Gas	-	-	-	-	(A)16.0	-	-	-
26	W	Naphtha	10.5	52.0	14.9	23.0	-	13.7	5.6	21.1
	E	Nat. Gas	-	-	-	32.0	(A)16.0	-	-	22.7
27	W	Naphtha	10.5	52.0	14.9	23.0	(E)16.0	13.7	5.6	21.2
	E	Nat. Gas	-	-	-	32.0	-	-	-	22.7
28	W	Naphtha	10.5	52.0	14.9	23.0	(E) 7.0	13.7	-	21.2
	E	Nat. Gas	-	-	-	32.0	(A) 9.0	-	-	22.7

*Note: (P) = DOP made via propylene
(E) = DOP made via ethylene
(A) = DOP made via acetylene

2.5.3 Operating and Product Cost Data

Raw material costs (total and foreign exchange) for natural gas, naphtha, salt, phthalic anhydride, benzene, and fuel oil together with the cost of transport from source to the site were first established.

Unit costs of utilities (total and foreign exchange) - i.e. electricity, steam, cooling water and demineralised water were determined. By-products and co-products were valued - i.e. acetylene off-gas, by-product hydrogen, liquid organic by-products, chlorine and caustic soda, ethylene and propylene.

Estimates of the capital costs of process units were then made from data obtained from various external sources and sources within H & G. These process units covered the production of:-

chlorine, ethylene, acetylene, vinyl, chloride, PVC, polyethylene, polypropylene, dodencyl benzene, acetaldehyde, 2-ethylhexanol and dioctylphtalate.

The production costs of each intermediate or product from a process unit, for each scheme, were then calculated and to the ex-works cost per metric ton of product was added an average transport cost per metric ton to the point of distribution, taken to be, the works itself, or the sea port in the opposite wing of the country, as appropriate.

From the information described above comparative annual costs for the seven selected schemes (plus scheme 14) are given in paragraph 2.5.3.1 below

2.5.3.1 Schemes chosen for further study

(i) Comparison of Schemes

Table of Comparative Annual Cost Figures in Rs million per year

Scheme No.:	1	8	14	21	23	24	26	27
Foreign Exchange Cost:	123	131	129	116	115	121	124	126
Total Cost:	209	232	229	232	227	230	229	226

The most important point about these figures is that the differences between the schemes are quite small; the range from lowest to highest is about 14% for foreign exchange and 11% for total cost.

Scheme 1, which makes all products from naphtha in the West, is the cheapest in total cost. Scheme 23, which makes all products

2.5.3.1 Schemes chosen for further study - cont.

in the West but makes PVC and DOP from natural gas, is the cheapest in foreign exchange (Rs 8 million/year less than Scheme 1) but total cost is Rs 21 million/year higher than Scheme 1. Neither of these schemes satisfies the reasonable desire of East Pakistan to have a share of the country's petrochemical industry.

The remaining schemes, which have a complex in the East, all have about the same total cost (Rs 20 to 23 million/year higher than Scheme 1), but have significantly different foreign exchange costs. The lowest in cost is Scheme 21, which makes the total requirements for PVC and DOP from natural gas in the East; its foreign exchange cost is Rs 7 million/year less than Scheme 1. This scheme allocates to East Pakistan nearly half of the petrochemicals process plant investment. Unfortunately, it does not supply vinyl chloride to the existing PVC producer in the West.

Scheme 26 is similar to Scheme 21 except that part of the PVC requirements are made from Naphtha in the West; foreign exchange cost is increased by Rs 8 million/year over Scheme 21. This scheme allocates to East Pakistan about one third of the petrochemicals process plant investment. It supplies vinyl chloride to the existing PVC capacity, and can still be put into effect if the highly advanced plans for a petrochemicals complex at Korangi, including vinyl chloride/PVC production, are sanctioned.

Once it is decided to make some or all of the vinyl chloride from natural gas, it is then cheaper to make DOP also from natural gas rather than naphtha, in foreign exchange cost at least. (Scheme 27 versus Scheme 26, and Scheme 24 versus Scheme 21).

Of the Schemes which have a complex in each wing of the country, Scheme 21 and Scheme 26 are the cheapest. They are therefore chosen for the final proposals and are summarised below. It is interesting to note however that Scheme 14 is only Rs 3 million/year more costly in foreign exchange than Scheme 26, and about the same in total cost as either of the two schemes chosen. Scheme 14 is an all-naphtha scheme which makes some PE and all the DDB in the East, and the balance in the West. Like Scheme 26 it supplies vinyl chloride to the existing PVC capacity.

Chosen Schemes

	Scheme 21	Scheme 26
West Pakistan	PE - Total Pakistan	PE - Total Pakistan
Site: Korangi	PP - Total Pakistan	PP - Total Pakistan
Feed: Naphtha	DDB - Total Pakistan	DDB - Total Pakistan
		PVC - West Requirements
		VCM - To Arokey

2.5.3.1 Schemes chosen for further study - continued

East Pakistan	Scheme 21	Scheme 26
Site: Ashuganj	PVC - Total Pakistan	PVC - East Requirements
Feed: Natural Gas	DOP - Total Pakistan	DOP - Total Pakistan

(ii) Foreign Exchange Saving on Each Product

Foreign exchange costs of the products for Schemes 21 and 26 extracted from the Interim Report and based on 1980 predicted import prices are in Rs/metric ton:-

Material:	PVC	PE	PP	DOP	DDB	NaOH
Imports, C&F:	1080	1290	1500	2050	1430	500
F.E. Cost Scheme 21:	574	752	1344	1266	1085	166
F.E. Cost Scheme 26:	671	726	1339	1298	1046	179
% saving Scheme 21:	47	42	10.5	38	23	67
% saving Scheme 26:	38	44	11	37	27	64

The general level of these foreign exchange savings are judged satisfactory in that they confirm that either scheme could break even in terms of foreign exchange at a production rate well below full capacity.

Only PP and DDB look of doubtful viability in terms of foreign exchange savings. Here, two points should be made. First, they are the only users of propylene; no more profitable outlets for propylene have been found as yet. In this situation, it might be reasonable to take propylene cost equal to only half the cost of ethylene. The effect of this would be to increase the foreign exchange savings figures to 21% for PP and to 46% (Scheme 21) or 50% (Scheme 26) for DDB and of course to reduce slightly the savings figures for PE and PVC to compensate. Second, it is recommended that the PP plant should be delayed, so that it can reach about 80% of its full capacity in its third year of operation. Taking these points into account, the manufacture of all products, including PP and DDB, should be capable of showing foreign exchange savings.

2.5.4 Summary and Conclusions of Preliminary Analysis of Petrochemicals Scheme

Five products were selected for petrochemical schemes - polyethylene, polyvinylchloride, dioctyphthalate, polypropylene and dodecylbenzene.

Possible processing schemes were devised so that each scheme would make the total Pakistan requirements of each of the five products. The capacity for each product was chosen to be equal to the predicted 1980 requirement, i.e. the predicted 1980 market demand less existing and sanctioned capacity.

2.5.4 Summary and Conclusions of Preliminary Analysis of Petrochemicals Scheme - continued

Four sites already selected in Section 2.3 were considered

Korangi, Karachi	- Project using naphtha in West
Multan	- Project using natural gas in West
Chittagong	- Project using naphtha in East
Ashuganj	- Project using natural gas in East

Unit costs of raw materials, including transport, were estimated for each site. Typical unit costs of utilities were taken to be the same for all four sites. A basis for calculating capital charges and overheads was developed. The foreign exchange element of each cost was estimated.

Annual costs of production, plus transport to the port in the opposite Wing where necessary, were calculated on the stated basis and compared.

The cost comparison showed that:

1. In overall cost, it is cheapest to make all the products from naphtha, in the West,

2. For each product, it is cheaper to produce for the whole country at one site rather than two (i.e. savings from combining production exceed savings in transport costs from producing separately for each market).

Two schemes were now selected for detailed analysis. These were Schemes 21 and 26 (see p.2.76 and 2.77)

2.5.5 Flow Diagrams of Selected Schemes

Flow diagrams for the two selected schemes are shown on pages 2.83 to 2.86; the two sites for each scheme are detailed separately.

The Flow Diagrams are based on the estimated annual production rates in 1980, and refer to pure components. Minor by-products and process or mechanical losses are not shown. The requirements for process or treated water, and for utilities in general, are excluded.

2.5.6 Cost Analysis of Selected Schemes

2.5.6.1 Total Site Facilities

Utilities

(a) Net daily requirements of electrical power, steam, compressed air, cooling water, and treated water were calculated for each of the proposed projects, based on the full annual production rates, equally distributed over 300 days/year of simultaneous operation of all process plants. From these average requirements the annual requirements of fuel, raw water and miscellaneous chemicals and supplies, for utilities, were estimated. The design basis for the facilities for generation of electrical power, steam and cooling water was taken to be 10% higher than these average daily figures. The total erected cost of these facilities was then estimated, within their 'battery limits' i.e. excluding

2.5.6.1 Total Site Facilities

Utilities - continued

distribution of these utilities to the process plants, as below in Rs million.

	Scheme 21	Scheme 26
Utilities West-Korangi	28.1	40.6
Utilities East-Ashuganj	40.4	29.0

Offsites

(b) Capital cost of off-sites, other than generation of electrical power, steam, compressed air, cooling water and treated water, and excluding site development, were then estimated.

The list of items to be covered under this heading includes:

Distribution of piped services and electricity
Piping of process fluids between process plants and offsites
Effluent treatment and drains
Tank Farm
Products storage and handling
Civil, including internal roads, pipetrack, boundary fence,
Buildings.
Equipment for workshops, laboratories and offices.
Estimated total off-sites in Rs millions are given below:

	Scheme 21	Scheme 26
Off-sites West (Korangi)	54	73
Off-sites East (Ashuganj)	57	44
Total off-site investment	111	117

Site Development

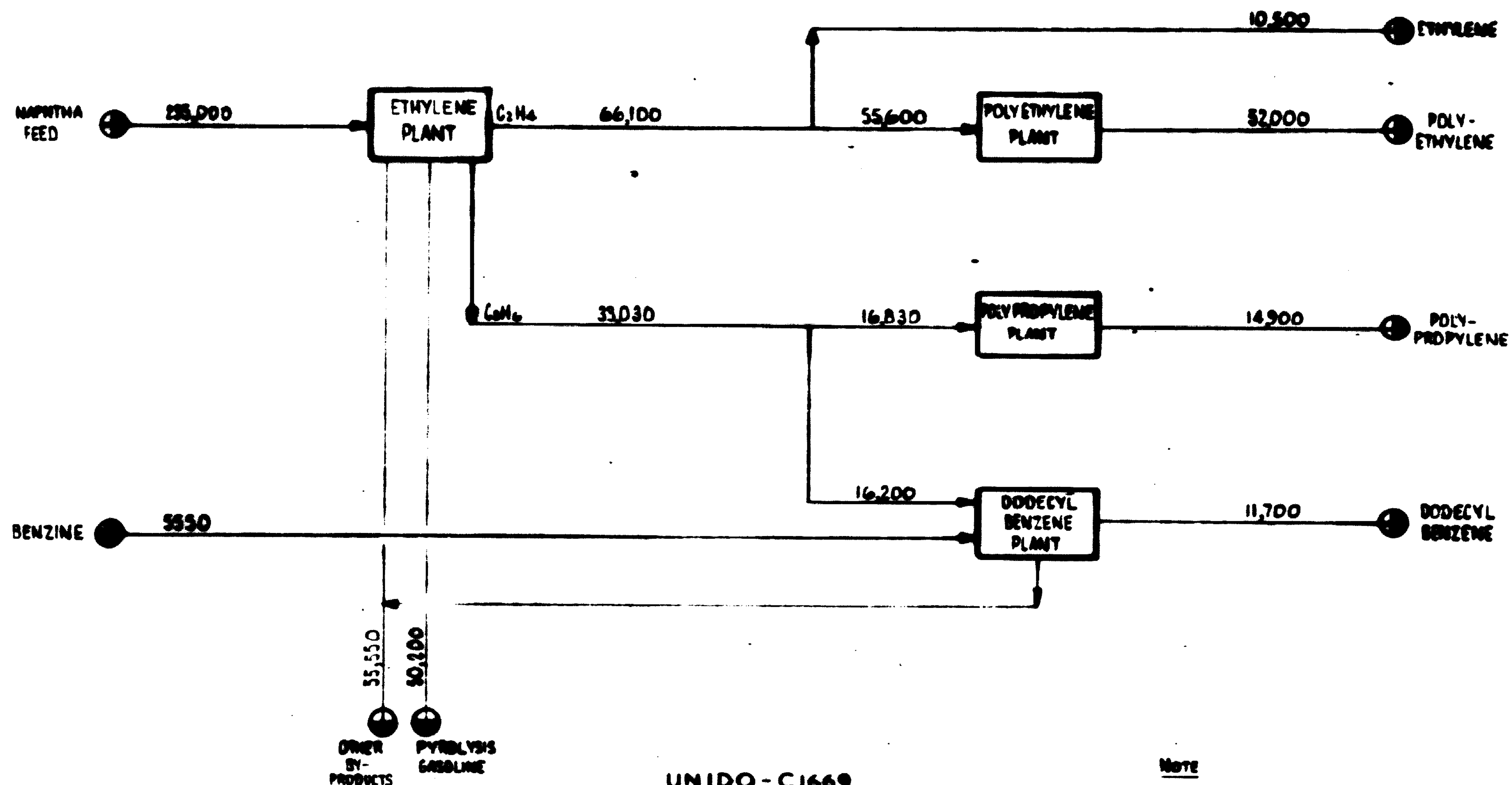
(c) The list of items to be covered under this heading includes:

Land cost
Filling and levelling of the site
Provision of access by road, rail and where appropriate, ship.
Piping of water and gas to the site, where appropriate
Effluent drain.

Site development costs were estimated as follows:

Ashuganj		Rs/acre
	Land	10,000
	Filling	65,000
	Road, rail, drain	30,000
	Wharf	20,000
		125,000

plus gas pipeline Rs 3.0 million total



Note
ALL QUANTITIES ARE IN METRIC TONS PER YEAR AND REFER TO PURE COMPONENTS.

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BLOCK DIAGRAM

WEST PAKISTAN - SCHEME 21

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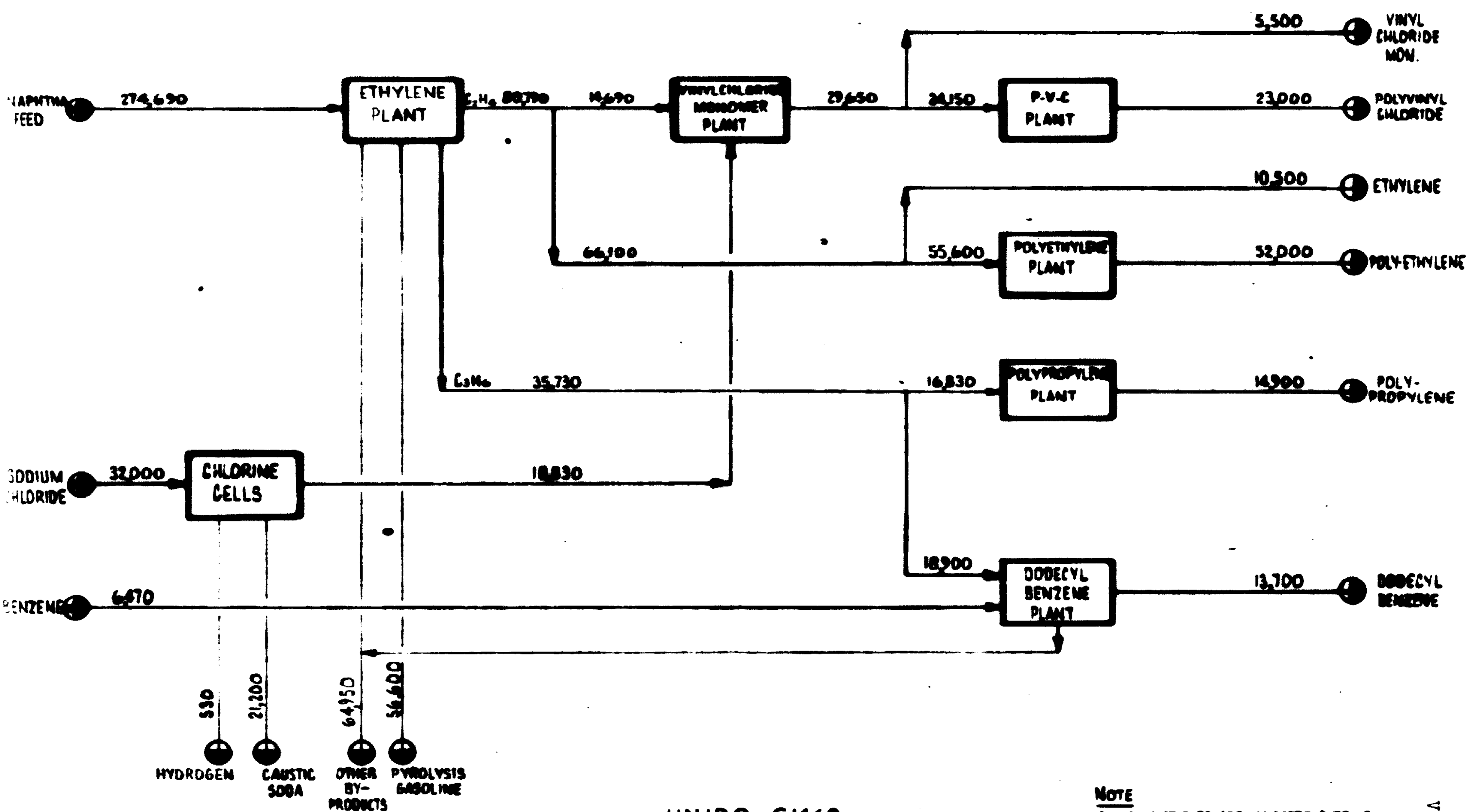

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BLOCK DIAGRAM

WEST PAKISTAN

NOTE
ALL QUANTITIES ARE IN METRIC TONS PER YEAR AND REFER TO PURE COMPONENTS.

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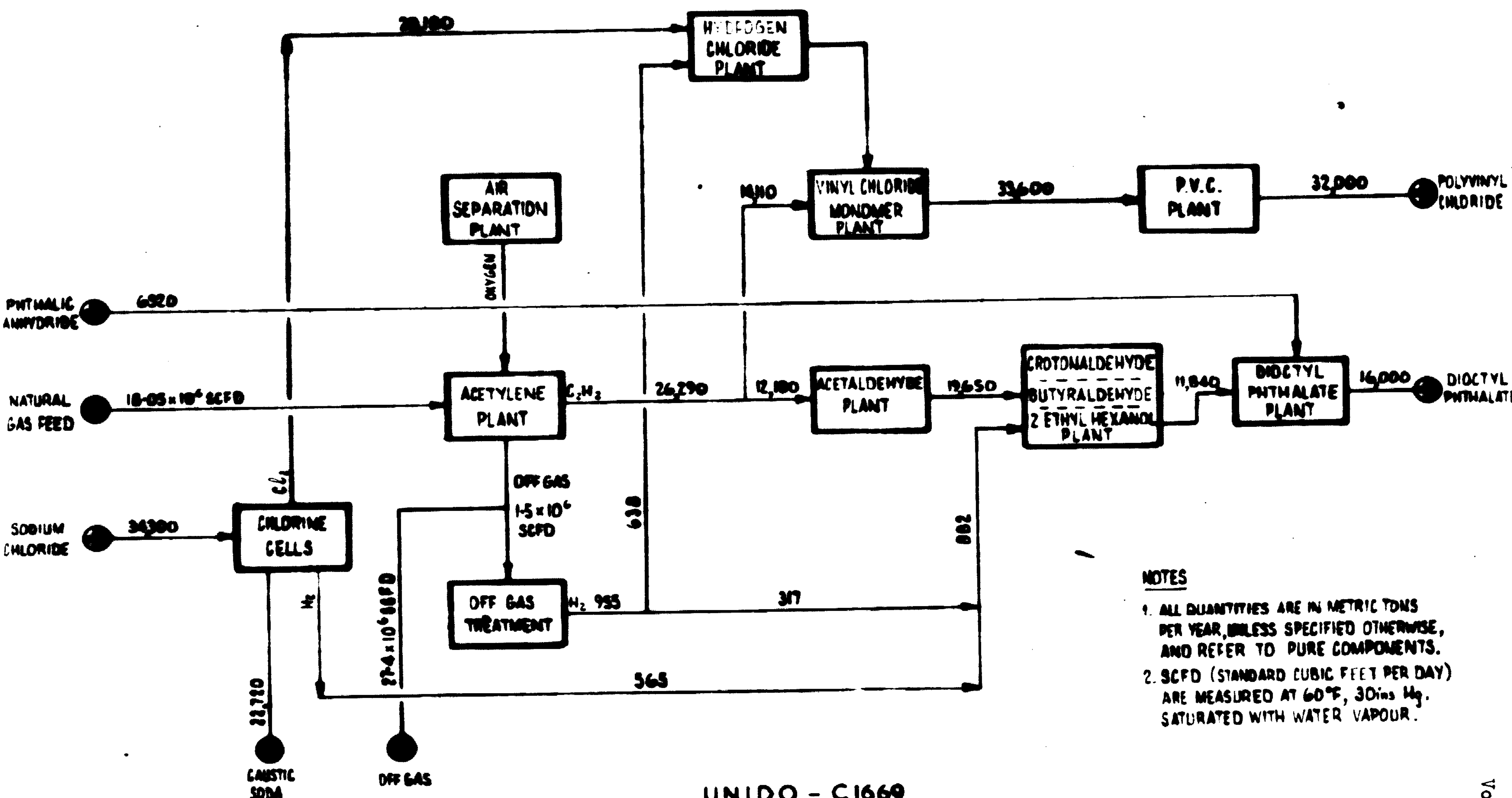

NOTES

1. ALL QUANTITIES ARE IN METRIC TONS PER YEAR, UNLESS SPECIFIED OTHERWISE, AND REFER TO PURE COMPONENTS.
2. SCFD (STANDARD CUBIC FEET PER DAY) ARE MEASURED AT 60°F, 30ins Hg. SATURATED WITH WATER VAPOUR.

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BLOCK DIAGRAM

EAST PAKISTAN - SCHEME 26

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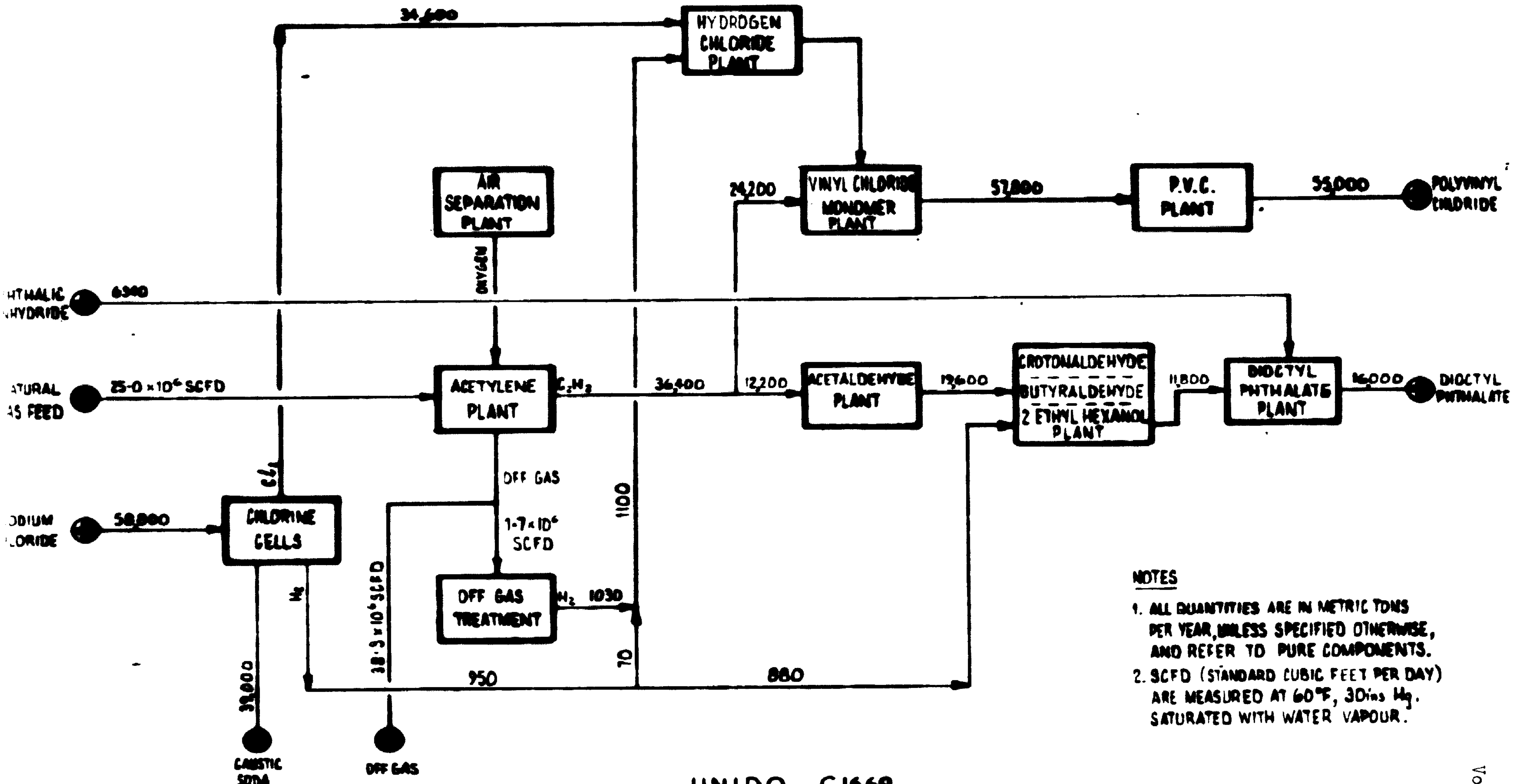

NOTES

1. ALL QUANTITIES ARE IN METRIC TONS PER YEAR, UNLESS SPECIFIED OTHERWISE, AND REFER TO PURE COMPONENTS.
2. SCFD (STANDARD CUBIC FEET PER DAY) ARE MEASURED AT 60°F, 30ins Hg. SATURATED WITH WATER VAPOUR.

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EAST PAKISTAN

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VOLUME I

(c) - Site Development - Continued

Korangi	Rs/acre
Land	8,000
Road, rail	20,000
Drain etc.	7,000
	35,000

2.5.6.2 Production Capacity and Timing

Production capacities of the completed complexes were based on the 1980 predicted requirements, as for the preliminary scheme comparison. As before, the DDB capacity for scheme 21 was limited to a lower figure by the availability of propylene.

The production requirements to satisfy the market predictions for the years 1974 to 1980 are, in thousands of metric tons per year:-

	'74	'75	'76	'77	'78	'79	'80
PE	11.8	16.0	20.8	26.6	33.5	42.0	52.0
PVC	20.2	24.0	28.5	33.7	40.0	47.0	55.0
PP	3.9	4.9	6.1	7.7	9.6	12.0	14.9
DOP	7.0	8.0	9.2	10.55	12.1	13.85	16.0
DDB	5.95	6.85	7.85	9.0	10.35	11.9	13.7
VCM	5.6	5.6	5.6	5.6	5.6	5.6	5.6
Ethylene	10.5	10.5	10.5	10.5	10.5	10.5	10.5

It was decided to commence production of all products except PP in 1974 on the grounds that this was the earliest practicable date and would allow the market demands to be met from 1975 onward. It was decided to delay production of PP until 1977 to improve profitability of this product.

To allow for the probable difficulties, with new chemical plants of complicated design and interlinked as a complex, it was decided to assume effective plant capacities of 30%, 70% and 100% in, respectively, the first, second, and third and subsequent years of operation of a new plant.

Extensions of existing plants should encounter fewer problems, so the corresponding figures for extensions were assumed to be 50%, 90% and 100%.

2.5.6.2 Production Capacity and Timing - continued

It was also decided that the following parts of the process plants could be omitted from initial construction and brought on stream in 1978:-

Naphtha complexes

Ethylene	:	1/3 of cracking furnace capacity
PE	:	½ capacity
Chlorine	:	½ capacity
PVC	:	½ capacity

Natural Gas Complexes

Acetylene	:	1/3 of burner capacity
Chlorine	:	1/3 capacity
PVC	:	1/3 capacity

Utilities, all Complexes

Steam generation	:	1/3 capacity
Electricity generation	:	1/3 capacity
Cooling Towers	:	1/3 capacity

The stagewise development of the projects will result in production capacity in 1975, 1978 and 1980 as tabulated below:

	Scheme 21			Scheme 26		
	'75	'78	'80	'75	'78	'80
Naptha Complexes						
PE	16.0	33.5	52.0	16.0	33.5	52.0
PVC	-	-	-	8.00	16.0	23.0
PP	-	9.6	14.9	-	9.6	14.9
DDB	6.85	8.7	11.7	6.85	10.35	13.7
VCM	-	-	-	5.5.	5.5	5.5
Ethylene	10.5	10.5	10.5	10.5	10.5	10.5
Natural Gas Complexes						
PVC	24	40	55	11.2	24.0	32.0
DOP	8	12.1	16.0	8	12.1	16.0

2.5.6.3 Investment Summary

Total investment for each project was obtained as the sum of the process plant investment, utilities, 'off-sites', and site development figures.

To estimate the delayed investment represented by the plant and utilities extensions 'on stream' in 1978, appropriate percentage factors were estimated and applied to the total investment figures of each unit. To these were added the whole of the PP plant figure to obtain the following figures for total delayed investment, in Rs million:-

	Scheme 21.	Scheme 26.
Delayed Investment Korangi	125	147
Delayed Investment Ashuganj	36	25

Hence, the following investment figures were obtained, in Rs million:-

	Scheme 21.			Scheme 26.		
	'75		'78/80	'75		'78/80
Excluding Site Development						
Korangi Total	260.9		385.9	398.7		545.7
Korangi F.E.	137.7		212.7	213.5		301.7
Ashuganj Total	330.1		366.1	256.0		281.0
Ashuganj F.E.	178.1		199.7	138.3		153.3
Site Development Only	(Area in acres)					
Korangi Total	2.8		2.8	3.5		3.5
Korangi F.E.	0.1	*80	0.1	0.2	*100	0.2
Ashuganj Total	10.5		10.5	9.2		9.2
Ashuganj F.E.	1.9	*60	1.9	1.8	*50	1.8

2.5.6.4 Basis of Costing

15% was added to the above total and foreign exchange investment figures to cover construction loan, contingencies, and working capital.

2.5.6.4 Basis of Costing - Continued

Capital charges were calculated at 18% on total and foreign exchange investment (8% interest and 10% depreciation) excluding site development, plus 8% interest (no depreciation) on site development.

Quantities of materials (including those for utilities) were calculated and the same unit costs as used in the preliminary costings applied to them.

Direct labour was estimated and charged at 9,000 Rs/man year including supervision.

Maintenance was calculated as 5% of investment excluding site development, applied to both total and foreign exchange figures.

Overheads were calculated as 10% of total ex-works basic cost.

Transport costs were calculated as in the preliminary costings. Transport cost were assumed to have negligible foreign exchange element.

2.5.6.5 Foreign Exchange Value of Products

The cost in foreign exchange of importing the products instead of manufacturing them was calculated from the following estimates of C and F prices for the years 1975-80, in Rs per metric ton:-

PE	1290
PVC	1080
PP	1500
DOP	2050
DDB	1430
Vinyl chloride	900
Ethylene	500
Caustic Soda	500

These figures are generally lower, by up to 10%, than the average figures for 1970 given in Section 2.2 because prices of these materials are expected to decline, and it was felt that conservative assumptions should be made when calculating foreign exchange savings.

These figures, and this applies generally to money figures in this Report, are in units of 1969/70 currency i.e. on the basis of fixed exchange rates and no inflation.

2.5.6.6 Annual Costs and Foreign Exchange Savings

Cost and savings tabulation sheets for each of the four complexes follow on pages 2.93 to 2.96. The results are then summarised on the following page, number 2.92.

2.5.6.7 Discussion of Cost Analysis

The capital charges used in the present simplified analysis are believed to be conservative; therefore, it is anticipated that the proposed projects will show a positive foreign exchange flow from 1977 at latest, and thereafter repay the earlier deficit within an acceptable number of years. Even if the foreign exchange flow predictions are not fully satisfactory for the projects as at present proposed, they can be made so by adjustments to their timing.

2.5.7 Summary of Petrochemicals Schemes Selected

The two alternative schemes (each a pair of complementary complexes in East and West Pakistan, together making petrochemicals for the whole country) already selected in Section 2.5.3 are further developed in Section 2.5.5 and 2.5.6.

Flow diagrams of the four complexes are included, (pages 2.83 to 2.86).

Requirements for utilities, off-sites, and site developments are estimated for the complexes. The phasing of the investment is considered. The majority of all the selected projects should start up in 1975, but it is concluded that the whole of the polypropylene plant should be started up in 1977, while parts of the ethylene, polyethylene, chlorine, polyvinylchloride, acetylene and utilities plants should all be delayed until 1978 start-up.

A cost analysis of each complex, total and foreign exchange, is carried out for each of the years 1975, 1978 and 1980. The basis of the cost calculation is stated. It is found that Scheme 21 (all PVC and DOP production in the East), is slightly cheaper in both total and foreign exchange cost than Scheme 26, (some PVC and all the DOP production in the East), but that the economics of either Scheme should be acceptable. In particular, either scheme is expected to make a positive contribution to Pakistan's balance of payments.

FINAL SCHEME ANALYSIS - SUMMARY
(Annual Cost, Rsx10^6)

SCHEME NO:		21			26		
YEAR		1975	1978	1980	1975	1978	1980
WEST	% Capacity (ethylene)	42	71	100	43	71	100
	Total Cost	96.3	146.7	159.0	142.9	203.3	219.0
	F.E. Cost	45.2	73.7	80.9	67.4	100.4	109 0
	F.E. to Import Products	35.7	75.3	111.5	54.4	108.1	154.8
	F.E. Savings	- 9.5	1.6	30.6	-13.0	7.7	45.8
EAST	% Capacity (acetylene)	56	78	100	53	80	100
	Total Cost	125.4	148.7	162.4	97.4	115.7	126.0
	F.E. Cost	54.0	62.7	66.2	42.8	49.8	52.8
	F.E. to Import Products	50.8	82.2	111.7	32.5	59.3	78.8
	F.E. Savings	- 3.2	19.5	45.5	-10.3	9.5	26.0
EAST AND WEST	Total Cost	221.7	295.4	321.4	240.3	319.0	345.0
	F.E. Cost	99.2	136.4	147.1	110.2	150.2	161.8
	F.E. to Import Products	86.5	157.5	223.2	86.9	167.4	233.6
	F.E. Saving	-12.7	21.1	76.1	-23.3	17.2	71.8

Note: F.E. = Foreign Exchange

FINAL SCHEME ANALYSIS - SCHEME 21 - WEST

Annual Costs, $Rsx10^6$

	1975		1978		1980	
	Total	Foreign	Total	Foreign	Total	Foreign
RAW MATERIALS						
Principal Feedstocks						
Naphtha	7.7	6.4	13.5	11.2	19.3	16.0
Benzene	4.3	1.7	5.5	2.2	7.4	2.9
Credits						
Gasoline	- 1.5	- 1.2	- 2.6	- 2.2	- 4.1	- 3.4
Organic By-products	- 2.0	- .2	- 3.2	- .3	- 4.6	- .5
Utility and Other Requirements						
Natural Gas	4.1	.4	5.9	.6	7.7	.8
Raw Water	1.2	.1	1.7	.2	2.3	.2
Catalysts; Chemicals	1.6	1.4	5.7	5.3	8.5	8.1
Packaging	.6	.2	.9	.4	1.2	.5
LABOUR	1.4	-	1.7	-	1.7	-
MAINTENANCE	15.0	7.9	22.2	12.2	22.2	12.2
CAPITAL CHARGES						
Interest and Depreciation	54.3	28.5	80.2	44.1	80.2	44.1
BASIC PRODUCTION COST	86.7	45.2	131.5	73.7	141.8	80.9
OVERHEADS	8.7	-	13.2	-	14.2	-
INTERWING TRANSPORT	.9	-	2.0	-	3.0	-
FINAL PRODUCTION COST	96.3	45.2	146.7	73.7	159.0	80.9
COST OF IMPORTED PRODUCTS						
(C & F Costs)						
Polythene		20.6		43.2		67.1
Polypropylene		-		14.4		22.4
Dodecyl Benzene		9.8		12.4		16.7
Ethylene		5.3		5.3		5.3
TOTAL		35.7		75.3		111.5
FOREIGN EXCHANGE SAVING		- 9.5		1.6		30.6

FINAL SCHEME ANALYSIS - SCHEME 21 - EAST

Annual Costs, Rsx10^6

	1975 Total	1975 Foreign	1978 Total	1978 Foreign	1980 Total	1980 Foreign
RAW MATERIALS						
Principal Feedstocks						
Natural Gas	3.1	.3	5.0	.5	6.8	.7
Salt (as 100% NaCl)	3.0	-	4.9	-	6.8	-
Phthalic Anhydride	10.5	4.2	15.4	6.2	20.9	8.3
Credits						
Acetylene Plant Off-gas	- 1.7	- .2	- 3.0	- .3	- 4.1	- .4
Utility and Other Requirements						
Natural Gas	2.3	.2	3.2	.3	4.1	.4
Raw Water	1.9	.2	2.7	.3	3.5	.3
Catalysts; Chemicals	2.1	1.5	3.3	2.3	4.7	3.3
Packaging	.7	.3	1.0	.3	1.4	.5
LABOUR	2.2	-	2.5	-	2.5	-
MAINTENANCE	19.0	10.2	21.1	11.5	21.1	11.5
CAPITAL CHARGES						
Interest and Depreciation	69.6	37.3	77.0	41.6	77.0	41.6
BASIC PRODUCTION COST	112.7	54.0	133.1	62.7	144.7	66.2
OVERHEADS	11.3	-	13.3	-	14.5	-
INTERVENING TRANSPORT	1.4	-	2.3	-	3.2	-
FINAL PRODUCTION COST	125.4	54.0	148.7	62.7	162.4	66.2
COST OF IMPORTED PRODUCTS						
(C & F Costs)						
PVC		25.9		43.2		59.4
Dioctyl Phthalate		16.4		24.8		32.8
Caustic Soda		8.5		14.2		19.5
TOTAL		50.8		82.2		111.7
FOREIGN EXCHANGE SAVING		- 3.2		19.5		45.5

FINAL SCHEME ANALYSIS - SCHEME 26 - WEST

Annual Costs, Rsx10^6

	1975 Total	1975 Foreign	1978 Total	1978 Foreign	1980 Total	1980 Foreign
RAW MATERIALS						
Principal Feedstocks						
Naphtha	9.7	8.0	16.0	13.3	22.5	18.7
Salt (as 100% NaCl)	.4	-	.7	-	.9	-
Benzene	4.3	1.7	6.5	2.6	8.6	3.4
Credits						
Gasoline	- 2.0	- 1.6	- 3.3	- 2.7	- 4.6	- 3.8
Organic By-products	- 2.3	- .2	- 3.8	- .4	- 5.3	- .5
Hydrogen	- .1	- .0	- .1	- .0	- .2	- .0
Utility and Other Requirements						
Natural Gas (Fuel)	6.5	.7	9.2	.9	12.2	1.2
Raw Water	1.8	.2	2.5	.3	3.3	.3
Catalysts; Chemicals	2.2	1.8	7.0	6.1	10.0	9.2
Packaging	0.6	.2	.9	.4	1.5	.6
LABOUR	2.2	-	2.7	-	2.7	-
MAINTENANCE	22.9	12.3	31.4	17.4	31.4	17.4
CAPITAL CHARGES						
Interest and Depreciation	82.9	44.3	113.3	62.5	113.3	62.5
BASIC PRODUCTION COST	129.1	67.4	183.0	100.4	196.3	109.0
OVERHEADS	12.9	-	18.3	-	19.6	-
INTERWING TRANSPORT	0.9	-	2.0	-	3.1	-
FINAL PRODUCTION COST	142.9	67.4	203.3	100.4	219.0	109.9
COST OF IMPORTED PRODUCTS						
(C & F Costs)						
Polythene		20.6		43.2		67.1
Polypropylene		-		14.4		22.4
PVC		8.6		17.3		24.8
Ethylene		5.3		5.3		5.3
Vinyl Chloride		5.0		5.0		5.0
Dodecyl Benzene		9.8		14.8		19.6
Caustic Soda		5.1		8.1		10.6
TOTAL		54.4		108.1		154.8
FOREIGN EXCHANGE SAVING		-13.0		7.7		45.8

FINAL SCHEME ANALYSIS - SCHEME 26 - EAST.

Annual Costs, $Rsx10^6$

	1975		1978		1980	
	Total	Foreign	Total	Foreign	Total	Foreign
RAW MATERIALS						
Principal Feedstocks						
Natural Gas	2.1	.2	3.7	.4	4.9	.5
Salt (as 100% NaCl)	1.4	-	3.0	-	3.9	-
Phthalic Anhydride	10.5	4.2	15.4	6.2	20.9	8.3
Credits						
Acetylene Plant Off-gas	- 1.1	- .1	- 2.2	- .2	- 2.9	- .3
Utility and Other Requirements						
Natural Gas	1.4	.1	2.2	.2	2.8	.3
Raw Water	1.3	.1	1.9	.2	2.4	.2
Catalysts; Chemicals	1.6	1.1	2.7	1.8	3.7	2.5
Packaging	.6	.2	.9	.3	1.2	.4
LABOUR	1.8	-	2.0	-	2.0	-
MAINTENANCE	14.7	8.0	16.2	8.8	16.2	8.8
CAPITAL CHARGES						
Interest and Depreciation	54.2	29.0	59.4	32.1	59.4	32.1
BASIC PRODUCTION COST	88.5	42.8	105.2	49.8	114.5	52.8
OVERHEADS	8.9	-	10.5	-	11.5	-
INTERWING TRANSPORT	-	-	-	-	-	-
FINAL PRODUCTION COST	97.4	42.8	115.7	49.8	126.0	52.8
COST OF IMPORTED PRODUCTS						
(C & F Costs)						
PVC		12.1		25.9		34.6
Dioctyl Phthalate		16.4		24.8		32.8
Caustic Soda		4.0		8.6		11.4
TOTAL		32.5		59.3		78.8
FOREIGN EXCHANGE SAVING		- 10.3		9.5		26.0

2.6 Conclusions and Recommendations

2.6.1 General

The purpose of Phase I of this study was to review the evidence and put forward alternative projects from which the Pakistan Government and UNIDO were to select four for more detailed examination in Phase II.

The projects put forward are listed in the relevant sections of the report, and of these, H&G recommended the following for examination in Phase II:-

(a) Nitrophosphate project at Multan - West Pakistan

(b) Petrochemical project based on naphtha at Korangi - Karachi - West Pakistan.

(c) Urea and Petrochemical project at Ashuganj - East Pakistan

(d) TSP plant at Khulna - East Pakistan

2.6.2 Fertilizers

2.6.2.1 West Pakistan

(i) Complexes designed to produce NP and straight N fertilizers are to be preferred to those producing "base" materials for subsequent compounding or blending in smaller units.

(ii) During the course of Phase I of the study, one project was sanctioned in principle by the Pakistan Government. This is the Punjab Fertilizers Ltd (was previously known as Ismail Cement) nitrophosphate project at Multan; furthermore, the Hyesons urea project, which was understood to have been withdrawn, now seems likely to proceed.

The Punjab Fertilizers project is not considered to produce sufficient P_2O_5 fertilizer for West Pakistan when it reaches full capacity. The nitrophosphate process does, however, produce fertilizers at lower costs than routes based on phosphoric acid.

In view of the upward revision of the West Pakistan N and P_2O_5 projected consumptions referred to in the footnote to the table of fertilizer requirements on page 2.7, the two projects (Punjab & Hyesons) would satisfy the N requirements of West Pakistan, in the period 1974/77. The projected P_2O_5 needs will, however, be significantly under supplied.

2.6.2 Fertilizers

2.6.2.1 West Pakistan - continued

(iii) Production and distribution costs of ammonium nitrate are significantly lower than those for ammonium nitrate limestone.

(iv) The market for potash-containing fertilizers is uncertain. An agronomic requirement exists in some areas on crops such as wheat. It is therefore recommended in any project that provision should be made in design for subsequent installation of equipment and facilities needed for production of potash-containing fertilizers.

2.6.2.2 East Pakistan

(i) Humphreys & Glasgow are in agreement with the current course of development of the fertilizer industry based on the use of straight fertilizers - urea, phosphate rock, TSP and potash.

(ii) Use of phosphate rock for acid soils must be strongly promoted.

(iii) The TSP and Urea Plants at Khulna and Ashuganj respectively proposed in this report are designed to achieve full production and meet the fertilizer shortfall in 1975/76.

(iv) It is uneconomic to use W. Pakistan gypsum for sulphuric acid production in East Pakistan. The processes for conversion of Byproduct gypsum to acid have not been operated continuously on full-scale and cannot be recommended. The use of sulphur must be proposed at present and will result in lower foreign exchange element of costs provided that its price falls to about $45 (c&f) per ton.

2.6.3 Petrochemicals

2.6.3.1 Products

PVC, polyethylene, dioctylphthalate, dodecylbenzene and polypropylene are the only products for which the demand is sufficient to provide an economic basis for manufacture in Pakistan. The manufacture of these will show significant annual savings in foreign exchange before 1980.

2.6.3.2 Timing

(i) It will probably be economic to start manufacture of the above products except polypropylene in 1974 to satisfy the market from 1975 onwards.

2.6.3.2 Timing - continued

(ii) It will not be attractive to start polypropylene manufacture until about 1977.

2.6.3.3 Feedstock, Process route, and Location

(i) The scheme which will give the minimum overall production costs is one in which the products listed in 2.6.3.1 are all made from naphtha in the West Wing.

(ii) Allocation of part of the production to the East Wing will increase overall costs by at least 10%, whether natural gas or naphtha is chosen as feedstock.

(iii) Allocation of all the PVC and all the DOP production to the East, the hydrocarbon feedstock being gas, results in about 5 % lower foreign exchange cost than a single naphtha complex in the West. However, this solution does not provide for supply of vinylchloride to the existing producer in the West and would conflict with the vinylchloride and PVC provided for in the Fauji complex.

(iv) Allocation of the manufacture of some of the PVC and all of the DOP to the East, from natural gas, results in about the same foreign exchange costs as a single naphtha complex in the West.

(v) Allocation of some of the polyethylene and all of the DDB production to the East, from naphtha, has about 7 % higher foreign exchange cost than a single naphtha complex in the West.

2.6.4 Further Study Recommended Beyond the Scope of the Present Contract

(i) For a country planning P_2O_5 fertilizer capacity, the future price of sulphur is of utmost importance. An investigation into this should be commissioned.

(ii) Agronomic data from field experiments in Pakistan are urgently required. Fertilizer materials used in these trials should be those on which future expansion in production capacity is likely to be based on economic grounds.

(iii) A co-ordinated buying policy for imported fertilizer materials should be formulated, if this does not already exist.

(iv) The problem of the poor competitive position of existing small fertilizer units, which will arise when new large-scale units are operating, must be analysed. Decisions on their future must be made and plans formulated for shutting them down or provision for subsidies.

2.6.4 Further Study Recommended Beyond the Scope of the Present Contract - continued

(v) A separate study of fibres should be undertaken so that fibres projects for East and West Pakistan can be prepared. These should be based on import of fibres monomers and are independent of the main petrochemicals development projects.

(vi) Co-operation with other developing countries in the production and marketing of key petrochemicals should be extended. The increase in the effective size of the markets could lead to overall economies and savings of 'hard' currency.

2.7 Review Stage for Phase I of Study (1/12/69 - 28/2/70)

Following presentation of the Interim Report by Humphreys & Glasgow Limited on 1/12/1969 the review was completed in three months, during which meetings were held in Vienna in December, and in Rawalpindi and Dacca in January and February.

Progress on various projects in Pakistan during the course of Phase I and the review period made the selection of projects for Phase II increasingly difficult. The situation for Fertilizers and Petrochemicals in each Wing is reviewed below

Fertilizers - West Pakistan

The H & G Phase I study proposed two alternative N and N:P fertilizer projects:

(a) A project located at Ismailwal and based on natural gas and using gypsum for the production of sulphuric acid. Products - urea and urea/DAP fertilizer, or
(b) A nitrophosphate project at Multan. Products - ammonium nitrate and NP nitrophosphate fertilizer.

By the end of Phase I, other independent studies of such projects had been made and the Pakistan Government had sanctioned a private-sector project at Multan. This is similar to that proposed by H & G. although of lower capacity. It was concluded that little was to be gained by repetition of the studies.

Fertilizers - East Pakistan

The H & G study proposed two complementary projects:

(a) Urea plant at Ashuganj (combined with a petrochemical complex),
(b) TSP plant at Khulna.

As in the case of the West Wing, similar independent studies had been undertaken and private-sector projects similar to those proposed were well advanced in the planning stage.

Petrochemicals - West Pakistan

In the Interim Report, data were presented for a number of complementary pairs of projects in East and West Pakistan. A project based on naphtha at Karachi was recommended. This was similar to the project proposed by the Fauji Foundation, and particularly so following the decision by Fauji to increase their ethylene cracker capacity.

Petrochemicals - East Pakistan

H & G recommended a complex at Ashuganj in which a natural gas based acetylene complex is integrated with a urea plant. The complex proposed by H & G is similar in concept to that planned by E.P.I.D.C. but with one important difference; the E.P.I.D.C. plan allows for exports of a number of products - P.V.C, acrylic fibre, urea and methanol etc. Such exports are not included in the complex proposed by H & G. This complex at Ashuganj has, however, been the subject of a number of feasibility studies and it was not considered necessary for H & G to repeat this work.

It was therefore agreed by U.N.I.D.O., the Planning Commission of the Pakistan Government and H & G that Phase II of the H & G study should concentrate on other projects, most of which were of a longer-term nature and were not in the form of detailed pre-investment analyses. The projects are listed and commented upon below.

Project No.1 - The further development of the petrochemicals complexes currently planned for East and West Pakistan.

The objective of this study was to recommend the second stage of construction for each site based on longer term forecast demands of petrochemicals.

Project No.2 - Proposals for the development of the aromatics, synthetic rubber and fibres industries in Pakistan in association with refinery and petrochemicals operations.

This study is intended to provide a strategy for the future development of the industry. It will enable proposals for investment to be assessed by the Government against their longer term objectives in this sector of industry.

Project No.3 - The utilisation of by-product gypsum from TSP plants at Chittagong, East Pakistan.

This primary investigation is involved with the production of sulphuric acid and cement from by-product gypsum - saving the import of sulphur and cement clinker.

Project No.4 - The development of the existing fertilizer plant at Multan in the context of future fertilizer requirements.

This study was to consider where further development of the existing plant and site would be appropriate and desirable for the Pakistan economy in view of current projects and the planned expansion of the fertiliser industry of West Pakistan.

APPENDIX I

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