CHAPTER 6

PROJECT EXECUTION

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PROJECT EXECUTION

The refinery as it is now anticipated, will rank as one of the largest installation in the world. Besides, it will be built as a grass-roots refinery at an isolated area including construction of crude oil pipeline and marine facilities.

The size and complexity of this project will require to develop a detailed execution program for organization, staffing, operation and time schedule of the entire project incorporating the all phases of the activity, that is, project management, engineering, construction and operation.
The efforts to accomplish it must be done prior to initiation of any detail work at early stage after the establishment of a company for the refinery.
In this chapter, a preliminary study on the project execution is made in order to provide a basis for cost estimates in Chapter 9.
The items covered are as follows:

- Preliminary Master Schedule
- Presumed Manpower Mobilization
- Refinery Organization and Staffing
- Training for Employee

6.1 Preliminary Master Schedule

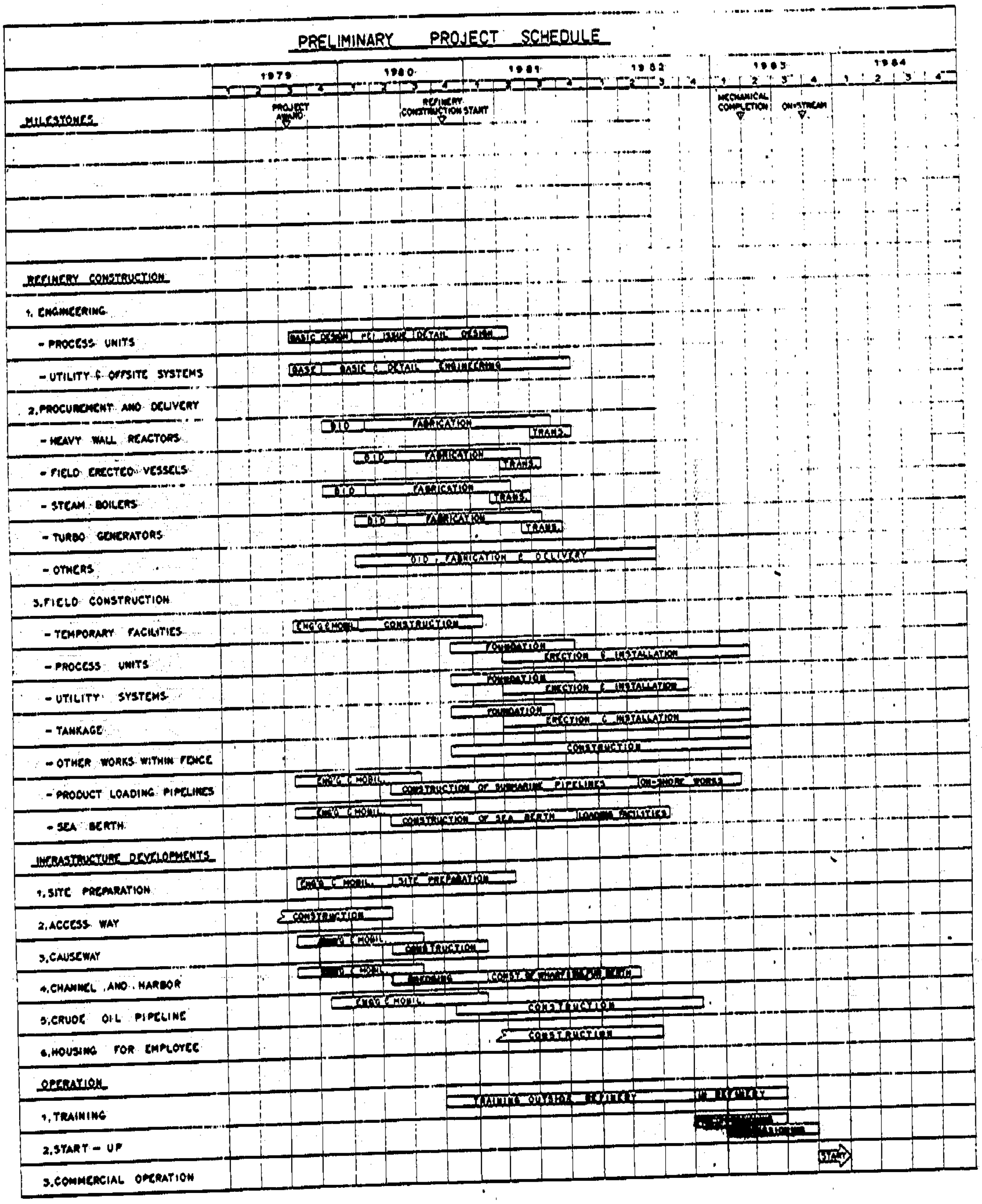
At the outset of the project, a master schedule outlining critical dates and milestones for the entire project will be prepared. This schedule should be developed based on the informations which are investigated in detail by the respective execution groups for engineering, procurement, transportation, construction, and start-up operation.

A preliminary master schedule is developed and presented in Figure 6.1 showing the schedule for constructing the 250,000 BPSD refinery based on the assumptions described below:

- It is predicted that the project is awarded to a prime contractor on August 1, 1979.
- Until the date of the project award, basic design requirements of process units are available to the contractor and process licensors have been selected.

- Basic engineering design data and general specification for the project are also available on that date.
- It is considered to arrange the early procurement for the critical delivery items such as heavy wall reactors, field erected vessels, steam boilers, and turbo generators.
- Four months lead time is considered for equipment bidding.
- Equipment delivery is based on the current condition from worldwide suppliers.
- Four months of equipment transportation period is considered from fabricator to the erection site.
- Infrastructural bases such as site preparation and access way are assumed to be developed within the dates shown in the figure.
- It is considered to require six months of lead time from the date of refinery's mechanical completion to the commercial operation.

With the above assumptions, it will require 50 months period including 44 months for construction and 6 months for start-up to implement the 250,000 BPSD refinery.
The period required to implement the 125,000 BPSD refinery will be essentially unchanged with the 250,000 BPSD.
In case of the 500,000 BPSD refinery construction, the refinery will be constructed in two trains, and first train will be in operation after 50 months are elapsed from the project award date and operation of the second refinery train will be commercial 9 months later from the first train.



IRAN-JAPAN EXPORT REFINERY

PRELIMINARY PROJECT SCHEDULE
500,000 BPSD CASE
FIGURE 6.1

6.2 Presumed Manpower Mobilization

Construction manpower is estimated for giving the magnitude of the manpower mobilization at peak time and during the entire construction period.

The estimation is made dividing the consturction manpower into the following three categories:

- Supervisory Staffs:
  Construction director and his staffs who will maintain the necessary control and provide the supervision and coordination for the entire field work.
- Direct Laborers:
  Foremen and skilled, semi-skilled, and unskilled labors such as brick masons, cement masons, carpenters, ironworkers, millwrighters, welders, pipefitters, electricians, instrumentmen, insulators, sheet metal workers, painters and other laborers.
- Indirect Laborers:
  Supporting personnel who will engage in construction and maintenance of the temporary facilities for the refinery construction.

Based on this manpower classification and statistical returns of similarly completed plants, the required manpower is built up along the sequence for constructing 250,000 BPSD refinery.
The results for supervisory staffs and direct laborers are presented in Figures 6.2 and 6.3 respectively.

In addition, manhours for constructing and maintaining temporary facilities are calculated.

Results thus calculated are summarized as total required manpower and number at peak time and presented in Table 6.1 for constructing each of the 125,000, 250,000 and 500,000 BPSD refinery.

Table 6.1

Presumed Manpower Mobilization

ITEM \ CAPACITY	125,000 BPSD	250,000 BPSD	500,000 BPSD
a. Supervisor and Staff			
Total (Man-Month)	3,160	4,210	6,650
Number at Peak Time (Man-Month/Month)	120	160	200
b. Labor in Direct Work			
Total (Man-Day)	1,930,000	2,565,000	4,050,000
Number at Peak Time (Man-Day/Day)	3,900	5,200	6,600
c. Labor in Indirect Work			
Total (Man-Day)	315,000	420,000	660,000
Number at Peak Time (Man-Day/Day)	450	600	750

Figure 6.2

Construction Supervisory Force Mobilization Plan

(250,000 BPSD CASE)

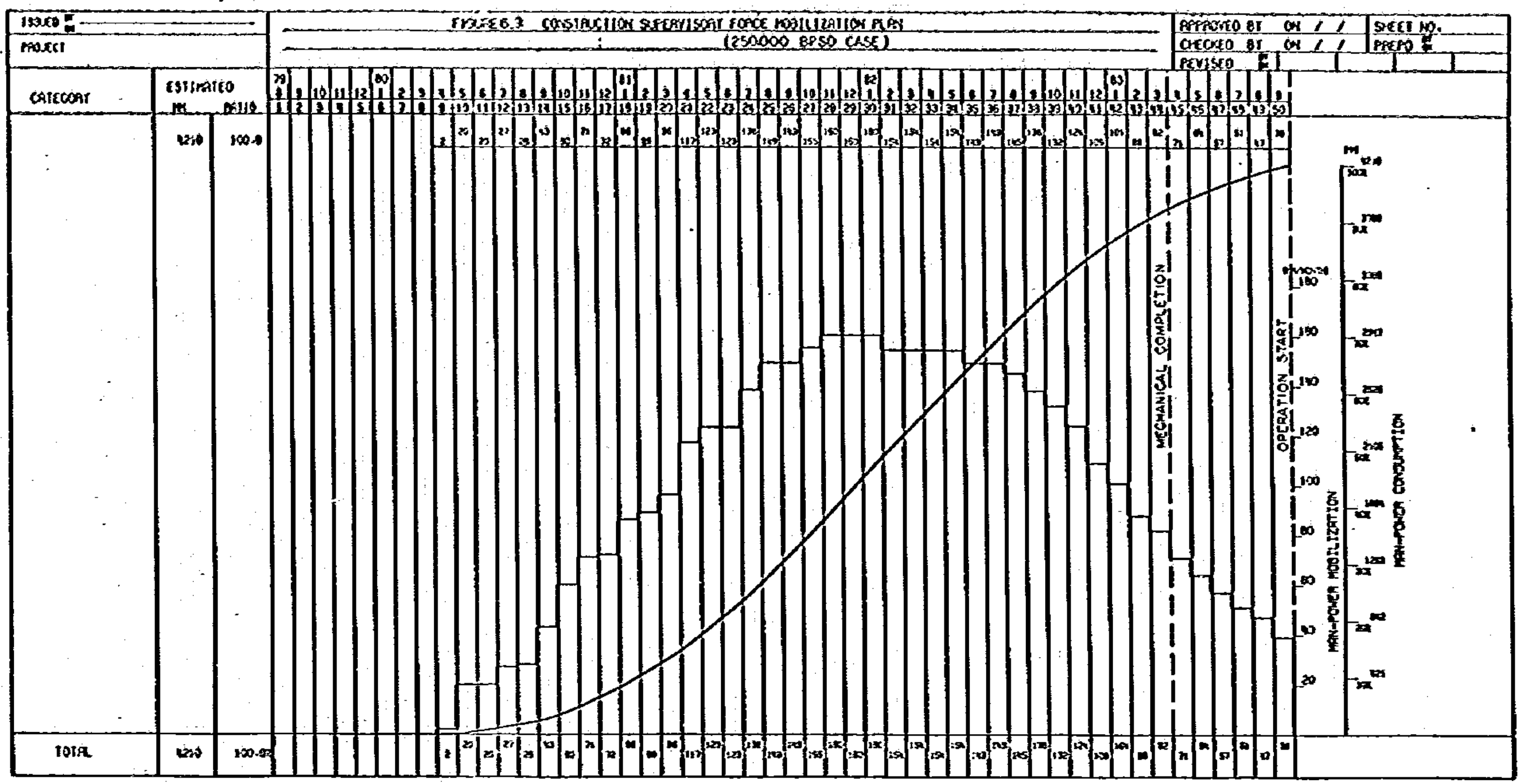
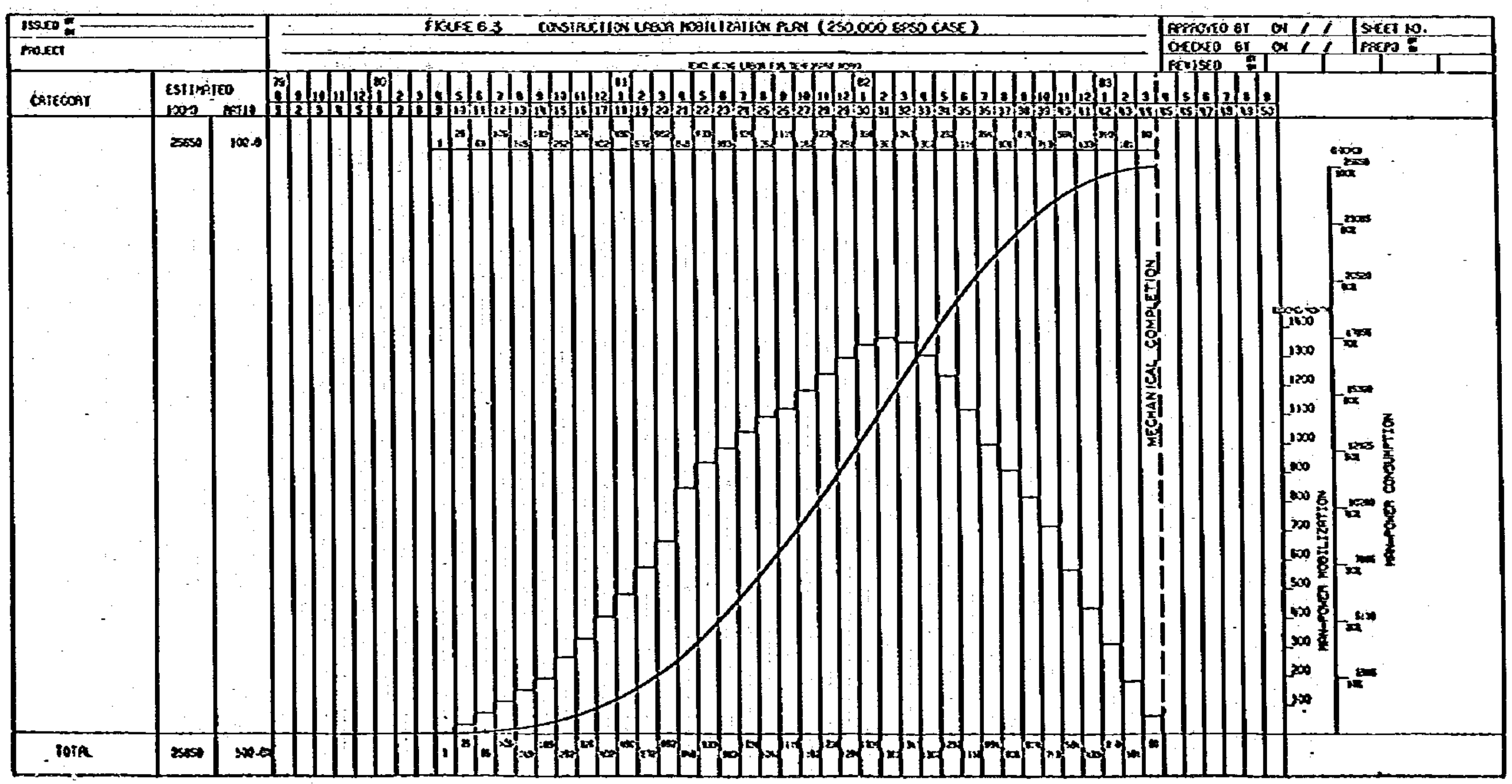


Figure 6.3

Construction Labor Mobilization Plan

(250,000 BPSD CASE)



6.3 Refinery Organization and Staffing

This paragraph deals with the organization and staffing for the refinery operation.

Possession of such organization and staffs as capable of operating and maintaining the refinery facilities and capable of providing the business, technical, and management functions will be a vital key to the success of the project.

The organization of the refinery is preliminarily developed and is shown in Figure 6.4.

Under the top management group which consists of the refinery manager and his assistant, the refinery is operated by the following four subdivided departments, each headed by a department manager.

- Production Department
- Technical Service Department
- Maintenance Department
- General Affairs Department

The organization is developed to be relatively flat so as to enable direct access to the top level supervision without a long chain of command.

According to this organization, the required personnel to operate the refinery is estimated and is summarized in Table 6.2 for the examined six cases.

This estimation is made based on the general criteria as follows:

- Annual operating hours of a personnel is defined to be 2,000 hours.
- A total five men is used to fill each shift position including extra personnel to cover sick leave, vacation, and overtime.

The number of required personnel is estimated by detailed analysis on all functions required for each department as described below:

Production Department

Staffing for the production department is presented with the classification of job responsibility and daytime and shift workers in Table 6.3.
The department manager has six area supervisors resorting him in 125,000 and 250,000 BPSD cases.

These men are responsible for No.1 process (Crude Distillation Group), No.2 process (Residue HDS Group), utility, storage and shipping, waste disposal, and marine areas.
The marine supervisor will be located at the harbor and be also responsible for the operation at the sea berth.
For the 500,000 BPSD case, three additional supervisors will be required, namely, two for process and one for utility areas.

Process units in the hydroskimming case will be operated in the above divided No.1 and No.2 process units so the shift foremen will be two for 125,000 and 250,000 BPSD cases and four for 500,000 BPSD case.
While in the hydrocracking case, additional shift foremen and operators to operate the hydrocracker are provided separately.

All of the operations in the marine area are considered to be done during daytime.

Technical Service Department

The technical service department has three sections each headed by a chief engineer and these are laboratory, technical service section, production planning section.
These sections are staffed to make the plant essentially self-sufficient in all technical and engineering functions necessary to operate the refinery and to control product quality.
Table 6.4 shows the workers in this department and additional testing personnel for product quality control is considered for 500,000 BPSD case.

Figure 6.1 Refinery Organization Chart

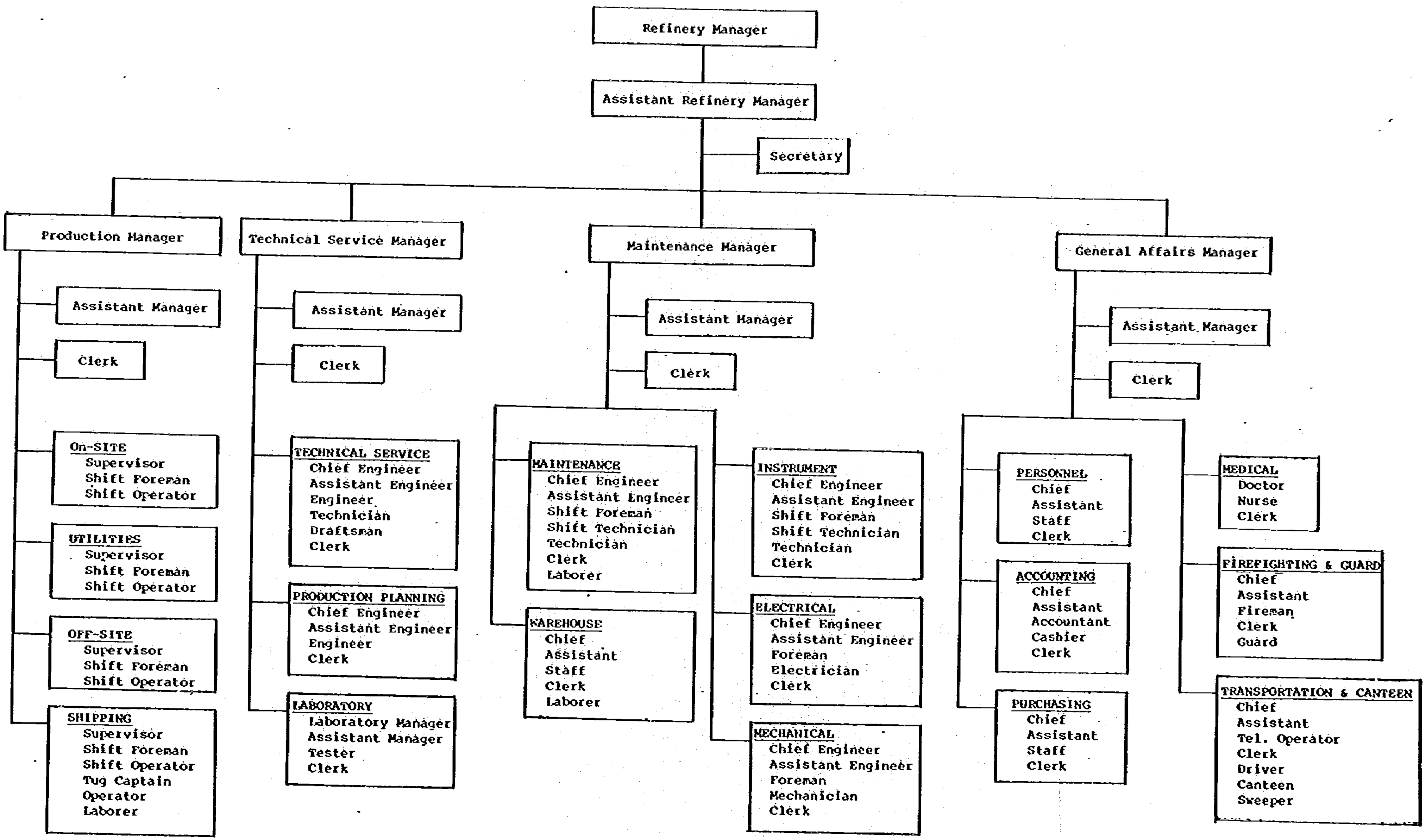


Table 6.2

Summary of Required Personnel

Position \ Configuration & Capacity	Hydroskimming		Hydrocracking	
	125,000/250,000 BPSD	500,000 BPSD	125,000/250,000 BPSD	500,000 BPSD
Refinery Manager	1	1	1	1
Assistant Refinery Manager	1	1	1	1
Secretary	2	2	2	2
Subtotal	4	4	4	4
PRODUCTION DEPARTMENT				
Manager and Assistant Manager	2	2	2	2
Supervisor	6	9	6	9
Clerk	6	6	6	6
On-site	145	275	180	330
Utilities	75	75	75	75
Off-site/Shipping	70	70	70	70
Subtotal Production Dept.	304	437	339	492
TECHNICAL SERVICE DEPARTMENT				
Manager and Assistant Manager	2	2	2	2
Clerk	2	2	2	2
Laboratory	27	51	27	51
Technical Service	18	18	18	18
Production Planning	5	5	5	5
Subtotal Technical Service Dept.	54	78	54	78
MAINTENANCE DEPARTMENT				
Manager and Assistant Manager	2	2	2	2
Clerk	2	2	2	2
Maintenance	80	130	80	130
Instrument	28	38	28	38
Electrical	19	19	19	19
Mechanical	35	35	35	35
Warehouse	15	15	15	15
Subtotal Maintenance Dept.	181	241	181	241
GENERAL AFFAIRS DEPARTMENT				
Manager and Assistant Manager	2	2	2	2
Clerk	2	2	2	2
Personnel	13	10	13	18
Medical	7	7	7	7
Accounting	8	11	8	11
Purchasing	8	10	8	10
Fire Fighting and Guard	35	37	35	37
Transportation and Canteen	28	28	28	28
Subtotal General Affairs Dept.	103	115	103	115
Grand Total	646	875	681	930

Table 6.3

Summary of Staffing for Production Department

Configuration and Capacity / Position	Hydroskimming 125,000/250,000 BPSD Day	Hydroskimming 125,000/250,000 BPSD Shift	Hydroskimming 500,000 BPSD Day	Hydroskimming 500,000 BPSD Shift	Hydrocracking 125,000/250,000 BPSD Day	Hydrocracking 125,000/250,000 BPSD Shift	Hydrocracking 500,000 BPSD Day	Hydrocracking 500,000 BPSD Shift
Manager and Assistant	2		2		2		2	
Supervisor	6		9		6		9	
Clerk	6		6		6		6	
<u>On-Site</u>								
Foreman		2		4		3		6
Operator		27		51		33		60
<u>Utilities</u>								
Foreman		1		1		1		1
Operator		14		14		14		14
<u>Off-Site</u>								
Foreman		2		2		2		2
Operator	8	5	8	5	8	5	8	5
Tug Captain	4		4		4		4	
Laborer	23		23		23		23	
Subtotal	49	51	52	77	49	58	52	88
Total	304		437		339		492	

Table 6.4

Summary of Staffing for Technical Service Department

Configuration and Capacity / Position	Hydroskimming 125,000/250,000 BPSD	Hydroskimming 500,000 BPSD	Hydrocracking 125,000/250,000 BPSD	Hydrocracking 500,000 BPSD
Manager and Assistant	2	2	2	2
Clerk	2	2	2	2
<u>Laboratory</u>				
Chief and Assistant	2	2	2	2
Tester	24	48	24	48
Clerk	1	1	1	1
<u>Technical Service</u>				
Chief and Assistant	2	2	2	2
Engineer	10	10	10	10
Draftman and Technician	5	5	5	5
Clerk	1	1	1	1
<u>Production Planning</u>				
Chief and Assistant	2	2	2	2
Engineer	2	2	2	2
Clerk	1	1	1	1
Total	54	78	54	78

Maintenance Department

The maintenance functions are grouped into the maintenance, instrument, electrical, mechanical and warehouse sections.

The maintenance section has the responsibility for area maintenance on shift and for the major maintenance works during the scheduled maintenance period such as pipe and exchanger work, sheet metal work, welding, carpentry and painting.

Mechanical section is at the maintenance shop and has the responsibility for the overhaul and maintenance of rotating equipment such as pumps, compressors, and turbines and other large and complicated mechanical equipment.

The instrument and electrical sections will overhaul and maintain instruments, analyzers, safety valves, computer and communication equipment, and office machines.

It is the duty of the warehouse section to provide all of the necessary maintenance materials, operating supplies, and spare parts, and to keep proper warehouse and inventory records.

The summary of staffing for the maintenance department is presented in Table 6.5.

As shown in the table, it is estimated that 131 employees for daytime working and 10 shift positions will be required for 125,000 and 250,000 BPSD cases and additional 15 employees for daytime and 9 shift positions will be required for 500,000 BPSD case.

General Affairs Department

This department has the responsibility for the overall managemental, financial, administrative, purchasing and accounting, and other general affairs.

The functions divided into six operating sections are clearly shown by the section titles as presented in Table 6.6 and there is little need for describing them in detail.

Most of employees in this department are daytime workers except for shift workers in the fire fighting and guard section.

Table 6.5

Summary of Staffing for Maintenance Department

Configuration and Capacity / Position	Hydroskimming				Hydrocracking			
	125,000/ 250,000 BPSD		500,000 BPSD		125,000/ 250,000 BPSD		500,000 BPSD	
	Day	Shift	Day	Shift	Day	Shift	Day	Shift
Manager and Assistant	2		2		2		2	
Clerk	2		2		2		2	
Maintenance								
Chief and Assistant	2		2		2		2	
Foreman		1		2		1		2
Technician	25	6	25	12	25	6	25	12
Clerk	3		3		3		3	
Laborer	15		30		15		30	
Instrument								
Chief and Assistant	2		2		2		2	
Foreman		1		1		1		1
Technician	10	2	10	4	10	2	10	4
Clerk	1		1		1		1	
Electrical								
Chief and Assistant	2		2		2		2	
Foreman	1		1		1		1	
Technician	15		15		15		15	
Clerk	1		1		1		1	
Mechanical								
Chief and Assistant	2		2		2		2	
Foreman	1		1		1		1	
Technician	30		30		30		30	
Clerk	2		2		2		2	
Warehouse								
Chief and Assistant	2		2		2		2	
Staff	4		4		4		4	
Clerk	1		1		1		1	
Laborer	8		8		8		8	
Subtotal	131	10	146	19	131	10	146	19
Total	181		241		181		241	

Table 6.6

Summary of Staffing for General Affairs Department

Position \ Configuration and Capacity	Hydroskimming				Hydrocracking			
	125,000/ 250,000 BPSD		500,000 BPSD		125,000/ 250,000 BPSD		500,000 BPSD	
	Day	Shift	Day	Shift	Day	Shift	Day	Shift
Manager and Assistant	2		2		2		2	
Clerk	2		2		2		2	
Personnel								
Chief and Assistant	2		2		2		2	
Staff	10		15		10		15	
Clerk	1		1		1		1	
Medical								
Doctor	2		2		2		2	
Nurse	4		4		4		4	
Clerk	1		1		1		1	
Accounting								
Chief and Assistant	2		2		2		2	
Accountant	3		4		3		4	
Cashier	2		4		2		4	
Clerk	1		1		1		1	
Purchasing								
Chief and Assistant	2		2		2		2	
Staff	5		7		5		7	
Clerk	1		1		1		1	
Fire Fighting & Guard								
Chief and Assistant	2		2		2		2	
Fireman		4		4		4		4
Guard	2	2	4	2	2	2	4	2
Clerk	1		1		1		1	
Transportation & Canteen								
Chief and Assistant	2		2		2		2	
Tel. Operator	3		3		3		3	
Driver	3		3		3		3	
Canteen	8		8		8		8	
Sweeper	10		10		10		10	
Clerk	2		2		2		2	
Subtotal	73	6	85	6	73	6	85	6
Total	103		115		103		115	

Required Personnel By Salary Grades

In corresponding to the job responsibility, the employees are classified into the following seven grades of job classes based on the NIOC's information as to salary structure.

- Grade A : Refinery Manager/Assistant
- Grade B : Department Manager/Doctor
- Grade C : Section Manager/Supervisor/Engineer
- Grade D : Foreman/Operator/Craftman/Secretaries/Nurses
- Grade E : Clerks
- Grade F : Laborers

The summary of the refinery employees classified with the above criteria is presented in Table 6.7 and the grade column on the personnel tabulations are given in Tables 6.8, 6.9, 6.10 and 6.11.

Table 6.7

Summary of Required Personnel by Salary Grade

Salary Grade	US$/Month	Hydroskimming		Hydrocracking	
		125,000/ 250,000 BPSD	500,000 BPSD	125,000/ 250,000 BPSD	500,000 BPSD
Class A	4,500	2	2	2	2
Class B	3,100	10	10	10	10
Class C	2,200	44	47	44	47
Class D	1,300	478	687	513	742
Class E	600	33	33	33	33
Class F	250	79	96	79	96
Total	-	646	875	681	930

Table 6.8

Summary of Staffing and Required Personnel
Cases: Hydroskimming 125,000/250,000 BPSD

Salary Grade / Position	Day Personnel A	Day Personnel B	Day Personnel C	Day Personnel D	Day Personnel E	Day Personnel F	Shift Personnel D	Shift Personnel F	Total
Refinery Manager	1								1
Assistant Refinery Manager	1								1
Secretary				2					2
PRODUCTION DEPARTMENT									
Manager and Assistant Manager		2							2
Supervisor			6						6
Clerk					6				6
On-site							145		145
Utilities							75		75
Off-site/Shipping				12		23	35		70
Subtotal Production Dept.	0	2	6	12	6	23	255	0	304
TECHNICAL SERVICE DEPARTMENT									
Manager and Assistant Manager		2							2
Clerk					2				2
Laboratory			2	24	1				27
Technical Service			12	5	1				18
Production Planning			4		1				5
Subtotal Technical Service Dept.	0	2	18	29	5	0	0	0	54
MAINTENANCE DEPARTMENT									
Manager and Assistant Manager		2							2
Clerk					2				2
Maintenance			2	25	3	15	35		80
Instrument			2	10	1		15		28
Electrical			2	16	1				19
Mechanical			2	31	2				35
Warehouse			2	4	1	8			15
Subtotal Maintenance Dept.	0	2	10	86	10	23	50	0	181
GENERAL AFFAIRS DEPARTMENT									
Manager and Assistant Manager		2							2
Clerk					2				2
Personnel			2	10	1				13
Medical		2		4	1				7
Accounting			2	5	1				8
Purchasing			2	5	1				8
Fire Fighting and Guard			2		1	2	20	10	35
Transportation and Canteen			2		5	21			28
Subtotal General Affairs Dept.	0	4	10	24	12	23	20	10	103
Grand Total	2	10	44	153	33	69	325	10	646

Table 6.9

Summary of Staffing and Required Personnel
Case: Hydroskimming 500,000 BPSD

Position \ Salary Grade	Day Personnel A	Day Personnel B	Day Personnel C	Day Personnel D	Day Personnel E	Day Personnel F	Shift Personnel O	Shift Personnel F	Total
Refinery Manager	1								1
Assistant Refinery Manager	1								1
Secretary				2					2
PRODUCTION DEPARTMENT									
Manager and Assistant Manager		2							2
Supervisor			9						9
Clerk					6				6
On-site							275		275
Utilities							75		75
Off-site/Shipping				12		23	35		70
Subtotal Production Dept.	0	2	9	12	6	23	385	0	437
TECHNICAL SERVICE DEPARTMENT									
Manager and Assistant Manager		2							2
Clerk					2				2
Laboratory			2	48	1				51
Technical Service			12	5	1				18
Production Planning			4		1				5
Subtotal Technical Service Dept.	0	2	18	53	5	0	0	0	78
MAINTENANCE DEPARTMENT									
Manager and Assistant Manager		2							2
Clerk					2				2
Maintenance			2	25	3	30	70		130
Instrument			2	10	1		25		38
Electrical			2	16	1				19
Mechanical			2	31	2				35
Warehouse			2	4	1	8			15
Subtotal Maintenance Dept.	0	2	10	86	10	38	95	0	241
GENERAL AFFAIRS DEPARTMENT									
Manager and Assistant Manager		2							2
Clerk					2				2
Personnel			2	15	1				18
Medical		2		4	1				7
Accounting			2	8	1				11
Purchasing			2	7	1				10
Fire Fighting and Guard			2		1	4	20	10	37
Transportation and Canteen			2		5	21			28
Subtotal General Affairs Dept.	0	4	10	34	12	25	20	10	115
Grand Total	2	10	47	187	33	86	500	10	875

Table 6.10

Summary of Staffing and Required Personnel
Cases: Hydrocracking 125,000/250,000 BPSD

Salary Grade / Position	Day Personnel						Shift Personnel		Total
	A	B	C	D	E	F	D	F	
Refinery Manager	1								1
Assistant Refinery Manager	1								1
Secretary				2					2
<u>PRODUCTION DEPARTMENT</u>									
Manager and Assistant Manager		2							2
Supervisor			6						6
Clerk					6				6
On-site							180		180
Utilities							75		75
Off-site/Shipping				12		23	35		70
Subtotal Production Dept.	0	2	6	12	6	23	290	0	339
<u>TECHNICAL SERVICE DEPARTMENT</u>									
Manager and Assistant Manager		2							2
Clerk					2				2
Laboratory			2	24	1				27
Technical Service			12	5	1				18
Production Planning			4		1				5
Subtotal Technical Service Dept.	0	2	18	29	5	0	0	0	54
<u>MAINTENANCE DEPARTMENT</u>									
Manager and Assistant Manager		2							2
Clerk					2				2
Maintenance			2	25	3	15	35		80
Instrument			2	10	1		15		28
Electrical			2	16	1				19
Mechanical			2	31	2				35
Warehouse			2	4	1	8			15
Subtotal Maintenance Dept.	0	2	10	86	10	23	50	0	181
<u>GENERAL AFFAIRS DEPARTMENT</u>									
Manager and Assistant Manager		2							2
Clerk					2				2
Personnel			2	10	1				13
Medical		2		4	1				7
Accounting			2	5	1				8
Purchasing			2	5	1				8
Fire Fighting and Guard			2		1	2	20	10	35
Transportation and Canteen			2		5	21			28
Subtotal General Affairs Dept.	0	4	10	24	12	23	20	10	103
Grand Total	2	10	44	153	33	69	360	10	681

Table 6.11

Summary of Staffing and Required Personnel
Case: Hydrocracking 500,000 BPSD

Salary Grade / Position	Day Personnel						Shift Personnel		Total
	A	B	C	D	E	F	D	F	
Refinery Manager	1								1
Assistant Refinery Manager	1								1
Secretary				2					2
<u>PRODUCTION DEPARTMENT</u>									
Manager and Assistant Manager		2							2
Supervisor			9						9
Clerk					6				6
On-site							330		330
Utilities							75		75
Off-site/Shipping				12		23	35		70
Subtotal Production Dept.	0	2	9	12	6	23	440	0	492
<u>TECHNICAL SERVICE DEPARTMENT</u>									
Manager and Assistant Manager		2							2
Clerk					2				2
Laboratory			2	48	1				51
Technical Service			12	5	1				18
Production Planning			4		1				5
Subtotal Technical Service Dept.	0	2	18	53	5	0	0	0	78
<u>MAINTENANCE DEPARTMENT</u>									
Manager and Assistant Manager		2							2
Clerk					2				2
Maintenance			2	25	3	30	70		130
Instrument			2	10	1		25		38
Electrical			2	16	1				19
Mechanical			2	31	2				35
Warehouse			2	4	1	8			15
Subtotal Maintenance Dept.	0	2	10	86	10	38	95	0	241
<u>GENERAL AFFAIRS DEPARTMENT</u>									
Manager and Assistant Manager		2							2
Clerk					2				2
Personnel			2	15	1				18
Medical		2		4	1				7
Accounting			2	8	1				11
Purchasing			2	7	1				10
Fire Fighting and Guard			2		1	4	20	10	37
Transportation and Canteen			2		5	21			28
Subtotal General Affairs Dept.	0	4	10	34	12	25	20	10	115
Grand Total	2	10	47	187	33	86	555	10	930

6.4 Training for Employee

Training for the refinery employee is essential to achieve a smooth operation of the project and will require an immense task for the execution. Careful consideration should be paid for the following:

- to hire qualified personnels.
- to develop and execute well-investigated training programs.
- to arrange competent instructors and training facilities.

In this study, required manpowers for trainees and trainers are estimated to provide a basis for the cost estimation in Chapter 9.
It is considered that the following training program will be conducted:

- Simulator and prototype plant training for foremen of process units
  - to be performed for four months in Japan.
- Classroom and on-the-job training for chief operators
  - to be performed for 12 months in NIOC's refinery and/or a public training center in Iran.
- Classroom training for laboratory testers
  - to be performed for six months in NIOC's refinery or a public training center in Iran.
- On-site training for all operators
  - to be performed for six months in the refinery site.

Trainings for the other employees such as maintenance craftmen, managerial and engineering personnels, accounting and clerical staffs are not included considering that the qualified personnels in the respective fields can be hired.

According to the above schedule, the required number of trainees and their manpower are summarized in Tables 6.12 and 6.13 also of trainers are in Tables 6.14 and 6.15.
It is noticed that the chief operators to receive the training should be hired before 18 months before the completion of the refinery construction.

Table 6.12

Required Number of Trainees

Class of Trainee \ Configuration and Capacity	Hydroskimming		Hydrocracking		Period (Month)
	125,000/ 250,000 BPSD	500,000 BPSD	125,000/ 250,000 BPSD	500,000 BPSD	
On-Site					
Foreman	10	20	15	30	4
Chief Operator	25	45	30	45	18
Operator	110	210	135	255	6
Utilities					
Chief Operator	10	10	10	10	18
Operator	60	60	60	60	6
Off-Site					
Chief Operator	10	10	10	10	18
Operator	23	23	23	23	6
Laboratory					
Tester	24	48	24	48	6
Total	272	426	307	481	-

Table 6.13

Manpower Summary of Trainees

(Unit: Man - Month)

Class of Trainee \ Configuration and Capacity	Hydroskimming		Hydrocracking	
	125,000/ 250,000 BPSD	500,000 BPSD	125,000/ 250,000 BPSD	500,000 BPSD
Foreman	40	80	60	120
Chief Operator	810	1,170	900	1,170
Operator	1,158	1,758	1,308	2,028
Tester	144	288	144	288

Table 6.14

Required Number of Trainers

Training Course \ Configuration and Capacity	Hydroskimming		Hydrocracking		Period (Month)
	125,000/ 250,000 BPSD	500,000 BPSD	125,000/ 250,000 BPSD	500,000 BPSD	
On-Site					
Foreman	2	2	2	2	4
Chief Operator	2/1	3/2	2/1	3/2	13/7
Operator	4	7	5	9	7
Utilities					
Chief Operator	2/1	2/1	2/1	2/1	13/7
Operator	2	2	2	2	7
Off-Site					
Chief Operator	2	2	2	2	13
Operator	1	1	1	1	7
Laboratory					
Tester	2	3	2	3	7
Recreiting	2	2	2	2	2
Total	21	27	22	29	-

Table 6.15

Manpower Summary of Trainers

(Unit: Man・Month)

Training Course \ Configuration and Capacity	Hydroskimming		Hydrocracking	
	125,000/ 250,000 BPSD	500,000 BPSD	125,000/ 250,000 BPSD	500,000 BPSD
Foreman	8	8	8	8
Chief Operator	92	112	92	112
Operator	49	70	56	84
Tester	14	21	14	21
Recreiting	4	4	4	4

CHAPTER 7

INFRASTRUCTURES FOR PROJECT DEVELOPMENT

CHAPTER 7

INFRASTRUCTURES FOR PROJECT DEVELOPMENT

This chapter contains a discussion of infrastructures essential to a successful implementation of this project. The timely arrangements of adequate infrastructures will be one of the most significant factors governing industrial project's success.

7.1 Definition of Infrastructures

The term "infrastructure", in general, means the underlying foundation required for implementing industrial activities.
Since the term is widely used in various meanings, the coverage of infrastructures will differ from one to another depending upon a specific project's conditions.

In this respect, major elements regarded as infrastructures are itemized classifying them into industrial and social infrastructures as follows:

Industrial Infrastructures

Industrial development in an isolated area will require some foundation for investment and successful operation of industries.
Generally, the area will be consolidated as an industrial estate, which satisfies primary requirements for industries such as land, transportation, raw materials and utilities.
According to this basic concept, industrial infrastructures specific to this project would include pipelines for crude oil supply, site preparation for refinery construction, and marine facilities for product shipment consisting of dredged channel, harbor and causeway.

Social Infrastructures

Until the commencement of refinery operation, a community capable of accommodating refinery employees are required to be developed in the vicinity of the site and also an access road for connecting refinery and community.
Besides, improvement of social environment is considered to be significant and essential to achieve a smooth operation of the industrial activities. Such social and public facilities supporting the business activities are also considered as social infrastructures.

Following this basic philosophy, a list of social infrastructures is presented below:

Table 7.1

List of Social Infrastructure

1. Administration	Public Offices, Public Center, Police Station, Fire Station
2. Housing	Housing for employee
3. Utility	Water, Electric, and Fuel Supply Systems Sewer System Dust Collection and Incineration Systems
4. Business Service	Shopping Center, Hotel, Bank
5. Transportation	Road and Public Traffic System, Air Port, Marine Facilities
6. Communication	Telephone and Post Offices
7. Education	Kindergarten, Elementary School, High School, Training Center
8. Health	Hospital, Clinic
9. Recreation	Public Hall, Gymnasium, Play Ground, Library, Cinema Theater
10. Others	

7.2 Infrastructures Available

Current Status in the Vicinity of Site

According to 1976 year's census, the population of Bushehr city is about 58,000 and the growth rate during the last decade is rather high to count 9.3 percent annually.

The peoples' occupancy in Bushehr area is mostly agriculture and fisheries. It is considered that local industries in the area will not be to make any significant contribution to support this project.

The major facilities to be expected as social infrastructures are centralized in Bushehr city with about 10 Km^2 urban area.

Current status of those in Bushehr city is described as follows:

Housing:

- Limited numbers of houses for rent is available.
- A tourist hotel with 40 rooms is available.
- A new 60 rooms hotel is under construction.

Utility:

- A desalination project is under way to produce 200,000 m^3/Day of fresh water for future requirement in the area.
- Main raw food items consumed are mostly supplied from nearby towns and Shiraz.

Transportation:

- Roads in the city are mostly asphalt paved.
- An asphalted road is connecting Bushehr to Shiraz through Burazjan and Kazerun.
- Roads to access to southern area of Bushehr are projected.
- There is no rail connection in Bushehr.
- A first-class domestic airport exists.
- Facilities in the Bushehr port consist of:
  - two jetties with 340 m length in total
  - one dolphin with 29 feet water depth
  - seven roofed warehouses with 4,500 m^2 area
  - four tugboats and one 100 tons mobile crane.

Communication:

- Telephone, cable, telex and mail are available at Bushehr.
- Number of telephone in the city is about 4,000.
- Bushehr is among the cities which are linked to Iran's microwave telephone system.

Health:

- The following medical facilities are available in Bushehr and for severe and specialized cases, the nearby facilities such as in Shiraz could be used:

- three hospitals with bed services
- 17 clinics
- five drug stores

. Contract for construction of a full service hospital with 480 beds has been awarded.

Education:

. In Bushehr area, the following Iranian schools are available:
- 16 kindergartens
- 30 elementary schools
- 16 junior and senior high schools
- 13 military schools
- 2 technical schools

Recreation:

. Recreation facilities available are:
- 4 sports stadiums
- 6 sports clubs
- 8 socker grounds
- 3 basket ball courts
- 1 tennis court
- 3 cinema theaters
- 7 libraries

Others:

. There are facilities for Air Force and Navy in the Bushehr Peninsula.

Major Industrial Developments in the Area

The country's industrialization program is being undertaken in Bushehr area.

Two nuclear power stations with 1,200 megawatt capacity for each are already being installed at Halileh, near Bushehr and expected to be operational by end-1980's and end-1981's respectively. The power system will be connected with the national grid.
Integrated with the power plants, two 100,000 m^3/Day capacity desalination plants are under construction and most of desalinated water will serve as municipal and industrial uses.

According to the target of the governmental Fifth Plan, the existing Bushehr port's expansion will be completed shortly and its annual handling capacity will reach as large as one million tons of general cargo after completion of the additional four berths and three warehouses.

Furthermore, projects such as ship building, alminium manufacturing, and methyl fuel project are planned to be developed in the area.

7.3 Discussion and Recommendation

Although the scope of infrastructure is subject to concessive agreements between the Iranian government and a venture company, discussions are made here limitedly to those which are considered as infrastructures in this study.

A discussion is also made on the alternative installations of electric power, fresh water, and natural gas supply systems when these utilities are available to the refinery.

Crude Oil Pipelines

The pipelines to Muhammad Ameri are outlined in Chapter 5.
Length and size for the alternate sites are summarized in Table 7.2.
No intermediate pumping station will be required for all cases.

Table 7.2
Installation Summary of Crude Oil Pipelines

Refinery Site	Length	Pipe Size for Capacity		
		125,000 BPSD	250,000 BPSD	500,000 BPSD
Farageh	95 Km	14 inches	18 inches	24 inches
Chughadak	140 Km	16 inches	20 inches	26 inches
Muhammad Ameri	165 Km	16 inches	20 inches	26 inches
Ameri	190 Km	16 inches	20 inches	26 inches

Note: Based on two pipelines for all cases.

Based on a preliminary estimate, the pipeline project will require three years construction period and a six months advanced completion before the refinery's start-up.

The project would cost about 60, 100, 120 and 140 millions dollars each for Farageh, Chughadak, Muhammad Ameri, and Ameri locations for 500,000 BPSD

crude through-put.
Crude oil transport operations will be controlled at the Gurreh pumping station under the NIOC's responsibility.
In order to achieve stable operation, closed and continuous communication between the station and refinery should be maintained.

Site Preparation

The area required to construct a refinery with an ultimate capacity of 500,000 BPSD is about 4,000,000 m^2.
The site preparation work volume and its cost will differ remarkably from one location to another as follows:

- Farageh
  - to prevent flooding, 2 m filling above existing ground level is required.
  - 8,500,000 m^3 of earth work is required.
  - Estimated cost is about 80 millions dollars.
- Muhammad Ameri
  - to be land graded.
  - 3,000,000 m^3 of earth work is required.
  - Estimated cost is about 20 millions dollars.
- Ameri
  - The land is required to be cut and filled, and finished to several ground levels.
  - 6,000,000 m^3 of earth work is required.
  - Estimated cost is about 50 millions dollars.

The site preparation is required to be completed until about six months after the start of field construction.

Dredged Channel, Harbor, and Causeway

Consolidation of an industrial estate requires infrastructual bases for marine operation such as channel, harbor, and causeway.
The outline of these services at Muhammad Ameri is presented in Chapter 5.
In this study, the harbor is planned to be capable of accommodating up to 10,000 DWT carrier for sulfur and bunker fuel oil shipments.
The harbor will also be used for handling general cargoes for the construction, operation, and maintenance of the refinery. The harbor will exert a major influence over industrialization of the area.

The estimated works and costs for each candidate site are summarized as follows:

- Farageh
  - Length of causeway is about 5.5 Km
  - Length of dredged channel is about 3 Km
  - Harbor accommodates 10,000 DWT sulfur carrier, 5,000 DWT bunker carrier and small ships.
  - Estimated cost is about 130 millions dollars.
- Chughadak
  - The existing Bushehr port is anticipated to be utilized and only construction of harbor will be required.
  - Estimated cost is about 70 millions dollars.
- Muhammad Ameri
  - Length of causeway is about 3.5 Km
  - Length of dredged channel is about 9 Km
  - Harbor accommodates 10,000 DWT sulfur carrier, 5,000 DWT bunker carrier and small ships.
  - Estimated cost is about 120 millions dollars.
- Ameri
  - Length of causeway is about 0.3 Km
  - Length of dredged channel is about 4 Km
  - Harbor accommodates 10,000 DWT sulfur carrier, 5,000 DWT bunker carrier and small ships.
  - Estimated cost is about 70 millions dollars.

In order to use the marine facilities for the refinery construction services too, these facilities should be completed until 21 months after the refinery project award when the first delivery of large equipment will be made.

<u>Utilities Supply Systems from Adjacent Facilities</u>

In this study, the plan is made based on that the refinery is entirely self-sufficient in utilities.

While, alternative study enclosed in Book III 'Supplement' covers primary utilities supply from adjacent facilities based on the following NIOC's suggestions:

. Electric Power Supply

A power plant consisting of two units is under construction in Bushehr. The first one will be in operation by late 1980 with 1200 megawatts power generation capacity. The second one with the same capacity will be commissioned by late 1981. Power supply to the refinery from these power generation units will be investigated.

. Fresh Water Supply

At present in Bushehr area available water is used for supplying the city requirements. A project for desalination of sea water is under way to produce 200,000 cubic meters of fresh water for future requirements in the area. The possibility of using the refinery requirement from these units is being investigated. During construction as practiced by other projects the required water should be brought to the site either by lorry tankers or installation of a small desalination unit.

. Natural Gas Supply

Possibility of supplying the natural gas to the refinery is being examined. One of those possibilities is the Kangan gas which is now being considered for the second Iran trunk gas line.

Depending on economics and availability of this gas, a pipeline may have to be laid to transfer the refinery gas requirement to the refinery. The quantity of gas required can only be estimated after selection of refinery processing scheme.

At this stage, provisions required for transporting these utilities are not investigated. It will be advantageous for the refinery project to use these utilities satisfying the following:

- Stable supply
- Timely arrangement for the refinery project
- Reasonable supply price

Requirements of these utilities in base case refineries are as summarized in Table 7.3.

Estimated Costs of Industrial Infrastructures

In order to facilitate the evaluation of investment to industrial infrastructures against the refinery's economics, a cost estimation is made for those corresponding to the base case refineries and presented in Table 7.4.

Community and Daily Transportation System

The refinery sites are far from Bushehr city, that is, 20 Km at the closest and 90 Km at the farthest.

In developing a community for the refinery employees, however, it will be advantageous to incorporate the convenience of the existing facilities at Bushehr city.

The daily transportation of the refinery employees would be made by a bus commuter system.

Therefore, consolidation of access road to reach the refinery branching from the existing trunk road will be required prior to commencement of the refinery operation.

Facilities to house the refinery employees and their families are preliminarily studied in the following:

- The permanent employees for the refinery are estimated to be about 650 for 125,000 BPSD and 250,000 BPSD cases and 900 for 500,000 BPSD in total.
- Residential facilities are planned by dividing the employees into the categories and distribution shown in Table 7.5.
  The plan indicated in the above table is to provide family residences for about 40 percent of employees and to provide single residences for 45 percent of employees.
  It is assumed that the remaining 15 percent are residents of Bushehr.
- As a result, the classified numbers of employees for housing become as shown in Table 7.6.
- It is then assumed that the facilities for employees who live with families can serve for five residents and for single employees, a hostel is adopted to accommodate.
  A summary of the employee housing facilities is presented in Table 7.7.

Besides, execution of such a big industrial activity as contemplated in this project will require various commercial services by local independent enterprises.

Including the workers who will engage in these enterprises, an order of

10,000 persons will newly reside in the Bushehr area.

Considering the size of above population, the existing amount and variety of social infrastructures in the area will not be sufficient to accommodate them.

Thus it is expected that Bushehr will be further developed as a central city of the southern part of Iran and its contribution will be large enough to implement this project and to reinforce the industrial opportunities of the area.

Table 7.3

Estimated Utility Requirements in Refinery

Refinery Capacity	125,000 BPSD	250,000 BPSD	500,000 BPSD
Electric Power, 10^3KW	17 - 19	34 - 37	68 - 75
Fresh Water, 10^3m^3/CD	4 - 5	8 - 10	16 - 20
Fuel, 10^9Kcal/CD	9.5 - 11	19 - 21	38 - 43

Table 7.4

Estimated Construction Costs of Industrial Infrastructures

Refining Capacity, BPSD	125,000	250,000	500,000
	(10^6US$)	(10^6US$)	(10^6US$)
Case 1 Hydroskimming			
1. Site Preparation	9.5	11.9	19.0
2. Channel, Harbor & Causeway	124.1	124.1	124.1
3. Crude Oil Pipelines	54.5	75.7	118.5
Total	188.1	211.7	261.6
	(10^6US$)	(10^6US$)	(10^6US$)
Case 2 Hydrocracking			
1. Site Preparation	10.0	12.5	20.0
2. Channel, Harbor & Causeway	124.1	124.1	124.1
3. Crude Oil Pipelines	54.5	75.7	118.5
Total	188.6	212.3	262.5

Table 7.5

Categories of Employees

Symbol	Status	Distribution %
F - 1	with Family - Managers	2
F - 2	with Family - Management Staffs	8
F - 3	with Family - Staffs and above 3 years Service	30
S - 1	Single - Management Staffs	5
S - 2	Single - Staffs and above 3 years Service	20
S - 3	Single - under 3 years Service	20

Table 7.6

Numbers of Employees by Categories

Symbol	Refinery Capacity		
	125,000 BPSD	250,000 BPSD	500,000 BPSD
F - 1	13	13	18
F - 2	52	52	72
F - 3	195	195	270
S - 1	33	33	45
S - 2	130	130	180
S - 3	130	130	180

Table 7.7

Summary of Houseing Facilities

Accommodate for	Area per Unit (m^2)		125,000/250, 000 BPSD			500,000 BPSD		
			No. of Units	Total Area (m^2)		No. of Units	Total Area (m^2)	
	Building	Land		Building	Land		Building	Land-
F - 1	400	2,000	13	5,200	26,000	18	7,200	36,000
F - 2	275	600	52	14,300	31,200	72	19,800	43,200
F - 3	175	400	195	34,200	78,000	270	47,300	108,000
S - 1	1,200	3,000	4	4,800	12,000	6	7,200	18,000
S - 2	6,000	3,000	2	12,000	6,000	3	18,000	9,000
S - 3	2,400	2,000	3	7,200	6,000	4	9,600	8,000
Grand Total			269	77,700	159,200	373	109,100	222,200

Following apartments are adopted for single employees:

Status	Floor Area per Resident	Size of Building
S-1	150 m^2	600 m^2 x 2 stories
S-2	100 m^2	600 m^2 x 10 stories
S-3	50 m^2	600 m^2 x 4 stories

CHAPTER 8

SITE SELECTION

CHAPTER 8

SITE SELECTION

This chapter contains a discussion of the refinery sites which locate in Bushehr area on the coast of the Persian Gulf.

In the process of designating the candidate sites, a map survey based preliminary screening study was made using the following major requirements for the project:

- Refinery Area: approx. 4,000,000 m^2 (500,000 BPSD)
- Water Depth at Product Loading Terminal: 20 m (200,000 DWT)
- Water Depth at Sulfur Loading Wharf: 10 m (10,000 DWT)
- Crude Pick-up Point: GURREH Pumping Station

Based on the result of the preliminary study which worked out seven (7) proposed candidate sites, site reconnaissance and boring tests were conducted.

Besides, data collections and interviews to the government officials and private companies were carried out in Bushehr.

The data obtained in the field was gathered for final review and analysis. The subsequent detailed investigation selected Farageh, Chugadak, Muhammad Ameri, and Ameri as the candidate sites for further comparison.

Execution of this investigation is based on the following data:

- Results of a field reconnaissance made by JICA
- Surface water hydrogy, near Kangan, Iran
  Dames & Moore, July 1977
- Results of a soil survey made by Dames & Moore
- Published topographic map (scale 1 : 50,000)
- Published marine charts (scale 1 : 25,000, 1 : 100,000 and 1 : 350,000)
- Published road map (scale 1 : 2,500,000)
- Published general map (scale 1 : 2,500,000)
- Miscellaneous publications
  Persian gulf pilot eleventh edition, 1967
  Geological and mining survey of Iran, report No.40, 1977
  A brief account of ancient and present Iranian reports, port and shipping organization, Teheran, Oct. 1971

8.1 Planning of Candidate Sites

The following are major items considered in the planning of candidate sites:

Restrictions in Bushehr Peninsula

Bushehr Peninsula is the prominent proposed site since the required depth of water exists at a short distance from the shore and soil condition would be suitable, but a nuclear power plant is at present under construction in the southern part of Bushehr Peninsula and construction of an oil refinery within 10 km of this is disallowed practically. Further, the northern part of Bushehr Peninsula is an urban area and a naval base is established in the central part, accordingly it may be difficult to find space suitable for the plant in the Bushehr Peninsula.

Utilization of the Infrastructure

Utilization of the existing infrastructure will make a great contribution to reduction of initial expenses and facilitate the construction program. In the subject district this has been prepared concentrically along with development of the urban area. Roads have been completed between neighbouring cities, but the condition of the roads along the coast of the Persian Gulf is rather poor.

As to harbours, the port of Bushehr is clearly a harbour qualified for foreign trade. Taking into account use of the port of Bushehr and the condition of the roads as mentioned above, the areas within which it is possible to utilize the infrastructures should be treated as possible sites.

As there is a possibility of electric power and water being supplied from nuclear power plant under construction, the utilization of water supply system and power transmission system must be kept in mind.

Proximity to the Crude Oil Pick-up Point

Crude oil is intended to be picked-up at the existing Gurreh pumping station about 130 km north east of Bushehr and transferred to the refinery through the planned pipeline.

Consequently, if the site of the oil refinery is far from Gurreh, the total length and line size of the crude oil pipe will increase proportionately.

Topography of a Location

For the oil refinery, flat and spacious land is desirable, not to mention provision of required site area. It is also a necessary condition for the effective function of the oil refinery in exporting products that the site be close to the sea, that is, the required depth of water for product and sulfur carriers is available and allows intake of sea water and discharge of waste water.

Suitability of a location depends on whether it can or cannot lay the refinery on plane compactly with satisfying the above requirements.

Taking the above factors into consideration and in accordance with NIOC's ideas on sites, various candidate sites were examined based on maps and marine charts. From the results of on-the-spot surveys and discussions made afterwards, four candidate sites were selected. These four candidate sites are shown in Figure 8.1.

An outline of each candidate site is as follows:

Candidate Site - FARAGEH (See Figure 8.2)

The site is located about 2 km east of Farageh, near the Helleh River and is surrounded by a flat landform at a height of about 10 m above sea level.

This site is the closest to Gurreh, the location of the pumping station. The required depth of water for product tankers is securable at a short distance from the coast. On the other hand, as the Hellen River follows a zigzag course, deposits huge amount of silt and sand in its river-mouth and bank erosion and flooding from rising river waters in the rainy season are apprehended. A poor subsoil extends to a depth of approx. 30 m from ground level and special precautions would be required in preparing foundations.

Candidate Site - CHUGHADAK (See Figure 8.3)

This site is located close to the road which connects Bushehr and Borazjan, so utilization of this road and utilization of the port of Bushehr, a little over 20 km away, is possible. The construction work required for facilities to provide utility services from the nuclear power plant located in Helileh is rather light.

On the other hand, this site is located at the farthest inland of the candidate sites and product pipelines and sulfur transportation facilities of 20 km and more would have to cross the Bushehr urban area. The soil is better than that of Farageh, but a poor subsoil exists at about 10 m depth from ground level.

Candidate Site - MUHAMMAD AMERI (See Figure 8.4)
This site is located midway between Muhammad Ameri and Delver. The ground height is nearly 8 m above sea level and the north end of the Tangestan mountain mass lies about 7 km behind the site. The Karuk mountain area (approx. 300 m above sea level) is nearby.

The distance to Bushehr is short and the distance to the coast is shorter among coastal candidate sites and this site is favorable with respect to land area conditions including soil type.

Here the sea bed slope is gentle, and product loading sea berth would have to be sited about 18 km from the shore to satisfy the mooring conditions for the required water depth.

Candidate Site - AMERI (See Figure 8.5)
This site is located north of Ameri, at a height of approx. 5 m above sea level. The mountainous area of Mand lying close behind, so the soil condition is judged to be good.

As to the sea area, the required depth of water is available at the shortest distance from the seashore among the candidate sites. The required distance of the crude oil pipeline in longest. The Bushehr town area is far and the condition of the roads in approx. 10 km mountainous area between Bashi - Rustami is not favorable.

8.2 Comparison of Each Candidate Site

To indicate the differences in conditions of each candidate site and in the environments quantitatively, the conditions of each candidate site and its environment are represented by the several key evaluation items and by listing the required construction work. A comparison is made by relating construction work volume to the key evaluation items. The correlation of both sides is as shown in Figure 8.6.

LEGEND

CANDIDATE SITE — FARAGEH, CHUGHADAK, MUHAMMAD AMERI, AMERI

BUSHER

BUSHER AIRPORT

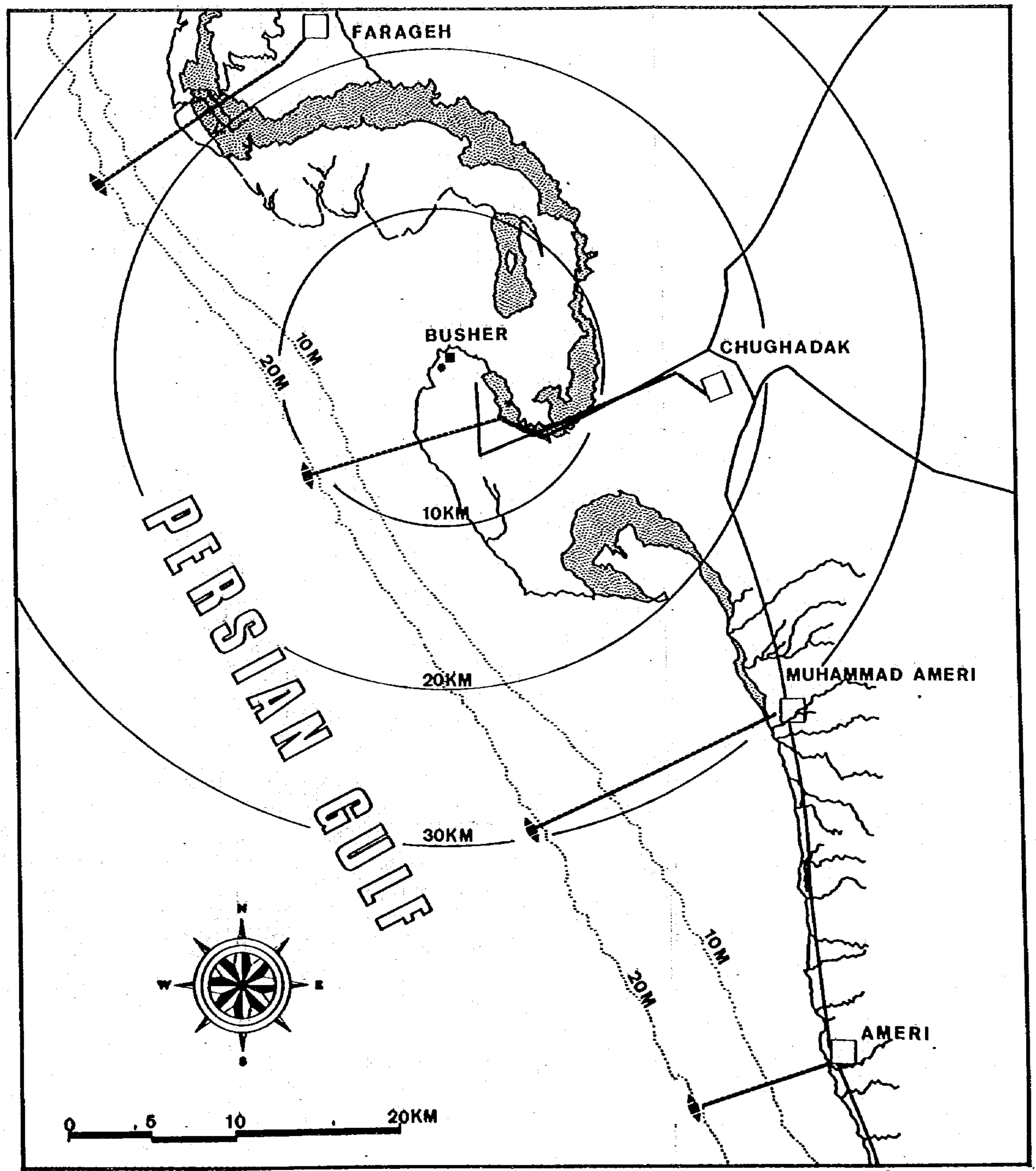
PIPE LINE

SEA BERTH

TIDAL FLATS

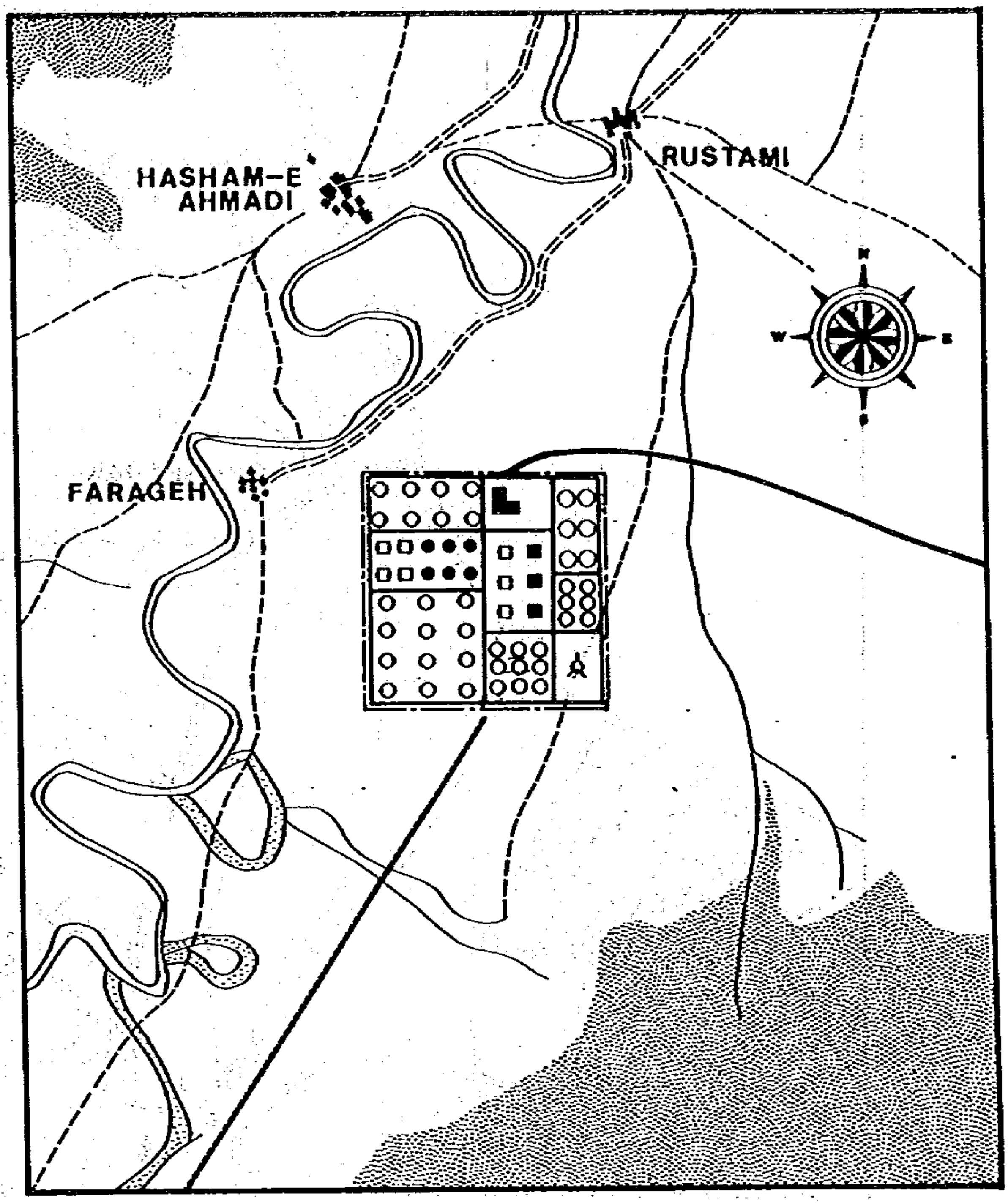
SOUNDING DEPTH

ROAD

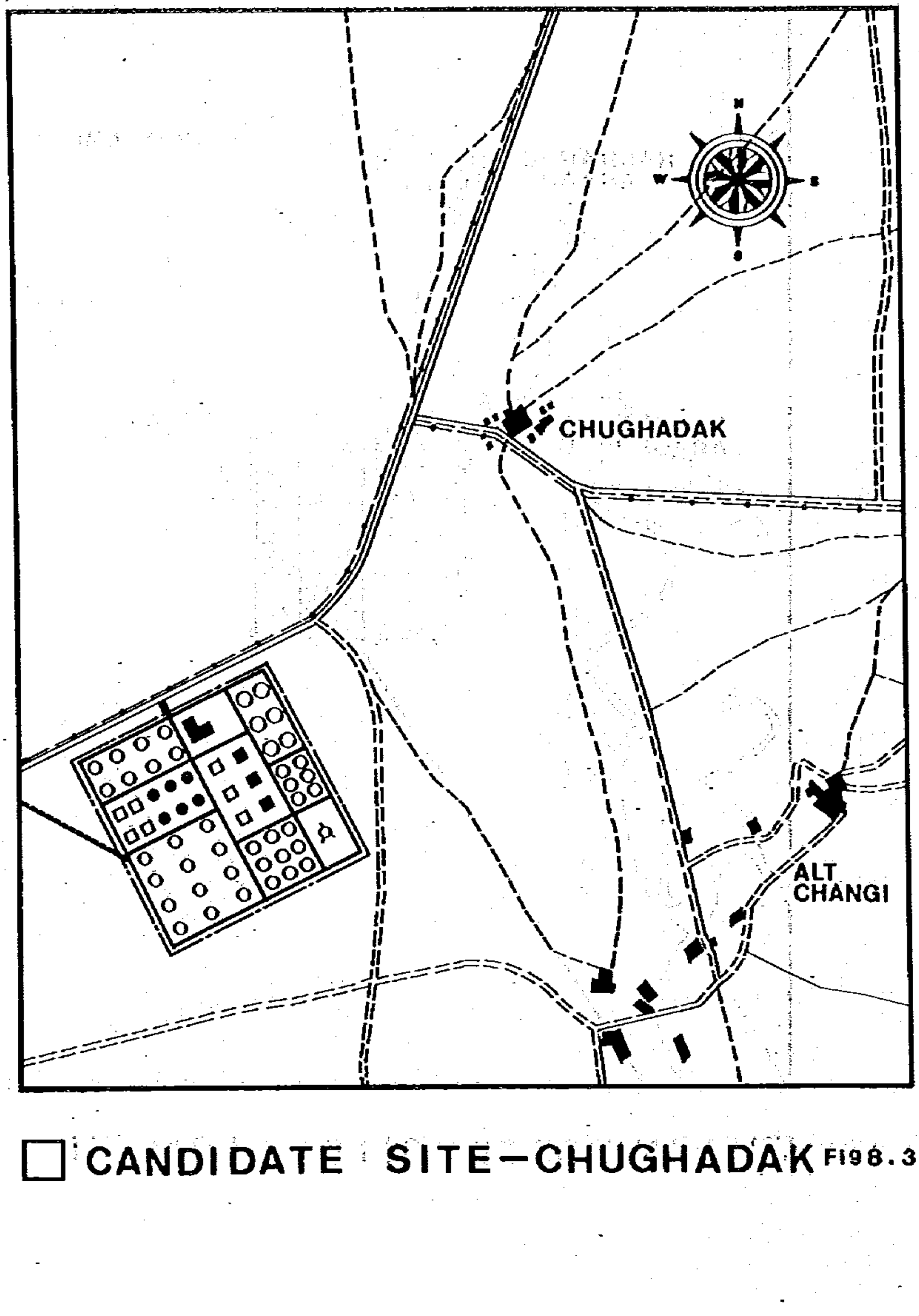


CANDIDATE SITE LOCATION MAP

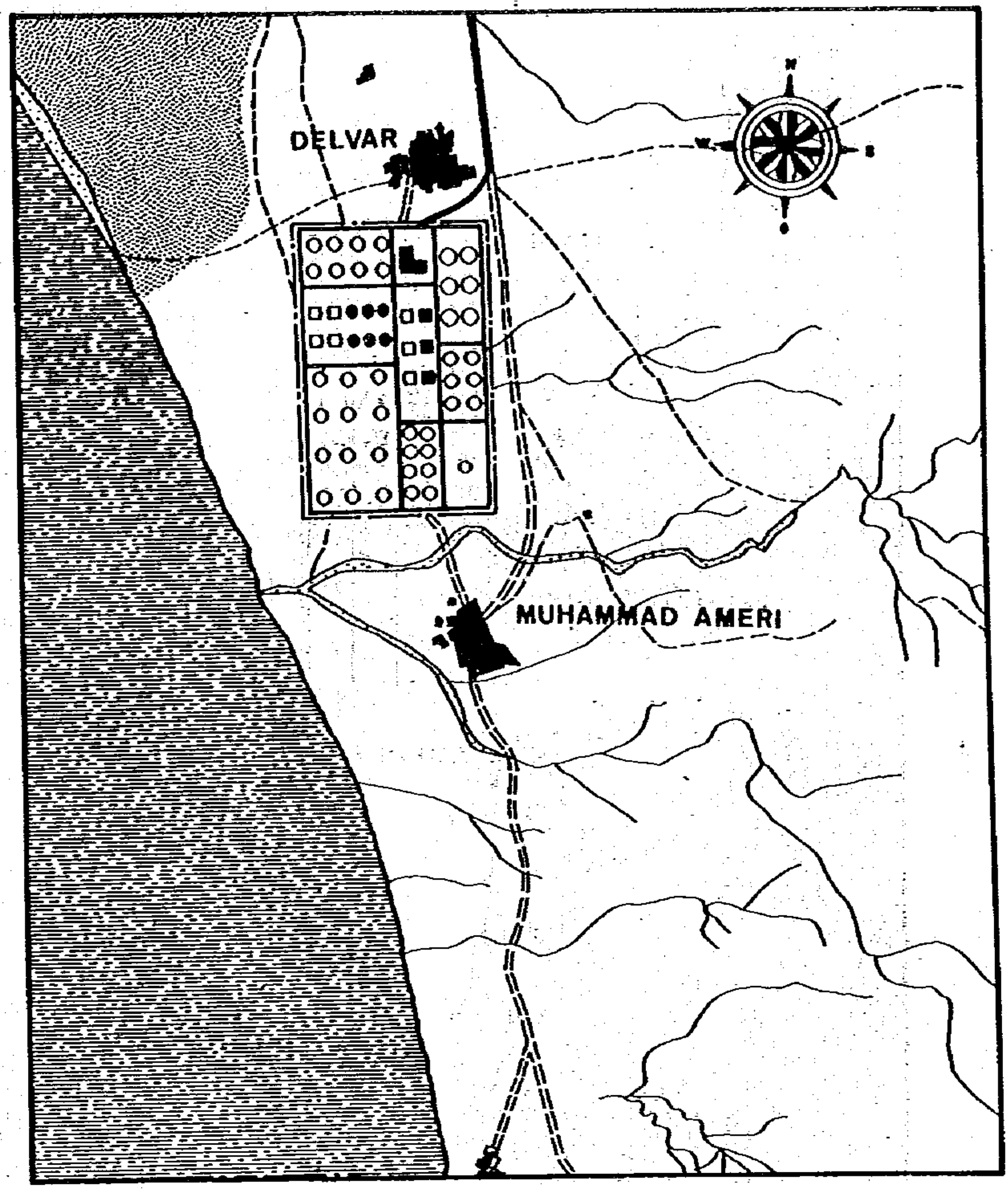
FIG 8.1



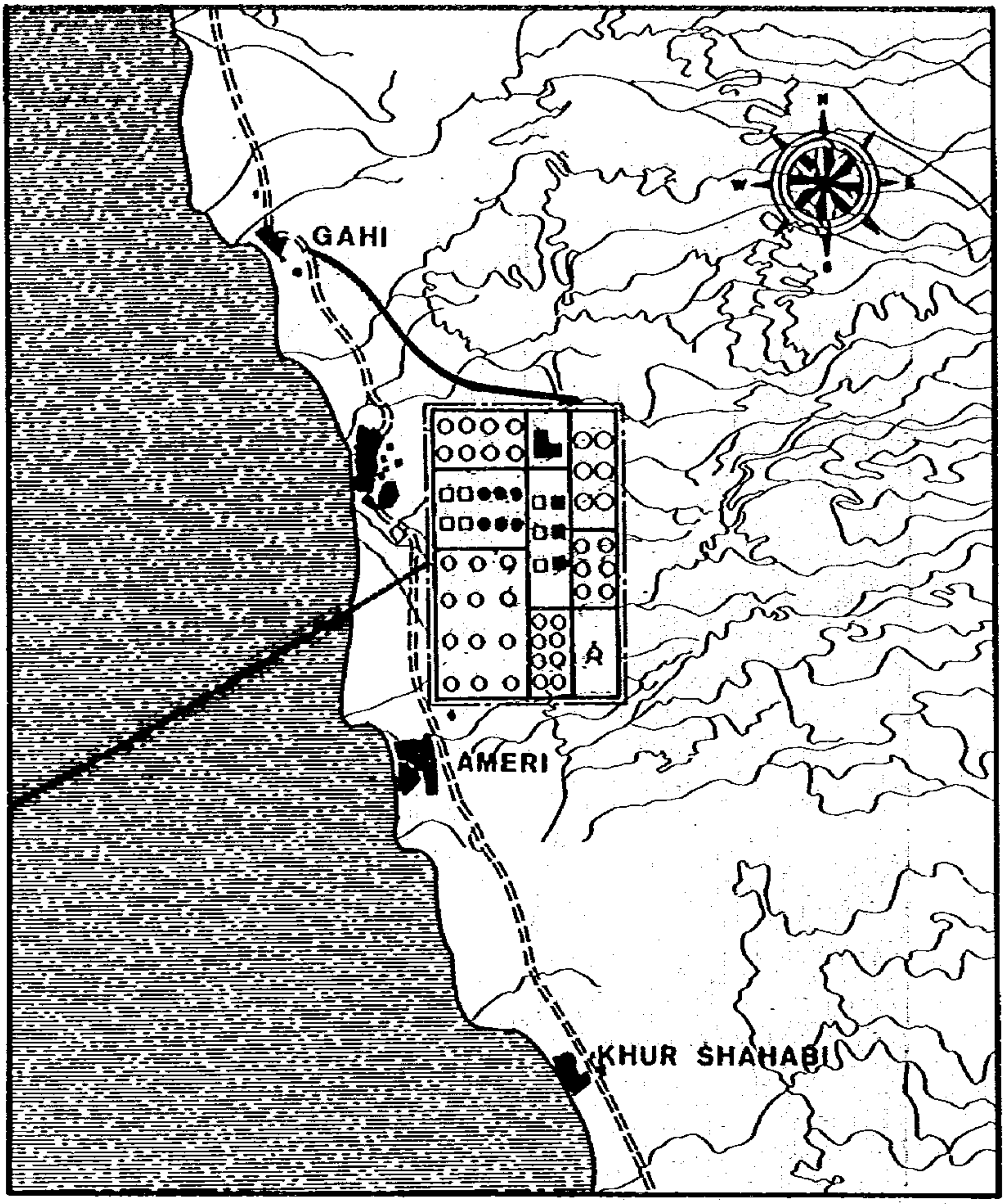
CANDIDATE SITE – FARAGEH Fig 8.2



CANDIDATE SITE—CHUGHADAK Fig8.3



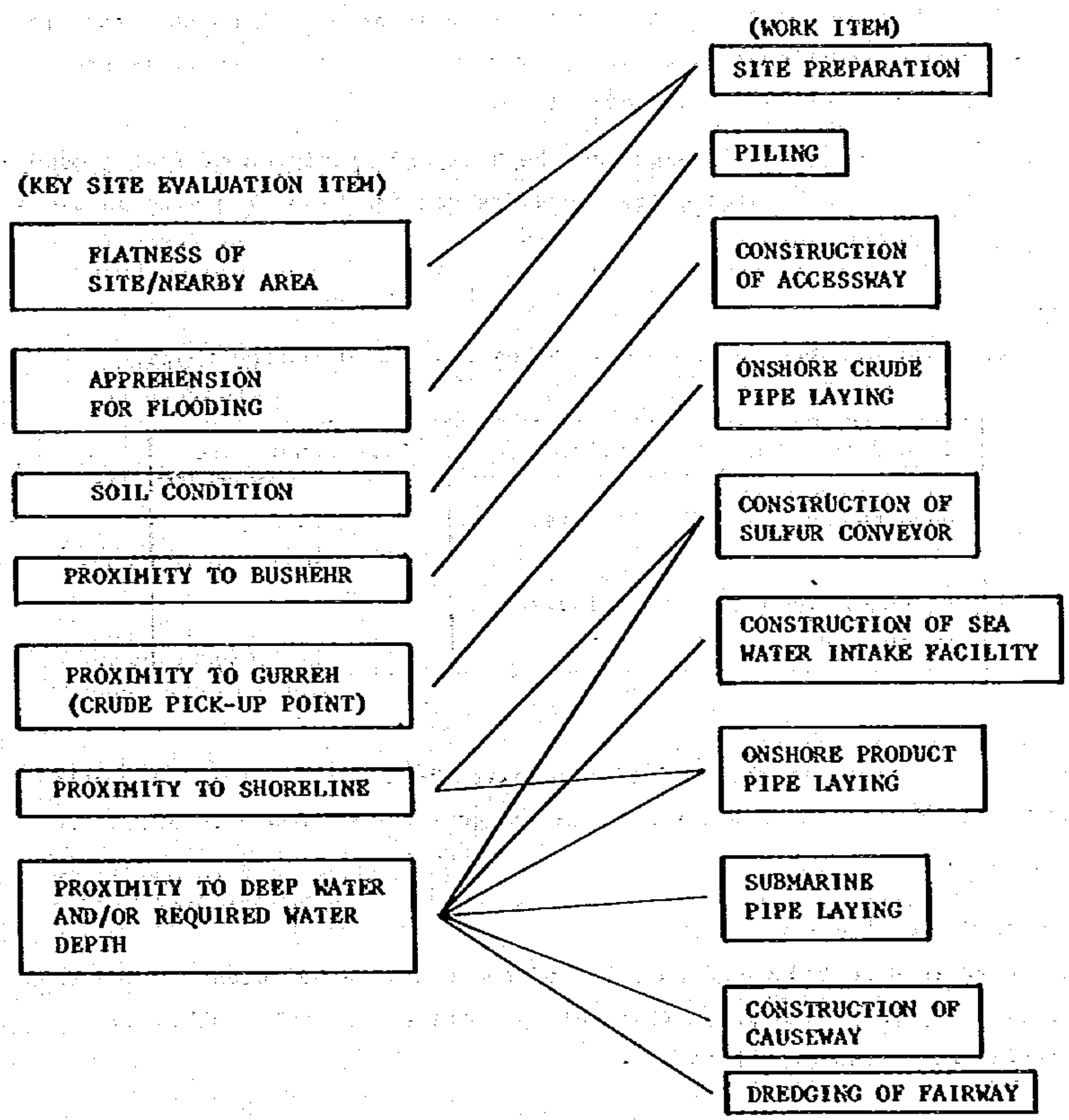
CANDIDATE SITE—MUHAMMAD AMERI Fig8.4



□ CANDIDATE SITE—AMERI   Fig 8.5

Figure 8.6

Correction Between Key Site Evaluation Item and Work Item



Preconditions for comparison of construction work volume are as follows:

Site Preparation

The candidate sites Farageh and Chughadak are planned with full-up ground at 2 m above existing ground level as a countermeasure against flooding.

At Muhammad Ameri and Ameri, the drainage basin areas behind the site are small, so construction of a drainage system around oil refinery is projected as a countermeasure against flooding.

At Ameri, the mountain rises behind the site and provision of flat ground on one level would be difficult, therefore construction of a site in tiers is projected.

Piling

The following are set up according to the results of boring tests.

Candidate Site	Piling	Pile length/each
FARAGEH	Required	30 m
CHUGHADAK	"	10 m
MUHAMMAD AMERI	Not required	
AMERI	"	

Accessways

Chughadak is taken as the head of road extension.
Bridge constructions of about 1 km on the mountainous route to Ameri are projected.

Onshore Crude Pipeline

The route is selected based on a map of scale 1 : 50,000 with a route from the existing pumping station (Gurreh) as short as possible following existing roads and pipelines.

Product Pipelines (Onshore Pipelines, Submarine Pipelines)

Laying an onshore product pipeline from the candidate site to the end of the causeway is projected.
Laying a submarine product pipeline from the end of the causeway to the sea-berth is projected.

Dredged Channel

Planned dredging to secure a required water depth of 10 m to the point of water depth 3 m is projected, taking the shortest route.

Causeway

Construction of a causeway between the seashore and the point of water depth 3 m is projected.

Sea Water Intake Facility

Provision of an exclusive waterway by dredging from the point of water depth 3 m to the coastline and laying a pipeline from the coast line to the candidate site is projected.

For the candidate site of Chughadak, the following preconditions are established separately.

- Assuming that it is possible to use the existing port of Bushehr, the construction of the dredged channel and causeway is deleted. But a project to newly construct an exclusive berth of sulfur-bunker carriers in the port of Bushehr is included.
- A conveyor system to transport sulfur, the same systems as in the other candidate sites, is projected.
- A planned route for an onshore product pipeline to cross the Bushehr Peninsula along the road going to Bushehr is used.
- It is planned to take sea water from the western sea area of Bushehr Peninsula and convey it to the oil refinery by pumps.

Advantages and Disadvantages of Candidate Sites

The major advantages and disadvantages of each candidate site are as shown in Table 8.1. Details are shown in Table 8.2.

To make an overall comparison based on the weighing of each work item, Table 8.3 shows construction costs of each item converted from respective work volumes. From this table it may be noticed that site preparation and piling are heavily weighed among onshore work items, while construction work costs for the causeway and submarine pipeline are heavily weighed among offshore work items.

It shows also that for overall construction expenses, Ameri is the lowest followed by Muhammad Ameri, Chughadak and Parageh in that order.

Table 8.1

Construction Works Comparison

Candidate Site	Advantage Minimum amount of ---	Disadvantage Maximum amount of ---
FARAGEH	Onshore crude pipe laying, submarine pipe laying	Site preparation, piling, causeway work
CHUGHADAK	Accessway work, causeway work, channel dredging	Site preparation, piling, sulfur conveyor work, sea water intake facility, onshore product pipe laying
MUHAMMAD AMERI	Site preparation, piling	Submarine pipe laying, channel dredging
AMERI	Piling, sulfur conveyor work, seawater intake facility work, onshore product pipe laying	Accessway work, onshore crude pipe laying

Table 8.2

Work Volume Comparison

Work Item \ Candidate Site	FARAGEH	CHUGHADAK	MUHAMMAD AMERI	AMERI
Site Preparation	To be filled 2 m above existing ground level to prevent flooding		To be land graded	The land to be cut and filled, and finished to several ground levels.
• Earth Work	8,500,000 m^3	Same as "FARAGEH"	3,000,000 m^3	6,000,000 m^3
• Soil Import	8,500,000 m^3		None	None
• Fill Material Haul Distance	5 km (To be gathered from nearby area)		None	None
• Slope Protection	None		None	160,000 m^2
Piling	30 m length x 37,500 nos.	10 m length x 37,500 nos.	None	None
Accessway . Distance from "CHUGHADAK"	45 km	None	30 km	60 km
Onshore Crude Pipeline . Distance from "GURREH"	95 km	140 km	165 km	190 km
Sulfur Conveyor . Distance from harbor	13 km	25 km from "BUSHEHR" port	4 km	0.5 km
Sea Water Intake Facility				
. Intake pipeline (Distance from shore-line)	7.5 km	21 km	1 km	0.2 km
. Dredging (Distance between shoreline and point of 3 m depth)	5.5 km	0.5 km	3.5 km	0.3 km
Product Pipeline				
. Onshore (Distance from causeway head)	13 km	21 km from shoreline	4.5 km	0.5 km
. Submarine	5.5 km	7.5 km	14.5 km	10 km
Causeway (Distance from point of 3 m depth) : Stone work	5.5 km	("BUSHEHR PORT" available) None	3.5 km	0.3 km
Dredged Channel	3 km (between 3 m - 10 m depth)	None("BUSHEHR PORT" available)	9 km (between 3 m - 10 m depth)	4 km (between 3 m - 10 m depth)

Table 8.3

Investment Cost Comparison
(MOHAMMAD AMERI as Base Cost)

(Unit: Millions US$)

Work Item	Description	FARAGEH	CHUGHADAK	MOHAMMAD AMERI	AMERI
Site Preparation	Area of site: 4,000,000 m^2	+59	+59	0	+29
Piling	To be applied "Process area"	+75	+25	0	0
Accessway	Asphalt concrete pavement: 8 m width	+ 6	-15	0	+34
Onshore Crude Pipeline	24" - 2 lines (case of FARAGEH) 26" - 2 lines (other cases)	-56	-18	0	+18
Sulfur conveyor	Conveyor capacity: 500 ton/hr	+16	+40	0	- 7
Sea Water Intake Facility	Pipe dia. 2,000 m/m, Carbon steel, Cement lining	+ 8	+23	0	- 2
Product Pipeline	42"-1 line, 32"-3 lines, 22"-1 line, (16"-1 line), 4"-1 line	-52	-25	0	-40
Causeway	Crown width: 20 m	+22	-39	0	-35
Dredged Channel	Width of fairway: 200 m	-18	-27	0	-15
Total		+60	+23	0	-18

On adding the construction costs for utilities, i.e., water and electrical power facilities, the above ranking does not change but the difference between Muhammad Ameri and Chughadak becomes small. If it is assumed that the accessway in the table has been completed already, the above ranking still does not change.

Besides the above comparison of initial expenses, the following items which are difficult to express in money terms should also be examined.

- Access from Bushehr urban area
- Dimensions of the open spaces behind the site
- Transportation of by-product sulfur
- Terms of construction

Each item is examined as follows with reference to the features of respective candidate sites:

Access from Bushehr Urban Area

Within the extent of the candidate sites, Bushehr has the largest scale, as a city possessing a harbour and air port.

Besides its convenience to the construction work, the close vicinity to Bushehr would provide miscellaneous merits during commercial operation after construction.

In the case of Chughadak, its distance from Bushehr is the shortest and it gives advantages in transportation on the assumption that materials and equipment are unloaded in the port of Bushehr.

In the case of Ameri, the distance from Bushehr is the longest at about 60 km of which about 10 km passes through mountainous areas with difficulties in commuting and transportation.

Dimensions of the Open Spaces Behind the Site

In the area of 4,000,000 m^2 which is a prerequisite of site selection, freedom to select the site configuration is desirable. Further, the need reserve surrounding areas for related facilities may occur and other industrial projects in future should, therefore, be anticipated.

In Ameri, there is a mountain close behind the area and the configuration of the site would be greatly restricted which is a demerit of this location.

Transportation of By-product Sulfur

In the refining capacity of 500,000 BPSD, about 700 TPSD of sulfur is produced as a by-product. Although the inland transportation method for this sulfur would depend on transportation distance etc., to evaluate each candidate site by comparing construction cost, the same basic conditions, i.e. a belt conveyor system is assumed for convenience.

As to Chughadak, this requires a projected belt conveyor system of a large scale, totalling 25 km including a section through Bushehr urban area.

As an alternative to the belt conveyor system transportation by trucks could be considered. In this case, a total of about 100 trucks per day and storage area of 10,000 ton sulfur in harbor area would be required. These expenses would be added to product costs.

Should either the belt conveyor system or trucking system be adopted, these would still remain technical and environmental problems to be solved before realization.

Terms of Construction

Construction of marine structures to unload super heavy cargoes and preparation of roads to transport general materials and equipment are major factors which govern the construction schedule.

In the case of Chughadak, the existence of Bushehr port and roads are advantageous, but on the other hand schedules of large scale earth works and piling must be supplemented as also in the case of Farageh.

8.3 Recommendation of the Oil Refinery Site

From the standpoint of initial investment, Ameri holds superiority followed by Muhammad Ameri, Chughadak and Farageh in order as mentioned previously. But the mountainous area of about 10 km between Bashi and Rustami was pointed out as an access problem to Ameri and road preparation in this area would include factors which are not accounted for simply by construction cost. And in regard to the dimensions of the open spaces behind the site, Ameri is the poorest site, and with respect to the prerequisite for an oil refinery of refining capacity 500,000 BPSD, it has no reserve space around it. Thus it cannot be said to be a suitable site. Amont other sites than Ameri, Muhammad Ameri has the lowest construction costs and the demerits such as mentioned for Ameri above are not so serious, consequently this is the candidate site recommended from an overall evaluation.

But if a prerequisite for refining capacity is set at 250,000 BPSD (required area of site 2,400,000 m^2), then there is the possibility to substitute Ameri for Muhammad Ameri.

In the case of electric power and water utility services supplied from Bushehr, Chughadak becomes advantageous since it is located near Bushehr.

The difference in scores between Chughadak and Muhammad Ameri then becomes small.

CHAPTER 9

COSTS ESTIMATION

CHAPTER 9

COSTS ESTIMATION

For each of the two refinery configurations at the three different crude throughput capacities, the capital requirements and operating costs are estimated for the Muhammad Ameri location. The results are summarized in Table 9.1.

The bases and procedures used in estimating these figures are described in the subsequent paragraphs. All costs are escalated and reflect economic conditions in Iran and expressed in US dollars.

Costs of social and industrial infrastructures are not included in this text, which are shown in Cahpter 7, Infrastructures for Project Development.

In this text, the capital requirements are divided into two categories, namely, the fixed capital investment and working capital. The former is subject to depreciation or amortization, while not for the later.

The operating costs estimated here are the direct operating costs of the refinery. They exclude capital-related expenses such as depreciation, interest on borrowed fund, and return on investment. The capital-related expenses and income tax are discussed in Chapter 11, Economic Analysis.

9.1 Capital Requirements

The capital requirement is the total fund that the owner must provide, either from equity capital or debt financing, to cover costs and expenses that will be incurred in bringing the refinery from the planning stage to commercial operation.

The capital requirement is divided into the following two categories and estimated:

a. Fixed Capital Investment; subject to depreciation or amortization:
   - Construction costs of installed facilities
   - Paid-up royalties
   - Initial catalyst and chemicals
   - Pre-operating expenses
   - Interest during construction

b. Working Capital; not subject to depreciation nor amortization:

- Land
- Oil inventories
- Catalyst and chemicals inventories
- Spare parts and warehouse supplies
- Cash on hand

The following are the bases and procedures used in estimating individual costs:

Constructin Costs of Installed Facilities
(Lines 1 through 4 of Table 9.1)

These lines show the estimated construction costs for the installed facilities defined in Chapter 5, Project Description.

The construction costs are developed mainly based on the facilties defined for Case-1 Hydroskimming at 250,000 BPSD crude throughput capacity, by evaluating the cost of major equipment reflecting current costs as of June, 1978 on a worldwide purchasing basis and comparing to similar prototypes in our file. Adjustments are made for differences in scope and capacity. A present-day installed-in-Japan cost thus obtained are, then, converted to an installed-in-Iran cost by adjusting cost elements such as freight charges, labor costs, camp costs, and rental charges for construction equipment.
The resulting cost factor is 1.28 times of domestic cost in Japan.

Despite the above, costs of facilities located outside of the refinery such as for product loading submarine pipelines and sea berth are estimated on an installed-in-Iran basis from the beginning of estimate.

Next, the cost is escalated based on an engineering and construction schedule formulated in Chapter 6, Project Execution, and an estimated escalation rate of labor and materials. Escalation rates used and the resulting overall escalation factors for facilities are as follows:

Escalation Rates:

. Materials	5 percent per annum
. Labor - Iranian	15 percent per annum
- Expatriate ex Japanese	ditto
- Japanese	6 percent per annum

Table 9.1

Capital Requirements and Operating Costs Summary

Configuration	Case 1 Hydroskimming			Case 2 Hydrocracking		
Refining Capacity, BPSD	125,000	250,000	500,000	125,000	250,000	500,000
<u>Capital Requirements (10^6 US$)</u>						
1. Process Units	247.2	409.6	819.2	290.1	482.3	964.5
2. Utilities System	112.3	181.6	313.1	118.5	192.9	329.4
3. Offsite/Auxiliaries	278.7	373.0	545.5	286.7	379.9	553.0
4. Product Transfer	189.5	189.5	211.6	189.5	189.5	211.6
5. Paid-up Royalties	1.8	3.6	7.1	2.9	5.8	11.6
6. Initial Catalyst and Chemicals	6.2	12.3	24.6	7.5	15.0	30.0
7. Pre-operating Expenses	38.9	39.1	47.7	40.1	40.3	49.6
8. Interest during Construction	97.2	137.3	231.2	103.6	153.1	256.9
9. Working Capital	101.8	152.8	245.8	105.5	157.9	251.4
Total Capital Requirements	1,073.6	1,498.8	2,445.8	1,144.4	1,616.7	2,658.0
<u>Operating Costs (10^3 US$/CD)</u>						
10. Salary and Wages	38.6	38.6	52.2	40.8	40.8	55.7
11. Overhead	16.6	16.6	22.5	17.5	17.5	24.0
12. Maintenance	53.0	80.4	144.0	58.5	89.5	161.3
13. Operating Supplies	3.4	4.7	7.8	3.6	5.1	8.4
14. Corporate Overhead	7.5	7.5	7.5	7.5	7.5	7.5
15. Insurance	4.4	6.2	10.5	4.7	6.7	11.3
16. Catalyst and Chemicals	27.8	55.3	110.4	25.8	51.3	102.5
Total Operating Costs	151.3	209.3	354.9	158.4	218.4	370.7
US$/BBL of Crude	1.42	0.98	0.84	1.49	1.03	0.87

Table 9.2

Construction Costs Summary : Case 1 Hydroskimming

	Capacity per Unit in	125,000 BPSD			250,000 BPSD			500,000 BPSD		
		Capacity	No.s	Cost 10^6US$	Capacity	No.s	Cost 10^6US$	Capacity	No.s	Cost 10^6US$
1. Process Units										
Atmospheric Crude Distillation	BPSD	125,000	1	36.5	125,000	2	69.6	125,000	4	139.2
Vacuum Flasher	BPSD	14,000	1	7.1	27,900	1	12.4	27,900	2	24.7
Gas Recovery	BPSD	3,800	1	2.6	7,500	1	4.6	7,500	2	9.1
Naphtha Hydrodesulfurizer	BPSD	26,500	1	15.0	52,900	1	22.7	52,900	2	45.4
Catalytic Reformer	BPSD	9,700	1	11.1	19,300	1	17.9	19,300	2	35.8
Kerosene Hydrodesulfurizer	BPSD	17,700	1	12.4	35,300	1	19.3	35,300	2	38.7
Gas Oil Hydrodesulfurizer	BPSD	26,900	1	16.8	53,800	1	26.4	53,800	2	52.8
Vacuum Gas Oil Hydrodesulfurizer	BPSD	7,200	1	11.2	14,300	1	17.0	14,300	2	33.9
Atmos. Residue Hydrodesulfurizer	BPSD	34,900	1	95.8	69,800	1	161.0	69,800	2	322.2
Hydrogen Generator	$10^6Nm^3/D$	0.83	1	24.0	1.66	1	37.7	1.66	2	75.4
Gas Treater	TPSD-H_2S	100	2	6.5	200	2	9.2	200	4	18.4
Sulfur Recovery	TPSD-S	90	2	6.8	180	2	9.6	180	4	19.2
Foul Water Stripper	TPSD	990	1	1.4	1,980	1	2.2	1,980	2	4.4
Subtotal Process Units				247.2			409.6			819.2
2. Utilities System										
Steam Generator	Ton/H	170	3	25.3	310	3	43.4	400	4	72.9
Power Generator	KW	14,000	3	20.4	16,000	4	30.0	19,000	6	51.2
Sea Water Intake	Ton/H	5,000	1	6.6	10,000	1	10.5	20,000	1	16.4
Desalinator	Ton/D	2,400	3	18.7	4,700	3	32.0	9,100	3	54.3
BFW Treatment	Ton/H	220	3	3.3	410	3	5.1	540	4	8.2
Cooling Water System	Ton/H	18,000	1	5.7	17,000	2	10.9	17,000	4	21.8
Refinery Fuel, Air & Inert Gas System		-		2.6	-		4.0	-		6.1
Utilities Distribution		-		29.7	-		48.7	-		82.2
Subtotal Utilities System				112.3			184.6			313.1
3. Offsite and Auxiliaries										
Tankage	10^3Kl	1,667		78.0	2,577		115.8	4,279		192.3
Interconnecting Pipelines				54.6			75.9			111.0
Blending/Loading Pumps				14.5			15.5			17.8
Sulfur Handling/Shipping				12.4			13.8			18.8
Instrumentation/Computer				23.2			31.3			44.9
Fire Fighting System				12.7			17.6			25.7
Relief, Blow Down, Effluent Treatment				14.0			18.0			27.0
Communication System				3.4			3.9			4.5
Site Development				24.3			30.4			48.6
Buildings and Equipment				41.6			47.8			54.9
Subtotal Offsite				278.7			370.0			545.5
4. Product Transfer										
Product Loaidng Pipelines	Km	19	6	126.8	19	6	126.8	19	6	126.8
Product Loading Sea Berths	DWT	200,000	1	47.0	200,000	1	47.0	200,000	2	69.1
Tags, Fire Boats, etc.				15.7			15.7			15.7
Subtotal Product Transfer				189.5			189.5			211.6
Total Construction Cost				827.7			1,153.7			1,889.4

Table 9.3

Construction Costs Summary : Case 2 Hydrocracking

	Capacity per Unit in	125,000 BPSD			250,000 BPSD			500,000 BPSD		
		Capacity	No.s	Cost 10^6US$	Capacity	No.s	Cost 10^6US$	Capacity	No.s	Cost 10^6US$
1. Process Units										
Atmospheric Crude Distillation	BPSD	125,000	1	36.5	125,000	2	69.6	125,000	4	139.2
Vacuum Flasher	BPSD	19,300	1	9.2	38,500	1	16.0	38,500	2	32.0
Gas Recovery	BPSD	4,700	1	3.1	9,400	1	5.5	9,400	2	10.9
Naphtha Hydrodesulfurizer	BPSD	26,500	1	15.0	52,900	1	22.7	52,900	2	45.4
Catalytic Reformer	BPSD	9,700	1	11.1	19,300	1	17.9	19,300	2	35.8
Kerosene Hydrodesulfurizer	BPSD	17,700	1	12.4	35,300	1	19.4	35,300	2	38.7
Gas Oil Hydrodesulfurizer	BPSD	28,900	1	18.0	57,700	1	28.1	57,700	2	56.3
Vacuum Gas Oil Hydrocracker	BPSD	9,900	1	44.2	19,700	1	74.0	19,700	2	148.0
Atmos. Residue Hydrodesulfurizer	BPSD	30,300	1	83.7	60,600	1	140.9	60,600	2	281.8
Visbreaker	BPSD	9,400	1	5.4	18,800	1	9.4	18,800	2	18.8
Hydrogen Generator	$10^6Nm^3/D$	0.55	2	36.7	1.10	2	57.7	1.10	4	115.3
Gas Treater	TPSD-H_2S	100	2	6.5	200	2	9.2	200	4	18.4
Sulfur Recovery	TPSD-S	90	2	6.8	180	2	9.6	180	4	19.2
Foul Water Stripper	TPSD	1,120	1	1.5	2,230	1	2.3	2,230	2	4.7
Subtotal Process Units				290.1			482.3			964.5
2. Utilities System										
Steam Generator	Ton/H	170	3	25.3	310	3	43.4	400	4	72.9
Power Generator	KW	15,000	3	21.4	17,000	4	31.4	21,000	6	55.2
Sea Water Intake	Ton/H	6,000	1	7.5	11,000	1	11.1	21,000	1	17.0
Desalinator	Ton/D	2,700	3	20.6	5,200	3	34.7	10,200	3	59.5
BFW Treatment	Ton/H	240	3	3.5	460	3	5.5	600	4	8.9
Cooling Water System	Ton/H	20,000	1	6.1	19,000	2	11.8	19,000	4	23.6
Refinery Fuel, Air & Inert Gas System		-		2.6	-		4.0	-		6.1
Utilities Distribution				31.5			51.0			86.2
Subtotal Utilities System				118.5			192.9			329.4
3. Offsite and Auxiliaries										
Tankage	10^3Kl	1,737		82.4	2,676		121.5	4,337		196.9
Interconnecting Pipelines				56.6			78.1			112.1
Blending/Loading Pumps				14.5			15.5			17.8
Sulfur Handling/Shipping				12.4			13.8			18.8
Instrumentation/Computer				23.2			31.3			44.9
Fire Fighting System				13.1			18.1			26.0
Relief, Blow Down, Effluent Treatment				14.0			18.0			27.0
Communication System				3.4			3.9			4.5
Site Development				25.5			31.9			50.1
Buildings and Equipment				41.6			47.8			54.9
Subtotal Offsite				286.7			379.9			553.0
4. Product Transfer										
Product Loading Pipelines	Km	19	6	126.8	19	6	126.8	19	6	126.8
Product Loading Sea Berths	DWT	200,000	1	47.0	200,000	1	47.0	200,000	2	69.1
Tags, Fire Boats, etc.				15.7			15.7			15.7
Subtotal Product Transfer				189.5			189.5			211.6
Total Construction Cost				884.8			1,244.6			2,058.5

Overall Escalation Factors (Relative to June, 1978 Cost):

. Process Units	1.13
. Utilities system	1.15
. Offsite/Auxiliaries	1.18
. Submarine pipelines and sea berth	1.10

The following are not included in the costs:

- Import duties and sales tax on equipment
- Rental fees for construction and temporary stock yard
- Compensations for fishery, etc.
- Allowances for force majeure events
- Premium for accelarated completion

The detailed cost breakdown is presented in Tables 9.2 and 9.3 for Case 1 and Case 2 respectively.

Paid-up Royalties

(Line 5 of Table 9.1)

Royalties are calculated based on a typical information from licensors for respective processes. No contact with licensors has been made specific to this study. No escalation allowance is considered for royalties, since they are generally negotiable between licensor and owner.

Royalties at 500,000 BPSD crude capacity are shown in Table 9.4. For 125,000 BPSD and 250,000 BPSD, the costs are lowered in proportion to crude capacity.

Initial Catalyst and Chemicals Costs

(Line 6 of Table 9.1)

These are the costs of catalyst and chemicals loaded into process equipment prior to startup. All unit costs are increased to reflect shipment to Iran. The costs are escalated at 5 percent per year, or a total of 22 percent, representing purchase in 1982.

The resulting costs are shown in Table 9.5.

Table 9.4

Paid-up Royalties

	Capacity per Unit in	Case 1 Hydroskimming		Case 2 Hydrocracking	
		Capacity	Royalties 10^6US$	Capacity	Royalties 10^6US$
For 500,000 BPSD					
Catalytic Reformer	BPCD	32,700	1.80	32,700	1.80
Vacuum Gas Oil Hydrodesulfurizer	BPCD	24,300	0.24	-	-
Vacuum Gas Oil Hydrocracker	BPCD	-	-	33,500	4.89
Atmos. Residue Hydrodeslfurizer	BPCD	111,600	3.84	97,000	3.33
Hydrogen Generator	10^6Nm^3/CD	2.25	1.08	3.17	1.43
Sulfur Recovery	TPCD-S	600	0.14	580	0.14
Total			7.10		11.59
For 250,000 BPSD			3.55		5.80
For 125,000 BPSD			1.78		2.90

Table 9.5

Initial Catalyst and Chemicals Costs

	Capacity In	Case 1 Hydroskimming		Case 2 Hydrocracking	
		Total Capacity	Cost 10^6US$	Total Capacity	Cost 10^6US$
For 500,000 BPSD					
Naphtha Hydrodesulfurizer	BPSD	105,800	0.63	105,800	0.63
Catalytic Reformer	BPSD	38,600	3.39	38,600	3.39
Kerosene Hydrodesulfurizer	BPSD	70,600	0.48	70,600	0.43
Gas Oil Hydrodesulfurizer	BPSD	107,600	0.97	115,400	1.04
Vacuum Gas Oil Hydrodesulfurizer	BPSD	28,600	0.52	-	-
Vacuum Gas Oil Hydrocracker	BPSD	-	-	39,400	7.71
Atmos. Residue Hydrodesulfurizer	BPSD	139,600	15.29	121,200	12.70
Hydrogen Generator	10^6Nm^3/SD	3.32	2.31	4.43	3.05
Gas Treater	TPSD-H_2S	800	0.65	800	0.65
Sulfur Recovery	TPSD-S	720	0.33	720	0.33
Total			24.58		30.00
For 250,000 BPSD			12.29		15.00
For 125,000 BPSD			6.15		7.50

Pre-operating Expenses
(Line 7 of Table 9.1)

Pre-operating expenses include the miscellaneous costs other than for plants that will be incurred during the period from the start of project until the end of startup.

The items included in the expenses and bases used are:

a. Operators Training: The costs are estimated based on the planned training schedule as described in paragraph 6.4 Training for Employee. An 80 percent of the standard salary is assumed to be paid for trainees as pre-salary during the training period.

b. Corporate Overhead: The cost equals to 80 percent of the corporate overhead incurred after the commencement of commercial operation is accounted throughout pre-operating period.

c. Administrative Costs: The salary and wages for the refinery staff before the start of commercial operation are accounted in this item. For the initial stage of project before the start of field construction, the costs for 20 engineering staff are considered.

For the period until the start of commercial operation after the field construction is commenced, the following schedule is used provided that the formulation of entire refinery's staff will be performed gradually during this period.

Staff Categories	Period
• Refinery manager, deputy manager, and secretaries • Department managers and their assistants • Section managers and their assistants • Supervisors of Production Department • Engineers of Technical Service Department	Throughout the construction and startup period.

. Other staff — For the last 12 months before the start of commercial operation.

An overhead allowance of 50 percent is added to the above costs.

d. Startup Costs: The costs incurred in startup period other than those for refinery personnel are accounted in this item. These include licensor and contractor startup assistances, chemicals, and operating supplies.

. Licensor Startup Assistance - 150 thousands US$ per process; 1.6 times for two trains

. Contractor Startup Assistance - A six months cost for 50 men from contractor is used for 125,000 BPSD and 250,000 BPSD crude capacities, while 1.6 times cost for 500,000 BPSD.

. Chemicals - Two months cost is used.

. Operating Supplies - Three months cost is used.

The resulting costs are shown in Table 9.6.

Interest during Construction
(Line 8 of Table 9.1)

This cost covers the interest on borrowed fund during engineering, construction and startup period. Based on a schedule of 44 months from the project award to mechanical completion and six months of startup, a typical 'S' shaped schedule of expenditure, and the following financing conditions, the interest to be paid is calculated using a computer simulation program as is detailed in Chapter 11, Economic Analysis.

. Source of Fund
  - Fixed investment ex. interest during construction:
    Equity capital/Long term loan = 25%/75%
  - Interest during construction: 100% long term loan
  - Working capital: 100% short term loan

. Interest Rates
  - Long term loan:

upto 1,000 millions US dollars	5.25% per annum
over 1,000 millions US dollars	8.00% per annum

  - Short term loan: 8.00% per annum

Table 9.6

Pre-Operating Expenses

Refining Capacity, BPSD	125,000	250,000	500,000
Case 1 Hydroskimming	(10^6US$)	(10^6US$)	(10^6US$)
1. Operators Training	5.32	5.32	7.79
2. Corporate Overhead	9.16	9.16	9.16
3. Administrative Costs	19.93	19.93	23.18
4. Startup Costs			
- Licensor Startup Assistance	0.44	0.44	0.71
- Contractor Startup Assistance	3.62	3.62	5.80
- Chemicals	0.08	0.15	0.30
- Operating Supplies	0.31	0.43	0.71
Total	38.86	39.05	47.65
Case 2 Hydrocracking	(10^6US$)	(10^6US$)	(10^6US$)
1. Operators Training	5.86	5.86	8.51
2. Corporate Overhead	9.16	9.16	9.16
3. Administrative Costs	20.34	20.34	23.99
4. Startup Costs			
- Licensor Startup Assistance	0.66	0.66	1.06
- Contractor Startup Assistance	3.62	3.62	5.80
- Chemicals	0.08	0.16	0.33
- Operating Supplies	0.33	0.47	0.77
Total	40.05	40.27	49.62

A schedule of 53 months, in liue of 44 months the above, from the project award to mechanical completion, is used for 500,000 BPSD crude capacity.

Working Capital

(Line 9 of Table 9.1)

Working capital is the fund that must be provided for the refinery to get it started and meet subsequent obligations as they come due. This includes cash, receivables, and inventories less payables.

In this estimate, the balance of receivables and payables are not taken into account since the credit terms for crude oil, product sale, etc., are not available at this stage. The estimate is made for the following five items:

a. Land: An allowance of US$ 5.0 millions is considered for all cases as per NIOC's instruction.

b. Oil Inventories: It is assumed that at the end of startup period, the refinery tankage is one-half full. No attempt is made for oil inventories in product pipelines. Oil inventories are priced at crude oil cost.

c. Catalyst and Chemicals Inventories: The only catalyst inventory provided is one batch replacement volume for one atmospheric residue hydrodesulfurizer. The chemicals inventory provided is for a six months supply. The prices used are 1983, landed in Iran.

d. Spare Parts and Warehouse Supplies: Spare parts and warehouse supplies are priced at 2 percent of the construction cost. These would be for two years supply.

e. Cash on Hand: Cash on hand is set at a level equal to two months cash expenditure ex. crude cost.

The resulting costs are shown in Table 9.7.

9.2 Operating Costs

There are two kinds of operating costs, one is direct operating costs and the other is capital related expenses such as interest, depreciation, and return on investment. The operating costs discussed in this section are direct operating costs. The capital related expenses are discussed in Chapter 11, Economic Analysis, where due considerations are also made to income tax and a certain profit on a DCF basis.

Table 9.7

Working Capital

Refining Capacity, BPSD	125,000	250,000	500,000
<u>Case 1 Hydroskimming</u>	(10^6US$)	(10^6US$)	(10^6US$)
Land	5.0	5.0	5.0
Oil Inventories	66.3	102.5	170.2
Catalyst and Chemicals Inventories	4.8	9.6	11.2
Spare Parts and Warehouse Supplies	16.6	23.1	37.8
Cash on Hand	9.1	12.6	21.6
Total	101.8	152.8	245.8
<u>Case 2 Hydrocracking</u>	(10^6US$)	(10^6US$)	(10^6US$)
Land	5.0	5.0	5.0
Oil Inventories	69.1	106.5	172.5
Catalyst and Chemicals Inventories	4.2	8.4	10.1
Spare Parts and Warehouse Supplies	17.7	24.9	41.2
Cash on Hand	9.5	13.1	22.6
Total	105.5	157.9	251.4

The direct operating costs are made up of seven items. They do not include crude cost. It is assumed that refinery pays no property tax. Utilities cost is not appeared in operating cost, because the refinery is self-supporting in utilities. Fuel consumption appears rather as a loss of product. The bases used in estimating each of the costs are as follows:

Salary and Wages
(Line 10 of Table 9.1)

Based on the refinery staff requirements with salary grades developed in paragraph 6.3 of this report and the information of salary structure received from NIOC during the visit to Iran in June, 1978, the payroll costs are estimated.

Since the raw information furnished by NIOC shows the salary and wage rates for each job class with indication of minimum and maximum figures, a modified salary structure is developed for study purposes and is presented in Table 9.8. These costs include special location allowances for working in the southern areas and are for the year of 1978.

Since operating costs are being represented for 1983, these costs are escalated by 8 percent per annum, or 47 percent in total. The resulting costs are shown in Tables 9.9 and 9.10 for Case 1 and Case 2 respectively.

Table 9.8

Salary Structure

Job Classifications	US$/Month
Class A, Refinery Manager/Assistant Manager	4,500
Class B, Department Manager/Doctor	3,100
Class C, Section Manager/Supervisor/Engineer	2,200
Class D, Foremen/Operators/Craftmen/Secretaries/Nurses	1,300
Class E, Clerks	600
Class F, Laborers	250

Table 9.9

Salary and Wages: Case 1 Hydroskimming

	US$/month	125,000/250,000 BPSD		500,000 BPSD	
		Total Personnel	1978 Cost 10^6US$/Annum	Total Personnel	1978 Cost 10^6US$/Annum
Class A	4,500	2	0.11	2	0.11
Class B	3,100	10	0.37	10	0.37
Class C	2,200	44	1.16	47	1.24
Class D	1,300	478	7.45	687	10.72
Class E	600	33	0.24	33	0.24
Class F	250	79	0.24	95	0.29
Total Payroll		646	9.58	875	12.97
1983 Cost			14.08		19.07
Per Diem Cost (10^3US$/CD)			38.6		52.2

Table 9.10

Salary and Wages: Case 2 Hydrocracking

	US$/month	125,000/250,000 BPSD		500,000 BPSD	
		Total Personnel	1978 Cost 10^6US$/Annum	Total Personnel	1978 Cost 10^6US$/Annum
Class A	4,500	2	0.11	2	0.11
Class B	3,100	10	0.37	10	0.37
Class C	2,200	44	1.16	47	1.24
Class D	1,300	513	8.00	742	11.58
Class E	600	33	0.24	33	0.24
Class F	250	79	0.24	95	0.29
Total Payroll		691	10.12	930	13.83
1983 Cost			14.89		20.33
Per Diem Cost (10^3US$/CD)			40.8		55.7

Overhead

(Line 11 of Table 9.1)

Overhead cost is calculated as 43 percent of the payroll based on the NIOC's suggestion. It is assumed that this cost covers payroll burden, living allowances, and plant overhead.

Maintenance

(Line 12 of Table 9.1)

Maintenance cost is calculated as a percentage of construction cost. The percentages used are as follows:

. Process units	4.0%/Annum
. Utilities system	3.0%/Annum
. Offsite/Auxiliaries	1.5%/Annum
. Product transfer	1.0%/Annum

Operating Supplies

(Line 13 of Table 9.1)

Operating supplies cover items such as lubricants, greases, instrument charts, office supplies, vehicle fuel, etc. The costs are priced at 0.15 percent of the construction cost.

Corporate Overhead

(Line 14 of Table 9.1)

Corporate overhead is accounted as an operating expense of the refinery, provided that a new company will be set up to manage operation and product sale. The cost is estimated on the basis that two offices, namely, an executive office in Teheran and a sales office in Tokyo, would be established.

The estimated cost is shown in Table 9.11. A 50 percent of the payroll cost is added as overhead cost and the resulting cost is escalated 47 percent to convert to 1983 cost. The costs are same for all cases.

Insurance

(Line 15 of Table 9.1)

Insurance burden for facilities and oil inventories is charged. The cost

Table 9.11

Corporate Overhead Cost

	Nos.	Salary US$/Month	1978 Cost 10^3 US$/Annum
Head Office (Teheran)			
President	1	6,800	82
Vice President	1	5,400	65
Executives	3	4,500	162
Staff	10	2,200	264
Secretaries	5	1,300	78
Clerks	5	600	36
	25		687
Overhead Expenses			344
Sub Total			1,031
Tokyo Office			
Manager	1	4,500	54
Duputy Manager	1	4,500	54
Staff	15	2,200	396
Secretaries	2	1,300	31
Clerks	2	600	14
	21		549
Overhead Expenses			275
Sub Total			824
Total Corporate Overhead			1,855
1983 Cost			2,727
Per Diem Cost (10^3 US$/CD)			7.5

is calculated based on the following:

- Insurance on facilities

  = (Av. Book Value of the Plant) x 0.3%/Annum

- Insurance on oil inventories

  = (Oil Inventories) x 0.17%/Annum

<u>Catalyst and Chemicals</u>

(Line 16 of Table 9.1)

Catalyst and chemicals costs are the average replacement cost based on expected catalyst life and the cost of chemicals resulted from refinery operation.

The unit costs of catalyst and chemicals are escalated at 5 percent per annum, or 28 percent in total, to convert the 1978 landed cost in Iran to 1983. The estimated costs are shown in Tables 9.12.

Table 9.12

Catalyst and Chemicals Cost

	Capacity In	Case 1 Hydroskimming		Case 2 Hydrocracking	
		Total Capacity	Cost 10^6 US$/A	Total Capacity	Cost 10^6 US$/A
<u>For 500,000 BPSD</u>					
Atmospheric Crude Distillation	BPSD	500,000	1.15	500,000	1.15
Vacuum Flasher	BPSD	55,800	0.02	77,000	0.03
Gas Recovery	BPSD	15,000	0.05	18,800	0.07
Naphtha Hydrodesulfurizer	BPSD	105,800	0.22	105,800	0.22
Catalytic Reformer	BPSD	38,600	0.46	38,600	0.46
Kerosene Hydrodesulfurizer	BPSD	70,600	0.23	70,600	0.23
Gas Oil Hydrodesulfurizer	BPSD	107,600	0.46	135,400	0.50
Vacuum Gas Oil Hydrodesulfurizer	BPSD	28,600	0.33	-	-
Vacuum Gas Oil Hydrocracker	BPSD	-	-	39,400	2.17
Atmos. Residue Hydrodesulfurizer	BPSD	139,600	32.28	121,200	26.83
Visbreaker	BPSD	-	-	37,600	0.05
Hydrogen Generator	10^6 Km^3/D	3.32	0.45	4.49	0.60
Gas Treater	TPSD-H_2S	850	0.07	800	0.07
Sulfur Recovery	TPSD-S	720	0.09	720	0.09
Utilities System			4.15		4.63
Offsite			0.31		0.31
Total			40.28		37.41
Per Diem Cost (10^3 US$/CD)			110.4		102.5
<u>For 250,000 BPSD</u> (10^3 US$/CD)			55.3		51.3
<u>For 125,000 BPSD</u> (10^3 US$/CD)			27.5		25.8

CHAPTER 10

OCEAN FREIGHT AND COSTS OF CTS

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OCEAN FREIGHT AND COSTS OF CTS

This chapter discusses freight costs to transport refined products from Iran to Japan and costs of CTS to be located somewhere in Japan. Since the location of CTS has yet been decided, the freight costs are first estimated on the basis of transportation distance from Kharg to Yokohama and, then, the effect of alternating the unloading port from Yokohama to the southern or northern parts of Yokohama is estimated. The freight costs are estimated based on newbuildings in 1983 and vessel sizes of 130,000 DWT and 200,000 DWT for white oils and black oils respectively. A brief discussion is also made for the case of utilizing medium size tankers chartered from the existing market.

A study is conducted for a CTS which serves as receiving and distribution terminal for the products come from the refinery in Iran. Major facilities in CTS are defined and upon which capital and operating costs are estimated. The required CTS margins to give ROE (DCF) of 11.8 percent are also estimated.

Bases used and the results of study are presented in subsequent paragraphs.

10.1 Ocean Freight for Refined Products

10.1.1 Newly Built Tanker Based Freight Costs

The initial year costs of product tankers newly built in 1983 are estimated in Volume 2 of the Supplement, the gist of which is shown in Table 10.1.

As is detailed in Volume 2, the 10 years average costs stay closely to the respective initial year's costs. Therefore, the initial year costs are used in this text.

Freight costs in 1983 for the product mix from the base case refineries are calculated using the freight for 130,000 DWT and 200,000 DWT tonners for white oils and black oils respectively. The resulting costs are shown in Table 10.2.

Table 10.1

Ocean Freight by Tanker Size and Category
(Transportation Distance: Kharg/Yokohama)

Clean Tankers		Dirty Tankers	
Tanker Size	Ocean Freight	Tanker Size	Ocean Freight
DWT	US$/LT	DWT	US$/LT
30,000	32.68	60,000	18.78
50,000	22.53	90,000	15.40
60,000	20.96	180,000	11.55
130,000	14.41	200,000	11.16

Table 10.2

Ocean Freight of Refined Products

	Sp.Gr.	Case 1 Hydroskimming			Case 2 Hydrocracking		
		US$/BBL A	Yield,% B	AxB	US$/BBL A	Yield,% B	AxB
Clean Products (14.41 US$/LT)							
Gasoline	0.746	1.69	10.0	16.9	1.69	10.0	16.9
Naphtha	0.725	1.64	9.9	16.2	1.64	12.5	20.5
Kerosene	0.801	1.81	14.1	25.5	1.81	17.4	31.5
Gas Oil	0.855	1.93	21.1	40.7	1.93	24.9	48.1
Subtotal Clean Product		1.69	55.1	93.3	1.81	64.8	117.0
Dirty Products (11.16 US$/LT)							
Low Sulfur Fuel Oil	0.918	1.61	28.2	45.4	1.61	20.6	33.2
Medium Sulfur Fuel Oil	0.942	1.65	7.0	11.6	1.65	5.1	8.4
Subtotal Dirty Product		1.62	35.2	57.0	1.62	25.7	41.6
Total Products		1.73	90.3	156.3	1.75	90.5	158.6

Since the freight costs estimated are for a transportation distance of Kharg/Yokohama, a certain adjustment will be necessary for altering the unloading port from Yokohama to the areas where CTS is to be located. However, since the location of CTS has yet been decided, a reference calculation is made by setting up hypothetical CTS locations at southern and northern parts of Japan, by which the range of freight cost covering almost all areas in Japan can be predicted.

The freight difference caused by changing the loading port from Kharg Island to Muhammad Ameri can be neglected, because the distance between the two ports is as short as about 30 sea miles.

A brief discussion is made by taking Kagoshima (Kyushu) and Tomakomai (Hokkaido) as typical southern and northern locations of CTS. The approximate transportation distances from Kharg Island are as follows:

	Distance (Sea Miles)
Kharg Is./ Yokohama	6,670
Kharg Is./ Kagoshima	6,170
Kharg Is./ Tomakomai	7,150

On the other hand, the freight cost estimation is based on 8 round trips between Kharg Island and Yokohama.

Based on the assumption that the vessel is out of service for 40 days in every two-year due to maintenance and its average navigation speed is 15.5 Knots, the time constitution of one round trip is estimated as follows:

	On Sea	In Port *)	Total
Kharg/Yokohama	35.9 days	7.2 days	43.1 days

*) Includes loss time for waiting.

Based on the same assumptions above and a 7.2 days in-port period, the time required for a round trip for Kagoshima and Tomakomai locations will become as follows:

	On Sea	In Port	Total
Kharg/Kagoshima	33.2 days	7.2 days	40.4 days
Kharg/Tomakomai	38.4 days	7.2 days	45.6 days

Therefore, yearly transportation available for the above two locations would be:

	No. of Round Trips per Year	Transport Quantity Relative to Yokohama
Kharg/Kagoshima	8.54	1.067
Kharg/Tomakomai	7.57	0.946

Table 10.3 presents the estimated freight costs relative to Yokohama on the basis that port charge and fuel cost are of variable, while the constant annual costs for the rest. Refer to Table 22 of Volume 2 in the Supplement for the source data.

The results of study show that the freight difference caused by alternating unloading port from Yokohama to Kagoshima or Tomakomai will be in the range of minus or plus 6 percent respectively.

10.1.2 Existing Tanker Market Based Freight Costs

An estimation is made for the existing products tanker market based freight costs. Although it is not likely that the refinery can charter the total required tonnage sufficiently from the existing market in 1983 and thereafter, the refinery would require charters from the market, either on the spot or long-term basis, to absorb possible unbalances in production, transportation, and marketing while keeping the service factor of exclusively chartered large vessels high.

In general, the percentage of long-term charters on the total tonnage assigned for respective services is not likely to exceed 85-90 percent level even for crude oils supplied on a long-term contract basis.
In this connection, a freight cost in 1983 on the existing market basis is estimated starting from the current AFRA (Average Freight Rate Assessment) rates. The changes in freight rates in recent years are shown in Table 10.4 and Figure 10.1.

As is observed from Table 10.4, the general dropping trends in tanker's market since 1974 have been slow downed recently and the markets has upturned remarkably for less than 45,000 tonners, most of which will serve as product carriers.
In this respect, it is assumed that the world tanker market today stands on its bottom and will show the increasing trends.

Table 10.3

Freight Costs Relative to Yokohama

Unloading Port Distance from Kharg Is., Sea Miles	Yokohama 6,670	Kagoshima 6,170	Tomakomai 7,150
130,000 DWT - Clean			
1. Annual Expenditure, 10^3US$			
- Fixed Charges	11,095	11,095	11,095
- Port Charge	467	498	442
- Fuel Cost	2,876	2,839	2,911
Total	14,438	14,432	14,448
2. Annual Transport Quantity, 10^3LT	1,002	1,069	948
3. Freight Cost, , US$/LT	14.41	13.50	15.24
4. Relative to Yokohama	-	0.937	1.058
200,000 DWT - Dirty			
1. Annual Expenditure, 10^3US$			
- Fixed Charges	12,995	12,995	12,995
- Port Charge	638	681	604
- Fuel Cost	3,690	3,642	3,735
Total	17,323	17,318	17,334
2. Annual Transport Quantity, 10^3LT	1,552	1,656	1,468
3. Freight Costs , US$/LT	11.16	10.46	11.81
4. Relative to Yokohama	-	0.937	1.058

Table 10.4

Changes in Tanker Freight Rates[1)]

(for Kharg - Yokohama)

Period	Tanker Size	General Purpose (16,500~24,999) DWT		Medium (25,000~44,999) DWT		Large I (45,000~79,999) DWT		Large II (80,000~159,999) DWT		VLCC (Over 160,000) DWT	
	Kharg-Yokohama WS Flat Freight US$/LT[2)]	% of WS	AFRA US$/LT	% of WS	AFRA US$/LT	% of WS	AFRA US$/LT	% of WS	AFRA US$/LT	% of WS	AFRA US$/LT
Year 1974	6.33	202.8	12.84	173.1	10.96	115.6	7.32	91.7	5.80	75.8	4.80
Year 1975	9.05	138.5	12.53	124.5	11.27	82.9	7.50	62.3	5.64	56.8	5.14
Year 1976	9.91	133.7	13.25	117.3	11.62	76.9	7.62	56.7	5.62	50.0	4.96
Year 1977	10.10	152.3	15.38	113.9	11.50	73.9	7.46	54.5	5.50	47.0	4.81
Jan.-Apr. 1978	10.70	155.0	16.59	112.1	11.99	69.8	7.47	51.8	5.54	44.6	4.77

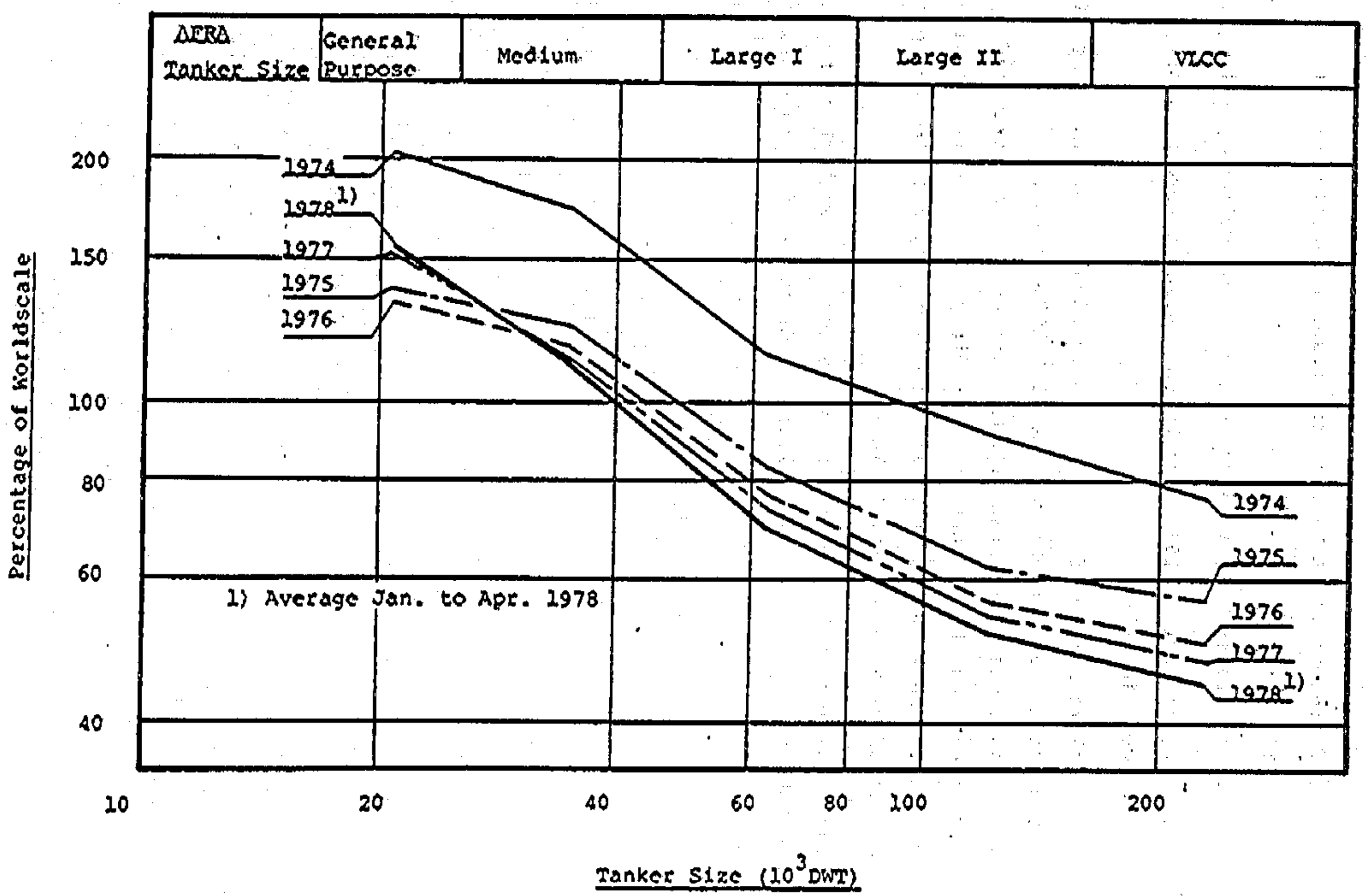
(Column group header: Percentage of World Scale and AFRA)

Note: 1) Based on Average Freight Rate Assessments (AFRA)

2) Average of the year.

Figure 10.1

Tankage Size V.S. Average Freight Rates (AFRA)



In estimating freight cost in 1983, the following steps are employed:

- Find present-day AFRA rate for respective sizes of carriers from Figure 10.1.
- Obtain present-day freight cost on an US dollars per long ton basis.
- Then, convert to 1983 cost by escalating 6 percent yearly, or 34 percent in total.

The escalation rate of 6 percent is based on an average cost rises of the world scale flat freight for the 1975-1978 period.
The freight cost for clean product carrier is also estimated by multiplying 1.08 factor to the freight rate for dirty product carriers with same tonnage. The 1.08 factor is assumed being referred to the recent spot market of clean and dirty tankers.

The resulting costs are presented, in contrast with those for newbuildings, in Tables 10.5 and 10.6 for clean and dirty carriers respectively.

Table 10.5

Freight Comparison of New and Existing Tankers in 1983 - Clean

Tanker Size	, 10^3 DWT		New Tankers Built in 1983			Existing Tankers	
			30	60	130	30	60
Freight in 1983	,$/LT		32.68	20.96	14.41	19.04	11.17
	Yield,%	Sp.Gr.					
Freight Cost ,$/bbl							
Gasoline	10.0	0.746	3.81	2.46	1.69	2.22	1.30
Naphtha	9.9	0.725	3.71	2.39	1.64	2.16	1.27
Kerosene	14.1	0.801	4.10	2.63	1.81	2.39	1.40
Diesel Oil	21.1	0.855	4.37	2.81	1.93	2.55	1.49
Average	-	0.798	4.08	2.62	1.80	2.38	1.39

Table 10.6

Freight Comparison of New and Existing Tankers in 1983 - Dirty

Tanker Size	, 10^3DWT		New Tankers Built in 1983			Existing Tankers	
			60	90	200	60	90
Freight in 1983	, $/LT		18.78	15.40	11.16	10.30	8.44
	Yield, %	Sp.Gr.					
<u>Freight Cost</u> $/bbl							
Low Sulfur Fuel Oil	28.2	0.918	2.70	2.22	1.61	1.48	1.21
Medium Sulfur Fuel Oil	7.0	0.942	2.77	2.28	1.65	1.52	1.24
Average	-	0.923	2.71	2.23	1.62	1.49	1.22

10.2 CTS Planning and Facility Definition

A preliminary planning is conducted for CTS having two major functions, namely, one is as a transit base for receiving products come from Iran and distributing them to consumers in Japan, and the other is as an oil stockpiling base.

In defining required tankage capacity, a stockpiling capacity of 90 days is used taking into account the Petroleum Stockpile Law and the related Ministerial Ordinances of Japan, in which 90 days stockpiling is obligated to establish until 1980.

The following describes bases and assumptions used in the study and the resulted plan for CTS.

Location of CTS

Two alternatives, namely, southern and northern part of Japan; specific location has yet been decided. Since the conditions specific to CTS are not available, the following are assumed as preconditions of site:

- Sufficient flat area is available.
- Deep water to enable accommodating 200,000 DWT class tankers is available at 2 Km offshore of the site.
- The site faces a harbor with sufficient depth and width for accommodating upto 30,000 DWT tonners.

Tankage

Tankage having the capacities to meet 90 days' stockpile requirements is to be provided.

In view of stockpiling economics as well as minimizing product qualities deteriorations due to long time storage, 45 days' stockpile is assumed to be covered by crude oil storage. It is to be considered that one barrel of crude oil is equivalent to 0.95 barrels of products. The 45 days' storage capacity for products will be more than ample to sustain smooth and stable operation of CTS.

In defining tankage capacity to meet 90 days' stockpile, average inventory rates of the following are to be used:

- For operation tanks — 45 percent
- For stockpiling tanks — 85 percent

The operation tanks are for 20 days or 1.5 times the quantity received from one largest vessel, whichever the larger. The tanks other than operation tanks are to be considered as stockpiling tanks. The capacity of total tankage to meet 90 days' stockpile requirements can be obtained using the following formula:

$$Tp = \frac{Do \times Po}{0.45} + \frac{(45-Do) \times Po}{0.85}$$

$$Tc = \frac{45 \times Po/0.95}{0.85}$$

Where,

Tp : Required capacity of product tanks (barrel)

Tc : Required capacity of crude tanks (barrel)

Do : Operation tank requirements expressed in equivalent days of CTS through-put (day)

Po : Rate of products passing through CTS (BPCD)

The tankage requirements for the base case refineries are as shown in Table 10.7.

As is observed from Table 10.7, the difference in total tankage requirements for Hydroskimming and Hydrocracking cases at the same crude capacity is within one percent range and is considered to be essentially the same. Since the quantity of products passing through CTS is almost same for both cases, other requirements such as for product receiving, shipping, waste water treating, etc. can be considered essentially the same.

Therefore, discussions hereafter are made limitedly for Hydroskimming cases. Table 10.8 presents the installed capacity of tanks for Hydroskimming cases.

Utilities System

It is assumed that the utilities system of CTS is to be designed on the basis of purchasing electric power, industrial water, and fuel oil, while internal generation for the rest such as steam, BFW, air, etc.

The requirements for purcahsed utilities for 500,000 BPSD crude capacity is estimated as follows; while proportional for lower crude capacities;

Table 10.7

Tankage Requirements

Corresponding Refinery	125,000 BPSD			250,000 BPSD			500,000 BPSD		
	Rates	Required Tankage		Rates	Required Tankage		Rates	Required Tankage	
	BPCD	Days 1)	10^3 Kl 2)	BPCD	Days 1)	10^3 Kl 2)	BPCD	Days 1)	10^3 Kl 2)
Case 1 Hydroskimming									
Crude Oil	100,990	52.9	849	201,970	52.9	1,699	403,940	52.9	3,398
Gasoline	10,630	89.3	153	21,250	73.9	253	42,500	73.9	506
Naphtha	10,470	89.3	150	20,940	73.9	249	41,880	73.9	498
Kerosene	14,980	73.9	178	29,960	73.9	356	59,920	73.9	713
Gas Oil	22,400	73.9	266	44,810	73.9	533	89,620	73.9	1,065
Fuel Oil (0.1% Sulfur)	29,970	78.1	386	59,930	73.9	731	119,860	73.9	1,462
Fuel Oil (1.5% Sulfur)	7,490	78.1	96	14,980	73.9	183	29,960	73.9	365
Total			2,078			4,004			8,007
Case 2 Hydrocracking									
Crude Oil	101,230	52.9	851	202,450	52.9	1,703	404,910	52.9	3,406
Gasoline	10,630	85.2	146	21,250	73.9	253	42,500	73.9	506
Naphtha	13,280	85.2	182	26,560	73.9	316	53,120	73.9	631
Kerosene	18,500	73.9	220	37,000	73.9	440	74,000	73.9	880
Gas Oil	26,320	73.9	315	52,640	73.9	629	105,820	73.9	1,258
Fuel Oil (0.1% Sulfur)	21,850	87.5	316	43,690	73.9	533	87,380	73.9	1,066
Fuel Oil (1.5% Sulfur)	5,460	87.5	79	10,920	73.9	133	21,840	73.9	266
Total			2,109			4,007			8,013

Notes

1) Figures indicate required volume of tankage in equivalent calendar days' product output.

2) Densities at maintain temparatures in tank is taken into account.

Table 10.8

Tankage Summary

(Case 1 Hydroskimming)

Service	Type	125,000 BPSD		250,000 BPSD		500,000 BPSD	
		No.s	Capacity, Kl	No.s	Capacity, Kl	No.s	Capacity, Kl
Crude	FRT	9	94,500	18	94,500	36	94,500
Gasoline	FRT	2	76,000	3	84,000	6	84,000
Naphtha	FRT	2	76,000	3	84,000	6	84,000
Kerosene	FRT	2	89,000	4	89,000	8	89,000
Gas Oil	CRT	3	89,000	6	89,000	12	89,000
Fuel Oil (0.1%S)	CRT	4	91,500	8	91,500	16	91,500
Fuel Oil (1.5%S)	CRT	2	58,000	2	91,500	4	91,500

- Electric power 8,200 KWD/CD
- Industrial water 1,700 Tons/CD
- Fuel oil 1,400 10^6Kcal/CD

Product Loading and Unloading Facilities

The products are assumed to be received from tankers with the following sizes:

White oils	Upto 130,000 DWT tonners
Black oils	Upto 200,000 DWT tonners

The assumed product shipping schedule is as follows:

Kind of Products	Vessel Size (DWT)	Percentage of Product Shipped
White Oils	10,000	30%
	5,000	60%
	2,000	10%
Black Oils	30,000	30%
	10,000	30%
	5,000	30%
	2,000	10%

The size distributions of product carriers assumed in this study are rather large compared with those presently used in Japan and are subject to further discussion.

The numbers of berths required to receive and distribute products are estimated by assuming the annual operable days and maximum service factor of respective berths as follows:

	Unloading Operation	Loading Operation
Annual operable days	180	300
Maximum service factor	60%	60%
Operating hours per day	24	12*)

*) 24 hours for vessels exceeding 10,000 DWT.

The estimated berth occupancy time for loading and unloading operations is shown in Table 10.9 and the resulting loading and unloading berth requirements are summarized in Table 10.10.

Table 10.9

Berth Occupancy Time for

Loading and Unloading Operations

	Berth Occupancy Time (hours)
Unloading Operations	
200,000 DWT	45
130,000 DWT	40
Loading Operations	
30,000 DWT	24
10,000 DWT	12
5,000 DWT	7
2,000 DWT	5

Table 10.10

Loading and Unloading Berths Requirements

(Case 1 Hydroskimming)

Corresponding Refinery Capacity BPSD	125,000	250,000	500,000
Loading Berths			
- White Oils Berths			
10,000 DWT	1	1	2
5,000 DWT	1	3	5
2,000 DWT	-	-	1
- Black Oils Berths			
30,000 DWT	1	1	1
10,000 DWT	-	-	1
5,000 DWT	1	2	2
2,000 DWT	-	-	1
Unloading Berths			
200,000 DWT	1	2	2
130,000 DWT	-	-	1

Pollution Prevention

a. Air pollution: Air pollution from CTS will not be significant due to its small fuel consumption as well as anticipated location far from the center of population; assumed to be prevented by using fuel oil with appropriate sulfur content to satisfy the environmental requirements.

b. Water pollution: The facilities enable to satisfy the following qualities requirement for disposed water are assumed to be provided:

pH	5.8 - 8.6
Oil Contnet	1 ppm max.
COD	15 ppm max.
SS	15 ppm max.

Tanker deballasting water is handled. Figure 10.2 illustrates the planned waste water treatment system for CTS.

Area Requirements

In estimating the area requirements for CTS, the laws and regulations presently being in effect in Japan, such as for tank spacing, diking, green and space requirements, are taking into account.
The resulting area requirements are shown in Table 10.11.

Required Personnel

The permanent staff requirements are estimated on the basis that maintenance force to cover peaks will be brought in from outside CTS and are shown in Table 10.12.

Other Aspects

a. A computer system for stock and shipping control is provided.

b. No attempt is made for further blending facility to make other grade of products.

c. Employee's housing is not considered.

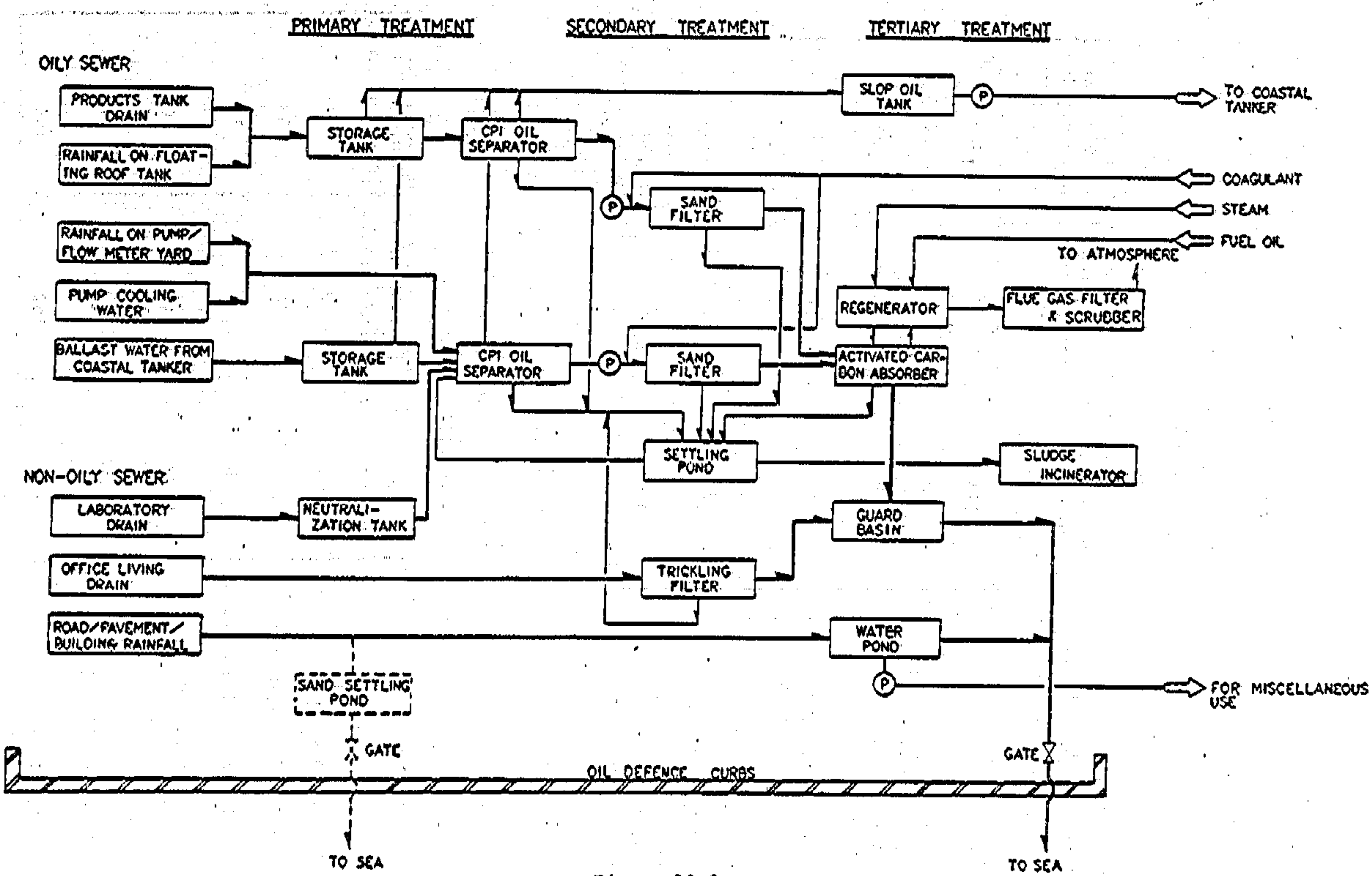


Figure 10.2

Block Flow Diagram of Waste Water Treatment for Products CTS in Japan

Table 10.11

Total Area Requirements

CTS in Japan

Corresponding Refinery	125,000 BPSD Hydroskimming	250,000 BPSD Hydroskimming	500,000 BPSD Hydroskimming
	$10^3 m^2$	$10^3 m^2$	$10^3 m^2$
Tankage	370	710	1,420
Pump Stations	20	20	30
Utilities & Waste Water Treatment	40	50	70
Control Center, Administration and Service	40	40	40
Roads, Pipeway & Sewer	140	240	470
Green & Open Area	200	360	670
Total Area	810	1,420	2,700

Table 10.12

Total Permanent Staff

CTS in Japan

	125,000 BPSD Hydroskimming	250,000 BPSD Hydroskimming	500,000 BPSD Hydroskimming
Terminal Manager & Secretary	2	2	2
General Service Department	45	50	55
Technical Service Department	18	18	18
Operating Department			
On-shore	34	37	40
Off-shore	30	30	44
Maintenance Department	25	25	25
Total	154	162	184

10.3 Capital and Operating Costs of CTS

The capital requirements and operating costs of CTS are estimated for the three different through-put capacities. The results are summarized in Table 10.13. The bases used in estimating the costs are described hereafter. All costs are escalated and expressed in US dollars.

The operating costs estimated here are the direct operating costs of CTS. They exclude capital related expenses such as depreciation, interest, and return on investment. These are discussed in paragraph 10.4, CTS Margin.

10.3.1 Capital Requirements

The capital requirement is divided into the following two categories and estimated:

a. Fixed Capital Investment; subject to depreciation or amortization:

- Construction costs of installed facilities
- Pre-operating expenses
- Interest during construction

b. Working Capital; not subject to depreciation nor amortization:

- Land
- Oil inventories
- Spare parts and warehouse supplies
- Cash on hand

The following are the bases used in estimating individual costs:

<u>Construction Costs of Installed Facilities</u>
(Lines 1 and 2 of Table 10.13)
These lines show the estimated construction costs for the installed facilities of the CTS.

The construction costs are developed mainly based on the facilities defined for CTS corresponding to Case-1 Hydroskimming at 250,000 BPSD crude capacity, by evaluating the cost of major materials reflecting current costs as of June, 1978 on a worldwide purchasing basis and comparing to similar prototypes in our file. Adjustments are made for differences in scope and capacity.

Table 10.13

Capital Requirements and Operating Costs Summary

CTS in Japan

Corresponding Refinery	125,000 BPSD Hydroskimming	250,000 BPSD Hydroskimming	500,000 BPSD Hydroskimming
Capital Requirements (10^6 US$)			
1. On-shore Facilities	162.2	273.7	501.1
2. Off-shore Facilities	96.0	125.9	195.0
3. Pre-operating Expenses	5.2	6.8	8.8
4. Interest during Construction	41.7	67.8	122.6
5. Working Capital	230.4	444.5	877.1
Total Capital Requirements	535.5	918.7	1,704.6
Operating Costs (10^3 US$/CD)			
6. Salary and Wages	10.3	10.8	12.3
7. Overhead	3.8	4.3	5.6
8. Maintenance	10.6	16.4	28.6
9. Insurance	2.1	3.6	6.7
10. Property Tax	8.5	13.7	24.5
11. Chemicals	0.3	0.5	1.1
12. Purchased Utilities	3.9	7.8	15.7
Total Operating Costs	39.5	57.1	94.5

Next, the costs are escalated based on an engineering and construction schedule of 36 months starting from July 1, 1980 and ending at June 30, 1983 and an estimated escalation rate of labor and materials. As the result, an overall escalation factor of 20 percent is predicted.

The detailed cost breakdown is presented in Table 10.14.

<u>Pre-operating Expenses</u>
(Line 3 of Table 10.13)

Pre-operating expenses include the miscellaneous costs other than for plants that will be incurred during the period from the start of project until the end of startup.

An allowance of ¥1.5 billions, or US$6.8 millions is considered for 250,000 BPSD case.

<u>Interest during Construction</u>
(Line 4 of Table 10.13)

This cost covers the interest on borrowed fund during engineering, construction and startup period. Based on a schedule of 36 months from the project award to mechanical completion and 3 months of startup, a typical 'S' shaped schedule of expenditure, and the following financing conditions, the interest to be paid is calculated using a computer simulation program as is detailed in Chapter 11, Economica Analysis.

. Source of Fund

- Fixed investment ex. interest during construction:
  Equity capital/Long term loan = 25%/75%
- Interest during construction: 100% long term loan
- Working capital: 100/ short term loan

. Interest Rates

- Long term loan:

70% of total fixed investment less interest during construction	6.05%/annum
The balanced portion	8.00%/annum

- Short term loan:

For land	7.03%/annum
For oil inventories	5.58%/annum
For others	8.00%/annum

Table 10.14

Construction Costs Summary

CTS in Japan

Corresponding Refinery	125,000 BPSD Hydroskimming	250,000 BPSD Hydroskimming	500,000 BPSD Hydroskimming
	10^6US$	10^6US$	10^6US$
1. On-shore Facilities			
Tankage	71.0	133.0	266.0
Interconnecting Pipelines	28.1	48.0	85.9
Loading Pumps	9.3	12.1	18.4
Instrumentation/ Communication	11.5	13.9	17.4
Waste Water Treatment	11.5	15.0	21.2
Utilities System	6.2	10.0	16.2
Fire Fighting System	6.3	11.0	19.3
Buildings and Equipment	1.9	1.9	1.9
Site Development	16.4	28.8	54.8
Subtotal On-shore Facilities	162.2	273.7	501.1
2. Off-shore Facilities			
Product Unloading Terminal	33.7	51.1	77.1
Product Receiving Pipelines	11.3	11.3	18.1
Product Loading Jetty	26.9	39.4	65.3
Tags, Fire-boats, etc.	24.1	24.1	34.5
Subtotal Off-shore Facilities	96.0	125.9	195.0
Total Construction Cost	258.2	399.6	696.1

Working Capital

(Line 5 of Table 10.13)

Working capital is the fund that must be provided for the CTS to get it started and meet subsequent obligations as they come due. This includes cash, receivables, and inventories less payables.

In this estimate, the balance of receivables and payables are not taken into account, since the credit terms are not available at this stage. The estimate is made for the following four items:

a. Land: Capital required to afford the land is charged.
   Assumed unit cost of land is ¥50,000/tsubo, or US$68.87/$m^2$.

b. Oil Inventories: A total of 90 days' oil inventories in the tanks and oil afloat for 20 days are takne into account, namely, for 110 days in total. Out of 110 days' inventories, 45 days' inventories are shared by crude oil.
   Oil Inventories are priced at the following:
   Crude Oil 14.00 US$/BBL
   Products 17.00 US$/BBL

c. Spare Parts and Warehouse Supplies: Spare parts and warehouse supplies are priced at 1 percent of the construction cost. This would be for two years supply.

d. Cash on Hand: Cash on hand is set at a level equal to two months cash expenditure except for product purchasing cost.

The resulting costs are shown in Table 10.15.

Table 10.15

Working Capital - CTS in Japan

Unit: 10^6US$

Corresponding Refinery	125,000 BPSD	250,000 BPSD	500,000 BPSD
Land	55.8	97.8	186.0
Oil Inventories	169.6	339.2	678.4
Spare Parts and Warehouse Supplies	2.6	4.0	7.0
Cash on Hand	2.4	3.5	5.7
Total Working Capital	230.4	444.5	877.1

10.3.2 Operating Costs

The operating costs discussed in this text are direct operating costs and made up of seven items. The bases used in estimating each of the costs are as follows:

Salary and Wages

(Line 6 of Table 10.13)

The payroll costs are estimated based on the permanent staff requirements developed in paragraph 10.2 and an assumed average salary of personnel. The assumed average salary in 1978 is ¥4.0 millions per year. The cost is converted to 1983 cost by escalating 6 percent per year, or 34 percent in total. The resulting average salary in 1983 is ¥5.36 millions per year, or 2,030 US$ per month.

Overhead

(Line 7 of Table 10.13)

Overhead cost is calculated as a percentage of annual payroll cost and construction costs as follows:

Overhead Cost = (30% of Payroll Cost) + (0.1% of Construction Cost)

Maintenance

(Line 8 of Table 10.13)

Maintenance cost is calculated as a percentage of construction cost. The percentage used is 1.5% per annum.

Insurance

(Line 9 of Table 10.13)

Insurance burden for facilities and oil inventories is charged. The cost is calculated based on the following:

- Insurance on facilities
  = (Av. Book Value of the Plant) x 0.3%/Annum
- Insurance on oil inventories
  = (Oil Inventories) x 0.17%/Annum

Property Tax

(Line 10 of Table 10.13)

The property tax is calculated based on the following:

- Property tax on facilities
  = (Av. Book Value of the Plant) x 1.4%/Annum
- Property tax on land
  = (Land Cost) x 1.6%/Annum

Chemicals

(Line 11 of Table 10.13)

This is the cost of chemicals resulted from CTS operation. The cost is escalated at 5 percent per annum, or 28 percent in total, to convert the 1978 cost to 1983.

Purchased Utilities

(Line 12 of Table 10.13)

This is the cost of utilities purchased from outside the CTS.
Unit costs used are:

Electric power	0.055 US$/KWH
Industrial water	0.090 US$/Ton
Fuel oil	10.7 US$/$10^6$Kcal

10.4 CTS Margin

An estimation of CTS margin is made based on the data developed in the foregoing paragraphs, by setting up economic parameters, and by means of a computer simulation. Definition of terms and procedures used in the estimation are detailed in Chapter 11, Economic Analysis. The bases used and the results of study are presented below.

10.4.1 Bases of Estimation

An economic calculation is made on a real time 1983 frozen basis. All costs are escalated to 1983 but no escalation is considered after 1983, when the CTS is assumed to be put into service. The required CTS margins to attain a certain level of return on equity capital on a discounted cash flow basis are calculated by means of a computer simulation.

The conditions set up as the bases of calculation are as follows:

(1) Base Case CTS

The CTSs corresponding to the hydroskimming refineries having 125,000 BPSD, 250,000 BPSD, and 500,000 BPSD crude capacities are taken as base.

(2) On-stream Factor at the Beginning Stage of Operation

Since the CTS handles products from the refinery, the on-stream factor of CTS is basically conforming to that of the refinery. However, the CTS must keep its oil inventories at a certain level to meet the requirements of Petroleum Stockpile Law in the expense of shipping volume, upon which the revenue of CTS is determined. Therefore, the CTS's on-stream factor at the beginning stage of operation has to be slightly lower than that of the refinery. On the basis that the inventory level increases gradually linked with the level of products to be handled, the calendar year based on-stream factor would become as follows:

	Operating Period of the Year	On-stream Factor (*)
1st year	3 months	0.53
2nd year	12 months	0.58
3rd year	12 months	0.95
After 4th year	12 months	1.00

(*) On-stream factor of 1.00 corresponds to that of 0.85 for the refinery.

(3) Operating Costs, Construction Costs, etc.

Based on the data developed in the foregoing paragraphs; Cost escalation until 1983 is taken into account, but no escalation is considered after the commencement of commercial operation.

(4) Financing Aspects

a. Equity/Debt Financing Ratio:

25 percent of total fixed capital investment less interest during construction is assumed to be provided from equity capital, while the rest from debt financing.

b. Terms of Accommodation for Long Term Loan:

In connection with the strengthening petroleum stockpile, the governmental financing with incentive interest rate is available for 70 percent of investment to the facilities.

. Interest rate:

- For 70% of total fixed investment less interest during construction	6.05%/Annum
- For the balanced portion	8.00%/Annum

. Repayment: Total surplus fund available after paying a certain level of dividend is to be charged.

c. Terms of Accommodation for Short Term Loan:

The governmental financing with incentive interest rate is also available, which is applicable to 50 percent of land investment and 90 percent of purchasing cost for oil to be stockpiled. The resulting weighted average interest rates are:

. Interest rate:

- For land	7.03%/Annum
- For oil inventories	5.58%/Annum
- For others	8.00%/Annum

. Repayment: Within one year and renewable

(5) Capital Expending Schedule

The equity capital is assumed to be invested at a constant percentage, i.e., 25 percent of the investment for the respective year. The assumed expending schedule of capitals to be invested is presented in Table 10.16.

(6) Project Life

Project life of 20 years is used.

(7) Depreciation

. Depreciation and amortization are based on the straight-line in 18 years with no salvage book value.

. Interest during construction is subject to depreciation.

Table 10.16

Basis of Capital Expending Schedule

	1980	1981	1982	1983	1984	1985
1. Fixed Capital Investment						
-Construction Cost	4.5%	52.5%	38.7%	4.3%	-	-
-Pre-operating Cost	10%	20%	20%	50%	-	-
2. Working Capital						
-Cash on Hand	*1)	-	-	*2)	-	-
-Land	100%	-	-	-	-	-
-Oil Inventories	-	-	-	16.6%	60.7%	22.7%
-Spare Parts and Warehouse Supplies	-	-	-	100%	-	-

Notes:

*1) 1.0 US$ millions for all cases

*2) Total required cash on hand less 1.0 US$ millions

(8) Income Tax

- Income Tax Rage: 55 percent
- Tax Holiday: None
- Deficit Carry-over: 5 years
- Other Incentives: None
- Interest on borrowed fund is subject to tax credit.

(9) Dividend

- Ordinary (Common): 10 percent max.
- Preferred: None

(10) Required ROE (DCF)

A required return on equity capital of 11.8 percent is used as a criterion to calculate required gross margin of the CTS likely to that for the refinery in Iran.
The level of 11.8 percent ROE itself will be subject to further discussion on appropriate occasion.

(11) Others

a. Interest on short-term loan during construction and startup period is assumed to be covered by long-term loan.

b. All incomes and expenditures are assumed to be occurred at the middle of fiscal year, namely, based on a mid-year account.

In order to facilitate ease of understanding on the base case conditions, the gist of these is presented in Table 10.17.

The results of CTS margin calculations are summarized in Table 10.18. CTS margins giving different ROEs are also calculated and presented in Table 10.19. The CTS margins for hydrocracking cases will be the same as those for hydroskimming cases.

Table 10.17

Basis of CTS Margin Calculations

Item	Base Case Conditions
. Interest rate	
- Long-term loan	70% of total fixed investment less interest during construction 6.05%/Annum
	The balanced portion 8.00%/Annum
- Short-term loan	For land 7.03%/Annum (average)
	For oil inventories 5.58%/Annum (average)
	For others 8.00%/Annum
. Depreciation	Straight line in 18 years; no salvage value
. On-Stream factor	1st year: 0.53; 2nd year: 0.58; 3rd year: 0.95; After 4th year: 1.00
. Project life	20 years
. Income tax rate	55%
. Tax holiday	None
. Equity capital invested	25% of total fixed investment less interest during construction
. Dividend	10% max. for ordinary dividend; no preferred dividend
. Required ROE (DCF)	11.8%

Table 10.18

Required CTS Margins

Corresponding Refinery	125,000 BPSD Hydroskimming	250,000 BPSD Hydroskimming	500,000 BPSD Hydroskimming
Weighted Average Interest Rate (%/Annum)			
Long-term Loan	6.57	6.58	6.59
Short-term Loan	6.16	6.12	6.11
DCF (%)			
Pre-tax ROI	12.93	12.90	12.89
Post-tax ROI	9.04	9.03	9.03
ROE	11.80	11.80	11.80
Payout Year (Years)	14.6	14.7	14.7
Gross Margin (US$/BBL)	2.28	1.82	1.61

Table 10.19

ROE (DCF) versus CTS Margins

Corresponding Refinery	DCF (%)			Gross Margin (US$/BBL)
	Pre-tax ROI	Post-tax ROI	ROE	
125,000 BPSD Hydroskimming	23.37	15.00	22.41	3.68
	14.68	10.00	13.71	2.48
	12.93	9.04	11.80	2.28
	12.13	8.62	11.00	2.19
	11.26	8.15	10.00	2.10
	10.42	7.71	9.00	2.01
250,000 BPSD Hydroskimming	23.35	15.00	22.45	2.91
	14.66	10.00	13.72	1.97
	12.90	9.03	11.80	1.82
	12.12	8.62	11.00	1.75
	11.25	8.15	10.00	1.68
	10.41	7.71	9.00	1.61
500,000 BPSD Hydroskimming	23.35	15.00	22.49	2.56
	14.65	10.00	13.73	1.75
	12.89	9.03	11.80	1.61
	12.09	8.61	11.00	1.55
	11.24	8.15	10.00	1.49
	10.40	7.71	9.00	1.44

CHAPTER II

ECONOMIC ANALYSIS

CHAPTER 11

ECONOMIC ANALYSIS

An economic analysis is made based on the data developed in the foregoing chapters, by setting up economic parameters, and by means of a computer simulation.
The results of analysis will serve as a guide information for further discussions and analysis to be made on appropriate occasions, where evaluations will be made including the factors not covered in this report.
Since no sales forecast for the subject refinery is available, the analysis with respect to what type of expansion will be most advantageous for this project is not conducted. Therefore, the economic analysis conducted in this text is of cost study nature.

Most of discussions made in this chapter are for a venture company having the following activities:

- Investment to construct refinery
- Purchasing crude oil
- Refining
- Sales of products on an FOB basis

It is assumed that the product transportation from Iran to Japan and the operation of CTS to be located in Japan will be managed by the separate venture companies.

A comparison including such activities, namely, an ex-CTS wharf based comparison, is made in the last paragraph of this chapter.

A required gross margin giving a certain level of profit is used as a criterion to evaluate alternatives.
In order to facilitate ease of understanding, the analysis is made by setting up 'base case' conditions and sensitivity analysis is conducted radially being centered by the base case. The base case conditions set up in this text do not represent, needless to say, neither the most likely conditions.

The sensitivity analysis is conducted to check the effects of changes in the following factors on the required gross margin:

- Required rate of return on equity
- Project life
- Crude oil cost
- Income tax: tax holiday
- Scope of refinery's investment: industrial infrastructure
- Construction cost

The bases and procedures used for the analysis and the results of study are presented in the subsequent paragraphs.

Reference is made in Appendix 1 for the effect of operating factor on product cost. A short-cut study is conducted to estimate product price levels on an Ex-CTS basis, on the conditions that annual cash flows available to the project is to be kept on such a level to attain ROE (DCF) of 11.8 percent regardless its through-put level.

11.1 Bases and Procedures

An economic analysis is conducted on a real time 1983 frozen basis. All costs except for crude cost, are escalated to 1983 but no escalation is considered after 1983, when the refinery is assumed to start its commercial operation. Effects of changes in crude cost are covered by sensitivity analysis.
The required gross margins to attain a certain level of return on equity capital on a discounted cash flow basis are calculated by means of a computer simulation.

11.1.1 Definition of Terms

The computer simulator provides the following five major economic parameters:

- Rate of return on investment before tax on a discounted cash flow basis: Pre-tax ROI (DCF)
- Rate of return on investment after tax on a discounted cash flow basis: Post-tax ROI (DCF)
- Rate of return on equity capital on a discounted cash flow basis: ROE (DCF)
- Gross margin
- Payout year

The following outlines the definition of each term:

Pre-tax ROI (DCF)

$$\sum_{i=o}^{n} \frac{Ii}{(1+r)^i} = \sum_{i=o}^{n} \frac{Pi}{(1+r)^i}$$

where,

r : Pre-tax ROI (DCF)

Ii: Investment in the i-th year 1)

Pi: Profit in the i-th year before deducting income tax, depreciation, and interest on borrowed fund. 2)

n : Project life plus construction and startup period expressed in years.

Note 1) The investment cost defined here is the total capital requirement less working capital and interest during construction.

Note 2) Interest on short-term loan to be provided to cover working capital is treated as one of the operating costs, namely, this interest is deducted in calculating the pre-tax and post-tax ROIs.

Post-tax ROI (DCF)

The post-tax ROI (DCF) is obtained using the same formula as defined above by substituting Pi values with those defined below.

Pi: Post-tax profit in the i-th year plus depreciation and interest on Long-term loan.

ROE (DCF)

$$\sum_{i=o}^{n} \frac{Ei}{(1+r)^i} = \sum_{i=o}^{n} \frac{Ai}{(1+r)^i}$$

where,

r : ROE (DCF)

Ei: Equity capital investment in the i-th year

Ai: Post-tax profit plus depreciation less principal repayment of long-term loan in the i-th year.

n : Project life plus construction and startup period expressed in years.

Gross Margin

The difference between average product selling price and average crude oil cost which is expressed in US$ per barrel.

Payout Year

The number of years required to payoff the borrowed fund on the basis that a certain percentage of total surplus fund available is charged for repayment. The numbers of year are accounted starting from the date of commencement of engineering and construction.

The payout year of borrowed fund is generally defined as follows:

$$Y_p = \frac{\text{(Total Borrowed Fund)}}{\text{(Post-tax Produt)} + \text{(Depreciation)} - \text{(Working Capital Increments)}}$$

In this study, however, the payout year is represented by the required financing term in which a company can repay the total of borrowed fund reasonably from its yearly cash flows available, while keeping a certain level of working capital and dividend.

In addition to the above terms, several terms necessary for the study are defined as follows:

(1) Construction and Startup Period

The period starting from the month when the investment is commenced until the end of startup. After that the commercial operation of the first train is commenced.

(2) Project Life

The period of commercial operation which is subject to economic evaluation.

(3) Infrastructure

The industrial infrastructures discussed in Chapter 7, which include crude oil pipelines, approach channel, harbor, causeway, and site preparation.

11.1.2 Study Bases

Base case conditions are set up as follows:

(1) Base Case Refineries

The hydroskimming and hydrocracking refineries each having 125,000 BPSD, 250,000 BPSD, and 500,000 BPSD crude capacities as defined in Chapter 5 are taken as base case refineries.

(2) On-stream Factor at the Beginning Stage of Operation

An appropriate overall on-stream factor of the refinery is considered to be 85 percent of design capacity, and the on-stream factor for the first 12 months is assumed to be 70 percent taking the 85 percent above as base. After the first 12 months is elapsed, the refinery is assumed to be operated at full load. Since the refinery is assumed to be on-stream by October, 1983, the calendar year based on-stream factor becomes as follows:

	Operating Period of the year	On-stream Factor
1st year	3 months	0.60
2nd year	12 months	0.66
After 3rd year	12 months	0.85

(3) Crude Oil Cost

Official sales price as of the end of June, 1978 is used and no escalation allowance is added.

Iranian Light	12.81 US$/bbl
Iranian Heavy	12.49 US$/bbl
Average	12.65 US$/bbl

(4) Operating Costs, Construction Costs, etc.

Based on the data developed in Chapter 9.
Cost escalation until 1983 is taken into account, but no escalation is considered after the commencement of commercial operation.

(5) Product Price

No product price is set up as pre-conditions, but is obtained as a result of computer simulation on the condition that a certain level of ROE (DCF) is to be secured.

(6) Financing Aspects

a. Equity/Debt Financing Ratio:

25 percent of total fixed capital investment less interest during construction is assumed to be provided from equity capital, while the rest from debt financing.

b. Terms of Accommodation for Long Term Loan:

- Source: Basically single source; a weighted average interest rate will be used due to limitation of the computer simulater utilized, in the case that plural sources are anticipated.
- Interest Rate: - Upto US$1,000 millions 5.25%/Annum
  - Over US$1,000 millions 8.00%/Annum
- Repayment: Total surplus fund available after paying a certain level of dividend is to be charged.

c. Terms of Accommodation for Short Term Loan:

- Application: Working capital and deficit covering fund are to be provided from short-term loan.
- Interest Rate: 8 percent per annum
- Repayment : Within one year and renewable

(7) Capital Expending Schedule

The equity capital is assumed to be invested as a constant percentage, i.e., 25 percent of the investment for the respective year. The assumed expending schedule of capitals to be invested is presented in Tables 11.1 and 11.2.

(8) Project Life

Project life of 20 years is used, while the sensitivity analysis covers the case of 15 years.

(9) Depreciation

- Depreciation and amortization are based on the straight-line in 10 years with no salvage book value.
- Interest during construction is subject to depreciation.

Table 11.1

Basis of Capital Expending Schedule
(125,000/250,000 BPSD)

	1979	1980	1981	1982	1983
1. Fixed Capital Investment					
- Construction Cost	3.5%	31.0%	47.5%	17.0%	1.0%
- Initial Catalyst and Chemicals	-	-	-	100%	-
- Paid-up Royalties	50%	-	-	-	50%
- Pre-operating Expenses	10%	10%	15%	20%	45%
2. Working Capital					
- Cash on Hand	*1)	-	-	-	*2)
- Land	100%	-	-	-	-
- Inventories	-	-	-	-	100%

*1) 2.0 US$ millions for all cases.

*2) Total required cash on hand less 2.0 US$ millions

Table 11.2

Basis of Capital Expending Schedule
(500,000 BPSD)

	1979	1980	1981	1982	1983	1984
1. Fixed Capital Investment						
- Construction Cost	3.0%	24.5%	39.5%	26.0%	7.0%	-
- Initial Catalyst and Chemicals	-	-	-	50%	50%	-
- Paid-up Royalties	50%	-	-	-	25%	25%
- Pre-operating Expenses	6%	8%	12%	17%	20%	15%
2. Working Capital						
- Cash on Hand	*1)	-	-	-	*2)	*3)
- Land	100%	-	-	-	-	-
- Inventories	-	-	-	-	*2)	*3)

Note: *1) 2.0 US$ millions for all cases.

*2) Cash on hand and inventories equal to those for 250,000 BPSD case are to be invested.

*3) The balanced portion to reach the requirements for 500,000 BPSD is to be invested.

(10) Income Tax

- Income Tax Rate : 55 percent
- Tax Holiday : None
- Deficit Carry-over: 5 years
- Other Incentives : None
- Interest on borrowed fund is subject to tax credit.

(11) Dividend

- Ordinary (Common): 10 percent max.
- Preferred : None

(12) Required ROE (DCF)

A required return on equity capital of 11.8 percent is used as a criterion to calculate required gross margin of the refinery. The ROE of 11.8 percent comes from that gross margins giving a post-tax ROI of 10 percent produce ROE of around 11.8 percent, on the basis that all debt financing is provided from a fund with 8 percent interest rate.

ROE is used in lieu of post-tax ROI in order to reflect an incentive interest rate applicable to the project on the required gross margin. The level of 11.8 percent ROE itself will be subject to further discussion on appropriate occasions.

(13) Others

a. Interest on short-term loan during construction and startup period is assumed to be covered by long-term loan.

b. All incomes and expenditures are assumed to be occurred at the middle of fiscal year, namely, based on a mid-year account.

11.2 Case Definition and Results of Study

A total of six base cases is studied on the base case conditions as described in paragraph 11.1.2. In order to facilitate ease of understanding, case definition indicating major conditions is presented in Table 11.3. The results are summarized in Table 11.4.

Gross margins giving different ROEs are also calculated and presented in Tables 11.5 and 11.6. Tables 11.7 through 11.12 present the capital expending schedule for each of the six base cases, upon which cash flow calculations are made.

Table 11.3

Case Difinition: Case 1-125 Base Case Refineries

Refinery Configuration	Hydroskimming			Hydrocracking		
Case No.	Case 1-125	Case 1-250	Case 1-500	Case 2-125	Case 2-250	Case 2-500
. Refining capacity, BPSD	125,000	250,000	500,000	125,000	250,000	500,000
. Weighted average interest rate						
- Long-term loan, %/annum	5.25	5.37	6.39	5.25	5.57	6.53
- Short-term loan, %/annum	8.00	8.00	8.00	8.00	8.00	8.00
. Crude oil cost	12.65 US$ per barrel					
. Project life	20 years					
. Income tax rate	55 percent					
. Tax holiday	None					
. Depreciation	Straight-line in 10 years; no salvage value					
. On-stream factor	85 percent but 60 percent for the first 12 months					
. Equity capital invested	25 percent of total fixed investment less interest during construction					
. Dividend	10 percent max. for ordinary dividend; no preferred dividend					
. Scope of refinery's investment	Investment for industrial infrastructures excluded					
. Required ROE (DCF)	11.8 percent					

Table 11.4

Results of Economic Analysis: Base Case

Configuration and Refining Capacity	Weighted Average Interest Rate(%/Annum)		DCF (%)			Gross Margin	Payout year
	Long-term Loan	Short-term Loan	Pre-Tax ROI	Post-Tax ROI	ROE	(US$/BBL)	(Years)
<u>Case 1 Hydroskimming</u>							
125,000 BPSD	5.25	8.00	11.79	8.57	11.80	6.83	11.9
250,000 BPSD	5.37	8.00	11.84	8.63	11.80	5.03	11.9
500,000 BPSD	6.39	8.00	12.31	9.15	11.80	4.42	11.9
<u>Case 2 Hydrocracking</u>							
125,000 BPSD	5.25	8.00	11.79	8.57	11.80	7.15	11.9
250,000 BPSD	5.57	8.00	11.91	8.73	11.80	5.28	11.9
500,000 BPSD	6.53	8.00	12.26	9.22	11.80	4.65	11.9

Table 11.5

ROE versus Gross Margin
(Case 1 Hydroskimming)

Refining Capacity (BPSD)	DCF (%) Pre-tax ROI	Post-tax ROI	ROE	Gross Margin (US$/BBL)	Payout Year (Years)
125,000	22.18	15.00	23.09	11.33	9.1
	14.08	10.00	14.54	7.67	11.4
	11.79	8.57	11.80	6.83	11.9
	11.15	8.16	11.00	6.61	11.9
	10.40	7.65	10.00	6.37	11.9
	9.73	7.13	9.00	6.16	12.1
250,000	22.15	15.00	23.02	8.11	9.1
	14.04	10.00	14.45	5.58	11.5
	11.84	8.63	11.80	5.03	11.9
	11.19	8.22	11.00	4.87	11.9
	10.45	7.70	10.00	4.71	11.9
	9.77	7.18	9.00	4.56	12.1
500,000	21.56	15.00	22.01	6.74	9.4
	13.54	10.00	13.40	4.69	11.6
	12.21	9.16	11.80	4.42	11.9
	11.73	8.75	11.00	4.32	11.9
	11.01	8.23	10.00	4.18	12.1
	10.46	7.73	9.00	4.07	12.5

Table 11.6

ROE versus Gross Margin

(Case 2 Hydrocracking)

Refining Capacity (BPSD)	DCP (%)			Gross Margin (US$/BBL)	Payout Year (Years)
	Pre-tax ROI	Post-tax ROI	ROE		
125,000	22.18	15.00	23.08	11.94	9.1
	14.09	10.00	14.55	8.04	11.4
	11.79	8.57	11.80	7.15	11.9
	11.14	8.16	11.00	6.92	11.9
	10.39	7.65	10.00	6.66	11.9
	9.72	7.12	9.00	6.43	12.1
250,000	22.09	15.00	22.90	8.57	9.2
	13.96	10.00	14.28	5.84	11.5
	11.91	8.73	11.80	5.28	11.9
	11.27	8.32	11.00	5.12	11.9
	10.54	7.80	10.00	4.94	11.9
	9.88	7.29	9.00	4.79	12.2
500,000	21.51	15.00	21.92	7.16	9.5
	13.49	10.00	13.27	4.93	11.7
	12.26	9.22	11.80	4.65	11.9
	11.78	8.82	11.00	4.55	11.9
	11.07	8.30	10.00	4.40	12.1
	10.53	7.80	9.00	4.29	12.6

Table 11.7

Capital Expending Schedule
(Case 1 Hydroskimming 125,000 BPSD)

	Total	1979	1980	1981	1982	1983
1. <u>Fixed Capital Investment</u> (10^6US$)						
- Construction Cost	827.7	29.0	255.6	393.1	140.7	8.3
- Initial Catalyst and Chemicals	6.2	-	-	-	6.2	-
- Paid-up Royalties	1.8	0.9	-	-	-	0.9
- Pre-operating Expenses	38.9	3.9	3.9	5.8	7.8	17.5
Subtotal Fixed Capital Investment	874.6	33.8	259.5	398.9	154.7	26.7
2. <u>Working Capital</u> (10^6US$)						
- Cash on Hand	9.1	2.0	-	-	-	7.1
- Land	5.0	5.0	-	-	-	-
- Inventories	87.7	-	-	-	-	87.7
Subtotal Working Capital	101.8	7.0	-	-	-	94.8
Total Capital Requirements (10^6US$)	976.4	40.8	260.5	398.9	154.7	121.5
Equity Capital to be Invested (10^6US$)	218.7	8.5	65.1	93.7	38.7	6.7

Table 11.8

Capital Expending Schedule
(Cse 2 Hydroskimming 250,000 BPSD)

	Total	1979	1980	1981	1982	1983
1. <u>Fixed Capital Investment</u> (10^6US$)						
- Construction Cost	1,153.7	39.4	357.7	548.0	195.1	11.5
- Initial Catalyst and Chemicals	12.3	-	-	-	12.3	-
- Paid-up Royalties	3.6	1.8	-	-	-	1.8
- Pre-operating Expenses	39.1	3.9	3.9	5.8	8.9	17.6
Subtotal Fixed Capital Investment	1,208.7	45.1	361.6	553.8	216.3	30.9
2. <u>Working Capital</u> (10^6US$)						
- Cash on Hand	12.6	2.0	-	-	-	10.6
- Land	5.0	5.0	-	-	-	-
- Inventories	135.2	-	-	-	-	135.2
Subtotal Working Capital	152.8	7.0	-	-	-	145.8
Total Capital Requirements (10^6US$)	1,361.5	53.1	361.6	553.8	216.3	176.7
Equity Capital to be Invested (10^6US$)	302.2	11.5	93.4	138.5	54.0	7.8

Table 11.9

Capital Expending Schedule
(Case 1 Hydroskimming 500,000 BPSD)

	Total	1979	1980	1981	1982	1983	1984
1. Fixed Capital Investment (10^6US$)							
- Construction Cost	1,889.4	56.7	462.9	746.3	491.2	132.3	-
- Initial Catalyst and Chemicals	24.6	-	-	-	12.3	12.3	-
- Paid-up Royalties	7.1	3.6	-	-	-	1.8	1.7
- Pre-operating Expenses	47.7	3.9	3.9	5.8	8.2	18.7	7.2
Subtotal Fixed Capital Investment	1,968.8	64.1	466.8	752.1	511.7	165.1	9.0
2. Working Capital (10^6US$)							
- Cash on Hand	21.6	2.0	-	-	-	10.6	9.0
- Land	5.0	5.0	-	-	-	-	-
- Inventories	219.2	-	-	-	-	135.2	84.0
Subtotal Working Capital	245.8	7.0	-	-	-	145.8	93.0
Total Capital Requirements (10^6US$)	2,214.6	71.3	466.8	752.1	511.7	310.9	102.0
Equity Capital to be Invested (10^6US$)	492.2	16.1	116.7	188.0	127.9	41.3	2.2

Table 11.10

Capital Expending Schedule
(Case 2 hydrocracking 125,000 BPSD)

	Total	1979	1980	1981	1982	1983
1. Fixed Capital Investment (10^6US$)						
- Construction Cost	884.8	31.0	274.3	420.3	150.4	8.8
- Initial Catalyst and Chemicals	7.5	-	-	-	7.5	-
- Paid-up Royalties	2.9	1.5	-	-	-	1.4
- Pre-operating Expenses	40.1	4.0	4.0	6.0	8.0	18.1
Subtotal Fixed Capital Investment	935.3	36.4	278.3	426.3	165.9	28.4
2. Working Capital (10^6US$)						
- Cash on Hand	9.5	2.0	-	-	-	7.5
- Land	5.0	5.0	-	-	-	-
- Inventories	91.0	-	-	-	-	91.0
Subtotal Working Capital	105.5	7.0	-	-	-	98.5
Total Capital Requirements (10^6US$)	1,040.8	43.4	278.3	426.3	165.9	126.9
Equity Capital to be Invested (10^6US$)	233.8	9.1	69.6	106.5	41.5	7.1

Table 11.11

Capital Expending Schedule
(Case 2 Hydrocracking 250,000 BPSD)

	Total	1979	1980	1981	1982	1983
1. Fixed Capital Investment (10^6 US$)						
- Construction Cost	1,244.6	43.6	385.8	591.2	211.6	12.4
- Initial Catalyst and Chemicals	15.0	-	-	-	15.0	-
- Paid-up Royalties	5.8	2.9	-	-	-	2.9
- Pre-operating Expenses	40.3	4.0	4.0	6.0	8.1	18.2
Subtotal Fixed Capital Investment	1,305.7	50.5	389.8	597.2	234.7	33.5
2. Working Capital (10^6 US$)						
- Cash on Hand	13.1	2.0	-	-	-	11.1
- Land	5.0	5.0	-	-	-	-
- Inventories	139.8	-	-	-	-	139.8
Subtotal Working Capital	157.9	7.0	-	-	-	150.9
Total Capital Requirements (10^6 US$)	1,463.6	57.5	389.8	597.2	234.7	184.4
Equity Capital to be Invested (10^6 US$)	326.4	12.6	97.4	149.3	58.7	8.4

Table 11.12

Capital Expending Schedule
(Case 2 Hydrocracking 500,000 BPSD)

	Total	1979	1980	1981	1982	1983	1984
1. Fixed Capital Investment (10^6 US$)							
- Construction Cost	2,058.5	61.8	504.3	813.1	535.2	144.1	-
- Initial Catalyst and Chemicals	30.0	-	-	-	15.0	15.0	-
- Paid-up Royalties	11.6	5.8	-	-	-	2.9	2.9
- Pre-operating Expenses	49.6	4.0	4.0	6.0	8.6	19.6	7.4
Subtotal Fixed Capital Investment	2,149.7	71.6	508.3	819.1	558.8	181.6	10.3
2. Working Capital (10^6 US$)							
- Cash on Hand	22.6	2.0	-	-	-	11.1	9.5
- Land	5.0	5.0	-	-	-	-	-
- Inventories	223.8	-	-	-	-	139.8	84.0
Subtotal Working Capital	251.4	7.0	-	-	-	150.9	93.5
Total Capital Requirements (10^6 US$)	2,401.1	78.6	508.3	819.1	558.8	332.5	103.8
Equity Capital to be Invested (10^6 US$)	537.4	17.9	127.1	204.8	139.6	45.4	2.6

11.3 Sensitivity Analysis

In order to check the effects of changes in the major factors which are taken as bases to calculate required gross margins, sensitivity analyses are conducted for the following:

Change Item	from	to
a. Project Life	20 years	15 years
b. Crude oil cost	12.65 $/bbl	±5.0 $/bbl
c. Tax holiday	None	10 years
d. Investment for industrial infrastructures	Not included	Included
e. Construction cost	Base	±10 percent

The effects of changes in required ROE have already been discussed concurrently with base cases.

The results of study are shown in Tables 11.13 and 11.14.

Table 11.13

Sensitivity Analysis
Change in Required Gross Margin
(Case 1 Hydroskimming)

Refining Capacity, BPSD	125,000	250,000	500,000
Required Gross Margin (US$/BBL) of Base Cases	6.83	5.03	4.42
Change in Required Gross Margin (US$/BBL)			
1. Project Life : 15 years	+0.43	+0.29	+0.28
2. Crude Cost : ±5 US$/BBL	±0.42	±0.41	±0.40
3. Tax Holiday : 10 years	-0.33	-0.24	-0.15
4. Scope : Including Infrastructure	+0.97	+0.59	+0.36
5. Plant Cost : ±10%	±0.46	±0.34	±0.27

Table 11.14

Sensitivity Analysis
Change in Required Gross Margin
(Case 2 Hydrocracking)

Refining Capacity, BPSD	125,000	250,000	500,000
Required Gross Margin (US$/BBL) of Base Cases	7.15	5.28	4.65
Change in Required Gross Margin (US$/BBL)			
1. Project Life : 15 years	±0.46	±0.33	±0.30
2. Crude Cost : ±5 US$/BBL	±0.41	±0.39	±0.39
3. Tax Holiday : 10 years	-0.36	-0.24	-0.16
4. Scope : Including Infrastructure	+0.97	+0.59	+0.37
5. Plant Cost : ±10%	±0.49	±0.36	±0.29

11.4 Ex-CTS Wharf Based Comparison

In order to evaluate alternatives which differ in their product mix, an ex-CTS based comparison is made taking into account the ocean freight for products, import tariffs, CTS margin, etc., and a product value evaluated by assumed ex-refinery product prices in Japan's market, 1983.

A discussion of ex-refinery product prices in Japan's market, 1983, is made in Appendix 2 of Chapter 11. In that text, it is assumed that the price differences among various grade of products in 1983 would be the same as those in 1978. The assumed ex-refinery product prices in Japan, 1983, which are used in this study, are presented in Table 11.15.

Table 11.15

Basis of Estimation:

Product Prices, Ocean Freights & Import Tariffs

Product	Product Prices in Japan, 1983 US$/BBL	Ocean Freights US$/BBL	Import Tariffs US$/BBL
Gasoline: regular	25.90	1.69	1.54
Naphtha	16.90	1.64	0.78
Kerosene	16.70	1.81	0.73
Gas Oil	17.82	1.93	1.37
L/S Fuel Oil (0.1%S)	16.83	1.61	0.54
M/S Fuel Oil (2.5%S)	13.96	1.65	0.54

The following describes briefly the bases and assumptions used in the study. The results of study are summarized in Tables 11.16 and 11.17.

Ex-CTS Required Average Product Price

The ex-CTS required average product price is given as a summation of the following six items:

- Crude oil FOB price
- Refinery margin
- Bunker fuel oil adjustment

- Ocean freight for refined products
- Import tariffs
- CTS margin

The price thus obtained is compared with the average product value evaluated by the assumed ex-refinery product prices in Japan, 1983, and the gap between two figures is used as a criterion to judge attractiveness of various alternatives.

Since this study does not cover the secondary transportation of refined products from CTS to the centers of consumption, which will be indispensable in the case that a CTS is located far from the centers of consumption, the absolute gap between two figures itself would not be useful, but the relative gaps will be useful enough.

<u>Crude Oil FOB Price</u>

Crude oil FOB price is based on the official sales price of Iranian light and heavy crude oils as of June 30, 1978. The average price is 12.65 US dollars per barrel.

<u>Refinery Margin</u>

The required refinery margin to give ROE (DCF) of 11.8 percent is used.

The margin is further broken down into the following four items for the purpose of presenting by what extent the individual element affects on the total gross margin:

- Operating costs: Direct operating costs per barrel of product on a mature year basis.
- Refinery fuel and losses: Loss of product resulted from refining operations; priced at crude oil cost and calculated by the following= formula:

$$Lp = Cp \times Yp/(1 - Yp)$$

where,

Lp : Refinery fuel and losses ($/bbl of product)
Co : Crude oil cost ($/bbl)
Yp : Yield of total salable products (-)

- Cost of working capital: Interest on short-term loan covering working capital; expressed in US dollars per barrel of product.
- Capital recovery: Cost per barrel of product to recover the total fixed investment within the designated project life insuring ROE (DCF) of 11.8 percent; defined to be the refinery margin less operating costs, loss, and cost of working capital.

Bunker Fuel Oil Adjustment

Since bunker fuel oil is sold to product tankers directly in Iran and not transported to Japan as product, an adjustment is made to reach the required average price of products ex bunker fuel oil. The adjustment is made using bunker fuel oil price of 10.3 US$/barrel and the following formula:

$$Ab = \frac{(Yp \cdot Pf - 0.03 \times 10.3)}{(Yp - 0.03)} - Pf$$

Where,

Ab : Bunker fuel oil adjustment ($/bbl of product)
Yp : Yield of total salable products (-)
Pf : Ex-refinery required average product price; FOB Iran cost ($/bbl)

The bunker fuel oil price of 10.3 US$/barrel is taken from the first-half 1978 spot price of 3.5 percent sulfur fuel oil in the gulf market.

Ocean Freight for Refined Products

Average ocean freight for refined products as discussed in Chapter 10 as well as Volume 2 of Supplement is used. The freight is based on tankers newly built in 1983 and transport distance of Kharg/Yokohama. The sizes of tankers are 130,000 DWT and 200,000 DWT for white oils and black oils respectively. The ocean freight for each product used in the study is presented in Table 11.15.

The freight cost adjustments will be required in the case that the CTS is located other than Yokohama area, for example:

CTS Location	Changes in Freight Cost
Hokkaido	+ 5.8 percent
Kagoshima (Kyūshū)	- 6.3 percent

The freight cost difference caused by alternating the loading port from Kharg island to Bushehr will be tolerable.

Import Tariffs

Import tariff is calculated based on the Japan's import tariff rates being in effect as of June 30, 1978.
The import tariff rate of naphtha for fuel use is applied for naphtha.
The primary assignment based import tariff rate is used for fuel oil 'C'.
The import tariff rates used in the study is shown in Table 11.15.

CTS Margin

The required CTS margin to give ROE (DCF) of 11.8 percent is used.
The CTS margin is discussed in detail in Chapter 10.

The margin is further broken down into the following three items and presented. The definition of each item is same as for the refinery margin discussed above:

- Operating costs
- Cost of working capital
- Capital recovery

Table 11. 16

Economic Evaluations Summary: Case 1 Hydroskimming

	Case No.	Case 1-125		Case 1-250		Case 1-500	
	Refining Capacity	125,000 BPSD		250,000 BPSD		500,000 BPSD	
Capital Requirements (10^6US$)	1. Refinery Fixed Investment	971.8		1,346.0		2,200.0	
	Working Capital	101.8		152.8		245.8	
	Subtotal Refinery	1,073.6		1,498.8		2,445.8	
	2. CTS Fixed Investment	305.1		474.2		827.5	
	Working Capital	230.4		444.5		877.1	
	Subtotal CTS	535.5		918.7		1,704.5	
	Grand Total	1,609.1		2,417.5		4,150.4	
Required Average Product Price Constitutions (US$/BBL)	Cost Items	Cost by Item	Accumulation	Cost by Item	Accumulation	Cost by Item	Accumulation
	1. Crude Oil Cost (FOB)	12.65	12.65	12.65	12.65	12.65	12.65
	2. Refinery Margin						
	- Operating Costs	1.53		1.06		0.90	
	- Refinery Fuel and Losses	0.91		0.91		0.91	
	- Cost of Working Capital	0.23		0.17		0.14	
	- Capital Recovery	4.16		2.89		2.47	
	Subtotal Refinery Margin	6.83	19.48	5.03	17.68	4.42	17.07
	3. Bunker Fuel Oil Adjustment	0.30	19.78	0.25	17.93	0.22	17.29
	4. Ocean Freight (Refined Products)	1.73	21.51	1.73	19.66	1.73	19.02
	5. Refined Product Import Tariff	0.90	22.41	0.90	20.56	0.90	19.92
	6. CTS Margin						
	- Operating Costs	0.40		0.29		0.24	
	- Cost of Working Capital	0.39		0.38		0.37	
	- Capital Recovery	1.49		1.15		1.00	
	Subtotal CTS Margin	2.28	24.69	1.82	22.38	1.61	21.53
	7. Ex-CTS Required Av. Product Price	24.69		22.38		21.53	
	8. Av. Product Value in 1983, Japan	17.83		17.83		17.83	

Table 11. 17

Economic Evaluations Summary: Case 2 Hydrocracking

	Case No.	Case 2-125		Case 2-250		Case 2-500	
	Refining Capacity	125,000 BPSD		250,000 BPSD		500,000 BPSD	
Capital Requirements (10^6US$)	1. Refinery Fixed Investment	1,038.9		1,458.8		2,406.6	
	Working Capital	105.5		157.9		251.4	
	Subtotal Refinery	1,144.4		1,616.7		2,658.0	
	2. CTS Fixed Investment	305.6		474.9		828.7	
	Working Capital	231.0		445.6		879.2	
	Subtotal CTS	536.6		920.5		1,707.9	
	Grand Total	1,679.9		2,535.4		4,362.6	
Required Average Product Price Constitutions (US$/BBL)	Cost Items	Cost by Item	Accumulation	Cost by Item	Accumulation	Cost by Item	Accumulation
	1. Crude Oil Cost (FOB)	12.65	12.65	12.65	12.65	12.65	12.65
	2. Refinery Margin						
	- Operating Costs	1.59		1.10		0.93	
	- Refinery Fuel and Losses	0.88		0.88		0.88	
	- Cost of Working Capital	0.23		0.17		0.14	
	- Capital Recovery	4.45		3.18		2.70	
	Subtotal Refinery Margin	7.15	19.80	5.28	17.93	4.65	17.30
	3. Bunker Fuel Oil Adjustment	0.31	20.11	0.25	18.18	0.23	17.53
	4. Ocean Freight (Refined Products)	1.75	21.86	1.75	19.93	1.75	19.28
	5. Refined Product Import Tariff	0.95	22.81	0.95	20.88	0.95	20.23
	6. CTS Margin						
	- Operating Costs	0.40		0.29		0.24	
	- Cost of Working Capital	0.39		0.38		0.37	
	- Capital Recovery	1.49		1.15		1.00	
	Subtotal CTS Margin	2.28	25.09	1.82	22.70	1.61	21.84
	7. Ex-CTS Required Av. Product Price	25.09		22.70		21.84	
	8. Av. Product Value in 1983, Japan	17.93		17.93		17.93	

APPENDIX 1

EFFECT OF THROUGH-PUT LEVEL ON PRODUCT COSTS

EFFECT OF THROUGH-PUT LEVEL ON PRODUCT COSTS

A short-cut and brief study is made for reference purpose to show the effect of through-put level of the refinery on the total product cost on an ex-CTS basis as defined in paragraph 11.4.

The calculation is made against absolute through-put levels rather than percentage ones and based on the assumption that a mature year based cash flows available to the refinery and CTS, which give ROE (DCF) of 11.8 percent, should be kept.

The study is conducted limitedly to the base case refineries with hydro-skimming configuration.

In order to facilitate the evaluation, all cost components are classified into variable and fixed portions, except for bunker fuel oil adjustment due to its nature, and are shown in Table 1.

The product prices to keep the designated profit level are calculated against various through-put levels.

The calculation results are shown in Figure 1 as well as Table 2.

As is observed from Figure 1, the market capacity to be assigned for the refinery has vital effects on its economics.

Table 1

Product Costs Classified by Fixed and Variable Portion

(for Base Cases at Full Operation)

	125,000 BPSD Hydroskimming		250,000 BPSD Hydroskimming		500,000 BPSD Hydroskimming	
	Fixed Portion	Variable Portion	Fixed Portion	Variable Portion	Fixed Portion	Variable Portion
	US$/BBL	US$/BBL	US$/BBL	US$/BBL	US$/BBL	US$/BBL
Refinery						
Crude Oil	-	13.56	-	13.56	-	13.56
Operating Costs	1.25	0.28	0.78	0.28	0.62	0.28
Cost of Working Capital	0.23	-	0.17	-	0.14	-
Capital Recovery	4.16	-	2.89	-	2.47	-
(Ex-Refinery Costs)	(5.64)	(13.84)	(3.84)	(13.84)	(3.23)	(13.84)
Ocean Freight	-	1.73	-	1.73	-	1.73
Refined Product Import Tariff	-	0.90	-	0.90	-	0.90
CTS						
Operating Costs	0.36	0.04	0.25	0.04	0.20	0.04
Cost of Working Capital	0.13	0.26	0.12	0.26	0.11	0.26
Capital Recovery	1.49	-	1.15	-	1.00	-
(CTS Margin)	(1.98)	(0.30)	(1.52)	(0.30)	(1.31)	(0.30)
Subtotal	7.62	16.77	5.36	16.77	4.54	16.77
Bunker Fuel Oil Adjustment	0.30		0.25		0.22	
Ex-CTS Required Av. Product Price	24.69		22.38		21.53	

Table 2

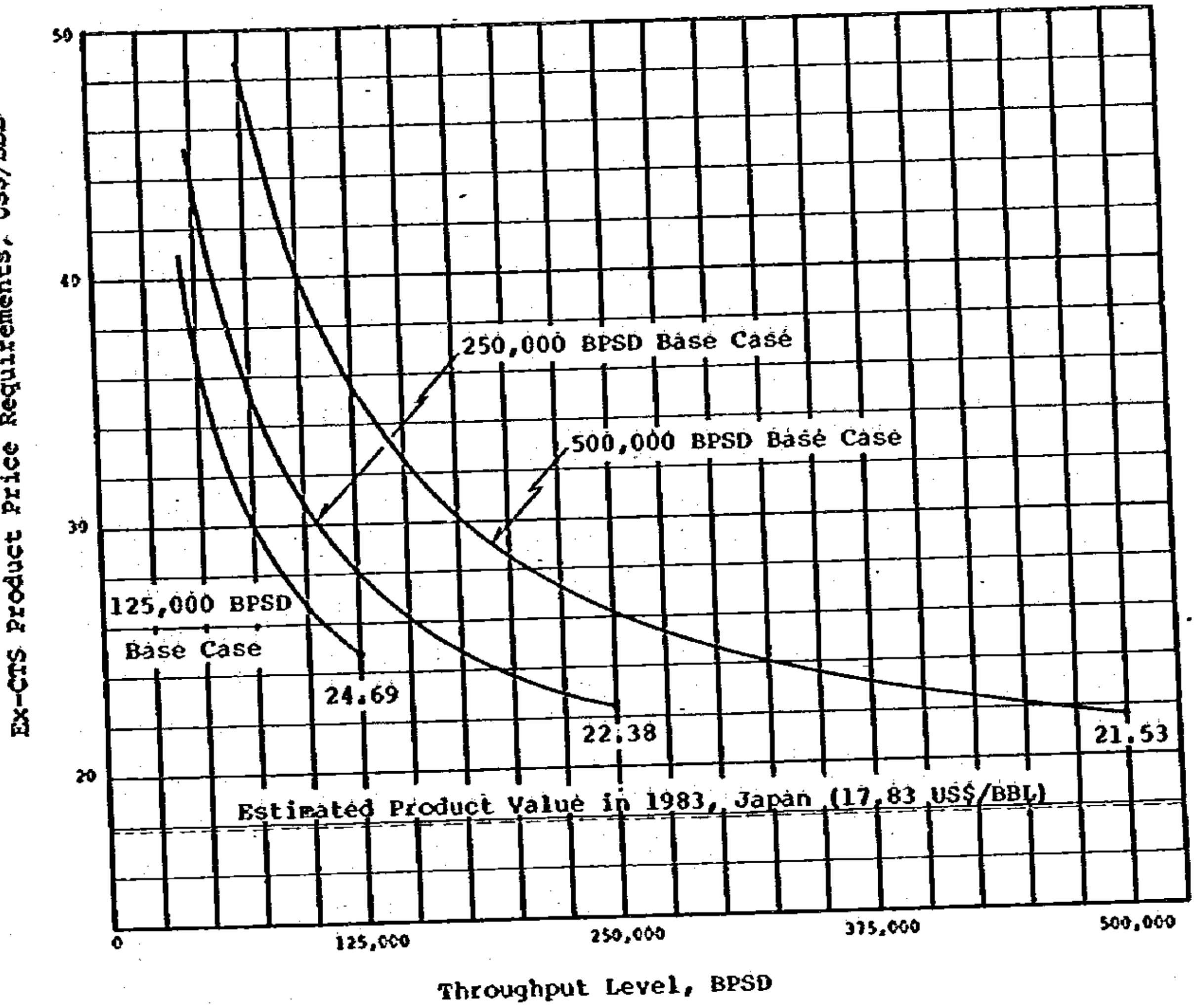
Product Cost by Plant Size & Throughput Level

Throughput Level[1] BPSD	125,000 BPSD Hydroskimming				250,000 BPSD Hydroskimming				500,000 BPSD Hydroskimming			
	Fixed Cost US$/BBL	Variable Cost US$/BBL	Bunker FO Adjustment US$/BBL	Ex-CTS Price US$/BBL	Fixed Cost US$/BBL	Variable Cost US$/BBL	Bunker FO Adjustment US$/BBL	Ex-CTS Price US$/BBL	Fixed Cost US$/BBL	Variable Cost US$/BBL	Bunker FO Adjustment US$/BBL	Ex-CTS Price US$/BBL
25,000	38.10	16.77	1.05	55.92	53.60	16.77	1.39	71.76	90.80	16.77	2.26	109.83
50,000	19.05	16.77	0.59	36.41	26.80	16.77	0.76	44.33	45.40	16.77	1.19	63.36
75,000	12.70	16.77	0.43	29.90	17.87	16.77	0.54	35.18	30.27	16.77	0.83	47.87
100,000	9.53	16.77	0.35	26.65	13.40	16.77	0.44	30.61	22.70	16.77	0.65	40.12
125,000	7.62	16.77	0.30	24.69	10.72	16.77	0.37	27.86	18.16	16.77	0.55	35.48
150,000					8.93	16.77	0.33	26.03	15.13	16.77	0.48	32.38
175,000					7.66	16.77	0.30	24.73	12.97	16.77	0.42	30.16
200,000					6.70	16.77	0.28	23.75	11.35	16.77	0.39	28.51
225,000					5.96	16.77	0.26	22.99	10.09	16.77	0.36	27.22
250,000					5.36	16.77	0.25	22.38	9.08	16.77	0.33	26.18
275,000									8.25	16.77	0.31	25.33
300,000									7.57	16.77	0.30	24.64
325,000									6.98	16.77	0.28	24.03
350,000									6.49	16.77	0.27	23.53
375,000									6.05	16.77	0.26	23.08
400,000									5.68	16.77	0.25	22.70
425,000									5.34	16.77	0.24	22.35
450,000									5.04	16.77	0.24	22.05
475,000									4.78	16.77	0.23	21.78
500,000									4.54	16.77	0.22	21.53

1) Throughout level is indicated as equivalent crude capacity with 85 percent on-stream factor.

Figure 1

Product Cost by Plant Size & Throughput Level



APPENDIX 2

ESTIMATED PRODUCT PRICES IN JAPAN 1983

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1. Introduction

In order to facilitate the evaluation of different product mixes from the refineries with technical alternatives, an estimation is made for the product prices in Japan 1983.

Since the comparison of various alternatives in planned to be based on an ex-CTS in Japan 1983, the product prices in Japan are estimated on an ex-refinery basis as it is considered to be the most closest ones to the 'ex-CTS', although they do not exactly correspond with each other.

In estimating the prices, the following steps are taken:

- Estimate the average ex-refinery product prices today in Japan based on a published information for refiners and primary distributors' selling prices and by deducting an average distribution and overhead cost in Japan.
- Assume the cost constitutions which made up the all products average price referring the standard price constitutions of petroleum products announced by the MITI in late 1975.
- Adjust the costs taking into account an escalation through 1978 to 1983 and anticipated increase in on-stream factor of the refineries in Japan.
- Add the cost incrementals to the prices in 1978, uniformly provided that price differences among various grades of products would remain unchanged, although it is not likely.

In short, present-day estimated ex-refinery prices with a constant price rise are assumed as those in 1983.

Details are presented in subsequent chapters.

3. Current Product Prices in Japan

Current selling prices of oil products in Japan are shown in Table 1, in which monthly average refining, marketing and primary distribution companies' selling prices for the January-March 1978 period are tabulated. While, Table 2 presents fuel oil C prices by sulfur grade that have been fixed between oil industry and electric power industry for the July-September 1977 period.

As is observed from Table 1, changes in selling prices of individual products in that period are not exactly linked with those in all products average price being affected by the market conditions then prevailing. However, the all products average price shows a rather constant dropping trend reflecting the changes in currency exchange rate which result in the decrease of yen based crude oil CIF cost.

In this respect, it could be said that the all products average price on a long-term basis, which determines refinery's revenue, will depend rather on the costs, while the market conditions then prevailing for individuals.

The forecast of market conditions, such as supply and demand gaps, for individual products in a certain future time period is practically impossible. Therefore, neither discussion for forecast of prices for individuals is made, but it is assumed that the price differences among various grades of products in future will remain unchanged.

Using the average selling prices of individual products for the January-March 1978 period as base and by deducting an average overhead and distribution cost, ex-refinery product prices are obtained.
As for fuel oil prices by sulfur grades in 1978, ¥2,500/kiloliter lower prices of Table 2 are used referring to the fuel oil price data for July-September 1977 and January-March 1978.
The resulting ex-refinery product prices in 1978 are presented in Table 3.

Table 1

Japan's Oil Product Price[1] - March 1978

(Unit: ¥/Kiloliter)

	Product Mix[2], %	1978		
		January	February	March
Motor gasoline (free of tax rated at ¥43,100/kiloliter)				
Premium grade	1.51	55,800	54,800	53,800
Regular grade	9.30	47,300	46,300	45,200
	10.81	48,490	47,490	46,400
Naphtha - average	12.62	28,300	28,400	26,000
petrochemical feed		26,000	26,000	25,600
Jet fuel	0.74	30,500	30,500	30,500
Kerosene - average	8.82	29,300	28,500	28,500
home use		29,300	28,400	28,000
Gas oil (free of tax rated at ¥19,500/kiloliter)	6.02	30,000	30,000	29,500
Fuel oil A	7.23	29,400	29,000	28,900
Fuel oil B	3.37	27,400	27,300	27,000
Fuel oil C - average	31.32	23,200	23,500	23,000
Fuel products average	80.93	29,340	29,210	28,440
Lube oils - premium grade	0.51	150,000	152,000	150,000
regular grade	0.21	54,000	54,000	53,000
	0.72	122,000	123,420	121,710
Asphalt, ¥/ton(=¥/kl)	1.46	24,200	24,200	25,000
Wax, ¥/ton(=¥/kl)	0.03	167,000	167,000	170,000
Grease, ¥/ton(=¥/kl)	0.02	220,000	220,000	210,000
LPG , ¥/ton		44,000	44,100	43,000
¥/kl	8.40	23,760	23,810	23,220
Crude oil for burning	8.44	24,000	24,000	24,000
All products average	100.00	29,090	29,000	28,320
All products average (Exclude Crude Burning)		29,500	29,460	28,700

(1) Refining, marketing & primary distribution companies' selling prices to secondary parties.
(2) Based on the actual results for fiscal 1976.
(3) Source: Japan Petroleum & Energy Weekly, May 15, '78.

Table 2

Fuel Oil C Prices by Sulfur Grade
July - September, 1977

% Sulfur	¥/kiloliter	% Sulfur	¥/kiloliter
0.1	29,700	1.6	25,100
0.2	29,300	1.7	24,700
0.3	29,000	1.8	24,300
0.4	28,700	1.9	23,900
0.5	28,400	2.0	23,500
0.6	28,100	2.1	23,300
0.7	27,800	2.2	23,100
0.8	27,500	2.3	22,900
0.9	27,200	2.4	22,700
1.0	26,900	2.5	22,600
1.1	26,600	2.6	22,500
1.2	26,300	2.7	22,400
1.3	26,000	2.8	22,300
1.4	25,700	2.9	22,200
1.5	25,400	3.0	22,100

Source: Japan Petroleum & Energy Weekly, May 15, '78

Table 3

Estimated Average Ex-refinery Product Prices

(January - March, 1978)

	Sulfur	Refinery Companies Selling Price 1)		Overhead & Distribution Costs 2)		Ex-refinery Product Price	
	(%Wt)	Yen/Kl	US$/BBL	Yen/Kl	US$/BBL	Yen/Kl	US$/BBL
Gasoline-Regular	-	46,300	30.67	2,800	5.17	38,500	25.50
Naphtha	-	25,800	17.09	900	0.59	24,900	16.50
Kerosene	-	28,800	19.08	4,200	2.78	24,600	16.30
Gas Oil	0.1	29,800	19.74	3,500	2.32	26,300	17.42
A Fuel Oil	0.7	29,100	19.28	3,000	1.99	26,100	17.29
B Fuel Oil	1.7	27,200	18.02	2,400	1.59	24,800	16.43
C Fuel Oil 3)	0.1	27,200	18.02	2,400	1.59	24,800	16.43
"	0.3	26,500	17.55	2,400	1.59	24,100	15.96
"	0.5	25,900	17.16	2,400	1.59	23,500	15.57
"	1.5	22,900	15.17	2,400	1.59	20,500	13.56
"	2.5	20,100	13.31	2,400	1.59	17,700	11.72
"	3.0	19,600	12.98	2,400	1.59	17,200	11.39
"	3.5	19,100	12.62	2,400	1.59	16,700	11.06

Notes:
(1) Jan. - Mar., 1978 Average
(2) Includes interest during credits period
(3) Deducts ¥2,500/Kl from Jul. - Sept. 1977 prices
(4) Exchange Rate : ¥240/US$ (Jan. - Mar., '78 Average)
(5) Source : Japan Petroleum and Energy Weekly except for item 2) above

3. Current All Products Average Price Constitutions in Japan

The standard product prices to be applicable for the December 1975 - November, 1976 period were announced by the MITI on December 1, 1975, where the product cost constitutions, upon which the prices were determined, were presented.

Being referred to the above product cost constitutions and based on the following assumptions, the product cost constitutions in the January-March 1978 period are predicted.

- Crude Oil Cost:
  Average CIF crude price through Oct., 1977 to Mar., 1978; that is 13.81 US$/Bbl or 21,300 Yen/Kl.
  (average exchange rate during the period: 245 Yen/US$)
- Import Tariff: 750 Yen/Kl
- Refinery Fuel and Losses: 5% loss is taken; priced at crude oil cost.
- Refining Costs: Escalation by 5% per annum, or 10% in total is considered.
- Adjustment for Imported Products: Assumed to remain unchanged.
- Overhead and Distribution Costs:
  Escalation by 5% per annum, or 10% in total, is considered.
- Interest: Interest is classified into two items, namely,
  - Interest for purchased crude oil
    7.5% annual interest for CIF crude oil
    6 months repayment term
  - Interest for sales credits
    8.0% annual interest the ex-refinery price, namely, selling price less overhead and distribution costs and interest for sales credits.
    Credit days: 75 days
- Profit: Assumed to remain unchanged.

The resulting all products average price constitutions for the January-March 1978 period are presented in Table 4.

Since the all products average price thus obtained shows a consistency with the actual one presented in Table 1, the assumed price constitutions developed above are seemed to be reasonable.

4. Incremental Costs from 1978 to 1983

Based on the all products average price constitutions and the following assumptions, incremental costs which influence the costs in future time period are estimated.

Assumptions

- FOB crude price

  Same as 1978's price; no escalation allowance is added.

- Freight of crude oil

  Escalated by 6% per annum, or 34% in total; freight between Percian Gulf and Yokohama by VLCC is assumed to represent the current all crude oils average freight cost of Japan.

- Refining costs, and overhead and distribution costs

  Escalated by 5% per annum, or 28% in total; the costs are assumed to be made up of the fixed and variable costs in the following proportions:

	Fixed Costs	Variable Costs
Refining Costs	75%	25%
Overhead and Distribution Costs	50%	50%

- On-stream Factor

  Change from 72% to 85%

- Interest: Crude Oil for 6 months at 8%/annum interest rate.

  Sales Credits for 75 days at 8%/annum interest rate.

- Import Tariff: 640 Yen/Kl

- Exchange Rate: 220 Yen/US$

In order to convert yen based costs presented in Table 4 into US dollar based ones, the costs are first classified into US dollar and yen based ones and then converted to dollars costs.

Crude oil cost and its related costs, such as refinery fuel and loss and interest for crude oil, are considered as dollar portion, while the rest as yen portion.

For the dollar portion costs, no adjustment is made against changes in the exchange rate, while necessary adjustments are made for the yen portion costs.

The resulting dollar based costs evaluated at the exchange rate of ¥220/US$ are as follows:

	Yen Based Cost (Yen/Kl)	Exchange Rate (Yen/US$)	US$ Basis (US$/Bbl)
Price of CIF Crude	21,300	245	13.81
Import Tariff	750	220	0.54
Refinery Fuel and Losses	1,160	-	0.76[1)]
Refining Costs	1,980	220	1.43
Adjustment for Imported Products	50	220	0.04
Overhead and Distribution Costs	2,540	220	1.87
Interest: Crude Oil	800	245	0.52
Sales Credits	430	220	0.31
Profit	180	220	0.13

1) (1.0/0.95 - 1.0) x (Price of Crude + Import Tariff)

The following discusses the changes in individual cost items which will influence the price level in 1983:

- Freight

  Current World Scale flat freight for Kharg Is./Yokohama is 10.70 US$/LT and AFRA rate for VLCC is about WS 45.

  Based on a yearly escalation rate of 6 percent, the freight cost incrementals until 1983 will be 1.63 US$/LT or 0.22 US$/Bbl.

- Refining Costs

  Refining costs in 1983 escalated by 5 percent per year will be 1.83 US$/Bbl.

  On the other hand, the increase of on-stream factor from 72% to 85% will result in the reduction of fixed costs by 0.21 US$/Bbl. Then, the refining costs in 1983 will be 1.62 US$/Bbl.

- Overhead and Distribution Costs

  Overhead and distribution costs in 1983 escalated by 5 percent per year will be 2.39 US$/Bbl.

  While, the changes in on-stream factor from 72% to 85% will result in the reduction of fixed cost by 0.18 US$/Bbl. Then, the costs in 1983 will be 2.21 US$/Bbl.

Table 4

Assumed All Products Average Price Constitutions in 1978

	Standard Average Price Constitutions (1975.12-1976.11)[1]	Assumed Average Price Consitutions (1978.1-1978.3)
Crude Oil Cost	23,560	21,300
Import Tariff	530	750
Refinery Fuel and Losses	1,270	1,160
Refining Costs	1,800	1,980
Adjustment for Imported Products	50	50
Overhead and Distribution Costs	2,350	2,590
Interest : for Crude oil	} 1,260	800
for Sales credits		430
Profit	180	180
Total (Refining Companies' Selling Price)	31,000	29,240 19.37 $/Bbl[2]

Notes : 1) Source: Based on the announcement by the MITI on Dec. 1, 1975

2) Exchange rate: 240 yen/US$ (Average exchange rate of the Jan.-Mar. 1978 period)

Table 5 presents the resulting all products average price constitutions in 1983 for both with and without improvement in on-stream factor of refineries in Japan. An estimated average cost increment between 1978 and 1983 is presented in Table 6, in which an ex-refinery average product price rise of 0.40 US$/Bbl is predicted.

In this connection, price of each product in 1983 is assumed to be higher than that in 1978 by 0.40 US$/Bbl uniformly.

Table 5

Assumed Average Selling Price Constitutions in 1983

Unit: US$/Bbl

	On-stream Factor	
	85%	72%
Crude Oil Cost	14.03 1)	14.03 1)
Import Tariff	0.46	0.46
Refinery Fuel and Losses	0.76	0.76
Refining Costs	1.62	1.83
Adjustment for Imported Products	0.04	0.04
Overhead and Distribution Costs	2.21	2.39
Interest: for Crude Oil	0.55	0.55
for Sales Credits	0.31	0.32
Profit	0.13	0.13
Refining Companies' Selling Price	20.11	20.51

Notes 1) Includes escalation of freight cost.

Table 6

Changes in Average Selling and Ex-refinery Prices Between 1978 and 1983

Unit: US$/Bbl

	On-Stream Factor	
	85%	72%
Average Selling Price in 1983	20.11	20.51
Average Selling Price in 1978	19.37 1)	19.37 1)
Average Selling Price Increments	0.74	1.14
Overhead and Distribution Costs Increments	0.34	0.52
Ex-refinery Average Price Increments	0.40	0.62

Notes 1) Exchange rate of average selling price in 1978 : 240 Yen/US$.