4.4 Productivity and Capacity Utilization of Major Equipment

Table 4-4 shows the productivity and capacity utilization of major equipment.

Table 4-4 Production Ratio and Plant Availability

Plant	Production Ratio	Plant Avalability
Direct Reduction	93.8 t/h, 2,250 t/day	312.5 days/year
Electric Furnace	9.64 heats/day	300 days/year
Continuous Casting	2.2 m/min, 1,144 kg/min	330 days/year
Bar and Rod	130 t/hr	508 hr/month
Lime Calcining	150 ∿ 220 t/day	330 days/year

4.5 Recommendation for Expansion Plan (Stage II)

Memorandum exchanged between the special committee and JICA on March 16 determined the plan to expand the current production program of annual 810,000 t on crude steel basis and 723,000 t on product basis up to the double capacity in future.

In compliance with the above agreement, we have made studies on the double capacity (namely, annual 1,620,000 t on crude steel basis and 1,646,000 t on product basis) as well as on the alternative future final capacity while considering the future demand forecast, optimum investment efficiency, raw material purchasing condition, works site condition, etc. As a result of researches described later, final capacity of 1,200,000 t/y on crude steel basis and 1,088,000 t/y on product basis is recommended for this works.

4.5.1 Demand Forecast

Demand forecast for bar and rod is described on Table 3.4 - 6, Page 3-35, Chapter 3, "Market Study".

Table 4-5 Demand forecast

Unit: 1,000 t

	1983	'84	'85	'86	'87	'88	'89	'90	'91	'92
Total demand (1)	920	1,009	1,105	1,209	1,322	1,443	1,574	1,716	1,869	2,034
Existing Production (2)	250	260	270	270	270	270	270	270	270	270
(1) - (2)	670	749	835	939	1,052	1,173	1,304	1,446	1,599	1,764

The time for the project start is not yet known. However, if it is assumed at September this year, the start-up time is planned at August, 1983 for steelmaking plant and November, 1983 for the bar and rod mill. Production program after start-up is shown on Table 4 - 1.

Table 4-6 Start-up program by calender year

Unit: 1,000 t

	1983	1984	1985	1986 ∿
Bar and rod production	11.9	304.3	636.35	723

When the Stage II construction program is assumed to start in 1984, the year following the completion of Stage I, the relationship between the steelmaking plant production and supply-demand forecast is as shown on Fig. 4 - 2.

Fig. 4-2 estimates as follows:

As is evident from Fig. 4-2, the planned bar and rod supply cannot meet the demand even at the double capacity. As this works does not have enough expansion space for Stage III to meet the demand expected for 1993 and after, it is recommended to stop the expansion at 1,088,000 t/y as

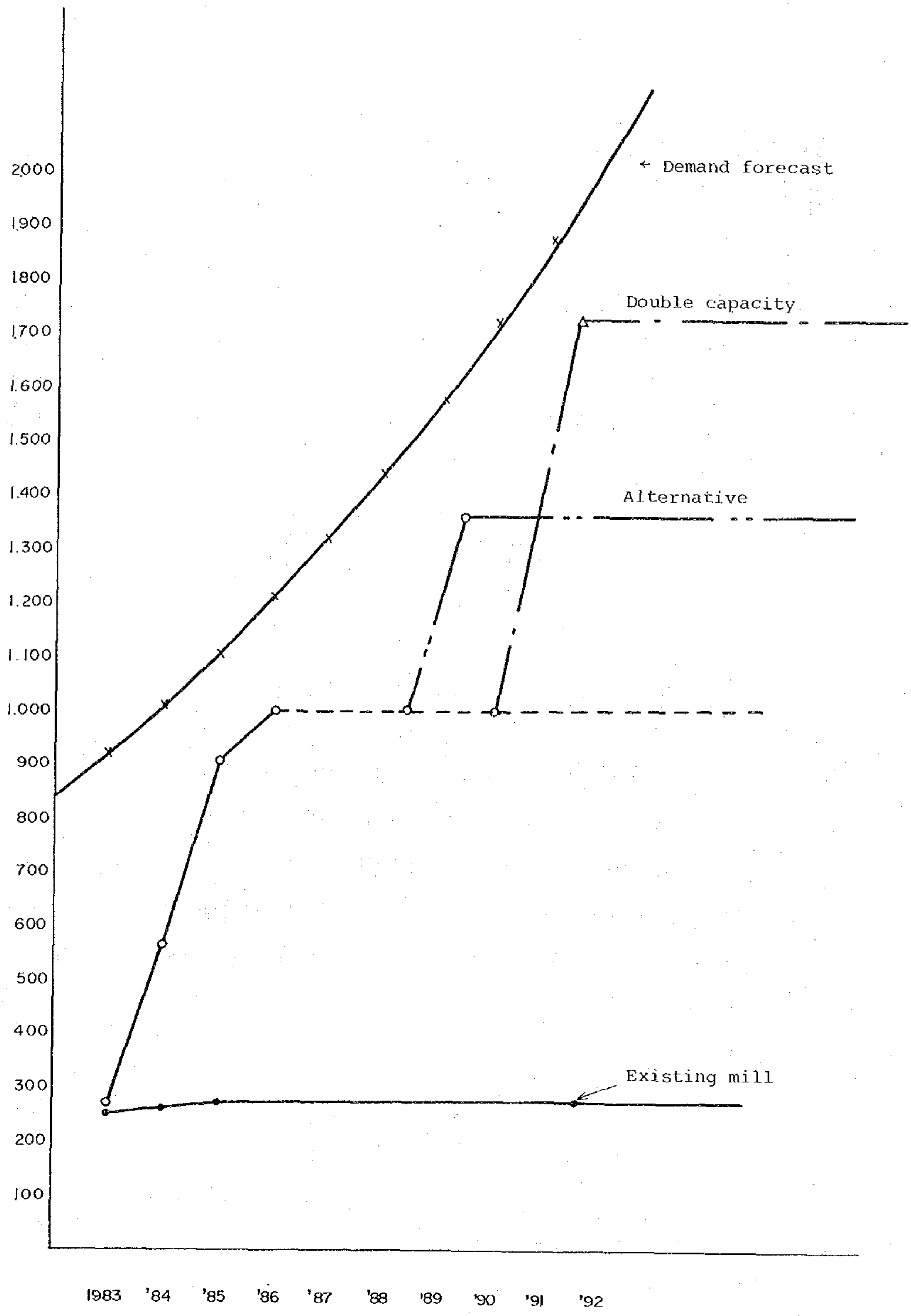


Fig. 4-2 <u>Supply and Demand</u>

described in the alternative proposal and to plan a new steel works on another site.

4.5.2 Equipment expansion plan

Table 4-7 shows the comparison between the double capacity proposal and the alternative proposal in terms of equipment and investment.

4.5.3 Scrap purchasing

As shown on Fig. 4-3 and Fig. 4-4, scrap purchasing amount is as follows:

Double capacity	284,000 t/year (Fe)
Alternative	173,000 t/year (Fe)

In the case of Egypt, all of scraps must be imported. As is well known, scrap import is greatly affected by the price fluctuation. Besides, import of large amount of scrap tends to push up its price. Accordingly, the plan must be directed toward reducing the scrap purchasing amount.

Alternative plan shows that the steel works can be operated only by scrap generated within the works.

The surplus sponge iron (125,000 ton/year) to be produced in D. R. plant can be sold to the other steel works.

4.5.4 Material flow

Fig. 4-3 shows the material flow in the double capacity plan and Fig. 4-4 shows the material flow in the alternative proposal.

Table 4-7 Equipment Expansion Plan

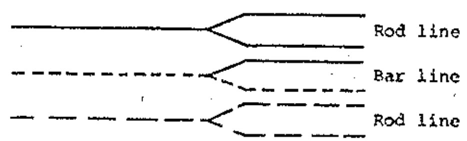
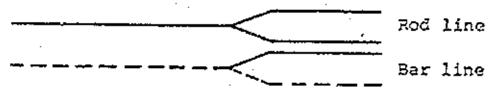
Plant \ Expansion	Double Capacity	Alternative Plan
DR Plant	600,000 t/year x 1 unit	600,000 t/year x 1 unit
Steelmaking	Whole of the same steelmaking plant as that at Stage 1.	70 T/heat EAF x 2 Fc's 4 strands CC x 2 machines
Bar and Rod	Whole of the same bar and rod mill as that at Stage 1.  	Reheating Furnace 1 unit Rougher 1 strand Intermediate 1 strand Bar Finishing 1 strand 
Land Reclamation	As the land must be 650m wide, it will be necessary to reclaim the Lake Maryut and relocate the lake side road to on the lake.	None
Other equipment	Most equipments have to be of double capacity.	Some equipments need reinforcement.
Investment	100%	Approx. 32%

Fig. 4-3 Material Flow for Double Capacity

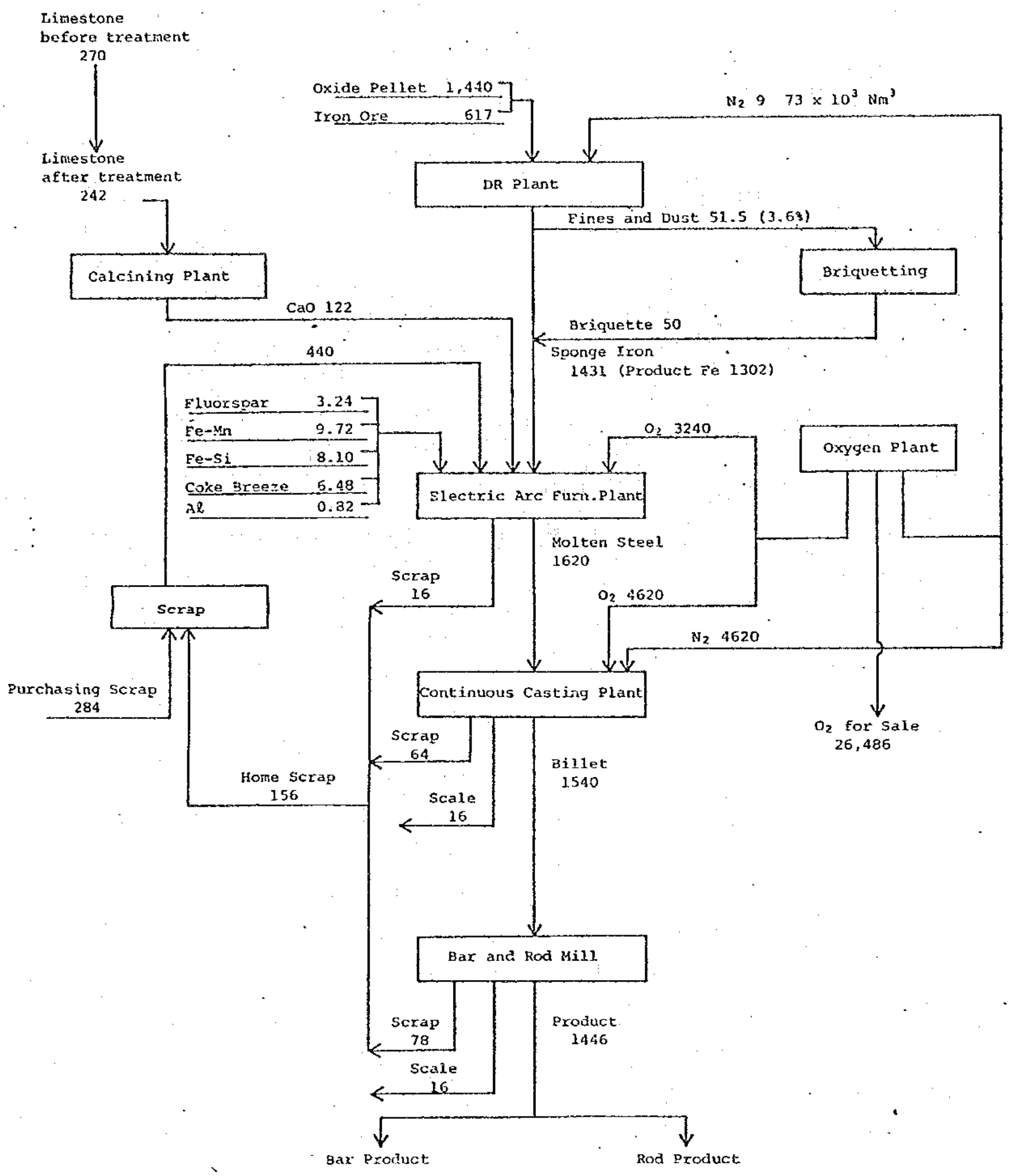
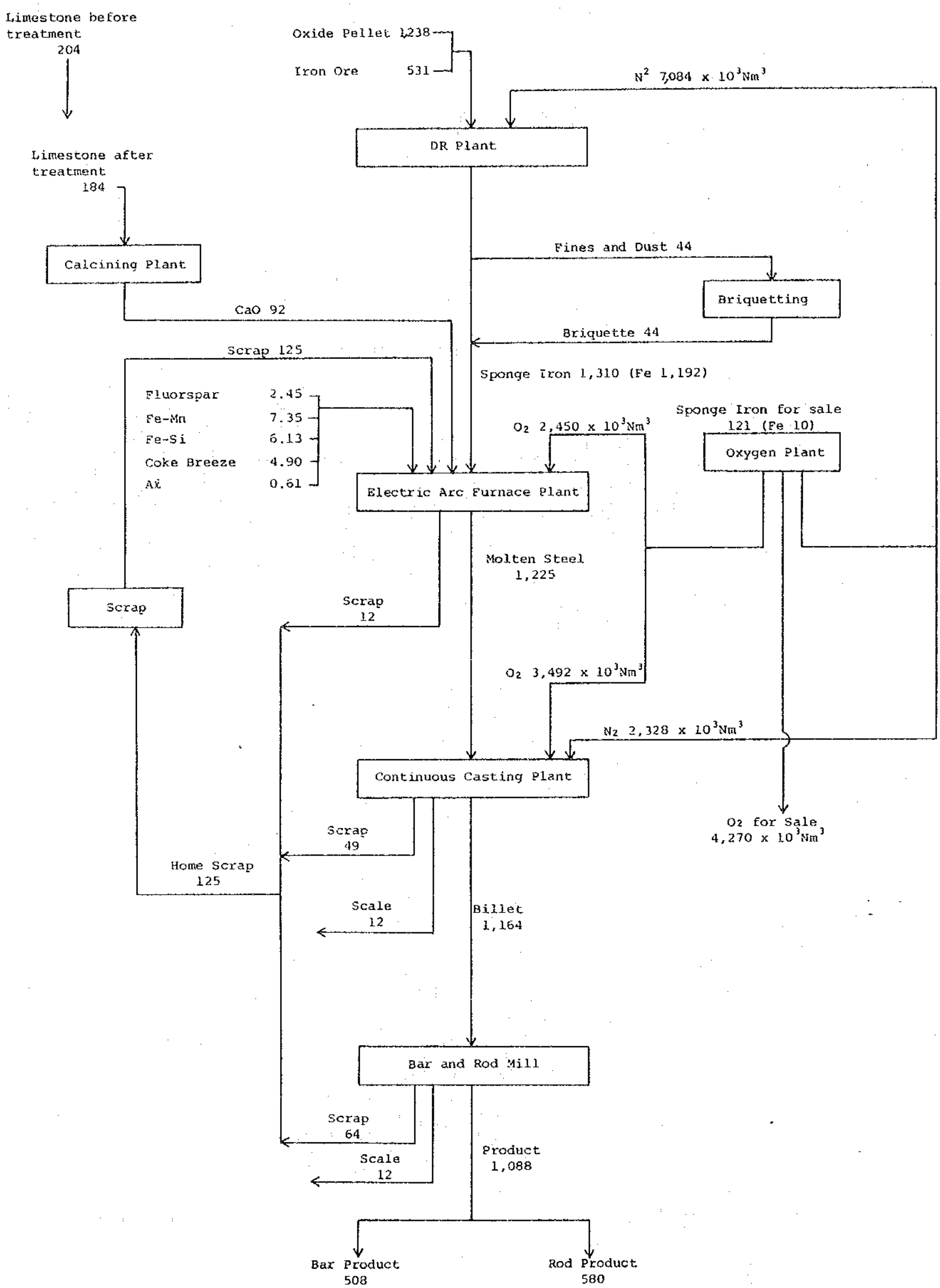


Fig.4-4 Material Flow for Alternative Plan



CHAPTER 5

Chapter 5 Study on Procurement of Raw Materials

5.1 Iron Ore (Pellets and Lump Ore)

Iron ores to be used for direct reduction process are selected among pellets, lump ore and fine ore in accordance with a process to be adopted. Since the study contemplates to adopt MIDREX process, study is made on pellets and sized lump ore (hereinafter simply called "lump ore") which are suitable for this process.

Ores of high iron content and low impurity should be selected for any direct reduction process due to following reasons:

The impurity contained in the ore cannot be eliminated at the stage of direct reduction and remains in sponge iron. The increase of impurities, which by-produces more quantity of slag, causes a decrease of productivity and an increase of power consumption at the stage of steel making. And furthermore, the unit quantity of sub-materials will be proportionally increased in order to remove this impurity. So the only way to prevent increase of various unit consumption and to improve productivity is to decrease the impurity contained in sponge iron and therefore it is very important to select high quality iron ores at the purchasing stage.

5.1.1 Supply Sources

Occurrences of some iron ore deposits have been reported in Egypt but development has been done only in Bahariya area. This deposit is composed of geothite and hematite of about 52% Fe and 9% LOI (loss on ignition). At present, there is no domestic production of iron ore which meets the quality requirement of the project. Therefore, the study is made on the premise that the required iron ore is imported in its entirety.

5.1.1.1 Pellets

Present overall production capacity of pellet plants in the world is about 260 to 290 million tonnes per year. All of them have been built for the purpose of producing pellets for blast furnaces. Recently, however, the construction of direct reduction plants has increased mainly in countries where cheap natural gas is available as reducing agent, and these plants have been using pellets as the main raw material suitable for direct reduction process.

Pellets are the product agglomerated by heat after the low grade iron ore from the mine is ground upgraded, and through this process it is possible to make pellets with high iron and low impurity contents required for the direct reduction process. Such pellets, the so-called direct reduction pellets, have been occupying the position as major raw material for direct reduction process. However, up to now the number of pellet manufacturers who can produce suitable pellets for direct reduction is small. Among such manufacturers, LKAB (Sweden) and CVRD (Brazil) have already been supplying extensively to many direct reduction plants in the world with high reliability. Besides them, there are Carol Lake (Canada), MINPECO (Peru) and SAMARCO (Brazil), but marketing areas of these producers are limited mainly to the U.S.A. and Canada.

On the other hand, the pellet manufacturers like BHP (Australia), Sydvaranger (Norway) and so on are restudying quality of their pellets with intention to sell to direct reduction plants under the background of oversupply of pellets for blast furnaces. SAMIA (Mauritania) is planning to produce pellets for direct reduction plants situated in the Middle East. However, in the study these pellets are not taken up because of no actual records. It is necessary to study these projects after their start-up; for instance SAMIA has an advantage for the project from the viewpoint of distance.

5.1.1.2 Lump Ore

MIDREX process cannot use fine ore, but can use lump ore combined with pellets. So there are many direct reduction plants which are studying combined use of cheap lump ore for the purpose of cost reduction.

Lump ores are being produced at many mining areas in the world. Same as in the case of pellets, lump ore shippers have an intention to sell to direct reduction plants who can be new customers. And now they are studying production of lump ore with suitable quality for the process and also are sending samples for testing purposes. Up to now, Mutuca (Brazil) is only one lump ore which is widely being sold to plants of MIDREX process in the world. However, according to the test results so far available, lump ores of Hamersley and

Mt. Newman (Australia) are also highly evaluated. Besides the above three brands, there are many high grade ores in India and Africa which will be candidates of new supply sources depending upon the results of future studies.

5.1.2 Transportation

5.1.2.1 Basic Concept for Reduction of Ocean Freight

There are two major factors which produce influence on the transportation costs (freight rate) for receivers of bulky cargo like iron ore.

One is whether the receiver is equipped with a large scale discharging port which allows transportation using large size vessels that can enjoy a scale merit. Especially because of price hike of crude oil in the past few years, the price of fuel oil for ship (usually called bunker oil) has also jumped up, and since the portion of bunker oil cost in the whole operation cost has become significant, freight differential between large and small size vessels has been getting larger and larger.

The another is the location of the receiver's discharging port. Freight rate varies depending on whether the loading port of next cargo, suitable for size of the vessel, is located near or distant from the discharging port, and whether chances to find cargoes are frequent or scarce.

Viewed from the standpoint of the above two factors, El Dikheila is planned to have a water depth of 20 m according to the current port development programme. With this depth, a 200,000 DWT vessel can be accommodated with full cargo. As to the location, in the Mediterranean area there are several oil loading ports for large size vessels. So El Dikheila enjoys a favourable position.

Note: Major Mediterranean oil loading ports for large size vessels are as follows;

Mersa Al Hariga (Libya)
Zuetina (Libya)
Es Sider (Libya)
Arzew (Algeria)
Ceyhan Terminal (Turkey)

5.1.2.2 Selection of Optimum Vessel Size

To select optimum vessel size for the project following three items are considered.

(a) Loading Port

Table 5.1-1 shows loading ports of iron ores under examination in the study.

Table 5.1-1 Loading Ports

Brands of Iron Ore	Loading Ports	Max. size of vessel to be accommodated (DWT)	Distance (sea mile)
CVRD (Brazil)	Tubarao	260,000	5,719
LKAB (Sweden)	Narvik	260,000 (with shift)	4,304
Hamersley (Australia)	Port Dampier	160,000	6,291
Mt. Newman (Australia)	Port Hedland	160,000 (short lifting)	6,343
Mutuca (Brazil)	Rio De Janeiro	60,000	5,988

(b) Freight Market

Freight differential between vessels larger and smaller than 100,000 DWT is so wide and freight market for vessels below 100,000 DWT fluctuates so widely, due to a variety of competing cargoes for such vessels, that to depend on vessel size of below 100,000 DWT will cause a violent fluctuation in raw materials costs. Therefore, in order to keep transportation cost as stable as possible, it is recommended to use vessels over 100,000 DWT.

(C) Cargo Combination

As El Dikheila is located near to oil loading ports in the Mediterranean area, it is desirable to employ ore-oil carriers (O/O) or ore-bulk-oil carriers (OBO). The most popular size of such vessels, freely operated in the world, is 150,000 to 160,000 DWT. Therefore it is desirable to employ this size of vessel to realize the stable ship space arrangements. The Suez Canal is expected to allow vessels of 150,000 to 160,000 DWT to pass with full cargo from 1981 onward after the completion of expansion work.

From the above, 100,000 to 160,000 DWT is selected as the optimum vessel size for El Dikheila. This size is believed to be appropriate in view of operation scale of this direct reduction plant. In normal operation, the consumption of pellets and lump ore amounts to around one million tonnes a year (about 85,000 tonnes a month). Therefore, one consignment corresponds to 1.2 to 2 months consumption, and this quantity is considered to be appropriate from the viewpoint of ore stock-yard operation and quality control.

5.1.2.3 Effective Transportation Pattern for Each Source

(a) CVRD

The most effective voyage is to transport pellets from Tubarao to El Dikheila and then to go back to Brazil with crude oil loaded at the Mediterranean area.

In case a vessel, after discharging pellets at El Dikheila, goes to Arabian Gulf via the Suez Canal to take crude oil for Brazil, an expected merit coming from reduced voyage duration in ballast will be offset by the Suez Canal toll. Therefore the ballast merit to be reflected to freight rate of pellets will not be realized.

(b) LKAB

The most effective voyage is to transport pellets from Narvik to El Dikheila and then to sail for Rotterdam area with crude oil loaded at the Mediterranean area (particularly east of Tunisia). In case of Algerian port, there is no significant merit because distances from Rotterdam and from El Dikheila are almost same.

(c) Hamersley and Mt. Newman

100,000 to 160,000 DWT O/O or OBO, which is employed for iron ore transportation from Atlantic area to the Far East (mainly to Japan) where there is an active cargo movement, goes to West Australia to take and transport the ore to El Dikheila via the Suez Canal. Then the vessel either takes crude oil in the Mediterranean area or sails directly to Atlantic area to take iron ore, coal and so on.

(d) Mutuca

As the loading port is small, the maximum size of vessel is 50,000 to 60,000 DWT, and the best way is to employ bulkers of that size which become free in US Gulf area or East Coast of South America.

5.1.2.4 Freight Rate

Freight rate for the study is calculated based on the concepts as explained in above. Since freight rate fluctuates from time to time depending on then prevailing freight market, in order to obtain long term freight rate index, the calculation for the study is made based on the cost of 160,000 DWT O/O built in 1978 and using the premise as shown in Table 5.1-2.

Actual freight rate will reflect the then prevailing market situation, but in the long run, it is expected that the average rate of such fluctuation is close to the rate based on the cost.

Table 5.1-2 Premises for Freight Rate Calculation

Items	Premises
Loading Rate	Based on the contracts of other buyers at each loading port
Discharging Rate	20,000 WLT/day
Prices of Bunker Oil	Heavy Oil A US$ 200/T Heavy Oil C US$ 100/T

5.1.3 Quality

The general idea of the quality required for MIDREX process was already outlined. Here the quality required for iron ore is expressed in terms of figures.

Both in case pellets alone are used and in case pellets and lump ore are jointly used, the quality of pellets or average quality of pellets and lump ore should satisfy the figures as shown below.

Chemical specification:

Fe ... + 66% P ... -0.05% S ... -0.02%

Physical specification:

Size - Pellets	9 - 16 mm	85% min.
Lump ore	10 - 30 mm	90% min.
	- 3 mm	4% max.

Fines (-3 mm) are screened and eliminated before the ore is charged.

Cold crushing strength:

Pellets .... 200 kg min.

5.1.4 Price

5.1.4.1 Pellets

The price of pellets is assumed to be US$0.44 per Fe unit dry metric ton (hereinafter called MTU). The present market price of pellets is at an extraordinarily low level of US$0.37 - 0.38/MTU. There is no doubt that actual pelletizing cost ranges around US$0.25 - 0.27/MTU. Therefore the market price has an allowance of only US$0.11 - 0.12/MTU as price of pellet feed. In view of the present market price level of lump ore and fine ore, the price of pellet feed should be US$0.17 - 0.18/MTU. Therefore complementing this difference of around US$0.06/MTU, the price of pellets is set at US$0.44/MTU.

5.1.4.2 Lump Ore

The price of lump ore is assumed on the basis of the present market price. Table 5.1-3 shows the contents of the study made in 5.1.1 to 5.1.4.

5.1.5 Selection of Supply Sources

Two sources of pellets and three sources of lump ore were listed up considering two points; ores will meet the required quality, producers will have high reliability as suppliers. From technical view point, it is desirable to operate with only one brand of pellets of high quality.

From economical view point, however, it is planned to use two brands of pellets in the first two years of operation, considering the result of comparative study on the price of CIF basis and diversification of supply sources to lessen the risks. One is LKAB or the like and the other is CVRD or the like.

From the third year onward, when the operation of direct reduction plant is expected to be stabilized, it is planned to jointly use lump ore of Hamersley or the like at the ratio of 30% in order to reduce the cost. When each 10% of pellets is replaced by lump ore, about one million dollars a year will be

Table 5.1-3 Brands of Iron Ore

Brands	Type of Ore	Chemical Analysis (%)						Size (m/m) (%)	Loading Port	Maximum Size of Vessel (DWT)	DRY Basis ($/T)		($/T)	Remarks
		Fe	SiO_2	Al_2O_3	P	S	H_2O				F.O.B.	Freight	C.I.F.	
CVRD (Brazil)	Pellets for D/R	68.10	0.90	0.84	0.026	0.005	2.0	8-18 min 90 - 5 max 4 Cold Crushing Strength: 350kg/pellet	Tubarao	260,000	29.96 (¢44/MTU)	7.33	37.29	Actual result good
LKAB (Sweden)	Pellets for D/R	67.82	1.43	0.53	0.013	0.006	2.0	5-16 min 91 +16 max 6 - 5 max 3 Cold Crushing Strength: 250kg/pellet	Narvik (Norway)	160,000 (260,000 with shift)	29.84 (¢44/MTU)	5.37	35.21	Actual result good
Mt. Newman (Australia)	Lump Ore	66.50	1.6 - 2.1	1.4	0.04	0.01	3.0	+30 max 4 - 6 max 7	Port Hedland	160,000 (short lifting)	17.96 (¢27/MTU)	9.99	27.95	Test result good
Hamersley (Australia)	Lump Ore	65.60	2.52	1.44	0.050	0.015	2.0	+30 max 0.3 - 6 max 2.5	Port Dampier	160,000	16.40 (¢25/MTU)	9.24	25.64	Test result good
MUTUCA (Brazil)	Lump Ore	69.0	0.5	0.9	0.02	0.005	3.6	+ 6 95	Rio de Janeiro	60,000	19.32 (¢28/MTU)	11.28	30.60	Actual result good

Note: Production capacity of pellets for D/R
CVRD: 5,000,000 t/y (actual production used for DR plant '78: 1,800,000 t)
LKAB: 3,000,000 t/y (actual production used for DR plant '78: 1,400,000 t)

saved respectively. Table 5.1-4 shows chemical composition and CIF prices in cases of pellets alone and combined use of lump ore at the ratio of 30%.

Table 5.1-4 Estimated Quality and Price of Iron Ore

	Charge Ratio			Chemical Composition (%)					CIF Price
	CVRD	LKAB	Hamersley	Fe	SiO_2	Al_2O_3	P	S	(US$/T)
1	50%	50%	-	67.96	1.16	0.68	0.019	0.005	36.25
2	35%	35%	30%	67.25	1.57	0.91	0.028	0.008	33.07
Required quality				+66.0			-0.05	-0.02	

Note: Chemical composition and price show figures of weighted average of charged materials.

5.2 Steel Scrap

5.2.1 Supply Sources

The project has to rely on imported scrap, because even now domestic scrap does not meet the demand from domestic consumers. In view of the location of El Dikheila, Europe except Scandinavia and Black Sea area of U.S.S.R. can be candidates of supply sources.

Europe, however, is basically consumer of steel scrap and there will be no space for export unless demand and supply position is slackened. Supply of Russian scrap is also unstable depending on the trend of Russian steel production level. The major source of imported scrap is firstly the U.S.A. who is exporting to various countries. Australia, who is exporting to Japan, South Korea and other Southeastern Asia, can also be a supply source. The Middle East, who is in geographically favourable position, is also attractive as a supply source, but steel scrap of this area involves some problems such as the majority of scrap being unprocessed, possibility of contamination of undesirable materials, possibility of embargoes by countries who have their own steel projects and so on. Therefore the U.S.A. is chosen as the main supply source with Australia and the Middle East as complementary sources.

5.2.2 Grade

Heavy melting scrap Nos. 1 and 2 of U.S. scrap standard are considered from the viewpoint of safety in electric arc furnace operation and stable supply and quality. Furthermore, shredded scrap is also taken into account because of easiness in discharging and handling.

5.2.3 Transportation

Table 5.2-1 shows popular sizes of vessels employed for each source.

Table 5.2-1 Size of Vessels for Each Source

Sources	Type of Vessel	Size (DWT)
U.S.A.	General Bulk Carrier	15,000 - 30,000
	Specialized Scrap Carrier	20,000 - 25,000
Australia	Specialized Scrap Carrier	18,000 - 23,000
Middle East	General Bulk Carrier	10,000

20,000 - 25,000 DWT is adopted as optimum size in consideration of a consignment of scrap offered by shippers.

Efficiency of discharging produces significant influence on ocean freight and eventually on the cost of imported scrap. Specialized scrap carrier equipped with magnet cranes and generator has high efficiency in discharging and can carry out self-discharging. However, as specialized scrap carriers are very small in number and majority of them are operated in Pacific area, it is rather difficult to secure sufficient number of the carriers in a stable manner. Therefore the new port of El Dikheila should be provided with an exclusive berth for scrap, shore cranes, magnets, hydraulic grabs, generator, chuter and cargo handling back hoe.

5.2.4 Price

The price of scrap fluctuates drastically depending on general economic situation and demand and supply position.

Since the end of 1973 FOB price of U.S. steel scrap has fluctuated between US$56 and US$160 in case of Heavy Melting Scrap No. 1 (at East Coast). The price of steel scrap is set at US$120, the average of FOB prices in past six months from October, 1978 to March, 1979.

The difference of prices between Heavy Melting Scrap Nos. 1 and 2 is assumed US$3 and the price of shredded scrap is assumed the same as Heavy Melting Scrap No. 1. The purchase of steel scrap is planned at the ratio of 80% Heavy Melting Scrap No. 1 plus shredded scrap and 20% Heavy Melting Scrap No. 2. Ocean freight of 20,000 to 25,000 DWT fluctuates drastically, and since the end of 1973 the freight rate from U.S. East Coast to Japan has fluctuated between US$13.50 and US$50, which corresponds to US$11 and US$46 in case of freight rate from U.S. East Coast to Egypt. The average freight rate in past six months from U.S. East Coast to Japan is US$23.60. The freight rate from U.S. East Coast to Egypt is set at US$20 on the premise that the discharging rate is 2,000 tonnes a day.

5.3 Sub-Materials

5.3.1 Ferro Silicon (Fe-Si)

Fe-Si is being produced in Egypt at around 4,000 tonnes per year by KIMA, who has an expansion plan. Therefore, it is assumed that Fe-Si is purchased from KIMA.

5.3.2 Ferro Manganese (Fe-Mn)

At present, there is no manufacturer of Fe-Mn in Egypt. Therefore it is assumed that Fe-Mn is purchased from overseas.

Comparing to Fe-Si, the ratio of power cost in total production cost of Fe-Mn is relatively low and the ratio of ore cost is high. So the ore producing countries and those which can purchase ores cheaply have competitiveness in cost and are main supply sources in the world. Table 5.3-1 shows major supply sources of Fe-Mn. In the study Norway and France are selected as main sources.

The price of Fe-Mn tends to follow the U.S. market and the fluctuation of the price is not so wide. Evaluation is made on the basis of the prices during six months of second half of 1978.

To secure stable supply and price of Fe-Mn, it is recommended to have more than two supply sources and, with one of them, to conclude a long term contract effective for more than one year covering about 50% of the total required quantity. In selecting supply sources, due consideration should be given to general situation of supplying countries, reliability of suppliers and competitiveness in cost.

Table 5.3-1 Supply Sources of Ferro Manganese

Sources	Estimated Production Capacity (Tonne/year)	Estimated Exportable Quantity (Tonne/year)	Comments
Norway	380,000	350,000	Stable delivery
France	370,000	170,000	Stable delivery Advantageous in ore procurement
Spain and Portugal	230,000	110,000	Advantageous in price due to short distance
India	170,000	100,000	Produces ore as well Unstable delivery Possibility of embargo
Brazil	120,000	50,000	Produces ore as well

5.3.3 Fluorspar

Currently a significant portion of domestic demand is covered by domestic production. It seems that the domestic production will cover some portion of the required quantity of the project, but there is uncertainty in its stable supply and quality. Therefore the study is based on the assumption that all required quantity is imported.

Fluorspar can be imported from Thailand and China who are exporting to many countries in the world with ample surplus for export, and from Spain and Italy who are near to Egypt. From the viewpoint of distance, Spain and Italy are selected as sources in the study.

The required annual quantity for the project is 1,600 tonnes and in case that fluorspar is transported in bulk, one consignment is requested more than 2,000 tonnes which corresponds to more than 15 month-consumption and then there will be problem from viewpoint of handling accomodation and stock yard capacity. Therefore in the study fluorspar is to be imported in around 300 tonne-consignment. In this case a liner boat is used and fluorspar is put into jute bags and packed into pallets of around one tonne each. The packing cost is set at US$90/tonne.

5.3.4 Limestone

In the vicinity of Alexandria, existence of high grade limestone has been confirmed and actual mining is under way in several places. There is no problem in securing the stable supply and quality of limestone required for the project.

Note: It is planned that a calcining plant is installed in the project and purchased limestone is burnt there. On the other hand it is informed that there is a calcining factory, from which the Egyptian Copper Works located in the Alexandria area is buying burnt lime at the price of 11 Egyptian Pounds (US$15.70) per tonne C&F basis, and that this calcining factory has considerable surplus capacity for the project.

5.3.5 Coke Breeze

Coke is being produced by EL NASR Co. for Coke and Chemicals in Helwan and is supplied to the Egyptian Iron and Steel Company. The domestic open hearth/electric furnace steel makers are buying the coke breeze from this company. It is assumed that the quantity required for the project is supplied by this company on a similar condition.

5.3.6 Aluminium

In Egypt aluminium smelting is being done by the Aluminium Company of Egypt and alumina is imported from Australia.

The company is only one smelter in Egypt and the majority of its products is exported, while a small portion is sold to domestic process manufacturers.

The quantity required for the project is 400 tonnes per year and this is so small that no problem is expected in domestic procurement. The supplier will be either the said smelter or major process manufacturers.

5.4 Graphite Electrode

The demand and supply position of UHP20, which is to be adopted in the project, is tight world-wide, especially in Europe. However, there are surplus production capacities in Japan, the U.S.A. and

West Germany, therefore it is assumed that the quantity required for the project is procured from those three countries.

The price has been fluctuating violently depending not only on production cost but also on demand and supply position. The current price level is around US$2,200 per tonne FOB, and is about US$1,000 higher than just a year ago. However, in view of the production cost, the price a year ago is extraordinarily low and the current level can be considered as the due price. So the current price is selected as the price for the study. It is necessary to select two or three countries as supply sources considering diversification of risks and present demand and supply position.

The study attached importance to smooth execution of procurement and assumed about 80% of the requirement coming from Japan who is punctual in execution of contracts and shipments.

5.5 Prices of Required Raw Materials and Their Demand and Supply Balance

Prices of raw materials adopted in the study are shown in Table 5.5-1. And the yearly quantities of purchase, consumption and inventory calculated on the basis of the production plan are shown in Table 5.5-2.

Table 5.5-1 Price List of Raw Materials

(unit: US$/T)

Materials		Import/ Domestic	Prices		
			C.I.F.	Inland Cost	Total
Iron Ore	Pellets (CVRD)	import	37.29	3.08	40.37
	Pellets (LKAB)	import	35.21	3.08	38.29
	Lump Ore (Hamersley)	import	25.64	3.08	28.72
Steel Scrap		import	143.00	2.54	145.54
Ferro Silicon		domestic	-	-	492.00
Ferro Manganese		import	426.00	18.20	444.20
Fluorspar		import	228.00	18.20	246.20
Limestone		domestic	-	-	2.90
Coke Breeze		domestic	112.20 (Ex Factory)	8.60	120.80
Aluminium		domestic	1,300.00 (Ex Factory)	8.60	1,308.60
Graphite Electrode		import	2,361.00	18.20	2,379.20

Table 5.5-2 Yearly Quantities of Purchase, Consumption and Inventory

(unit: T)

Year	-1	1			2			3			4～		
Materials	Purchase (Inventory)	Purchase	Con-sump-tion	Inven-tory	Purchase	Con-sump-tion	Inven-tory	Purchase	Con-sump-tion	Inven-tory	Purchase	Con-sump-tion	Inven-tory
Iron Ores	80,000	562,900	477,900	165,000	994,700	989,700	170,000	1,029,800	1,024,800	175,000	1,027,000	1,027,000	175,000
Pellets	80,000	562,900	477,900	165,000	994,700	989,700	170,000	723,100	768,100	125,000	719,000	719,000	125,000
Lump Ore	-	-	-	-	-	-	-	306,700	256,700	50,000	308,000	308,000	50,000
Steel Scrap	50,000	68,400	86,200	32,200	133,800	128,600	37,400	149,500	149,500	37,400	149,500	149,500	37,400
Ferro Silicon	160	2,122	1,962	320	3,868	3,848	340	4,050	4,050	340	4,050	4,050	340
Ferro Manganese	600	2,903	2,353	1,150	4,688	4,618	1,220	4,860	4,860	1,220	4,860	4,860	1,220
Fluorspar	260	1,026	786	500	1,580	1,540	540	1,620	1,620	540	1,620	1,620	540
Limestone	2,700	67,378	65,078	5,000	127,680	127,680	5,000	135,000	135,000	5,000	135,000	135,000	5,000
Coke Breeze	130	1,700	1,570	270	3,089	3,079	270	3,240	3,240	270	3,240	3,240	270
Aluminium	15	194	177	32	386	383	35	410	410	35	410	410	35
Graphite Electrode	490	2,432	1,960	962	3,886	3,848	1,000	4,050	4,050	1,000	4,050	4,050	1,000

CHAPTER 6

Chapter 6. Plant Description

6.1 Location and Access

6.1.1 Site Conditions

The site conditions of the steel works are very sensitive to the cost of finished products. Therefore, in selecting the site, various factors should be carefully examined. Particularly, in establishing the works that depends its major raw materials upon foreign supply, adequate port facilities are to be secured at first.

Secondly, the steel works requires wide space of land with good geographical conditions and foundation enough to sustain heavy structure and facilities.

Thirdly, stable supplies of utilities such as electricity, water, fuel, etc. with reasonable price should be assured.

In addition to the foregoings, facilities of overland transportation such as road and railway spur, availability of labor, proximity to the market, living environment are also important factors in selecting the location.

El Dikheila, the proposed site for this project, is located on the coast of the Mediterranean Sea, some 15 km west of the city of Alexandria which has a population of 3 million, and could be the center of future industrialization in the Arab Republic of Egypt.

The earlier investigation reports have proved that this particular site is the most suitable location for the proposed new works.

Followings are the main features of site conditions:

1) Acceptability of raw materials through the port facilities to be constructed at the Dikheila Bay.

2) Availability of natural gas as main fuel which is produced off-shore Abu Qir, about 45 km north of the site.

3) Availability of sufficient water, due to its proximity to the branch of the Nile.

4) Easiness of constructing heavy structures due to good soil conditions and non-earthquake zone.

5) Good living environment due to favorable climatic conditions.

6) Availability of labor force due to proximity to Alexandria, and no necessity to build living accommodations for this project.

7) Proximity to the market for the steel products and good connection to the existing road and railway.

Location of site is shown on DWG No. 6.1-01.

6.1.2 Geographical and Geological Features

El Dikheila District is located between the shoreline of Dikheila Bay and Lake Maryut, stretching narrowly from east to west. Alexandria - Mersa Matrouh Road traverses this district almost at its middle, and geographical and geological features differ substantially on both sides of this road. On the area to the north of the road (between the bay and the road), the ground is flat and its ground level is as low as M.S.L. (Mean Sea Level) + 1.0m. On its surface lies marine deposit including silt or silty clay, etc. Port facilities and raw material yards are planned for this area.

On the area to the south of the road (between the road and the lake), exposed limestone is observed in the form of mountains. It is called Abu Sir Ridge. As a result of disorderly digging of limestone over an extended period, the ground surface is extremely rugged, with the ground level ranging from M.S.L. + 2.0m to M.S.L. + 30.0m. The steel plant is to be constructed here after leveling and preparation of the ground. It is expected that the leveling work requires transportation of great amount of soil and the soil disposal yard.

Limestone constituting the bed has the compressive strengh of 12 ∿ 40 kg/cm^2, which can bear heavy structures. Ground formed by refilling loosely quarry waste may have only a limited bearing capacity and high compressibility. This point must be borne in mind in the construction of foundation. Laboratory test shows that its modulus of deformation after compaction is E - 250 kg/cm^2. Countermeasures such as compaction or replacement are indispensable to the construction of heavy structures in this type of ground.

6.1.3 Weather

Data of weather conditions in El Dikheila District are shown on Tables 6.1.3-1 ∿ 6.1.3-7. Data listed were obtained from the observation of Egyptian Weather Agency at this district (lat. 31°08' N. and long. 29°48' E., ground level 0.9m).

Data show evidently little rainfall here throughout the year, and the average temperature ranges from 13°C to 26°C. Moreover, strong winds which affects building design or port operation very rarely occurs: wind velocity of more than 15 m/sec. is observed only once or twice a year. As a conclusion, this district is considered optimum in terms of weather.

Table 6.1.3-1 Frequency of wind direction in Dikheila

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Period
No wind	1.1	0.7	0.9	0.7	0.7	0.7	0.4	0.3	0.7	0.9	1.9	1.3	1958 ∿ 1970
Variance	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.2	0.2	"
Wind direction													
345° ∿ 14°	7.4	12.8	1.33	20.8	24.8	31.2	44.7	43.6	40.1	21.4	16.5	9.0	"
15° ∿ 44°	4.8	8.9	9.5	13.3	18.1	13.8	7.3	11.7	19.8	18.7	17.5	6.0	"
45° ∿ 74°	3.0	5.9	6.7	9.4	9.5	6.4	1.0	1.8	5.5	13.8	14.2	5.2	"
75° ∿ 104°	3.0	5.5	5.3	6.5	4.4	2.5	0.2	0.4	1.2	6.4	7.3	6.1	"
105° ∿ 134°	4.8	5.4	6.9	7.4	5.1	2.7	0.1	0.2	1.2	5.6	5.1	6.2	"
135° ∿ 164°	5.9	6.5	6.3	6.8	5.3	2.7	0.3	0.3	1.3	5.5	3.2	8.1	"
165° ∿ 194°	7.0	6.2	4.7	3.5	2.4	1.6	0.3	0.2	1.7	4.5	4.2	6.5	"
195° ∿ 224°	9.3	6.6	4.2	2.0	1.2	1.0	0.4	0.8	1.6	3.4	5.0	11.3	"
225° ∿ 254°	15.1	8.3	4.3	1.6	1.2	0.9	0.7	0.7	1.2	2.5	5.5	15.7	"
255° ∿ 284°	14.8	8.4	6.8	3.1	2.3	1.7	1.3	0.9	1.2	2.3	3.9	10.1	"
285° ∿ 314°	12.1	9.8	12.3	8.9	7.2	8.6	10.7	6.6	5.1	3.6	5.3	6.2	"
315° ∿ 344°	11.6	14.9	18.7	15.9	17.7	26.1	32.6	32.5	19.3	11.3	10.2	8.1	"

Table 6.1.3-2 Frequency of wind velocity in Dikheila

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Period
Wind velocity													
1 ∿ 3 knots	17.0	17.3	10.9	11.0	14.4	11.8	8.7	11.6	15.0	20.6	23.2	20.1	1958 ∿ 1970
4 ∿ 6	21.7	22.9	17.4	18.4	21.6	18.7	16.7	19.4	22.2	24.3	24.7	22.6	"
7 ∿ 10	27.8	27.4	31.5	37.0	36.4	39.1	41.6	42.4	39.9	35.7	30.4	26.9	"
11 ∿ 16	22.6	23.5	29.5	29.6	24.9	28.5	31.0	24.9	21.4	17.8	16.8	21.2	"
17 ∿ 21	6.6	5.3	7.4	2.9	1.8	1.2	1.6	1.4	0.8	0.7	2.2	5.3	"
22 ∿ 27	2.8	2.4	2.2	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.7	2.3	"
28 ∿ 33	0.4	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	"
34 ∿	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	"
Average wind velocity (knots)	8.8	8.7	9.7	9.0	8.0	8.6	9.0	8.5	7.7	7.0	7.1	8.3	1957 ∿ 1970
Max. wind velocity (knots)	57	66	57	46	48	43	33	31	44	51	56	52	1958 ∿ 1970

Table 6.1.3-3 Atmospheric pressure in Dikheila

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Period
Average atmospheric pressure (mbs)	1017.4	1017.9	1015.3	1013.8	1013.3	1011.9	1009.1	1009.3	1012.9	1015.6	1017.5	1017.4	1957 ∿ 1970
Max. atmospheric pressure (mbs)	1031.4	1031.1	1026.8	1024.6	1022.9	1019.6	1015.0	1016.2	1021.8	1024.0	1029.1	1028.5	"
Min. atmospheric pressure (mbs)	998.2	1000.9	995.3	995.6	1000.9	1002.2	1002.4	1003.7	1002.0	1002.8	1001.5	997.7	"

Note: Values are modified on the basis of M.S.L. (mean seal level)

Table 6.1.3-4 Atmospheric temperature in Dikheila

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Period
Average max. atmospheric temperature (°C)	18.0	18.5	20.9	23.2	25.3	27.9	28.9	29.7	28.7	26.8	23.6	20.2	1957 ∿ 1970
Average min. atmospheric temperature (°C)	9.5	10.2	12.0	14.2	16.9	20.8	22.6	23.4	22.0	18.6	15.5	11.1	"
Average temperature (°C)	13.6	14.4	16.1	18.3	21.9	24.1	25.7	26.4	25.2	22.7	19.7	15.5	"
Max. temp. (°C)	28.1	35.6	39.7	43.4	42.4	45.6	37.1	39.7	39.8	35.4	37.3	28.0	"
Min. temp. (°C)	3.5	5.6	6.1	7.2	11.0	13.9	17.4	17.0	15.4	11.1	8.2	4.2	"

Table 6.1.3-5 Humidity in Dikheila

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Period
Average relative humidity (%)	66	65	61	63	67	70	71	70	66	67	68	65	1957 ∿ 1970
Max. relative humidity (%)	100	100	98	100	100	96	99	97	100	100	100	100	1961 ∿ 1970
Min. relative humidity (%)	5	11	3	8	6	11	39	16	24	22	18	9	"

Table 6.1.3.6 Rainfall in Dikheila

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Period
Average rainfall/month (mms)	58.0	24.8	10.7	1.7	1.6	0.0	0.0	0.0	2.0	15.2	24.9	40.3	1957 ∿ 1970
Max. rainfall/day (mms)	40.2	41.4	14.7	7.3	17.9	0.0	0.0	0.0	21.6	38.2	42.8	63.3	"

Table 6.1.3-7 Average abnormal weather days in Dikheila

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Period
Rainy day (rainfall of more than 0.1mm)	10.8	6.4	4.4	1.6	0.9	0.0	0.0	0.0	0.4	3.6	4.6	6.6	1957 ~ 1970
Cloud of dust (visibility of more than 1000m)	0.5	0.7	1.6	1.3	1.0	0.3	0.0	0.0	0.1	0.0	0.1	1.6	"
Sandstorm (visibility of less than 1000m)	0.4	0.3	0.8	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.4	"
Fog (visibility of more than 1000m	0.4	0.7	0.4	0.8	0.9	0.1	0.1	0.1	0.4	0.4	1.5	1.1	"
Fog (visibility of less than 1000m)	0.8	0.6	0.1	0.6	0.5	0.2	0.1	0.1	0.1	0.7	1.1	1.4	"
Strong wind (wind velocity of more than 34 knots)	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	"
Thunderstorm	1.0	0.4	0.2	0.1	0.1	0.0	0.0	0.0	0.2	0.9	0.6	0.7	"

Note: 1 knot = 1.85 km/hr.

6.1.4 Access

1) Port facilities

In the Dikheila Bay, mineral jetties (19m depth x 400m length) is planned to be constructed, alongside which 160,000 DWT class ore carriers can dock. Iron ores (or oxide pellets) are unloaded here to be stocked in the raw material yard. This yard is connected to the steelmaking plant via conveyor.

Mineral jetties also take secondary materials such as charge of imported scrap, refractories, ferro alloy, etc.

2) Road and railroad

By connecting the roads within the plant premises to Alexandria - Mersa Matrouh Road, it can be used as transportation ways for secondary materials and products as well as commuter road. Access road to the new Dikheila port is also planned as a part of port facilities.

Railroad within the plant premises is connected to the existing one along Lake Maryut, and thus further to the railroad network of Egypt. Railroad is mainly used for the transportation of products.

6.1.5 Land preparation

Site area required for the construction of the integrated steel works is one million square meters (500m x 2,000m). Because of higher site ground level exceeding the surrounding area and extreme undulation caused by disorderly excavation of limestone, land preparation is necessary before starting the construction work.

The land preparation is planned based on the following preconditions.

(1) Site levelling is high enough to insure full performance of the works.

(2) Land preparation plan was based on the survey chart prepared by IMC in 1978.

(3) Surrounding roads scheduled to be connected to roads and railways in the work premise are laid on approx. MSL +7.0m and the railway on approx. MSL +5.0m.

(4) Surplus earth produced by land preparation work is carried outside the work premise and place for disposal is provided by the time when the works start. (It is desirable to effectively use surplus earth for banking and enbankment.)

Based on these conditions, in this Feasibility Study, comparison and examination have been made for alternative A that proposes work foundation height of MSL +7.0m and B of MSL +9.0m. Results are as follows:

(1) Comparison of earth quantity involved

	Excavation	Backfilling	Surplus earth
Alternative A (GL = MSL +7.0m)	5,250,000m^3	750,000m^3	4,500,000m^3
Alternative B (GL = MSL +9.0m)	3,700,000m^3	1,400,000m^3	2,300,000m^3

Note: Earth quantities are calculated according to topographic map prepared in 1978, all of them being approximate values.

(2) Execution period

The construction of this project is scheduled to last 50 months from start of engineering to the start of plant operation and grading work must be completed before the start of foundation work. Although the start of foundation work differs plantwisely, it is set at 14 months for both alternatives A and B assuming that grading work is started in accordance with normal practice.

Alternative A (GL = MSL +7.0m)

° Execution period: 14 months (number of working days: 350 days)

° Quantity of excavated earth: Approx. 15,000 m^3/day

° Quantity of earth carried outside: Approx. 13,000m^3/day

Alternative B (GL = MSL +7.0m)

° Execution period: 14 months (number of working days: 350 days)

° Quantity of excavated earth: Aprox. 10,600 m^3/day

° Quantity of earth carried outside: Approx. 6,600m^3/day

(If construction equipment of the same size and quantity as alternative A is used, the execution period required for grading work will be decreased to approx. 9.5 months)

(3) Connection to surrounding roads and railways

Alternative A (GL = MSL +7.0m)

Suitable and no problems.

Alternative B (GL = MSL +9.0m)

Road: To connect public roads (road surface height: MSL +7.0m) with roads in the premise it is necessary to provide 50m approach even if road gradient is assumed to be 4%. Further detailed examination is required depending on location road structure, etc. to determine whether ground level or elevated approach is to be provided. As an example, it is on the ground level, 108,000m^2 (54m x 2,000m) dead space is produced.

Raiways: Same examination as the roads is required but if gradient is set at 2.5%, the approach is 80m longer as compared with alternative A.

Raw material conveyor: No problems.

(4) Construction cost

Alternative A (GL = MSL +7.0m) 3,150,000,000 yen

Alternative B (GL = MSL +9.0m) 2,220,000,000 yen

Note: Construction cost shown herein covers only grading work and does not include cost for connection to roads, railways, etc.

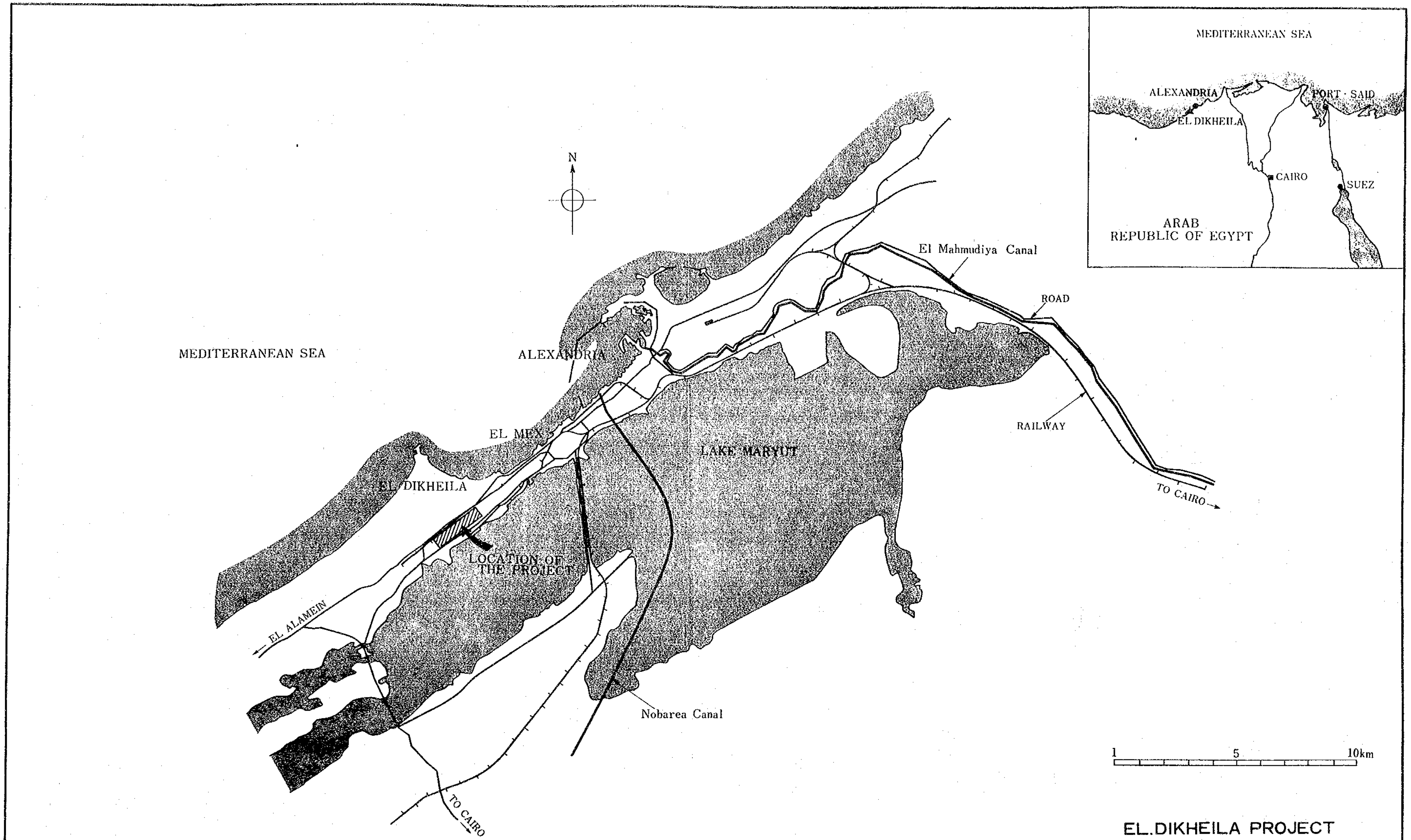
(5) Overall evaluation

Both alternatives A and B have their own merits and demerits and the selection should be made only after detailed examination. However at the present stage we recommend alternative A for the reasons given below:

a) In the case of alternative B, connection to the roads railways, etc. is difficult and considerable expenditure is expected. In addition many structures are constructed on enbankment, which may also increase work cost.

b) Surplus earth produced by grading work can be effectively used for other works.

Therefore estimation of land prepartion cost of this project is made based on alternative A.



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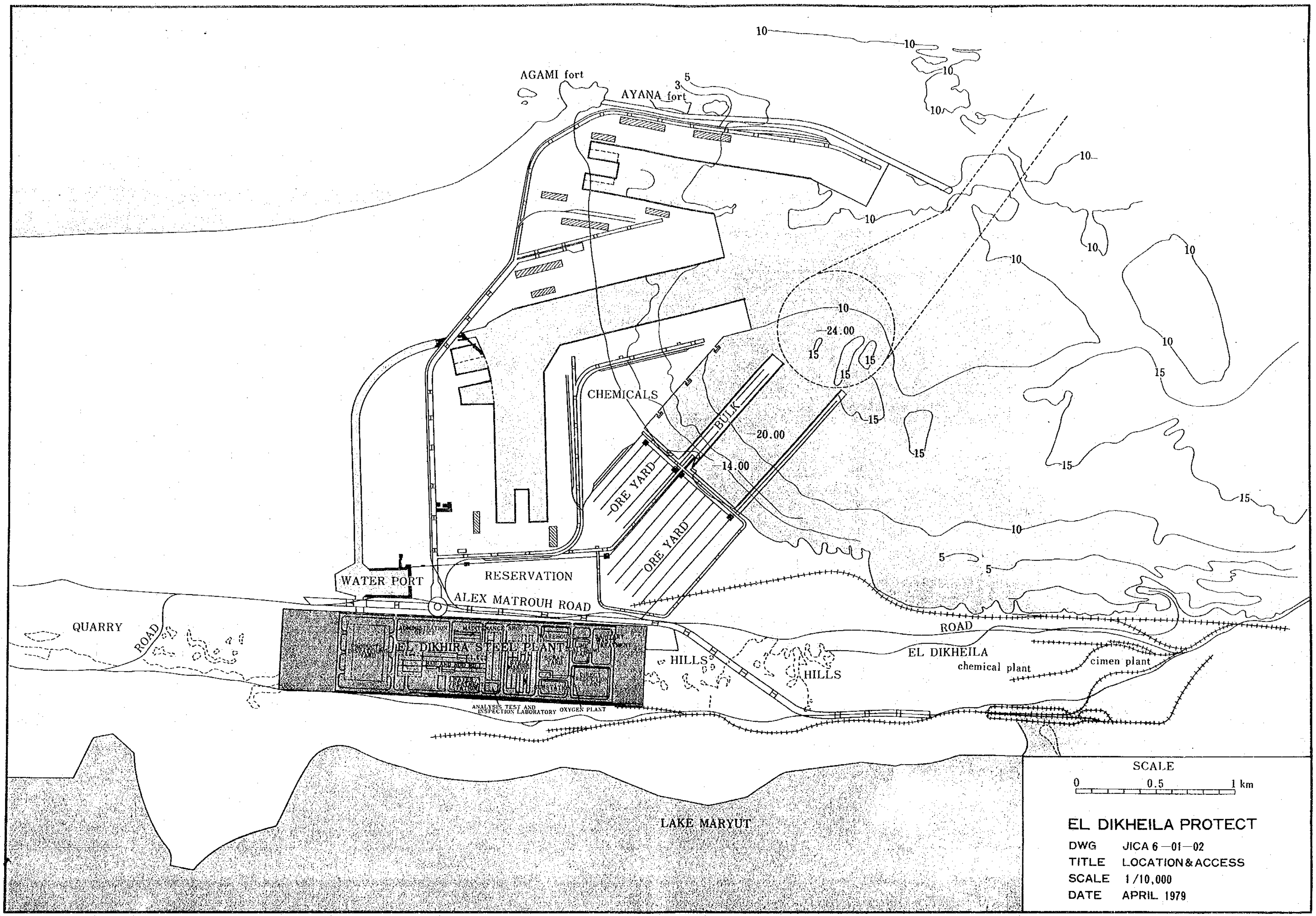
DWG JICA 6—01—01
TITLE LOCATION PLAN
SCALE 1/100,000
DATE APRIL 1979


AGAMI fort
AYANA fort
CHEMICALS
BULK
ORE YARD
ORE YARD
RESERVATION
WATER PORT
ALEX MATROUH ROAD
QUARRY
ROAD
EL DIKHIRA STEEL PLANT
ANALYSIS TEST AND INSPECTION LABORATORY
OXYGEN PLANT
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DWG JICA 6—01—02
TITLE LOCATION & ACCESS
SCALE 1/10,000
DATE APRIL 1979

6.2 General Layout

6.2.1 Site of this project is located in the proximity of the new Alexandria Port, extending the distance of 500m from south to north and max. 2200m from east to west, with its south-north boundary running along the road. To the north of site, construction of the new Alexandria Port and raw material yard is planned, and Lake Maryut is located to its south.

6.2.2 Ground level is MSL + about 2m at the raw material yard of new port, MSL + 7m at Alexandria - Matrouh Road to the north, MSL + 7m at the plant site, and MSL + about 2m at the road on Lake Maryut side. Accordingly, the main gate is connected to the Alexandria - Matrouh Road. The railway, whose gradient should generally be less than 2.5%, is planned for the south side of plant site in view of configuration of the land and existing railroad. Transportation of oxide pellet from the ore yard in the new mineral jetty to the plant site is made via belt conveyor. Electricity will be supplied to the south side of plant site by means of the transmission line crossing Lake Maryut.

Layout is determined after thorough consideration of above peripheral conditions.

6.2.3 This layout was prepared for two cases of future enlargement of tapping capacity at 1,200,000 t/y and 1,600,000 t/y, with the current production target at 723,000 t/y on the final product base.

6.2.4 From the general point of view, the works layout must be such that the handling frequency and amount to be handled are kept minimal to reduce the handling costs for raw material, secondary raw material, and semi-finished product. In the case of this plant, whose site length from south to north is as short as 500m, the straight line arrangement is optimum. This kind of arrangement plant ensures highly effective material handling.

6.2.5 DWG JICA - 6-2-01 shows the layout for the future tapping amount of 1,200,000 t/y. Features of this plan are as follows:

1) Since oxide pellet (primary raw material) and sponge iron (product), is handled via belt conveyor D.R. plant is located at optimum position between the ore yard and steelmaking

plant. The D.R. plant to be provided is one unit at present and two units in future. Various equipment such as ore storage bin, sponge iron storage bin, and water treatment facilities which these two units can use commonly is compactly designed.

2) Steelmaking plant includes a lime calcining plant and scrap yard effectively arranged. A large amount of sponge iron is handled by means of belt conveyor. Lime calcining plant includes a limestone storage yard, where a shovel loader is used. Burnt lime (product) is loaded from the storage bin onto the exclusive dump car. The dump car carries the burnt lime via the hopper to the belt conveyor (for the sponge iron) which is connected to the Steelmaking plant. Because of scrap transportation by dump truck, the scrap yard is provided adjacent to the plant. EAF slag is transported via the exclusive self-loader for the sanitary waste treatment.

Billets are transferred effectively to bar and rod mill by motor-driven exclusive cars.

To enable the future tapping of 1,200,000 t/y, a space for extention of the steelmaking plant building to the north of the site is provided.

3) Because the bar & rod mill is effectively jointed with the steelmaking plant, hot charge is possible. At the tapping level of 1,200,000 t/y, the bar and rod combination mill can be turned into the bar and rod separate mill by adding one reheating furnace. Product is transported to the products dispatching yard by the exclusive trailer.

4) Products dispatching yard is provided near the mill end to receive products from the bar and rod mill via the trailer according to the rolling schedule and to classify them by users and ship by the trucks prepared by users.

5) Principal road and main gate are so positioned as to ensure smooth transportation of scrap, limestone, and products. As regards the railroad facilities, the railway for dispatching and the marshalling yard for locomotives of Egypt Railway Authority are planned. Also the arrangement is planned to enable loading on the wagon by using forklift along the principal road.

6) The substation is arranged adjacent to the steelmaking plant, which is a principal power consumption shop facing Lake Maryut.

7) DR plant has its own water treatment station. The steelmaking plant and bar and rod mill, have the one water treatment station.

8) Most of oxygen from the oxygen plant is consumed by the steelmaking plant while nitrogen by DR plant. Accordingly, the oxygen plant, when provided between these plants will contribute to minimizing the piping distance.

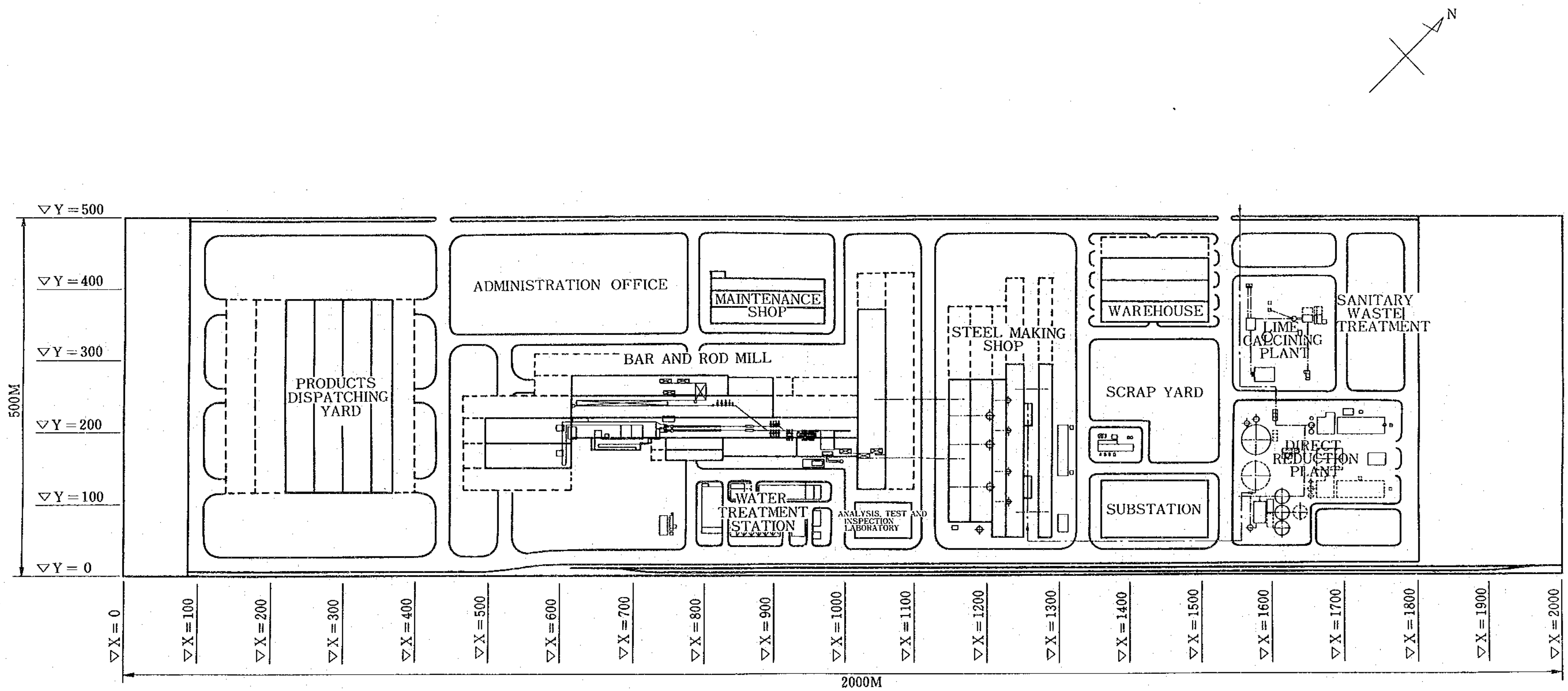
9) As the bricks, ferro alloy, etc. to be used by the steelmaking plant occupy most of storages, the warehouse is arranged adjacent to the steelmaking plant.

10) Inspection and analysis activities are made mostly for the steelmaking plant and bar and rod mill. In particular, arrangement of air tube for transportation is planned for the steelmaking plant which requires the analysis to be completed within short period.

As is evident from the above description, the layout for the future 1,200,000 t/y will ensure smooth material flow in Stages I and II, and the transfer to Stage II is achieved with the minimum investment.

6.2.6 DWG JICA - 6 - 20 - 02 shows the layout for the case of 1,600,000 t/y tapping. In this plan, two mills of the bar and rod mill and the rod mill are required to achive planned production. Production ratio between these mills is about 12 : 4. Judging from the current mill capacity, the rod mill is not effective. Besides, at this 1,600,000 t/y level, two steelmaking plants are necessary to arrange repair shop for furnace cover effectively. From the viewpoint of effectiveness, it is advisable to set the production ratio at 8 : 8.
As a result, billet transportation between the steelmaking shop and the bar and rod mill solely by the motor-driven car is impossible: about 400,000 t/y has to be handled by the trailer.

In short, effective material flow is not ensured from Stage I to Stage II.
Besides, increase in the land preparation cost in Stage I as well as increased investment in the transfer to Stage II will prove that this plan is not advisable as a whole.



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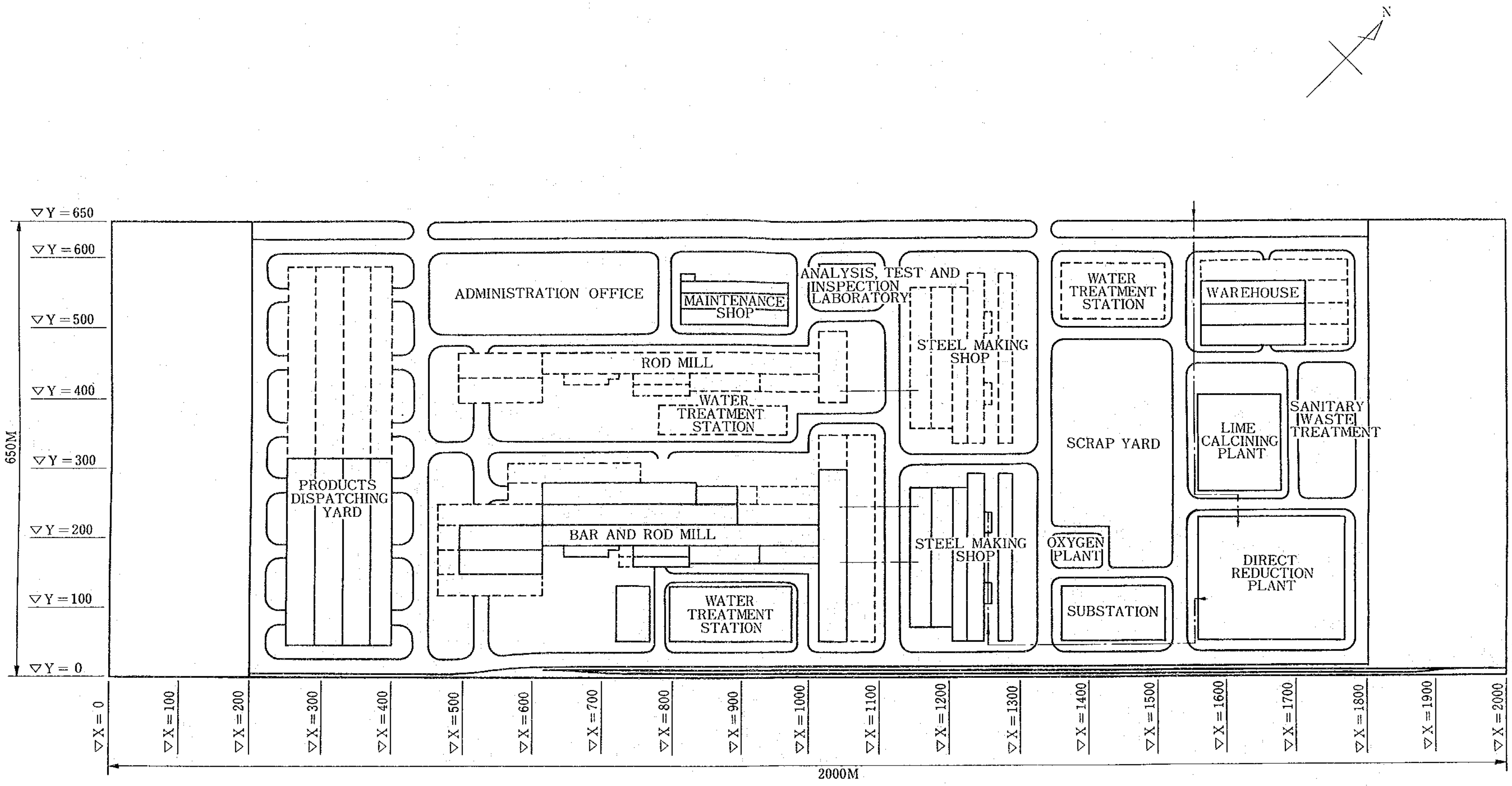
DWG. NO. JICA-6-2-01
TITLE GENERAL LAYOUT
SCALE 1/2000
DATE APRIL 1979



EL DIKHEILA PROJECT

DWG. NO. JICA-6-2-02
TITLE GENERAL LAYOUT
SCALE 1/2000
DATE APRIL 1979

6.3 Direct Reduction Plant

6.3.1 Process Evaluation

The direct reduction processes which are considered in this study are limited to gaseous reduction processes, because natural gas, which is produced at the Abu Qir gas well, is utilized as a reductant in this direct reduction plant.

The most suitable direct reduction process should be selected out of the commercially available processes which have been industrially proven.

Table 6.3-1 shows the capacities of the various types of DR plant in operation throughout the world up to the end of 1978 and their estimated capacities in 1980.

Table 6.3-1 Capacities of DR Plants throughout the World

(Unit: 1,000 t/y)

Process	1970	1975	1978	1980
Midrex	400	1,600	3,690	9,255
HyL	915	1,635	3,255	8,752
Purofer	150	150	860	860
Armco	0	330	330	330
* Others	1,785	3,668	4,782	4,982
Total	3,250	7,383	12,917	24,179

Note: * - Including processes using solid reducing agents (coal)

As is clear from Table 6.3-1, two DR processes using gas are at present predominant in the field of direct reduction. This indicates that the two processes, i.e. the Midrex and HyL processes, have been technically proven and commercialized. Therefore, the Midrex and HyL processes have been selected for this study. These processes are closely examined and compared as follows.

6.3.1.1 Midrex Process

The Midrex process was developed in 1965. After industrial experiments, two plants with an annual capacity of 200,000 tons were installed in 1969 in

Portland, Oregon, U.S.A.

This process was initially developed by Midland-Ross but is presently owned by Midrex, Corp., U.S.A.

Plants in operation as of the end of 1978 are listed with the first year of operation and production capacity.

U.S.A.	Gilmore	1969	200,000 t/y x 2
U.S.A.	Georgetown	1971	400,000 t/y
West Germany	Hamburg	1972	400,000 t/y
Canada	Sidbec No.1	1973	400,000 t/y
Argentina	Dalmine	1976	330,000 t/y
Venezuela	Sidor	1977	360,000 t/y
Canada	Sidbec No.2	1977	600,000 t/y
Qatar	QASCO	1978	400,000 t/y
Argentina	Acindar	1978	400,000 t/y

Furthermore, several plants are presently under construction. The Midrex process is a continuous shaft furnace process, where oxide pellets or a mixture of iron ore and oxide pellets are reduced at around 800°C. The reducing gases are produced by means of the catalytic reforming of natural gas and part of the top gas ($CO_2 + H_2O$).

The reduced products are gas-cooled in the lower part of the shaft furnace. The degree[*)] of metallization is about 92 - 95% (average 93%) at an average energy consumption of 2.8 Gcal per ton of sponge iron. Fig. 6.3-3 shows a flowsheet of this process.

*) $\frac{\text{Metallic Fe in Sponge Iron}}{\text{Total Fe in Sponge Iron}} \times 100$

The main features of the process are as follows:

1) Reduction is continuously performed in a shaft furnace by a countercurrent flow of reducing gas and iron oxide.

2) The oxygen from iron oxide exists as CO_2 and H_2O in the top gas, and is used for the reforming to produce reducing gas. (This process employs the closed circuit system in which part of the shaft furnace top gas is circulated and is reused in the process.)

3) CO_2 reforming as well as H_2O reforming take place concurrently.

Main advantages of these features are as follows:

1) High plant efficiency
2) Low gas consumption
3) Low water consumption

4) Very stable product quality

5) High degree of metallization of product

On the other hand, the process has the following disadvantages:

1) Depending upon the type of iron ore, the burden in the shaft furnace is apt to cause clustering, since the reducing gas temperature can be raised to a limited extent.

2) The electric power consumption is somewhat high.

3) It is necessary to pay attention to the sulfur content of iron ore.

6.3.1.2 HyL Process

The start of development of the HyL process dates back to the 1950s. In 1957, the first plant with an annual capacity of 95,000 tons was constructed in Monterrey, Mexico.

This process was jointly developed by HyLSA and Kellogg, but the selling rights for the process are now owned by Pullman.

Plants in operation as of the end of 1978 are listed below:

Mexico	Monterrey No. 1, HyLSA	1957	95,000 t/y
Mexico	Monterrey No. 2, HyLSA	1960	270,000 t/y
Mexico	Tamsa	1967	235,000 t/y
Mexico	Puebula No. 1, HyLSA	1969	315,000 t/y
Brazil	USIBA	1974	300,000 t/y
Mexico	Monterrey No. 3, HyLSA	1974	420,000 t/y
Venezuela	Sidor	1976	420,000 t/y
Mexico	Puebula No. 2, HyLSA	1977	700,000 t/y
Indonesia	Krakatau No. 1	1978	500,000 t/y

Moreover, several plants are currently being constructed. It should be noted that the plants in operation are mainly situated in Latin America.

The reduction of oxide pellets in this process is carried out in fixed bed reactors at 870 - 1,030°C in four steps: charging and discharging, actual reduction in two steps and cooling. The reducing gases are produced by the catalytic reaction of steam and natural gas. The degree of metallization ranges between 80 and 92% (average 85%) with an average gas consumption of 3.2 Gcal per ton of sponge iron. Fig. 6.3-1 shows a flowsheet of the process.

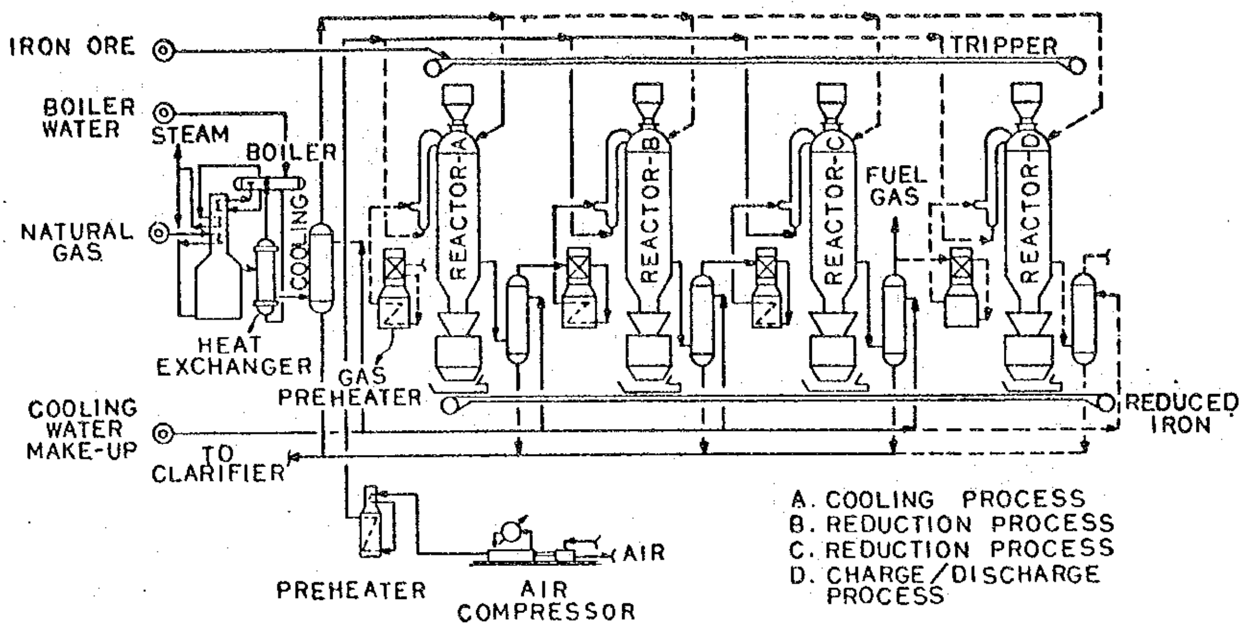


Fig. 6.3-1 Flowsheet of HyL process

The main features of the process are as follows:

1) Process is batch using fixed bed reactors, which are used in a cyclical manner.

2) The gas from the reactor is used as the fuel and is not circulated through the process.

3) Steam reforming is conducted, for the production of reducing gases.

The main advantages of these features are as follows:

1) The maintenance of the reactors is possible without a complete stop of production.

2) Low electric power consumption.

3) Clustering in the reactors seldom occurs.

4) The allowable sulfur content of iron ore is a little higher than in the Midrex process.

On the other hand, the process has the following disadvantages:

1) High total energy consumption (natural gas and electric power)

2) Considerable fluctuations in the quality of products, especially in the degree of metallization and the carbon content.

6.3.1.3 Comparison of the Two Processes

A comparative table (Table 6.3-2) has been prepared using standard operational data to make a comparison between the Midrex process and the HyL process.

For both processes, the comparison is made on the basis of a 600,000 ton-per-year module.

As is apparent from Table 6.3-2, the degree of metallization is different (Midrex process: 93% and HyL process: 85%) under standard operating conditions, therefore, the data at a degree of metallization of 85% for the Midrex process is shown in parentheses so as to make the comparison meaningful. In this case, an increase in production of 20% occurs in the same plant when using the Midrex process.

6.3.1.4 Selection of Process

The comparison and examination of the Midrex and HyL processes made on the basis of their outlines, features and operating data are summarized below:

1) In the Midrex process, sponge iron with uniform quality has been produced under stable operating conditions. In particular, this process ensures a high degree of metallization and proper control of carbon contents. This means that the Midrex process is more advantageous for the production of sponge iron for steelmaking.

2) From the raw material supply point of view, the two processes have almost the same requirement for iron ore and pellet quality except for the sulfur content. However, in the HyL plants few types of oxide pellets - namely, ARDAZA (Mexico) and CVRD - are used, while ten to eleven types of oxide pellets - such as LKAB, CVRD, Carol Lake and Hilton - as well as lump ore are used, either alone or in mixture in the Midrex plants.

3) The total energy consumption (natural gas and electric power) in the Midrex process is lower than in the HyL process.

From the above considerations, the Midrex process will be one of the most suitable processes for this project. Therefore, the technical and economic aspects of this feasibility study are tentatively based on the Midrex process. The process to be adopted for this project is, however, not yet fixed. The final selection of the process shall only be made after scrutinizing the bid evaluation.

Table 6.3-2 Comparison Sheet

Item	Midrex Process	HyL Process
a) Product		
Form	Sponge	Sponge
Degree of metallization	92 - 95% (85%)	80 - 92%, average 85%
Carbon content	Changeable within the range of 0.8 - 2.7%	Stable at approx. 2.2% and unchangeable
Apparent specific gravity	Approx. 3.2 (Approx. 3.1)	Approx. 3.1
Discharge temp.	60°C or below	60°C or below
b) Raw material	Pellets and/or lump ore	Pellets and/or lump ore
	Sulfur is the only important constituent for which there exists a limitation for the operation of Midrex plants. For the standard flowsheet, sulfur in the ore should not exceed 0.01% on the average. In the modified flowsheet an average maximum sulfur content of 0.02% is acceptable.	
c) Unit consumption	All figures indicate consumption per ton of product (songe iron).	
Iron ore (+6 mm) (Theoretical value at 67% Fe)	1.35 t (1.32 t)	1.32 t
Natural gas	2.8 (2.4) Gcal	3.2 Gcal
Electric power	135 (113) kWH	73 kWH
Water	0.2 - 1.5 m^3	1.9 m^3
d) Reduction furnace		
Type	Moving-bed shaft furnace	Fixed-bed retort
Reducing gas blowing temperature	760 - 900°C	1,000 - 1,100°C
e) Reformer furnace		
Type	Tube & box type	Tube & box type
Reforming process	CO_2 & H_2O reforming	Steam reforming
Reforming temp.	960°C	840°C

6.3.2 Production Plan

6.3.2.1 Basic Design Data

This study is based on the design data shown in Table 6.3-3, as follows:

Table 6.3-3 Gaseous Direct Reduction
Basic Design Data

(1) Plant Capacity		703,000 t/y
(Nominal)		(600,000 t/y)
Total Fe of Songe Iron		92.7%
Metallization, Nominal		93 %
(Range)		(92 - 95%)
Carbon Content, Nominal		1.5%
(Changeable range)		(0.8 - 2.7%)
Product Fe		651,000 t/y
(2) Plant Availability		
(Rated oper.)		312.5 days/y
		(7,500 h/y)
(Expected)		333.3 days/y
		(8,000 h/y)
(3) Average Production Rate	Hourly	93.8 t/h
	Daily	2,250 t/d

(4)	Oxide Feed	Hourly	135.3 t/h
	to oxide screen	Daily	3,248 t/d
	(Total Fe : 67.96%)	Yearly	1,015,000 t/y
	Oxide Screen Undersize		4% max.
	(-3 mm)		(=41,000 t/y)
	Furnace Feed		974,000 t/y

6.3.2.2 Production Plan

The capacity of this plant is 703,000 t/y as shown in Table 6.3-3. If this figure is defined as 100% plant capacity, production of the plant after the first month of operation will be 50% capacity, and it will gradually increase thereafter. By the end of the first year, production will reach 100% capacity.

Regarding the iron oxide feed, only oxide pellets shall be used during the first and second years, while the personnel acquire operational expertise. From the third year, a mixture containing approximately 30% lump ore shall be used.

6.3.2.3 Material Flow/Balance

Drawings No. JICA-6.3-01 and JICA-6.3-02 show the general layout and elevation respectively.

The oxide feed (pellets and/or lump ore) is conveyed from the ore yard to the oxide day bin. The capacity of the bin is 3,600 tons, which is equivalent to the requirement for about 24 hours' operation. Then the oxide feed is drawn out according to the production rate. After the fines are removed with a screen, the oxide feed is fed to the top of the furnace.

The removed oxide fines can be sold to cement plants as an additive to raw material, or to sintering plants as iron raw material.

The metallized product from the furnace is sent to the product storage bins and stored under inert atmosphere. These bins can store 18,000 tons, or enough to meet about 8 days' steel making shop requirement.

After the product is screened, the undersize is agglomerated into briquettes, then both the screen oversize and the briquettes are transported to the steel making shop.

Fig. 6.3-2 shows the material balance of this direct reduction plant.

6.3.2.4 Expansion Plan of DR Plant

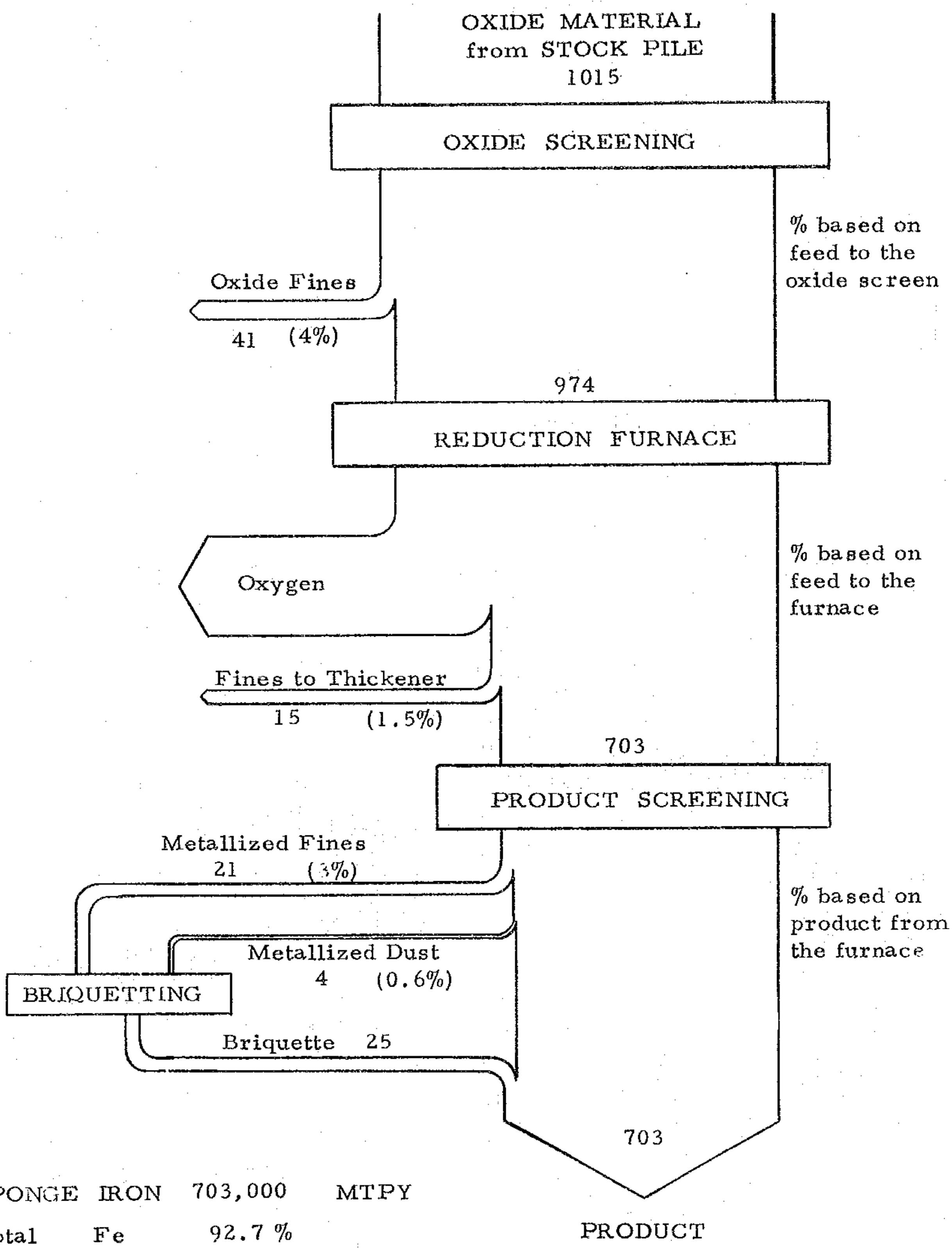
The expansion plan of this project is mentioned in Section 4.5.

In case of the alternative plan, equipment expansion of one 400,000 t/y module is enough from the point of sponge iron demand. However one 600,000 t/y module is proposed same as the double capacity plan.

Because the selection of the 600,000 t/y module has the several advantages i.e., to achieve spare parts interchangeably, to decrease imported scrap by decreasing scrap mixing ratio, to make available a certain amount of sponge iron for sale to other local steel plants in Egypt and, in general, to get operational flexibility.

Therefore, the 600,000 t/y module is selected in stead of the 400,000 t/y module.

Fig. 6.3 - 2 MATERIAL BALANCE OF DR PLANT



SPONGE IRON		703,000	MTPY
Total	Fe	92.7 %	
Product	Fe	651,000	MTPY

x 1,000 MTPY

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6.3.3 Process and Equipment Description

The Midrex direct reduction process is designed to convert iron oxides, in the form of pellets or lump ore, to highly reduced products suitable for steelmaking. To accomplish this, the reduction process utilizes a continuous flow of reducing gases to chemically extract oxygen from the iron oxide pellets and to carburize the reduced products. A simplified Process Flow Schematic is shown in Fig. 6.3-3.

The reduction process is carried out below the fusion temperature of the feed material. Hydrogen and carbon monoxide gases, produced in the reformer, are introduced into the burden in the reduction furnace under controlled analysis and temperature conditions. The ascending gases heat the descending raw material to the reduction temperature, enabling hydrogen and carbon monoxide to react with the iron oxides, which creates highly metallized products. The primary chemical reactions occurring in the Midrex direct reduction process are:

1) Reduction $Fe_2O_3 + 3H_2 \longrightarrow 2Fe + 3H_2O$

$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$

2) Carburizing $3Fe + 2CO \longrightarrow Fe_3C + CO_2$

3) Reforming $CH_4 + H_2O \longrightarrow CO + 3H_2$

$CH_4 + CO_2 \longrightarrow 2CO + 2H_2$

Upon leaving the reduction furnace, the partially spent gas (top gas) is cleaned and cooled by the top gas scrubber, mixed with natural gas to prepare the mixture for the reforming process, preheated in the process gas preheater, and is recirculated to the reformer. Reforming takes place over a catalyst which is indirectly heated in a refractory lined furnace. Reforming results in increased gas volume of approximately 30%. The process gas preheater increases the thermal efficiency of the plant by utilizing hot flue gases produced by firing the reformer.

Excess top gas (top gas fuel), resulting from the gas volume expansion, and natural gas are used, along with preheated combustion air, to fire the reformer burners.

In the lower portion of the reduction furnace, cooling gases are recirculated to cool the burden before discharge. Upon leaving the cooling zone, cooling gas is passed through venturi scrubbers to condense the water vapor and remove dust particles before the gases are compressed and recirculated.

Major equipment and systems that make up the Midrex direct reduction plant are listed in the following Table 6.3-4.

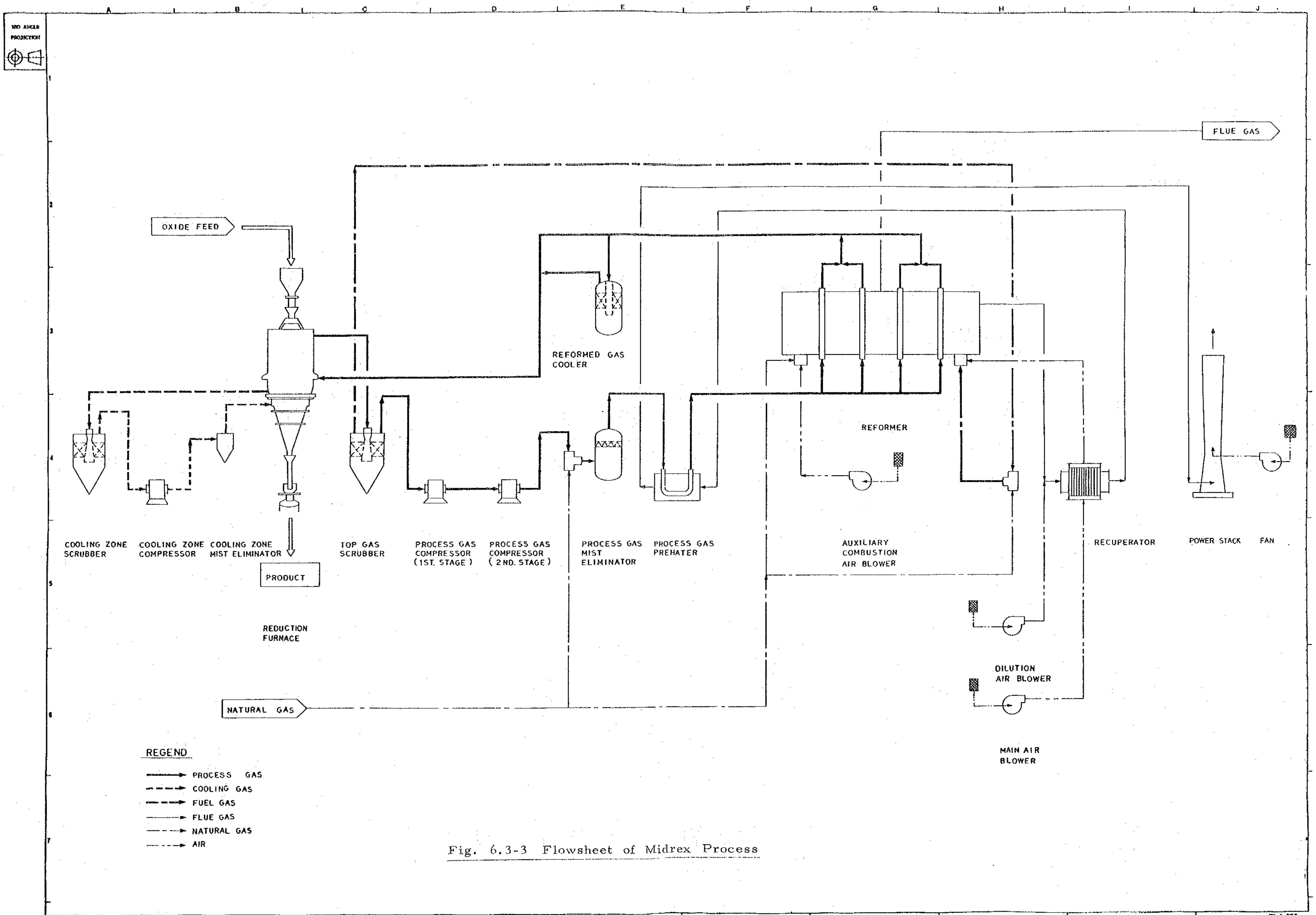


Fig. 6.3-3 Flowsheet of Midrex Process

Table 6.3-4 Major Equipment List

	Equipment or System	Q'ty	Description
1	Direct Reduction Furnace	1	Shaft Furnace (Nominal capacity 600,000 t/y) equiped with Charge Hopper, Slide Gates, Burden Feeders and Wiper Bar
2	Reformer	1	200 mm dia. Tubes with Catalyst
3	Top Gas Scrubber	1	Venturi and Packed Tower Type
4	Cooling Zone Scrubber	1	- ditto -
5	Reformed Gas Cooler	1	Packed Tower Type
6	Seal Gas Cooler	1	Packed Tower Type
7	Preheater	2	Shell & Tube Type Heat Exchanger
8	Recuperator	2	Shell & Tube Type Heat Exchanger
9	Stack	1	Height: Approx. 50 m
10	Process Gas Compressor	4	Positive Displacement Type Rotary Lobe Compressors
11	Cooling Zone Compressor	1	- ditto -
12	Main Air Blower	1	Centrifugal Air Blower

Equipment or System	Q'ty	Description
13 Auxiliary Air Blower	1	Centrifugal Air Blower
14 Dilution Air Blower	1	Centrifugal Air Blower
15 Seal Gas Compressor	2	Rotary Lobe Compressors
16 Mist Eliminator	3	for Process Gas, Cooling Gas & Seal Gas
17 Piping System	1 set	including Valves and Fittings
18 Dust Collection System	1 set	composed of Cyclones, Venturi Scrubbers, Fans and Dust Storage Bin
19 Compressed Air System	1 set	composed of Plant Air Compressor, Instrument Air Compressor and Dryer
20 Briquetting System	1 set	Capacity: 20 MT/H
21 Water System	1 set	composed of Clarifier, Cooling Towers and Pumps
22 Electrical and Instrumentation System	1 set	Max. Capacity: 22 MVA
23 Product Storage Bin	3	Capacity: 6,000 MT x 3 equiped with Feeders
24 Oxide Day Bin	3	Capacity: 1,200 MT x 3 equiped with Feeders
25 Material Handling System	1 set	composed of Screens, Cluster Mill, Belt Scalts and Belt Conveyors

6.3.4 Data for Operation Cost Estimation

The operation requirements to produce one ton of sponge iron are listed below.

1) Iron Oxide Pellets — 1.444 tons (Oxide Fe 67.96%)
2) Natural Gas — 309 Nm^3
   @9,070 Kcal/Nm^3 (Net) (2.8 Gcal - Net)
3) Electric Power — 135 KWH
4) Fresh Industrial Water — 1.5 m^3
5) Nitrogen Gas — 3.1 Nm^3
6) Personnel
   15 - Administrative — 0.044 man-hours
   41 - Operating — 0.122 man-hours
7) Maintenance and Operating Supplies — $3.5

6.3.5 Organization and Manpower Requirements

The following personnel are required for the smooth operation of the DR plant as shown in Table 6.3-5.

Table 6.3-5 Manpower Requirements

General Administration

Plant Manager	1
Process Engineer	2
Plant Engineer	2
Assistant Plant Engineer	3
Operating Superintendent	1
Assistant Superintendent	4
Secretary	1
Clerk	1
Total	15

Operating Labor

General Foreman	1
Shift Foreman	4
Assistant Shift Foreman	4
Plant Operator	12
Operators' Helper	8
Loadout Operator	4
Laborer	8
Total	41

6.3.6 Desulfurizing Facilities

The natural gas supplied from the Abu Qir gas well contains 75 ppm (Vol.) sulfur as shown in Table 6.10-8. However, the sulfur in natural gas is restricted. If the sulfur content is more than 5 ppm, the catalyst in the reformer tube shall be damaged, and consequently the reforming capacity shall be reduced. Therefore desulfurizing facilities, which remove sulfur from the natural gas up to the safety level (3 ppm), are taken into consideration in this study.

Among several desulfurizing processes, the Stretford process has been selected for the following reason.

Within the total sulfur content of natural gas, H_2S is the main component while the quantity of organic sulfur is less than 2 ppm. The Stretford process can remove H_2S up to less than 1 ppm. Therefore the total sulfur content can be reduced to less than 3 ppm.

The Stretford process is the only process which can reduce the sulfur level to such a figure by a single process. Other methods require the combination of two processes in order to achieve same result. The Amine process in combination with the Zinc Oxide process can be employed, but the initial cost is higher than that of the Stretford process in this case.

Therefore in this study it is assumed that the Stretford process is to be used.

Operation requirements and personnel requirements for the desulfurizing facilities are included in the figures for the direct reduction plant.

6.3.7 Brief Comparison of Production Cost of Sponge Iron and Molten Steel (Reference Only)

The cost comparison sheets of sponge iron base and molten steel base between the Midrex process and the HyL process are shown in Table 6.3-6 and 6.3-7 respectively.

Figures for the Midrex process are based on this feasibility study. Figures for the HyL process are based on the recent published data, and some of them are corrected according to the calculation results to make fair comparison with the Midrex process. And those figures which are not shown in the HyL published data are assumed to be same as the Midrex figures. It is assumed that the same oxide raw material is used for both processes.

These costs are the operation cost of the eighth year after starting this project, regardless of inflation factor, and excluding depreciation and interest.

6.3.7.1 Cost of Sponge Iron

As shown in Table 6.3-6, the operation cost of the HyL process is a little higher than that of the Midrex process due to the higher unit energy consumption. This difference is more remarkable when the metallization is 90% in the HyL process.

In the operation data of the HyL process, the electricity consumption is zero, the reason for which is that the Puebla No.2 Plant is designed to produce its own electric energy from steam generated throughout the process.

6.3.7.2 Molten Steel Cost

The molten steel costs shown in Table 6.3-7 are calculated based on the following premises.

Sponge Iron/Scrap Ratio;

Sponge Iron : Scrap - 75 : 25
(Fe base)

Fe Yield;

50% of FeO in sponge iron is assumed to be taken away as slag, and Fe in auxiliary raw material is neglected.

Yields in each metallization are as follows;

Metallization	93%	90%	85%
Yield	93%	91.9%	90%

In actual operation using both the Midrex sponge and the HyL sponge, Fe Yields show respectively 2-4% higher than the above figures, depending upon the operating condition. However they are adopted according to the figures of this feasibility study which includes safety factor.

Electric Power Consumption;

According to the HyL data, the electric power consumption is 640 KwH/t-molten steel, but this figure excludes electric power consumption at the supporting facilities, which is supposed to be about 30 KwH/t-molten steel. So, 670 KwH/t-molten steel is assumed.

The operation data, when using sponge iron of 90% metallization, is not published, so 640 KwH/t-molten steel is assumed based on theoretical calculation.

Meanwhile, the figure of 700 KwH/t-molten steel used in this feasibility study includes a little excess in order to admit variety of operating condition such as scrap quality, etc.

As shown in Table 6.3-7, the calculation result says that the operation cost is higher when using the sponge iron of lower metallization.
The biggest factor is the difference of yield, and this comes from FeO content in the sponge iron.

Table 6.3-6 Brief Comparison of Sponge Iron Production Cost

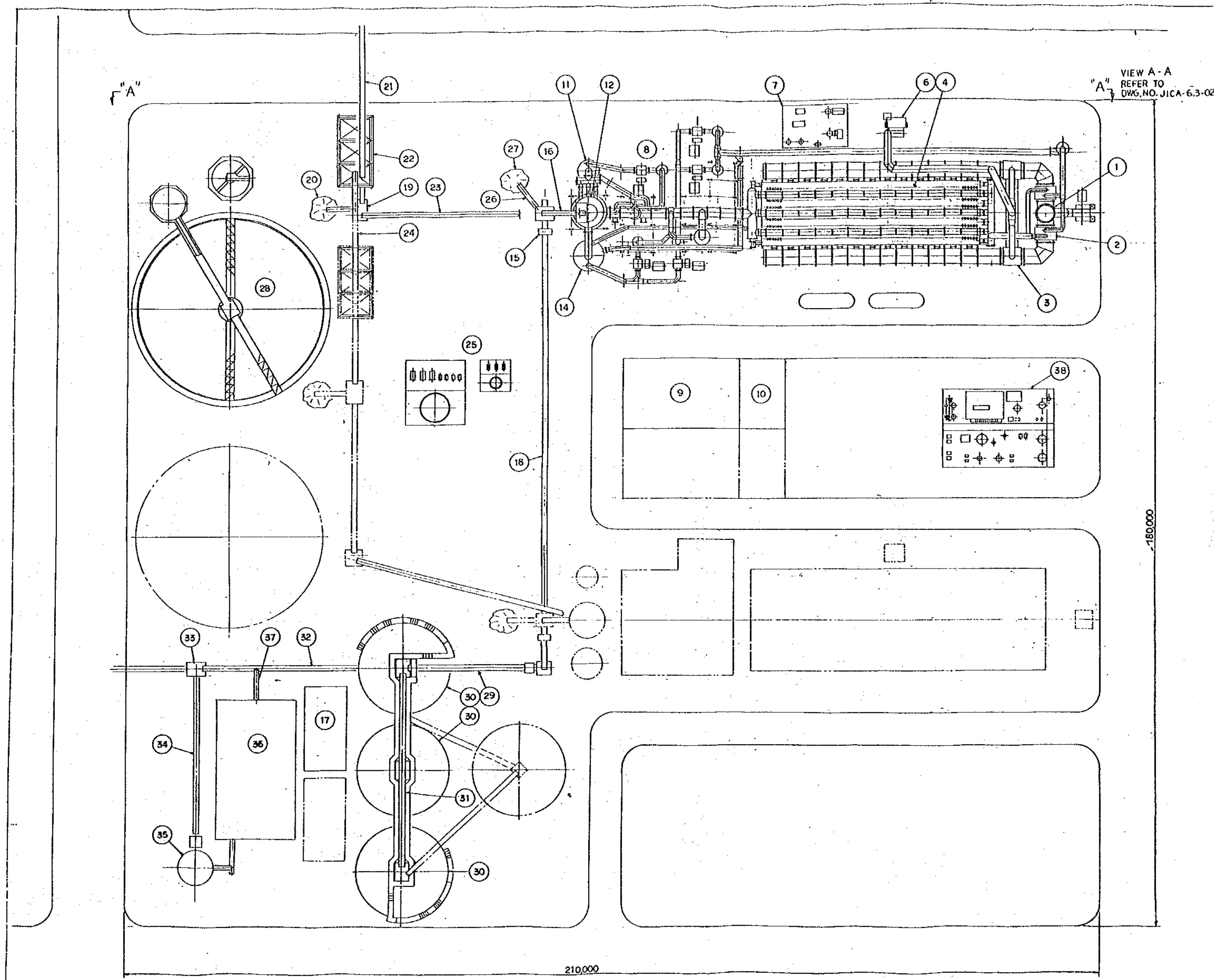
	Q'ty Unit	Unit Price (U.S.$)	Expected Figures in F/S Report				*1 Actual Figures in Puebla No.2 (1977)			
			Midrex (Metallization 93%)		HyL (Metallization 85%)		HyL (Metallization 90%)		HyL (Metallization 85%)	
			Q'ty	Cost($)	Q'ty	Cost($)	Q'ty	Cost($)	Q'ty	Cost($)
Variable Cost										
Iron Ore	MT	36.200/MT	1.436	51.983	*2 1.396	50.535	*2 1.415	51.223	*2 1.396	50.535
Natural Gas	Nm^3	$0.087/Nm^3$	309	26.883	353	30.711	*3 416	36.192	*3 384	33.408
Electric Power	KwH	0.025/KwH	135	3.375	73	1.825	0	0	0	0
Water	m^3	$0.327/m^3$	1.5	0.491	1.9	0.621	2.02	0.661	1.85	0.605
Nitrogen	Nm^3	$0.055/Nm^3$	3.1	0.171	3.1	0.171	3.1	0.171	3.1	0.171
Operating Expendables	-			0.210		*4 0.210		*4 0.210		*4 0.210
Intra-Mill Transportation	MT	0.732/MT	0.078	0.057		0.057		0.057		0.057
Fixed Cost										
Employees Wages	M-H	1.398/M-H	0.166	0.232	0.12	0.168	0.13	0.182	0.12	0.168
Benefits	-			0.060		0.043		0.047		0.043
Maintenance	-			3.390		3.390		3.390		3.390
Factory Overhead	-			0.082		0.082		0.082		0.082
Others (Royalty)	-			2.000		2.000		2.000		2.000
Sponge Cost/MT				88.934		89.813		94.215		90.669
Total Fe in Sponge	(%)		91.0%		88.4%		89.6%		88.4%	
Fe Cost/MT				97.730		101.598		105.151		102.567

* Note:
1. Source; Stahl und Eisen, 1978, No.23
2. Theoretically calculated based on same premise as Midrex. (Original: 1.32, 1.35)
3. Corrected based on Natural Gas calolific value. (Original: 382, 414)
4. Corrected, because original figures seem too large. (Original: 0.9, 0.99)

Table 6.3-7 Brief Comparsion of Molten Steel Production Cost

	Q'ty Unit	Unit Price (U.S.$)	Expected Figures in F/S Report		*1 Actual Figures in Monterrey			
			Midrex (Metallization 93%)		HyL (Metallization 90%)		HyL (Metallization 85%)	
			Q'ty	Cost($)	Q'ty	Cost($)	Q'ty	Cost($)
Variable Cost								
Sponge	MT		0.8827	78.503	*2 0.9108	85.811	*2 0.9425	85.456
Scrap	MT	153.2/MT	0.2716	41.609	*2 0.2720	41.670	*2 0.2778	42.559
Fe-Mn/Fe-Si	Kg	0.446/Kg	11	5.123				
Lime	Kg	0.028/Kg	75	2.122	*3 40	1.120	*3 40	1.120
Coke Breeze	Kg	0.121/Kg	4	0.484	0	0	0	0
Fluorspar/Al	Kg	0.458/Kg	2.5	1.146				
By-Product Scrap	MT	-153.2/MT	0.01	-1.532				
Natural Gas	Nm^3	$0.087/Nm^3$	2	0.174				
Electric Power	KwH	0.025/KwH	700	17.500	*4 640	16.000	670	16.750
Water	m^3	$0.327/m^3$	3.4	1.112				
Oxygen	Nm^3	$0.055/Nm^3$	2	0.110	*5 2	0.110	*5 1.2	0.066
Compressed Air	Nm^3	$0.004/Nm^3$	15	0.060				
Furnace/Ladle Brick	Kg	0.590/Kg	11.5	6.785				
Refractory of Repairing	Kg	0.375/Kg	11	4.125		3.190		3.190
Electrode	Kg	2.379/Kg	5	11.895	5.3	12.609	5.3	12.609
Miscellaneous	-			3.991				
Intra-Mill Transportation	MT	0.732/MT	0.5907	0.432				
Fixed Cost								
Employees Wages/Benefits	-			1.063				
Maintenance				3.625				
Factory Overhead	-			0.299				
Molten Steel Cost/MT				178.626		182.788		184.028

* Note:
1. Source: Equivalent Metallization of Sponge Iron, ILAFA Congress, Oct., 1976
2. Calculated based on scrap ratio of 25%. (Original: 0.8423, 0.3191)
3. Corrected because original figure seems too small. (Original: 5.7)
4. An additional electricity consumption is theoretically 6 KwH/MT of molten steel per each 1% less metallization of sponge. (Original: No data)
5. Calculated based on carbon balance. (Original: No data)
6. Blank figures in the HyL column are adopted with the Midrex figures.

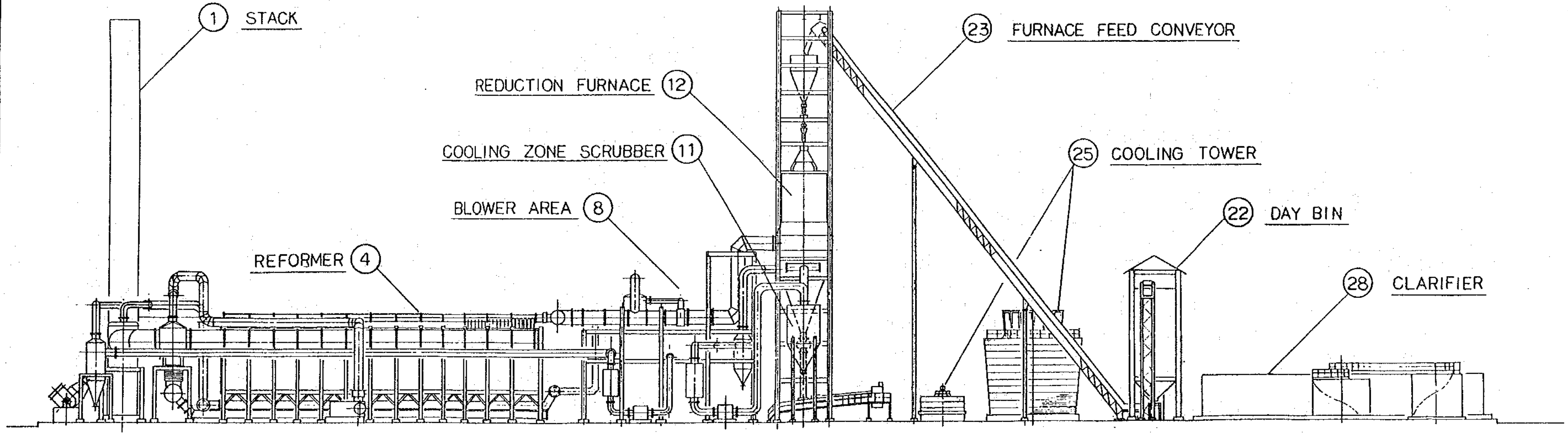


LEGEND

1 STACK
2 PROCESS GAS PREHEATERS
3 RECUPERATORS
4 REFORMER
5
6 MAIN AIR BLOWER
7 COMPRESSOR BUILDING
8 BLOWER AREA
9 CONTROL ROOM
10 TRANSFORMER AREA
11 COOLING ZONE SCRUBBER
12 REDUCTION FURNACE
13
14 TOP GAS SCRUBBER
15 PRODUCT SCALE
16 FURNACE DISCHARGE CONVEYOR
17 DUST COLLECTION FACILITY
18 PRODUCT TRANSFER CONVEYOR
19 OXIDE SCREEN
20 OXIDE FINES PILE
21 OXIDE DAY BIN CONVEYOR
22 DAY BIN (1200 T × 3)
23 FURNACE FEED CONVEYOR
24 OXIDE TRANSFER CONVEYOR
25 COOLING TOWER AREA
26 POTABLE REMET CONVEYOR
27 REMET PILE
28 CLARIFIER
29 SURGE BIN FEED CONVEYOR
30 6000 M.T. SURGE BIN × 3
31 STORAGE BIN TRANSFER CONVEYOR
32 PRODUCT LOAD OUT CONVEYOR
33 PRODUCT SCREEN
34 PRODUCT FINES CONVEYOR (BRIQUETTING)
35 PRODUCT FINES BIN
36 BRIQUETTING FACILITY
37 BRIQUETTE DISCHARGE CONVEYOR
38 DESULFURIZING FACILITY

------ FUTURE

ELDIKHEILA PROJECT
Dwg. No. JICA-6.3-01
DIRECT REDUCTION PLANT GENERAL LAYOUT
Scale
Date April, 1979



VIEW "A ~ A"

ELDIKHEILA PROJECT
Dwg. NO. JICA-6.3-02
DIRECT REDUCTION PLANT ELEVATION
Scale
Date APRIL, 1979