3-4-3 Quechua Mine

Since this mine is still under investigation, definite water requirement have not yet been given. However, it is estimated to be in a range from 8,000 m^3/day to 12,500 m^3/day, which is the largest amount among the three mines. The Allahualla River flowing near the Quechua Mine has a catchment area of 62 km^2. The drought water discharge, as measured in this field survey, is 430 l/min (620 m^3/day), which is much less than the demand.

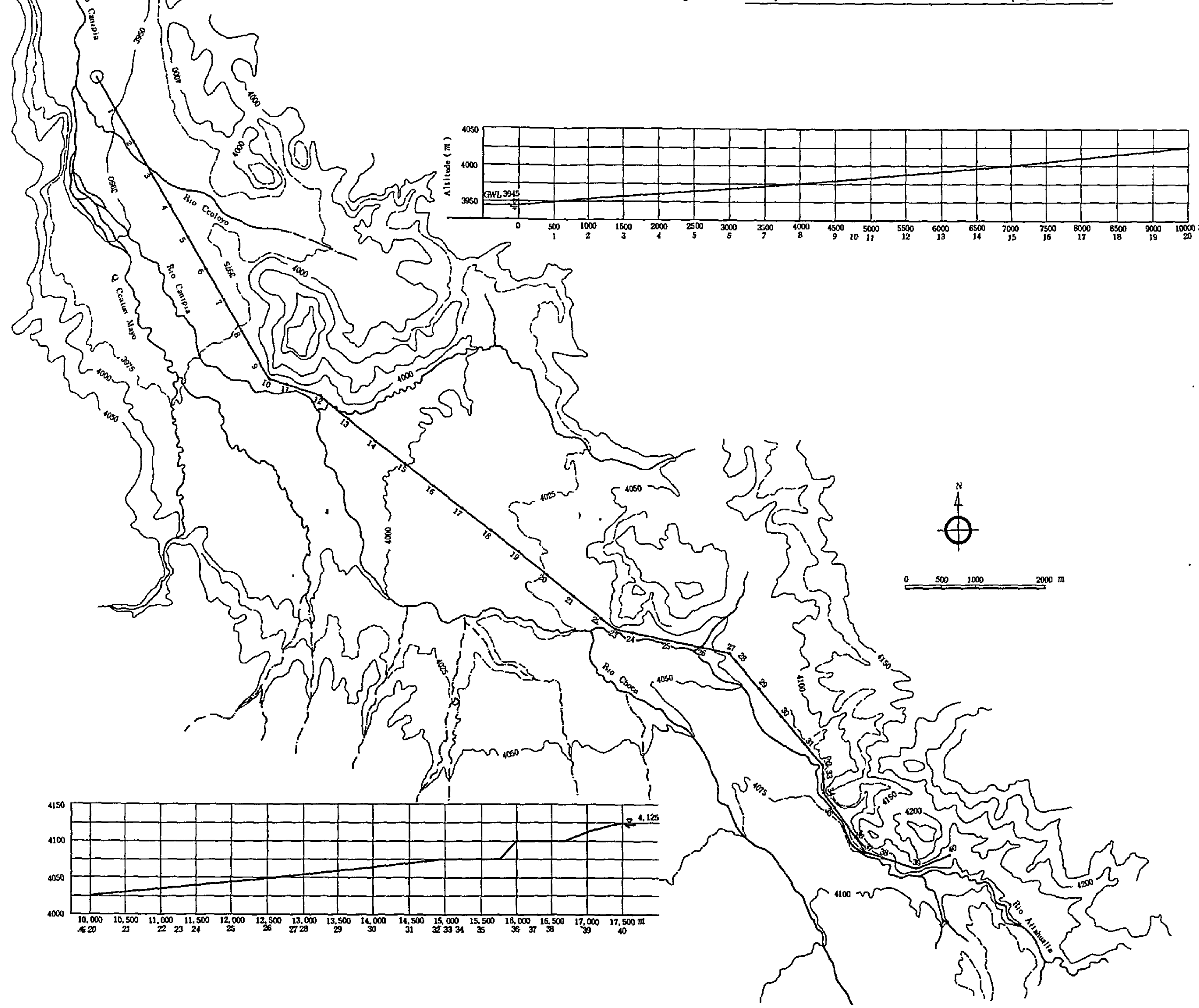
There are three possible alternatives for source of the water: the Oguero River 33 km northwest of the Quechua Mine; the Salado River flowing on the east side; and the influent stream water of the Cañipia River flowing in the same watershed as the Quechua Mine. These alternatives are to be examined in order as follows; (1) possible water-intake site on the Oquero River is about 3,850 m above sea level and transport distance is over 30 km; (2) a proposed water-intake site on the Salado River is 3,900 m above sea level and transport distance is about 15 km but the piping allignment must go over hills which divide the Salado River and Cañipia River basins at an elevation of 4,350 m; (3) the proposed water-intake site on the Cañipia River is 3,925 m above sea level and transport distance is about 17.5 km. It is necessary, however, to bring in influent stream water (non-pressurized underground water) because surface runoff is not sufficient to meet mine requirements.

By rough calculation, the sum of operation cost for a 100 m lift plus depreciation costs of initial construction are nearly equal to depreciation costs of the initial investment in laying steel pipe underground for a horizontal distance of approx. 7 km. Therefore, the Salado water-intake plan is far more expensive than the Cañipia water-intake plan. By the same token, the Ocoruro plan is evidently more expensive than the Cañipia plan.

From the above considerations, the confluence of the Cañipia and Ccatun Mayo Rivers (catchment area: 349 km^2) is an appropriate site for water-intake to the Quechua mine. This site is located at the center of a circularshaped valley of about 50 km^2 which consists of extensive marshland. The alluvial bed of the swamp is assumed to be formed of gravel and it's depth may be tens of meters. The surface of undercurrent water (non-pressurized underground water) is near the ground surface. Judging from the topography, river conditions and visual inspection around the area, the Study concludes that there is a fairly large amount of rechargeable underground water layer (depression storage) by which the industrial water requirement (10,300 m^3/day) at the Quechua Mine may easily be supplied.

Because this water-intake site is downstream from the Quechua Mine itself, it is feared that surface water may be affected by waste water from the mine. However, the waste water from the Atalaya Mine currently in operation has had no serious effect on the quality of surface water. Further, in view of the fact that influent stream water will be pumped up, the

Fig. 4-8 Proposed Water-Intake Plan for Quechua Mine



water quality will not be so polluted as to become unsuitable for ore dressing even if it is contaminated by mine waste water.

For domestic water, half the requirement would be taken from the Allahualla River nearby the mine, as mentioned earlief. The other half is pumped up from wells in and around the housing districts.

The proporsed water-intake site is given in Photo 4-3 and Fig. 4-8 together with the routes of the pipelines. Table 4-9 shows rough dimensions of facilities and construction costs (as of October, 1979).

Photo 4-3 Prospective Water-Intake Point on Cañipia River (viewed from downstream)

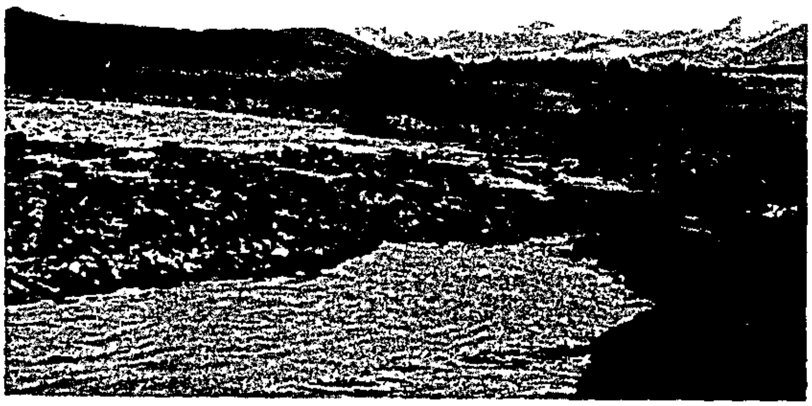


Table 4-9 Dimensions on Industrial Water-Intake Structures for Quechua Mine and Construction Costs (as of Oct. 1979)

Item		Rough Dimensions		Construction cost (in thousands of soles)
(a)	Water-intake			
	Influent water intake	Percorated underground pipe (Concrete pipe) ø800 mm x 100 m ø500 mm x 100 m		13,600
	Connecting well	Concrete 2 units		900
	Suction pit	Concrete 1 unit (including pump house pump head)		2,200
	Under water pump	2.4 m^3/min. 10 m Pump head 6 units (2 units as standby reserve)		8,100
	Intake channel	10 m, Concrete		1,600
			Subtotal	26,400
(b)	Water Conveyance			
	Suction pit	Concrete	1 unit	3,000
	Pump house	50^2m		2,700
	Pump	9.6 m^3/min, 150MH, 2 units (1 unit as standby reserve) including installation cost		40,600
	Pipeline	500 mm black G.O. 175 km including installation cost and accessory equipment		342,000
			Subtotal	388,300
(c)	Distributing reservoir			
	Head tank	5000 m^3 x 2 units concrete structure		21,800
			Subtotal	21,800
(d)	Domestic Water Supply			
	Surface water-intake pump	423 l/min, Concrete weir 560 l/min, 20 MH x 2 units (1 unit as standby reserve)		500 800
	Shallow wells	4 shallow wells, 10 m (including casing etc.)		4,000
	Pump	150 l/min, 13 MH x 5 units (1 unit as standby reserve)		500
	Pipe	ø100 mm x 500 m		2,200
	Distributing reservoir	500 m x 2 units		3,000
	Purifying equipment			500
			Subtotal	11,500
			Total	448,000

4. Irrigation Plan

The purpose of this section is to provide basic information necessary to formulate irrigation plans in the agriculture and livestock farming sector. Detailed information for irrigation projects in the area is presented in Chapter 8.

4-1 General Outline

The Project ARea is located on highlands at an elevation over 3,900 m. Climatic conditions are unfavorable for cultivation. As mentioned in 1-2-1, there are wide seasonal fluctuations in the minimum daily temperature. Even papa amarga, a pure breed of potato said to be resistant to low temperatures, often suffers from cold-weather damage in June.

Precipitation marks a sharp distinction between the wet and dry seasons as mentioned in 1-2-2. During the wet season between April to October, 770 mm of rain on the average for the past years is close to the total annual precipitation is recorded. Consequently, little effective rain is observed in the dry season.

The earth is acidic and the topsoil is only 40-50 cm deep throughout the Project Area. Under the topsoil is either a deep gravel layer or limestone.

Due to these natural conditions, the project area is inferior to other low-elevation areas as regards caltivation. Farm products consumed in this area at present are supplied from either the Arequipa or Cuzco areas. The fact is that it is less advantageous for this area to supply its own needs even allowing for the costs of marketing and transportation from other areas.

However, if a stable supply of irrigation water is available, it may be possible to cultivate improved varieties of potatoes in addition to the papa amarga now being grown and to harvest crops before cold-weather comes in June.

Under the general conditions mentioned above, there may be little economic advantage in carrying out irrigation projects independently in the Project Area. A possible measure is to build up a foundation for agricultural production by utilizing facilities related to mine development to the maximum extent compatible with the performance of the mine development project.

4-2 Selection of Suitable Irrigation Area

In the project area, there are two potential areas for irrigation. They have easy access to water-intake structures of the mines as well as topographical advantages. One is a river errace along the left bank of the Salado River and the other it is Finaya Pampa extending south of Yauri City.

However, there are some constraints on these; (1) the water of the Salado River is so affected by hot springs scattered throughout its upper reaches (1,000 ppm of salt during the dry season) that it is unsuitable for irrigation purposes. (2) the surface water discharge in the Cañipia River flowing through the pampas south of Yauri City is too small for irrigation.

From the above considerations of potential areas and constraints, the possible source of irrigation water is limited to the Ocoruro River. The proposed irrigation site is Pampa Canlli on the left bank of the Salado River where an open channel flow from the Ocoruro River is possible. The area of about 500 ha is currently under rain-fed cultivation. This area is on the river terrace land formed by the Salado River, decending slowly towards the east.

The topsoil at this site is 40-50 cm in depth with a pebble underbase (see Photo 4-4). Tests of soil samplings at the site are given in Chapter 8.

Photo 4-4 Top Soil Layer in Irrigation Site

4-3 Availability for Irrigation Water and Irrigation Plan

4-3-1 General Outline of Irrigation Plan

It is proper to construct headworks close to the water-intake weir to be built for the Coroccohuayco Mine at a point above the confluence of the Ocoruro and Salado Rivers. The obtainable discharge for irrigation in the most severe drought period is one that will not interfere with the quantity of water-intake for the mine. This is 0.165 m^3/s, which is estimated by subtracting 0.035 m^3/s (mine requirements) from

0.20 m^3/s (average annual drought water discharge of the Ocoruro River).

However, it is certain that average discharge during the dry season is more than the drought water discharge above mentioned. It is also expected that a considerable portion of mine water requirements may be supplemented by underground water springing from mining the pits. Therefore, the Study employs the discharge of 0.2 m^3/s as the normal design discharge for irrigation facilities.

The intake-weir is of course commonly used with the Coroccohuayco Mine. A receway should be built along the road from the intake to Yauri City. The length to the entrance of the irrigation fields would be 7 km. The slope gradient of the raceway is 1/1000, and is of a trapezoidal concrete channel A plan for the irrigation farming method is given in Chapter 8.

Major structural dimensions of irrigation facilities from the intake to the farm land are given in Table 4-10 together with construction costs (as of October 1979).

Table 4-10 Dimensions of Irrigation Structures and Construction Costs

Item	Dimensions	Construction Cost (in thousands of soles)
(a) Intake	Built in mine suction pit, concrete structure with stop log gate Q max = 0.4 m^3/s Q mini = 0.165 m^3/s	400
(b) Raceway	Concrete, trapezoidal cross-section Grade 1/1000, Length 7 km	21,600
	Total	22,000

5. Urban Water Supply

A description is given in this section of the present state of water supply in Yauri and Hector Tejada Cities as well as what effects water-intake and waste water of the three mines will have on water supply conditions in both cities.

5-1 Waterworks in Yauri City

The present source of water supply is surface runoff from the Huayllumayo River near Pampachaco, situated 12 km south of Yauri City. From this intake site, water is conveyed through a 3 m wide soil channel for a distance of approximately 6 km where it is then divided into domestic water and power generation water. Domestic water is carried through a sedimentation pond (15 m long) by steel pipe (8 in dia.) to the distribution head tank (150 m^3 capacity) on a hill in Yauri City. There is no purification plant in the system. Power generation water is carried through a soil channel to the head tank of a small hydroelectric power plant (maximum possible output: 10 kW) in Yauri City. This power generation water channel passes through the pampas south of Yauri City and a portion of the water is used for irrigation and domestic purposes along the way.

The feeding capacity of the water supply system is about 800 m^3/day during the dry season and 1.500 m^3/day during the wet season. Available quantity per person per day during the dry season is about 140 ℓ, allowing for a 30% distribution loss, which does not mean a serious shortage. There are 400 hydrants for both private and common use in the city. The quality of the water is very poor and is unsuitable for drinking.

Under these circumstances, a general plan to improve the existing supply system has been completed by Ministerio de Vivienda. The plan contemplates making use of the Cañipia River as a water-intake source. This is under the influence of dressing waste water from the Atalaya Mine currently in operation and the Quechua Mine planned for future development. Further, the Cañipia River may not have sifficient surface runoff to feed the water supply system of Yauri City because a large quantity of the discharge is expected to be used at the Quechua Mine. Therefore, it is not wise to make use of the Cañipia River as source water for Yauri City from the view points of quantity and quality. From the above, substantial coordination is strongly needed between the improvement planning of Yauri City's water supply system and the development planning of Quechua mine.

It is recommendable for Yauri City to make use of the Huayllumayo River as a source of domestic water supply. The Huayllumayo River flows in a different watershed from the Cañipia River basin. Thus the intake-water will not be affected by mine development.

5-2 Urban Water Supply in Hector Tejada City

From 1967 to 1977, the Pallpatamayo River was used as a water source for drinking purposes. Water was pumped up to an elevated water distribution tank (30 m^3 capacity) located at the center of the city. In 1977, however, the water-intake source was changed to springs on a hill near the Coroccohuayco Mine site because of problems posed by fuel costs for pumping. From the springs, water is carried by gravity through a 2-in. pipe to the elevated tank for a distance of 11 km.

There are about 100 hydrants in the city. Available quantity per person per day in about 150 ℓ, and the water rate is 100 soles per hydrant per month.

As water is from springs, it is of superior quality, causing no problems. However, the springs run dry during the dry season between June and September.

Because the springs are located within the Coroccohuayo mining area, they may well be affected by mine development. That is, the underground water level will falling as a result of mining in the area. Then the springs may dry up and no longer serve as a source for Hector Tejada's water supply. Therefore, with the development of the Coroccohuayo Mine, it will be necessary either to use the former Pallpatamayo River source, 2 km north of Hector Tejada City, which poses no quality or quantity problems, or to expand the Coroccohuayco Mine waterworks to meet city requirements, feeding the city via the existing pipelene.

6. Summary and Recommendations for Further Detailed Studies

The Project Area is generally so rich in water resources that it is technically and economically possible to meet water requirements.

As to the Quechua Mine, it would be advisable to make a quantitive study of influent stream water on the Cañipia River, i.e., a pumping test on the river channel.

As for domestic water, the Tintaya Mine has a problem with the quality of water from the Salado River. During the dry season in particular, measures such as water softening and dilution with underground water, are necessary. The Quechua Mines will have no problem with water quality, but it will be necessary to consider utilization of underground water since surface water is not sufficient to meet requirement.

As a matter of general opinion, this area abounds in undergraund water. If there should be a shortage of river surface water, it may be partially covered by utilizing underground water near the mines.

Future survey of water resources will move to the detailed design stage in line with the remarks presented in this general survey as well as in keeping pace with the mine development implementation plan.

CHAPTER 5

RAILWAY TRANSPORTATION

CHAPTER 5 RAILWAY TRANSPORTATION

1. Outline of Peruvian Railways

1-1 Outline

Since the Andes Mountains run from north to south almost precisely through the center of Peru, the country can be divided into three regions: a coastal area, a mountainous area and a jungle area. The coastal area in the west has very little rainfall and the entire region is desert except for some oases. The central mountainous area is a highland with an average altitude of 4,000 m and the climate is cool. The eastern part of the country is almost entirely trackless jungle.

Because of such severe geographical conditions and the uneven distribution of economic activities, the development of railways has been greatly hindered, and not only the national railway network but also the trunk line running from north to south along the coast are still incomplete. The railways which link the cities built in the oases along the coast and the cities and mines in the mountains consist of only two, the Ferrocarril Central de Perú and the Ferrocarril del Sur. They are both made up of short dispersed sections about 100 km long.

The total length of the railways in Peru is 1,970 km. This consists of 1,672 km of national railways managed by the Empresa Nacional de Ferrocarriles (ENAFER) under the Ministerio de Transportes y Communicaciones (MTC) and 300 km of private railways operated by mining and other companies. The transport capacity is low and the railways are undeveloped when compared with those in other countries of Latin America.

1-2 Railway Network

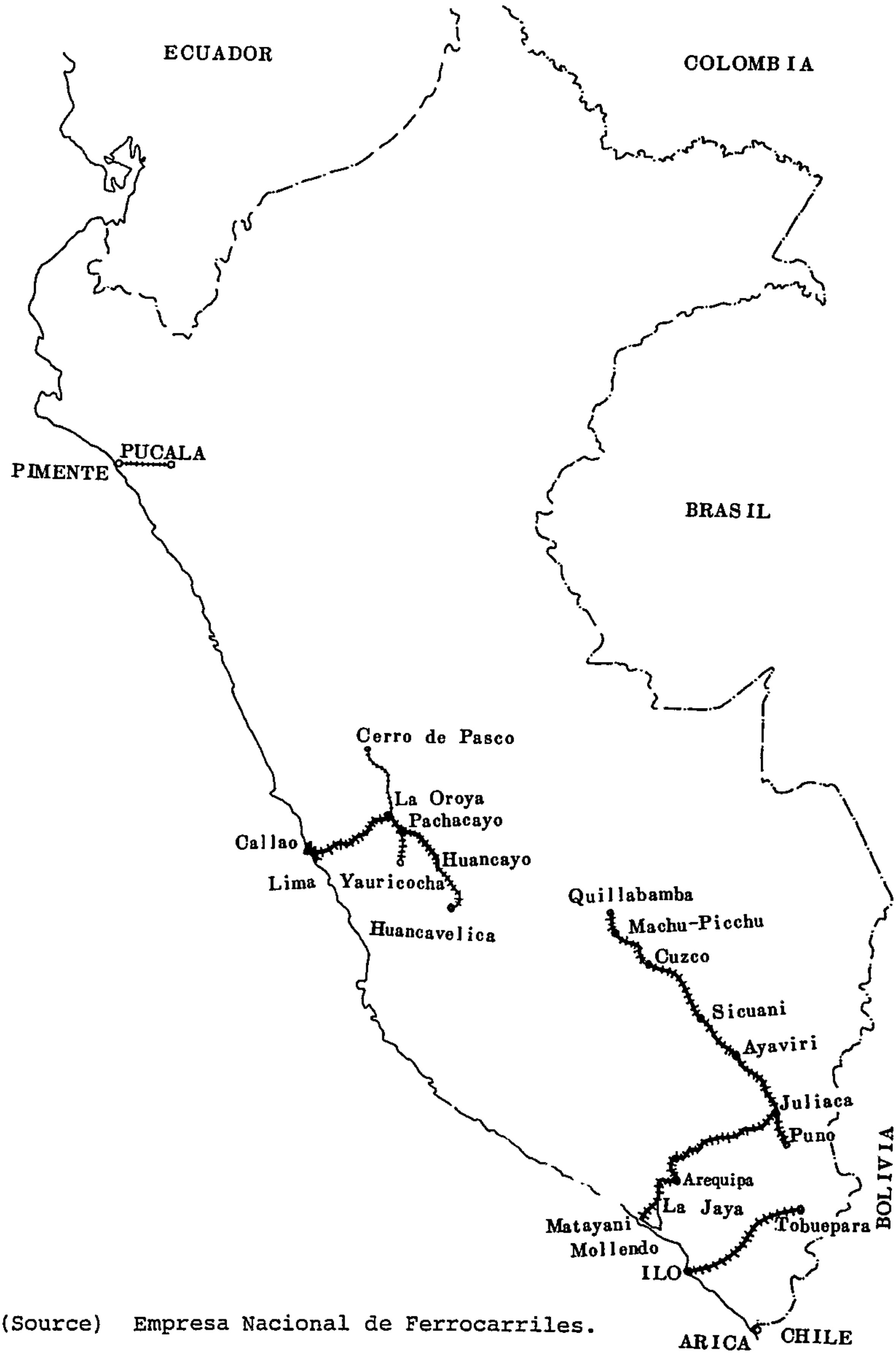
The Peruvian railway network is as shown in Fig. 5-1. The main lines and total lengths are shown in Table 5-1.

The Ferrocarril Central de Perú consists of 382.3 km connecting Callao, the largest port in Peru, the La Joya mines, and Huancayo in the central agricultural region via the capital, Lima; and another 128.7 km between the terminal point, Huancayo, and Huancavelica. It plays a major role in the Peruvian economy.

The Ferrocarril del Sur consists of 928 km from the ports of Mollendo and Matarani to Puno and Cuzco Via Peru's second largest city, Arequipa, with a branch at Juliaca; 171.2 km between Cuzco and Quillabamba; and 62 km between Tacna on the Chilean border and Arica. There are also two international railways, one of 209 km between Puno and Guaqui and the other of 121 km between Puno and Chaguaya, which connect Peru and Bolivia via Lake Titicaca.

There is an agreement on free railway passage between the governments of Peru and Bolivia and both passengers and freight are transported via the Lake Titicaca ferry. Because the line gauge on the Peruvian side is 1.435 m and that on the Bolivian side is

Fig. 5-1 Peruvian Railway Network



(Source) Empresa Nacional de Ferrocarriles.

Table 5-1 Gauge and Length of Each Line

Line	Gauge (m)	Total length (km)
Public (ENAFER)		
Ferrocarril Central de Perú		
Callao — La Oroya — Huancayo	1.435	382.3
Hyancayo — Huancavelica	0.914	128.7
Ferrocarril del Sur		
Mollend / Matarani > Arequipa — Juliaca < Puno / Cuzco	1.435	928.0
Cuzco — Quillabamba	0.914	171.1
Tacna — Arica	1.435	62.0
Subtotal		1,672.1
Private		
La Oroya — Cerro de Pasco	0.914	122.0
Ilo — Toquepala	1.435	136.0
Pucara — Pimente	0.914	42.0
Subtotal		300.0
Total		1,972.1

(Source) Empresa Nacional de Ferrocarriles. JETRO.

1 m, freight must be transshipped at Guaqui. Since the gauge of the line on the ferry boat is 1.435 m, freight from Bolivia must also be transferred at Guaqui. The Peruvian and Chilean Governments also have an agreement on free passage of railway traffic between the two countries. There is a shuttle service using the same train between Tacna and Arica, and passengers do not have to change trains.

1-3 Lines and Rolling Stock

Table 5-2 gives an outline of the current lines and rolling stock of ENAFER.

1-4 Organization

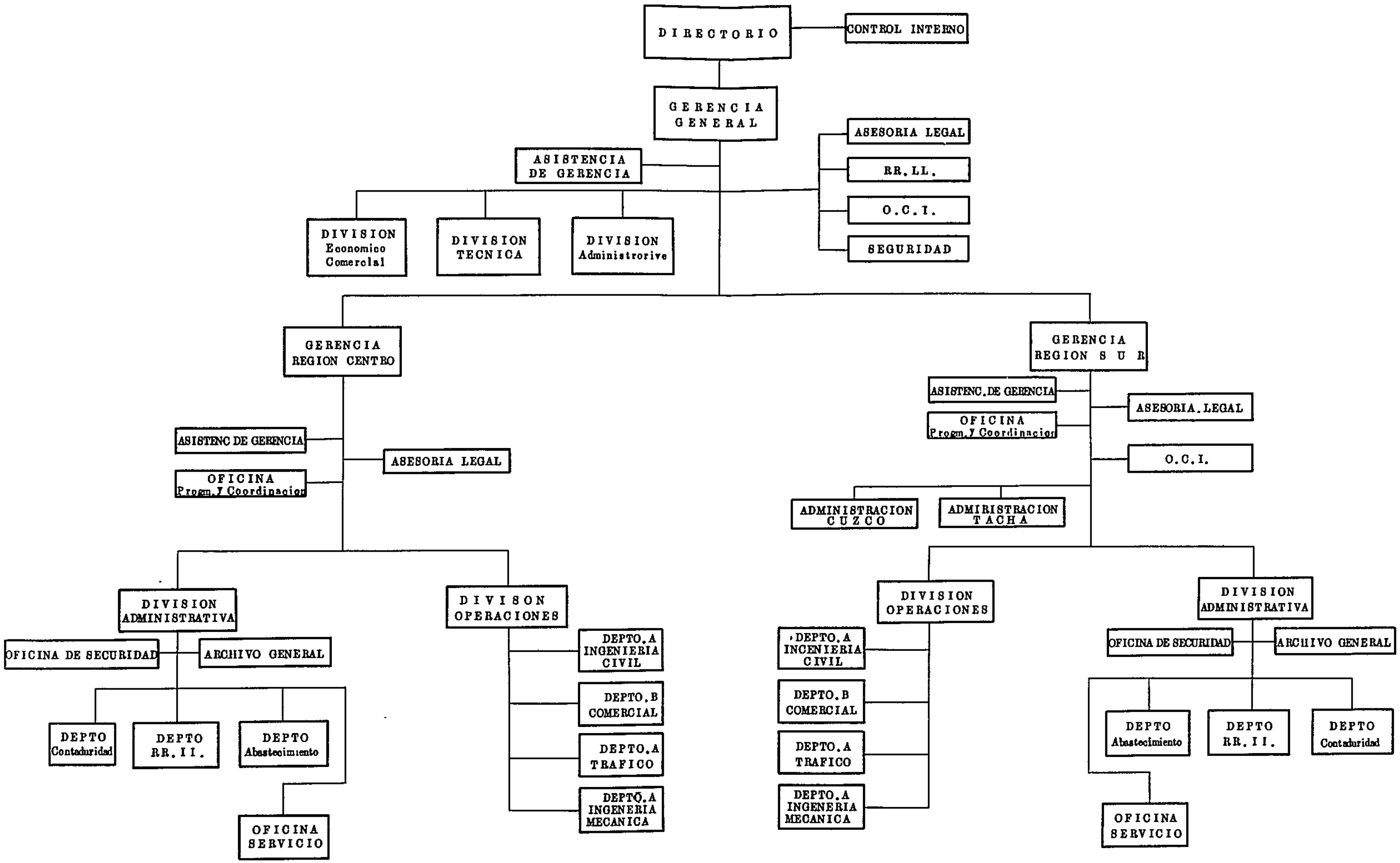
ENAFER is under the control of MTC and its organization is as shown in Fig. 5-2. Under the General Director, there are two general managers, one for Ferrocarril Central de Peru and one for the Ferrocarril del Sur. Under these general managers, there are administrative and operating departments for each railway. The administrative departments are in charge of accounting and

Table 5-2 Lines and Rolling Stock (Dec. 21, 1977)

	Ferrocarril Central de Perú			Ferrocarril del Sur				
	Callao Huancayo	Hyancayo Hvelica	Subtotal	Matarani Cuzco	Cuzco Chaullay	Tacna Arica	Subtotal	Total
Gauge (m)	1.435	0.914		1.435	0.914	1.435		
Main lines (km)	382.333	128.700	511.033	927.956	149.490	62.000	1,139.446	1,650.479
Sidings (km)	103.795	6.374	110.169	84.376	8.582	6.642	99.600	209.769
Highest point (m)	4,781	3,678		4,476	3,676	554		
Stations	19	8	27	49	10	3	62	89
Locomotives								
Diesel Electric 2,400 HP	19		19	10			10	29
" " 1,800/2,000				17			17	17
" " 1,200	6		6	10	5		15	21
" " 900	5		5	1			1	6
Mechanical Diesel or Diesel Electric	3		3	3			3	6
Steam	1	6	7		4	1	5	12
Subtotal	34	6	40	41	9	1	51	91
Self-propelled cars	3	9	12		5	7	12	24
Passenger cars	40	30	70	83	36	5	124	194
Freight cars	1,093	91	1,184	901	107	41	1,045	2,233

(Source) Empresa Nacional de Ferrocarriles.

Fig. 5-2 Organization of the Empresa Nacional de Ferrocarriles



(Source) Empresa Nacional de Ferrocarriles.

procurement of materials and the operating departments handle operation of the lines and the required civil and mechanical engineering work.

There is a total of 5,935 employees of ENAFER, 894 of whom are non-union members and 5,041 of whom are union members. Of these employees, 3,530 work for Ferrocarril del Sur, 490 of whom are non-union employees and 3,040 of whom belong to a union.

1-5 Reconstruction and New Line Construction Plans

1-5-1 Reconstruction Plan

A reconstruction plan is now being drafted to replace worn-out rolling stock and equipment to meet transport requirements up to 1990. Such replacements have not been made previously because of lack of funds.

This plan is being prepared in cooperation with a Hungarian survey team and according to the advice of the Instituto Nacional de Planiticacion (INP). The funds, which will come from ENAFER's own capital, government subsidies and foreign sources, are to be used for the purchase of locomotives, freight cars, passenger cars, and track equipment and devices. Table 5-3 shows reconstruction plan materials.

Table 5-3 Reconstruction Plan Materials

Sector	Ferrocarril Central de Perú		Ferrocarril del Sur	
	Callao — Huancayo	Huancayo — Huancavelica	Matarani — Cuzco	Cuzco — Chaullay
Locomotives	6	—	16	2
Passenger cars	35	32	104	6
Freight cars	404	174	250	22
Rails and accessories (t)	10,750	12,500	9,680	—
Bridges	45	1,130	—	—
Ties and accessories (t)	140,000	16,300	187,000	—

(Source) Empresa Nacional de Ferrocarriles.

1-5-2 New Line Construction Plans

To apply the advantages of large-scale transport capacities of railways, survey and construction of new lines using government subsidies is now being promoted.

In 1978, a 21.5 km extension of the Cuzco - Chaguaya line to Quillabamba was opened. In the construction of a new line between Matarani and Ilo, the roadbed of the 15 km between Matarani and Mollendo has been completed and the section is to be opened in 1980. Once this is completed, it will be possible to remove the line between Mollendo and La Joya (87km). Partial construction has also been started in the vicinity of Toquepala, near the terminal point of this new line.

International transport between Peru and Bolivia is currently via Lake Titicaca, but construction has begun on a new line of 142 km between Puno and Desaguadero to provide a land link. This should be completed in 1982.

In addition, construction is planned for the lines shown in Fig. 5-3. Current survey conditions are as shown in Table 5-4.

Table 5-4 Survey of New Line Construction

Sector	Current Status
1. Caripa — Condorcocha — Tarma (60 km)	Caripa — Condorcocha Sector (16 km) Survey complected
2. Santa Clara — Cajamarquilla (12 km)	Survey completed
3. Matarani — Ilo — Tacna (210 km)	Survey planned
4. Puno — Desaguadero	Survey planned
5. Ilo — Ilave	Survey planned
6. Tacna — Arica (60 km)	Studies on reconstruction planned
7. San Jose — Cerro Verde (16 km)	Survey planned

(Source) Empresa Nacional de Ferrocarriles.

2. Present Condition of Ferrocarril del Sur

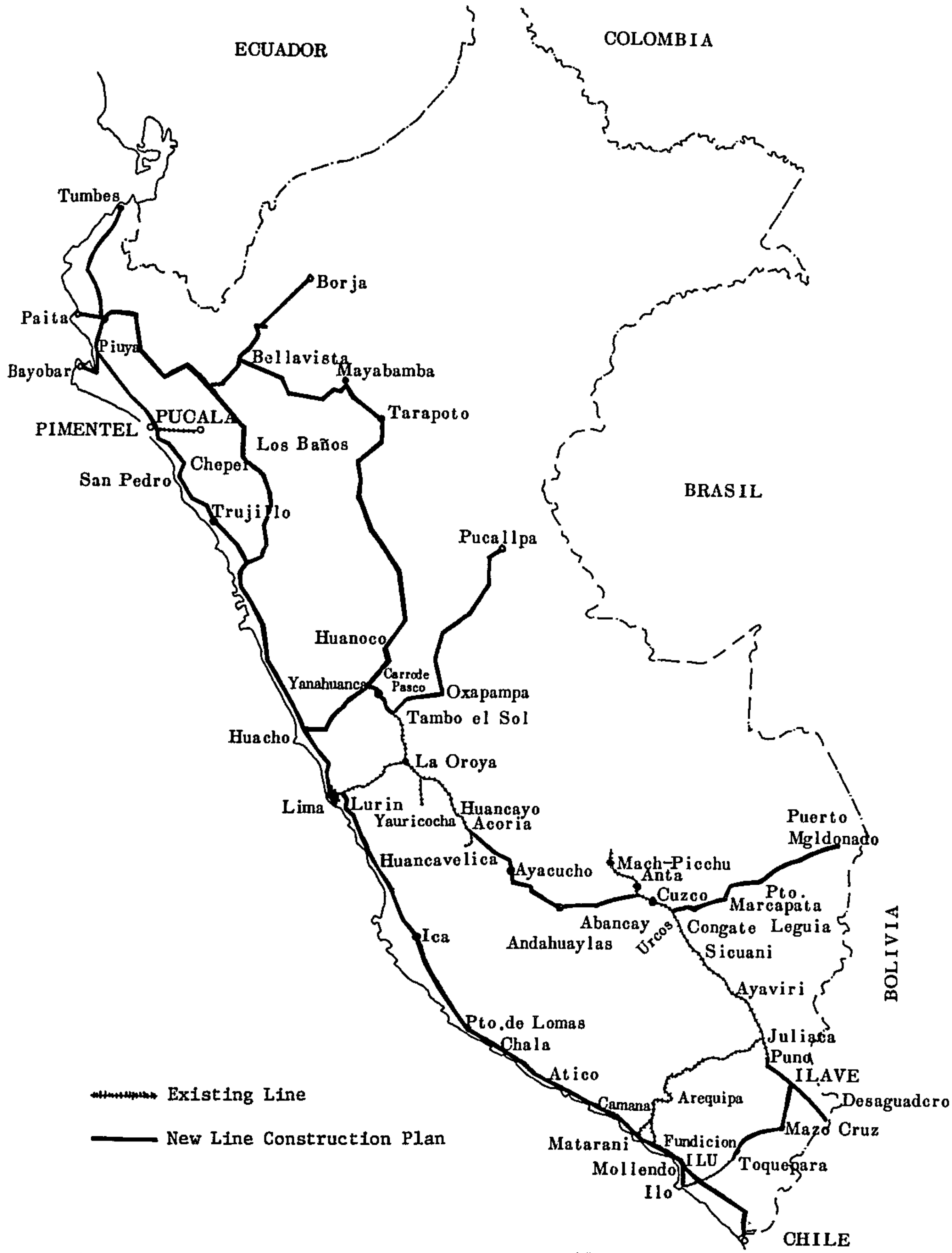
2-1 Outline

Ferrocarril del Sur runs from the coastal ports of Matarani and Mollendo, crosses the Andes Mountains and connects with the cities of Juliaca, Puno, Cuzco and Quillabamba in the mining region. Therefore, there are many steep gradient sections, and with the exception of the 62 km between Tacna and Arica, the transport capacity on about half of the 1,099 km line is somewhat limited. The number of tons which can be transported by each type of locomotive is as shown in Table 5-5.

These sections are all single track and among them, the 147 km section between Matarani and Areguipa and the 87 km section between Mollendo and La Joya are only for freight trains. The other sections carry both passenger and freight trains. (Refer to Photo 5-1).

The number of trains differ according to the day of the week, but between Arequipa, Juliaca and Puno, there are two passenger trains and three freight trains including night trains, while between Puno, Juliaca and Cuzco, there is only one passenger train and two freight trains. In the section connecting Cuzco, Machu-Picchu and Quillabamba, there are not only passenger and freight trains but also sightseeing trains operating daily. International transport to Bolivia via Lake Titicaca is carried by one passenger train and 2 ∿ 3 freight trains daily.

Fig. 5-3 Plans for New Railway Lines



(Source) Empresa Nacional de Ferrocarriles.

Photo 5-1 Freight Train Stopped at An Intermediate Station

Table 5-5 Tractive Tonnage for Each Type of Locomotive

(Unit ; t)

		Sector Ferrocarril del Sur	550	Acoplado 550/550	570	Acoplado 570/570	450	Acoplado 450/450	650	Acoplado 650/650
MATARANI ~ PUNO	Down	MATARANI - LA JOYA	300	600	365	715			350	700
		MOLLENDO - AREQUIPA	300	600	350	700			350	700
		AREQUIPA - PILLONES	300	600	300	600			350	700
		PILLONES - JULIACA	900	1800	900	1800			900	1800
		JULIACA - PUNO	900	1800	1000	2000	800	1600	1000	2000
	up	PUNO - JULIACA	900	1800	1000	2000	800	1600	1000	2000
		JULIACA - STA. LUCIA	900	1800	900	1800	800	1600	900	1800
		SANTALUCIA - CRO. ALTO	400	800	400	800	250	500	400	800
		Mixture of above	600	1200	600	1200	400	800	600	1200
		CRO. ALTO - PILLONES	800	1600	800	1600			800	1600
		PILLONES - AREQUIPA	300	600	300	600			300	600
		AREQUIPA - MOLLENDO	300	600	350	700			350	700
		LA JOYA - MATARANI	300	600	350	700			350	700
JULIACA ~ CUZCO	Down	JULIACA - STA. ROSA	750	1500			750	1500		
		STA. ROSA - ARARANCA	500	1000			500	1000		
		ARARANCA - LA RAYA	300	600			200	400		
		LA RAYA - SICUANI	450	900			350	700		
		SICUANI - HUAMBUTIO					750	1500		
		HUAMBUTIO - CUZCO					500	1000		
	up	CUZCO - SICUANI					750	1500		
		SICUANI- MARANGANI	500	1000			500	1000		
		MARANGANI - LA RAYA	300	600			200	400		
		LA RAYA - STA. ROSA	450	900			350	700		
		STA. ROSA - JULIACA	750	1500			750	1500		

(Source) Empresa Nacional de Ferrocarriles.

2-2 Amounts Transported

2-2-1 Freight Transport

Tabel 5-6 shows the changes in freight transport over the last five years. In 1972, 813,000 tons or 669,800,000 ton-km of freight were transported by rail. The same level continued thereafter and in 1977, the figures were 787,000 tons or 673,000,000 ton-km. The number of tons decreased by 3% while the number of ton-km increased by 0.5%. The reason for this did not appear to be a decrease in transport demand, but rather an inability to provide transport capacity to meet the demand due to insufficient maintenance of facilities, rolling stock, etc. To cope with these problems and to expand railway transport, a committee was formed to promote rationalization of freight transport, and tentative plans concerning such matters as strengthening of transport capacity and preparation of lists of freight to be handled by railways are being investigated.

Table 5-6 Changes in Freight Transport

(Section : Matarani ∿ Cuzco)

	1972	1973	1974	1975	1976	1977
Railway Freight						
Tons shipped (1,000)	813	793	828	795	804	787
Net ton-km (Million)	338.8	349.4	346.5	345.7	334.5	330.5
Total ton-km (Million)	669.8	666.7	668.3	681.7	660.5	673.0
Net ton-km/ total ton-km (%)	50.0	52.4	51.8	50.7	50.6	49.1
Price per net ton-km (Centavos)	90.0	94.6	99.3	108.5	166.1	249.3
Total ton-km shipped (TKB)	796.1	802.1	809.4	882.1	848.4	863.5
Lake Titicaca steamer						
Tons shipped (1,000)	187	187	178	142	142	123
Net ton-km (Million)	32.4	32.5	32.9	24.5	24.9	21.5
Price per net ton-km (Centavos)	62.6	62.8	82.1	104.1	126.0	176.0

(Section : Cuzco ∿ Chaullay)

	1972	1973	1974	1975	1976	1977
Freight						
Tons shipped (1,000)	61.8	36.7	46.5	42.6	40.9	32.3
Net ton-km (Million)	5.7	5.9	12.9	13.5	11.3	8.6
Total ton-km (Million)	10.5	8.1	N.A.	41.5		10.9
Net ton-km/ Total ton-km (%)	54	73	N.A.	33		79
Price per net ton-km (Centavos)	55	116	N.A.	70		260
Total ton-km shipped	29.4	30.9	N.A.	42.0		54.5

(Source) Empresa Nacional de Ferrocarriles.

Tables 5-7 and 5-8 show changes in freight transport and the types of freight shipments respectively for general freight and ore both domestically and internationally. The percentage of ore in domestic transportation is 12% in tons and 64% in ton-km. The percentage in international transportation is 11% in tons and 65% in ton-km. The percentage of international transport with respect to total transport is 16% in tons and 19% in ton-km.

The primary freight products from the coast to the mining region, including Bolivia, are fuel (30%), flour and grain (15%) and sugar, rice and other foods (7%). Freight to the coast includes ore (19%), cement and synthetic fertilizers (6%) from both within Peru and Bolivia.

2-2-2 Passenger Transport

Table 5-9 shows changes in the passenger transport over the last five years. In 1972, there were 807,000 passengers transported or 150,249,000 pass.-km. There has been a steady increase every year and in 1977 the figures were 1,520,000 passengers and 463,293,000 pass.-km. This was a two-fold increase in passengers and a three-fold increase in pass.-km.

Passenger transport was almost all within Peru. International transport has been changing to roadways. In 1972, it represented 0.5% of total rail transport, while in 1977, it was only 0.2%.

2-3 Type of Lines

Ferrocarril del Sur connects the main cities of the coast and the mining region. Since the topography is very harsh, rather sharp curves and steep gradients are used. Table 5-10 shows the standards of the present line from Mollendo and Matarani to Puno and Cuzco. Fig. 5-4 is a profile of the line and Fig. 5-5 shows the axial loads and wheelbases of the locomotives.

Table 5-7 Changes in Freight Shipped

	1972	1973	1974	1975	1976	1977
Tons shipped						
(Matarani — Cuzco section)						
Domestic						
Freight	557,162	545,124	539,439	578,634	594,208	582,672
Ore	69,292	65,562	60,527	64,798	71,314	79,250
International						
Imported goods	66,445	67,978	81,491	65,402	48,471	44,675
Exported ore	119,708	114,004	100,720	86,484	90,049	80,496
Total	812,607	792,668	782,177	795,318	804,042	787,093
Index	100	98	96	98	99	97
Percentage of international total	23	23	23	19	17	16
Lake steamer						
Freight	66,446	76,199	75,693	60,995		
Ore	119,707	111,150	101,694	86,666		
Total	186,153	187,349	177,387	147,661	142,101	123,491
Index	100	101	95	79	76	66
Ton-km shipped						
Net ton-km						
Domestic						
Freight	225,822	229,383	233,268	249,903	240,172	239,963
Ore	24,652	29,366	23,128	21,169	24,636	29,149
International						
Freight	32,733	33,723	39,885	32,507	24,719	21,301
Ore	55,664	56,888	50,259	43,154	44,929	40,167
Total	338,871	349,360	346,540	346,733	334,450	330,580
Index	100	103	102	102	99	98
Percentage of Total	26	26	26	22	21	19
Average shipping distance (km)	417.0	440.7	443.0	436.0	416.0	420.0

(Source) Empresa Nacional de Ferrocarriles.

Table 5-8 Freight Shipped (1977)

Shipping direction		Freight (t)	Freight (t.km)	Number of rolling stock or starts	Ore (t)	Ore (t.km)	Number of rolling stock or starts
Domestic							
On consignment	Up	466,666	159,282,426	15,007			
	Down	80,146	29,934,107	3,517	79,061	29,081,419	2,094
Consolidation	Up	23,074	9,620,644	32,575	39	17,457	2
	Down	12,786	5,125,402	24,206	150	49,735	3
Subtotal		582,672	293,962,579		79,250	29,148,611	
International							
On consignment	Up	37,114	17,534,045	1,048			
	Down	16	8,032	1	80,496	40,167,384	2,247
Consolidation	Up	7,474	3,724,021	2,820			
	Down	71	35,287	13			
Subtotal		44,675	21,301,385		80,496	40,167,384	2,247
Total		627,347	261,263,964		154,746	69,315,995	

(Source) Empresa Nacional de Ferrocarriles.

Table 5-9 Passenger and Baggage Statistics

	1972	1973	1974	1975	1976	1977
(Matarani ∿ Cuzco Section)						
Passengers						
Number of Pass.	807,561	839,692	1,004,258	1,184,075	1,311,792	1,539,883
Pass. - km	150,246,374	159,959,627	229,087,261	254,170,551	311,464,129	463,293,125
Average travelling distance (km)	186.0	190.5	228.1	214.7	237.4	300.9
Profit per pass.-km (Centavos)	36.5	39.5	35.5	43.3	56.0	57.0
Baggage						
Ton-km	4,063	4,093	5,395	6,344	6,531	7,100
Net Ton-km	1,680,654	1,675,306	2,500,589	2,326,525	2,667,130	2,595,823
Profit per Pass. - km (Centavos)	355.2	346.3	261.0	382.9	487.4	760.6
(Lake transport)						
Lake Titicaca Steamer						
Passengers						
Number of Pass.	4,885	4,256	5,942	4,889	3,449	2,650
Pass. - km	1,024,309	889,809	1,241,773	1,021,801	720,841	553,242
Profit per Pass. - km (Centavos)	109.0	117.4	104.9	123.2	229.3	446.0
Baggage						
Ton-km	523	501	535	588		
Net ton-km	109,307	104,709	103,037	122,802		

(Source) Empresa Nacional de Ferrocarriles.

Table 5-10 Line Standards

Gauge	1435 mm
Steepest gradient	4.9 %
Minimum curve radius	110 m
Maximum axial load	18.5 t

(Source) Empresa Nacional de Ferrocarriles.

2-4 Rail Construction

Rail standards are shown in Table 5-11. Fig. 5-6 shows rail structure standards.

Table 5-11 Rail Standards

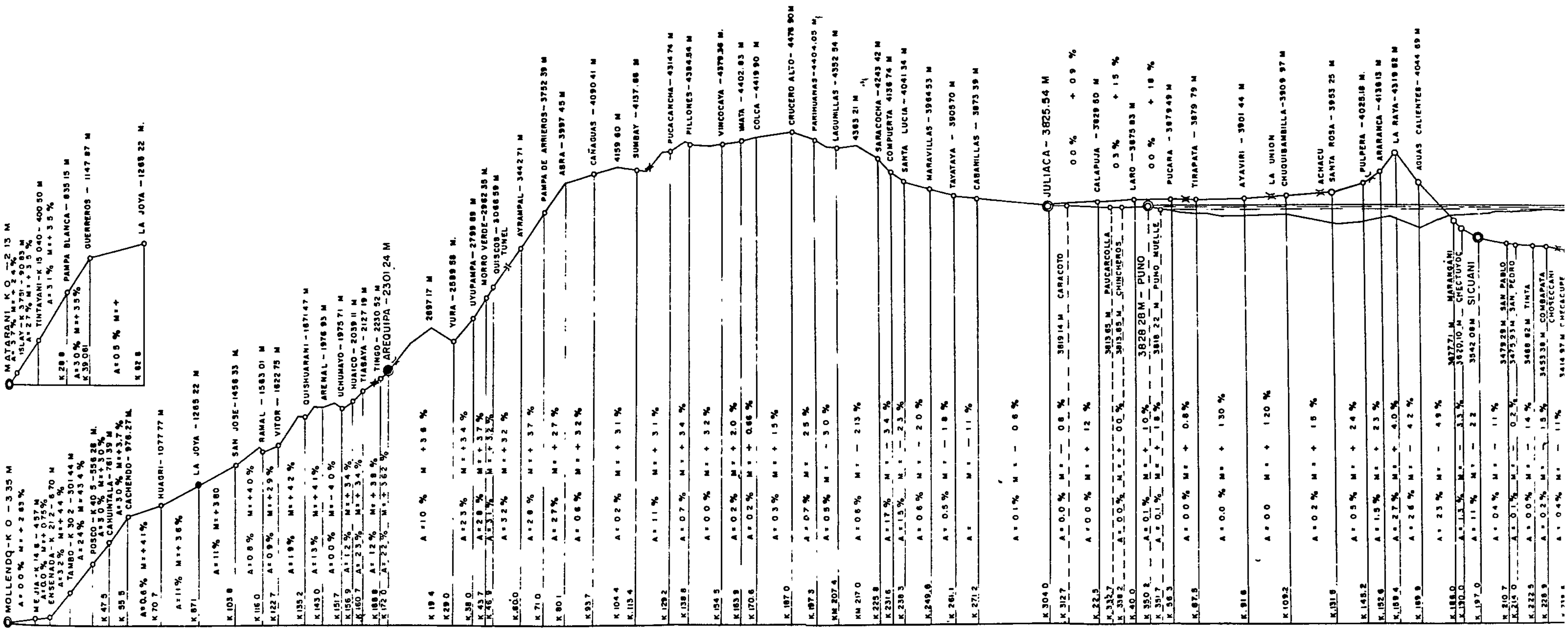
Type	Sector	Standards
Road bed	Complete line	Crushed stone, thickness under ties: 15 cm
Ties	Complete line	Dimensions 20 cm x 15 cm x 240cm Material Eucalyptus Interval 60 cm (1700 t/km)
Rails	Arequipa ∿ Juliaca Juliaca ∿ Sicuani Sicuani ∿ Cuzco	80 ∿ 75 P/Y 75 P/Y 60 P/Y

(Source) Empresa Nacional de Ferrocarriles.

2-5 Lines and Stations

Fig. 5-7 shows a plan of the Matarani ∿ Cuzco line which is related to the present project. Names and distances of the main, intermediate and unmanned stations; type of sidings, signal stations, etc. are given.

Table 5-12 shows the distances between each station, the line distances and the altitudes for each station. The highest station is Crucero Alto, 187 km from the starting point of Arequipa and 4,477 m above sea-level.


MOLLENDO - K 0 - 3.35 M
MEJIA - K 14.8 - 4.37 M
ENSENADA - K 21.2 - 6.70 M
TAMBO - K 30.2 - 30.144 M
POSCO - K 40.5 - 556.28 M
CAHUINTALA - 761.39 M
CACHENDO - 976.27 M
HUAGRI - 1077.77 M
LA JOYA - 1265.22 M
SAN JOSE - 1456.33 M
RAMAL - 1583.01 M
VITOR - 1622.75 M
QUISHUARANI - 1671.47 M
ARENAL - 1976.93 M
UCHUMAYO - 1975.71 M
HUAICO - 2039.11 M
TIABAYA - 2127.19 M
TINGO - 2230.52 M
AREQUIPA - 2301.24 M
YURA - 2589.58 M
UYUPAMPA - 2799.86 M
MORRO VERDE - 2962.35 M
QUISCOS - 3066.59 M
TUNEL
AYRAMPAL - 3442.71 M
PAMPA DE ARRIEROS - 3752.39 M
ABRA - 3997.45 M
CAÑAGUAS - 4090.41 M
SUMBAY - 4137.86 M
PUCACANCHA - 4314.74 M
PILLONES - 4384.54 M
VINCOCAYA - 4379.36 M
MATA - 4402.83 M
COLCA - 4419.90 M
CRUCERO ALTO - 4476.90 M
PARIHUANAS - 4404.05 M
LAGUNILLAS - 4352.54 M
SARACOCHA - 4243.42 M
COMPUERTA - 4138.74 M
SANTA LUCIA - 4041.34 M
MARAVILLAS - 3964.53 M
TAYATAYA - 3905.70 M
CABANILLAS - 3873.39 M
JULIACA - 3825.54 M
CARACOTO
PAUCARCOLLA
CHINCHEROS
3828.28 M - PUNO
PUNO MUELLE
CALAPUJA - 3829.50 M
LARO - 3875.83 M
PUCARA - 3879.49 M
TIRAPATA - 3879.79 M
AYAVIRI - 3901.44 M
LA UNION
CHUQUIBAMBILLA - 3909.97 M
ACHACU
SANTA ROSA - 3953.25 M
PULPERA - 4025.18 M
ARARANCA - 4136.13 M
LA RAYA - 4319.82 M
AGUAS CALIENTES - 4044.69 M
MARANGANI
CHECTUYOC
SICUANI
SAN PABLO
SAN PEDRO
TINTA
COMBAPATA
CHOSECCANI
CHECACUPE
MATARANI K 0 - 2.13 M
ISLAY - K 3.751 - 90.83 M
TINTAYANI - K 15.040 - 400.50 M
PAMPA BLANCA - 635.15 M
GUERREROS - 1147.87 M
LA JOYA - 1268.22 M

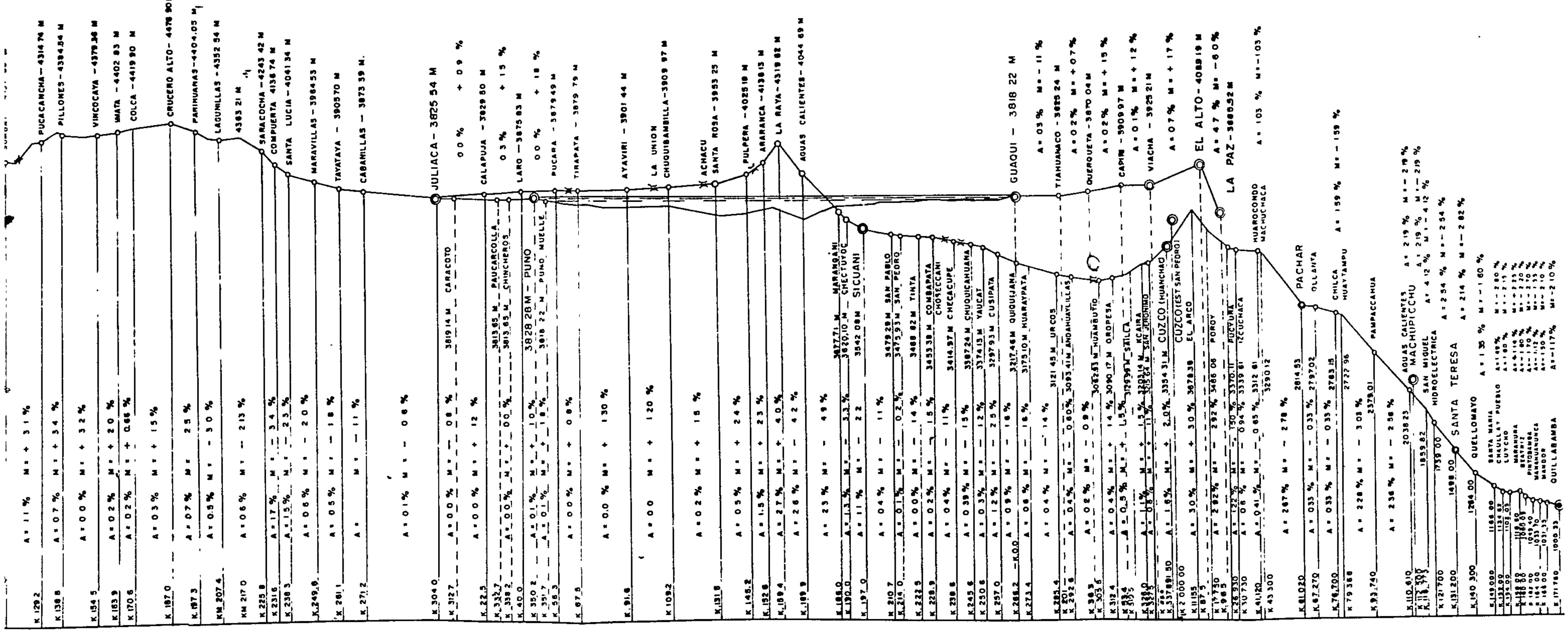
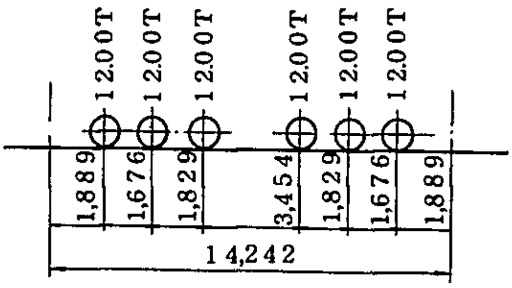


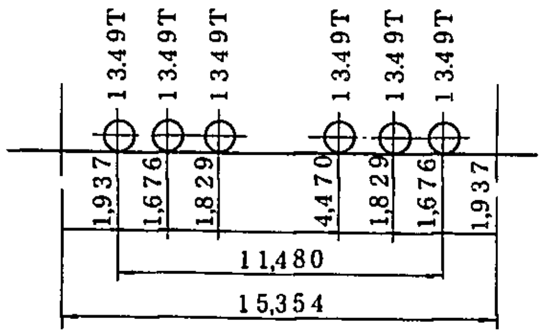
Fig. 5-4 Line Profile

Fig. 5-5 Locomotive Axial Loads and Wheelbases



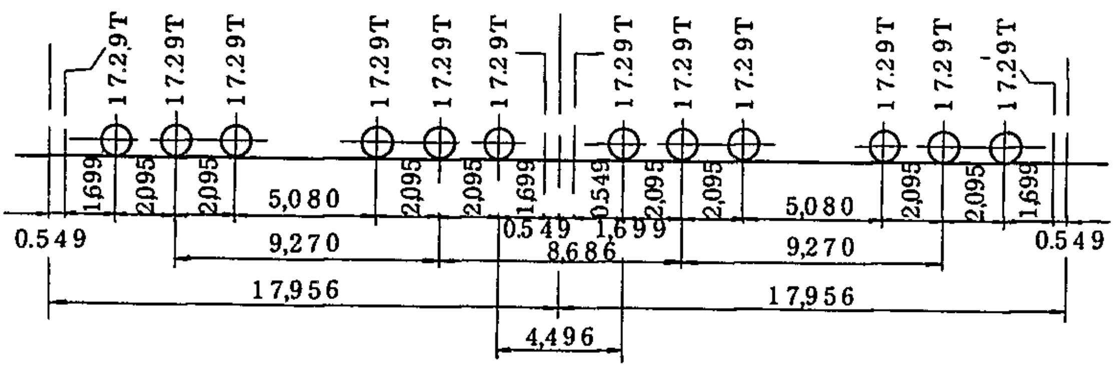
(Total load 72.00T)

300 CLASS(300)



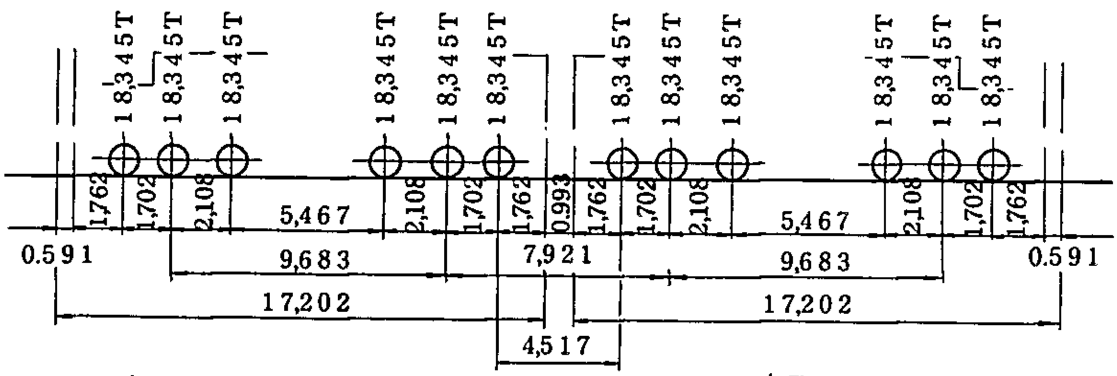
(Total load 72.00T)

350 CLASS(350～360)



(Total load 103.74T) (Total load 103.74T)

500 CLASS(500～505)



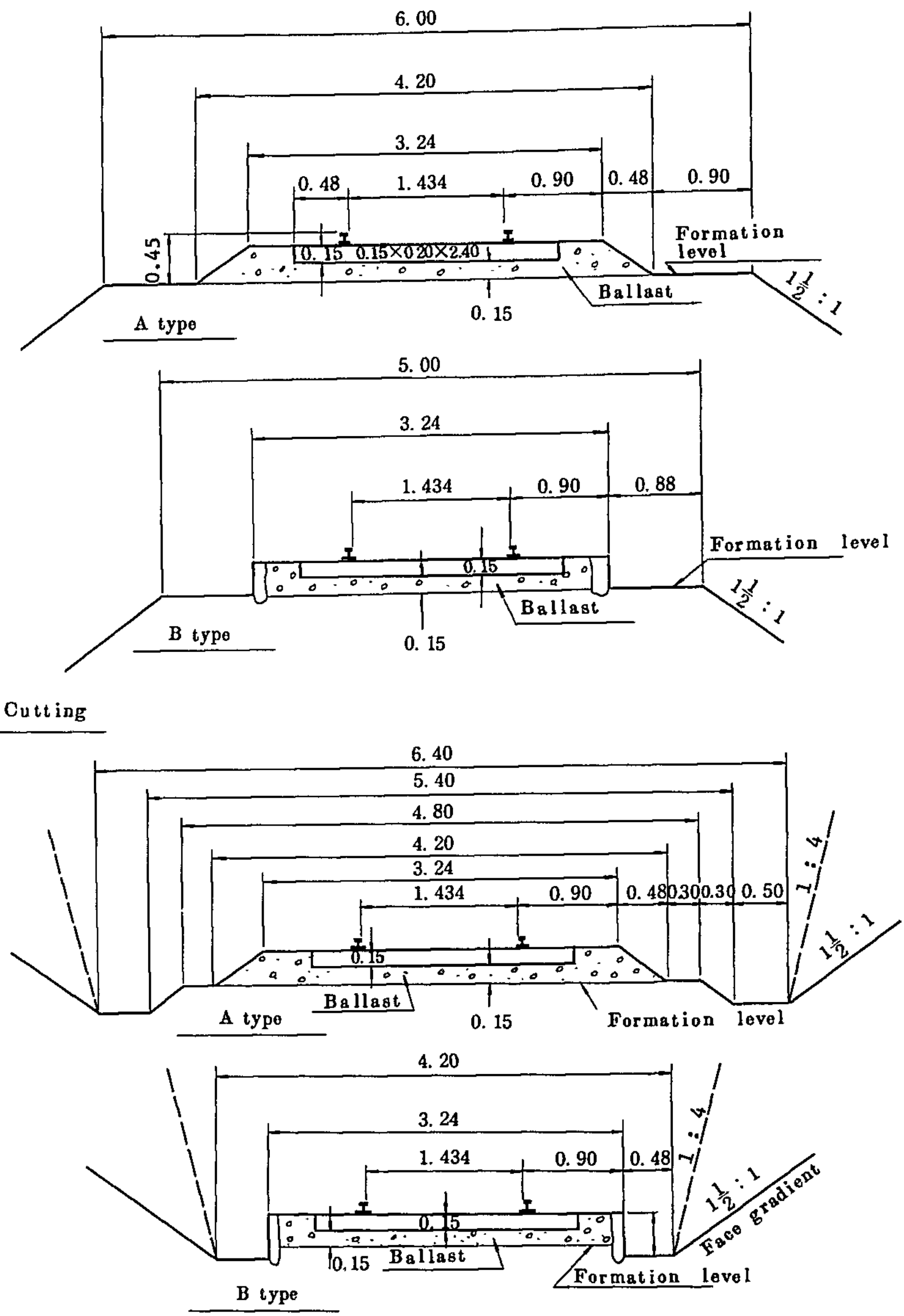
(Total load 110,070T) (Total load 110,070T)

550 CLASS(550～555)

(Source) Empresa Nacional de Ferrocariles.

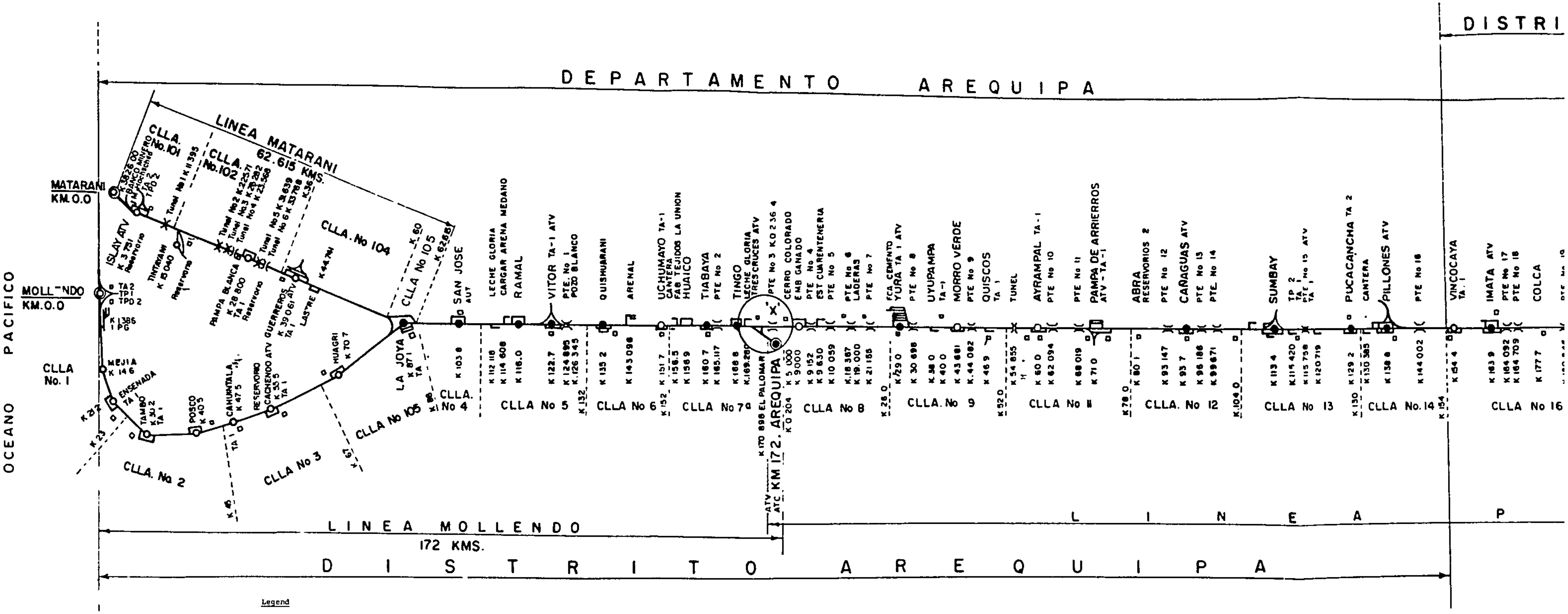
Filling

Fig. 5-6 Rail Structure Standards



(Source) Empresa Nacional de Ferrocarriles.

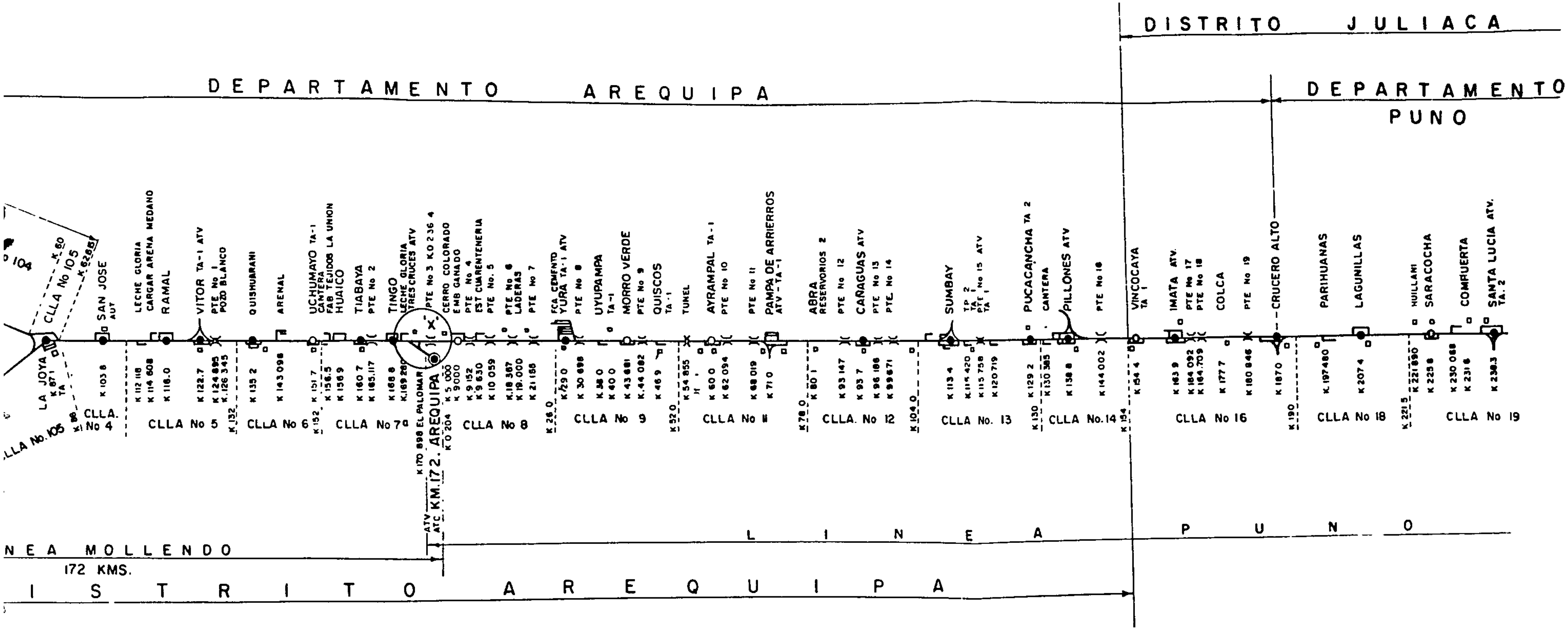
Fig. 5-7 Line I



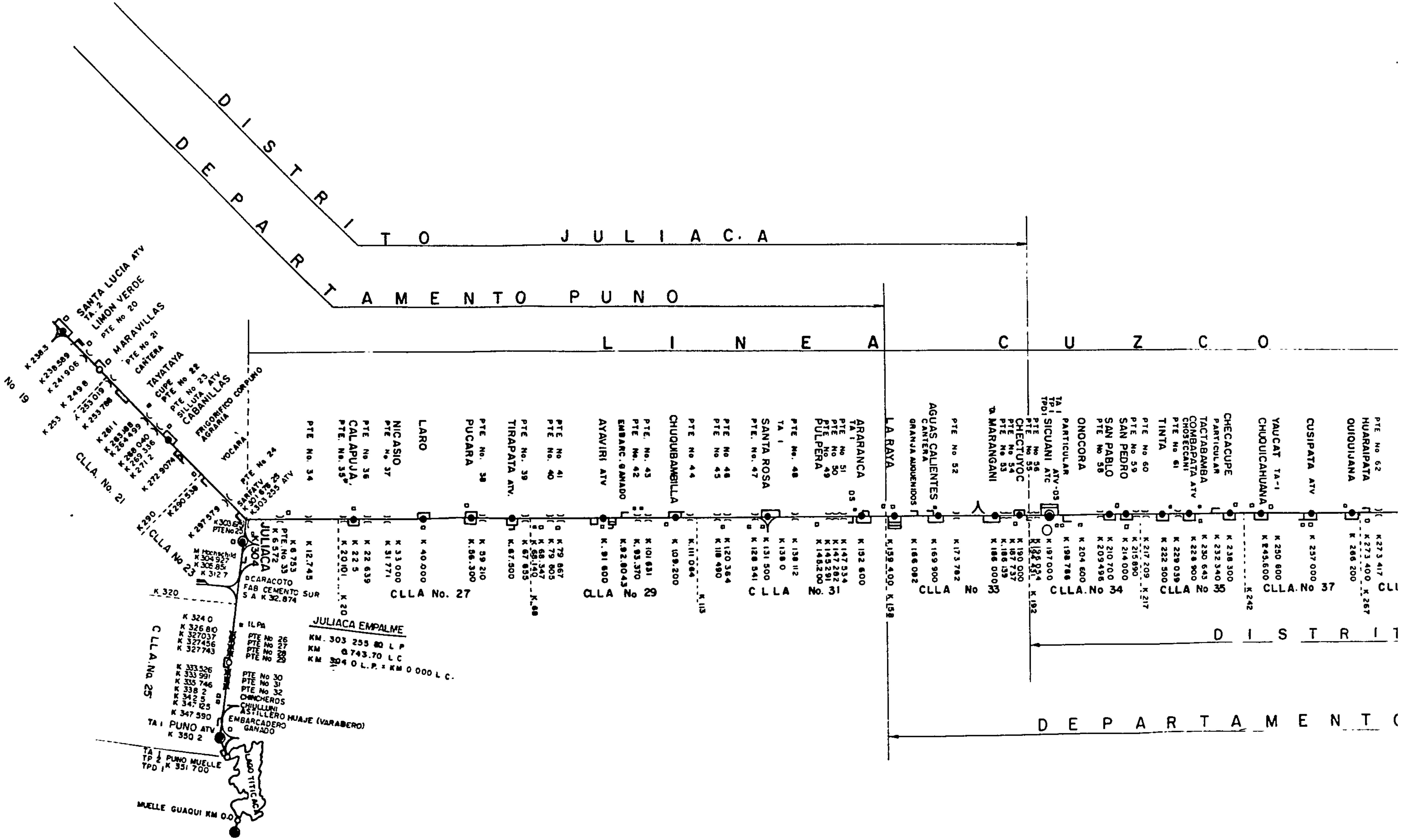
Legend

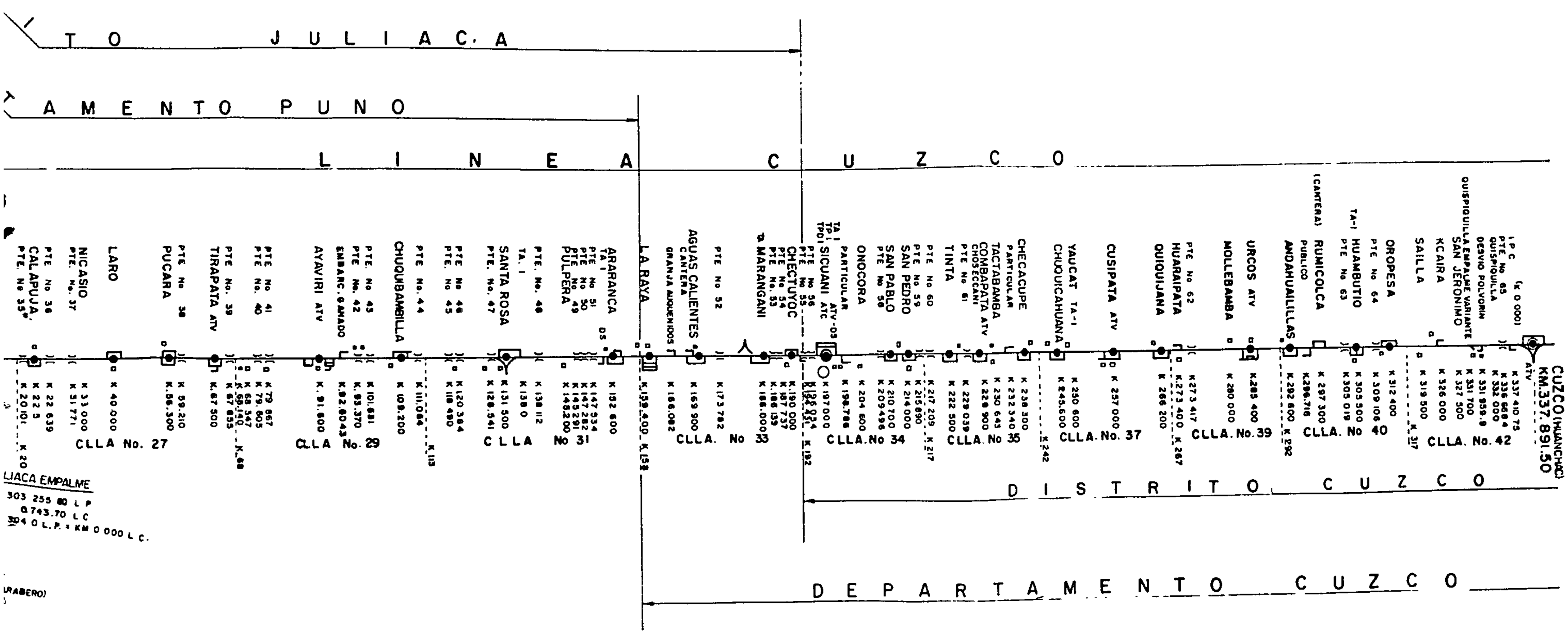
- Main station
- Intermediate station
- Unmanned station
- Railway section
- Signal staion
- siding (can enter in both directions)
- siding (can enter in only one direction)
- Reversing tirangle
- Bridge
- Tunnel
- Turnplate
- T A. Water tank
- T. P Oil tank
- T P D Diesel oil tank
- D S Refuge track

Fig. 5-7 Line Plan



h directions)
-y one direction)


DISTRITO JULIACA
DEPARTAMENTO PUNO
LINEA CUZCO
DISTRIT
DEPARTAMENT
JULIACA EMPALME
KM. 303 255 80 L P
KM 0 743.70 L C
KM 304 0 L.P. = KM 0 000 L C.
JULIACA
SANTA LUCIA ATV
LIMON VERDE
MARAVILLAS
TAYATAYA
CABANILLAS
YOCARA
CARACOTO
PUNO ATV
PUNO MUELLE
LAGO TITICACA
MUELLE GUAQUI KM 0.0
CALAPUJA
NICASIO
LARO
PUCARA
TIRAPATA ATV.
AYAVIRI ATV
CHUQUIBAMBILLA
SANTA ROSA
PULPERA
ARARANCA
LA RAYA
AGUAS CALIENTES
MARANGANI
CHECTUYOC
SICUANI
ONOCORA
SAN PABLO
SAN PEDRO
TINTA
COMBAPATA ATV
TACTABAMBA
CHECACUPE
CHUQUICAHUANA
YAUCAT
CUSIPATA
QUIQUIJANA
HUARAIPATA
CLLA. No. 21
CLLA No 23
CLLA. No 25
CLLA No. 27
CLLA No 29
CLLA No. 31
CLLA No 33
CLLA. No 34
CLLA No 35
CLLA. No 37



TO JULIACA
AMENTO PUNO
LINEA CUZCO
DISTRITO CUZCO
DEPARTAMENTO CUZCO
CLLA No. 27
CLLA No. 29
CLLA No 31
CLLA. No 33
CLLA. No 34
CLLA. No 35
CLLA. No. 37
CLLA. No. 39
CLLA. No 40
CLLA. No. 42
CALAPUJA
NICASIO
LARO
PUCARA
TIRAPATA ATV
AYAVIRI ATV
CHUQUIBAMBILLA
SANTA ROSA
PULPERA
ARARANCA
LA RAYA
AGUAS CALIENTES
MARANGANI
CHECTUYOC
SICUANI ATC
ONOCORA
SAN PABLO
SAN PEDRO
TINTA
COMBAPATA ATV
TACTABAMBA
CHECACUPE
CHUQUICAHUANA
YAUCAT TA-1
CUSIPATA ATV
QUIQUIJANA
HUARAIPATA
MOLLEBAMBA
URCOS ATV
ANDAHUAILILLAS
RUMICOLCA
HUAMBUTIO
OROPESA
SAILLA
KCAIRA
SAN JERONIMO
CUZCO (HUANCHAC)
KM. 337.891.50
JULIACA EMPALME

Table 5-12 Distances Between and Altitudes of Stations Between Matarani and Cuzco

Station name	Distance from previous station (km)	Line distance (km)	Altitude (m)
MOLLENDO	0.0	0.0	3
Mejia	14.6	14.6	5
Ensenada	6.6	21.2	7
Tambo	9.0	30.2	301
Posco	10.3	40.5	556
Cahuintala	7.0	47.5	761
Cachendo	8.0	55.5	976
Huagri	15.2	70.7	1,078
MATARANI	0.0	0.0	2
Islay	3.8	3.8	91
Tintayani	11.2	15.0	401
Pampa Blanca	13.8	28.8	835
Guerrero	10.2	39.0	1,148
La Joya	48.0	87.0	1,265
San Jose	17.0	104.0	1,456
Ramal	12.0	116.0	1,563
Vitor	7.0	123.0	1,623
Quishuarani	12.0	135.0	1,871
Uchumayo	17.0	152.0	1,976
Huayco	5.0	157.0	2,039
Tiabaya	4.0	161.0	2,127
Tingo	8.0	169.0	2,231
AREQUIPA	3.0	172.0	2,301
Yura	29.0	29.0	2,590
Uyunampa	9.0	38.0	2,800
Quiscos	9.0	47.0	3,067
Ayrampal	13.0	60.0	3,443
Pampa de Arriero	11.0	71.0	3,752
Canaguas	23.0	94.0	4,090
Sumbay	19.0	113.0	4,138
Pucacancha	16.0	129.0	4,315
Pillones	10.0	139.0	4,385
Vincocaya	16.0	155.0	4,379

Station name	Distance from previous station (km)	Line distance (km)	Altitude (m)
Imata	9.0	164.0	4,403
Crucero Alto	23.0	187.0	4,477
Lagunillas	20.0	207.0	4,353
Saracocha	19.0	226.0	4,243
La Compuerta	6.0	232.0	4,127
Santa Lucia	6.0	238.0	4,041
Maravillas	12.0	250.0	3,965
Taya Taya	11.0	261.0	3,906
Cabanillas	10.0	271.0	3,873
JULIACA	33.0	304.0	3,526
Caracoto	9.0	313.0	3,819
Paucarcolla	20.0	333.0	3,814
PUNO	17.0	350.0	3,828
Puno Muelle	2.0	352.0	3,818
Carapuja	23.0	23.0	3,830
Nicasio	9.0	32.0	
Laro	8.0	40.0	3,876
Pucara	4.0	56.0	3,879
Tirapata	12.0	68.0	3,880
Ayaviri	24.0	92.0	3,901
Cnuquibambilla	17.0	109.0	3,910
Santa Rose	23.0	132.0	3,953
Araranca	21.0	153.0	4,136
La Raya	6.0	159.0	4,320
Aguas Calientes	11.0	170.0	4,045
Marangani	16.0	186.0	3,678
Chectuyoc	4.0	190.0	3,620
SICUANI	7.0	197.0	
Onocora	8.0	205.0	
San Pablo	6.0	211.0	3,479
San Pedro	3.0	214.0	3,476
Tinta	9.0	223.0	3,469
Combapata	6.0	229.0	3,453

Station name	Distance from previous station (km)	Line distance (km)	Altitude (m)
Checacupe	10.0	239.0	3,415
Chuquicahuana	7.0	246.0	3,387
Yaucat	5.0	251.0	3,374
Cusipata	6.0	257.0	3,298
Quiquijana	11.0	246.0	3,217
Huaraypata	27.0	273.0	3,175
Mollebamba	7.0	280.0	
Urcos	5.0	285.0	3,121
Andahuaililillas	8.0	293.0	3,093
Rumicolca	4.0	297.0	
Hambutio	9.0	306.0	3,063
Oropesa	6.0	312.0	3,091
Sailla	8.0	320.0	3,130
San Jeronimo	8.0	328.0	3,216
CUZCO	10.0	338.0	3,358
SAN PEDRO	2.0	2.0	3,400
El Arco	9.2	11.0	3,678
Poroy	6.7	18.0	3,480
Pucycuta	9.2	27.0	3,380
IZCUCHACA	3.7	31.0	3,340
HUAROCONDO	10.0	41.0	3,320
Paropiso	4.0	45.0	
Acojolino	1.9	47.0	
Pomatales	6.0	53.0	2,990
Rapeca	5.0	58.0	
Pachar	3.5	61.0	2,800
OLLANTA	6.0	67.0	2,790
Tanccac	6.0	73.0	2,770
Chilca	4.0	77.0	2,760
Chuquillusca	5.0	82.0	2,635
Pampacchua	12.0	94.0	2,400
Artillerayoc	4.0	98.0	

Station name	Distance from previous station (km)	Line distance (km)	Altitude (m)
Cedrobamba	3.0	101.0	2,240
Lucmachayoc	3.0	105.0	2,180
Hidroelectrica	2.0	107.0	
Aguas Calientes	4.0	111.0	2,040
Machu-picchu	1.7	113.0	1,998
Mandor	1.9	114.0	1,980
San Miguel	4.0	118.0	1,972
Intihuatana	1.9	120.0	1,827
Santa Teresa	11.0	131.0	1,510
Chaullay	18.0	150.0	1,200
Quillabamba	21.5	171.5	-

(Source) Empresa Nacional de Ferrocarriles.

2-6 Operation Safety Equipment

The blocking systems of the trains are of the table and ticket block type in almost all of the sections. This system is intended to prevent train collisions by permitting only one train to enter each section; only the driver who has the table and ticket for the section concerned issued by the stationmaster can operate in that section.

The main line signals are in the form of a disk resembling a semaphore which is hidden when indicating "go" and appears to indicate "stop". (Refer to Photo 5-2).

Photo 5-2 Signal (stop indication)

At night, colored lights are used for the same two indications. The types of signals installed in the larger stations include home signals indicating whether a train can enter or not and departure signals indicating whether a train can leave the station or not. However, in intermediate sized stations, there is only one signal in the center of the station.

No operating equipment is as yet used to prevent erroneous handling, or assure train routes by cross-linking among the signals and between signals and points.

2-7 Communications Equipment

Long-distance communications are performed by means of electric wires in parallel with the tracks because of the small number of trains. These wires consist of two for telephone communication and one grounded wire for telegraphic communication. The telephones are of the curtain type while manual Morse code devices are used for telegraphic communications.

Wired telephones are sufficient to meet the needs of long-distance communication. The reason for this is that, according to the train time-table, there are at most only two trains operating simultaneously at any hour of the day in the main sections of the line (Arequipa - Matarani, Arequipa - Puno and Juliaca - Cuzco).

Communications between the following pairs of points are performed by means of high-frequency wireless communication (simplexes: "push-to-talk" device).

Arequipa - Lima
Arequipa - Puno
Arequipa - Matarani
Juliaca - Cuzco

2-8 Rolling Stock

Trains operating in the Mollendo ∿ Matarani ∿ Puno ∿ Cuzco section are all pulled by locomotives and therefore, there are three types of rolling stock: locomotives, freight cars and passenger cars.

All locomotives are now of the diesel type. Air brakes are used and communications are performed by means of automatic liaison devices.

Repairs of the rolling stock are carried out in shops located in Arequipa. However, the major problem involved in such repairs in an insufficiency of repair parts, followed by worn-out equipment such as repair machinery, and finally, low technical levels.

Table 5-13 shows the number of various types of locomotives and freight cars as of 1979. There are 41 locomotives but only about half of them are operating. Many cannot be repaired and remain idle.

Table 5-13 Number of Each Type of Locomotive and Freight Car (as of Oct. 1979)

Locomotives		
2400 HP	Diesel electric	10
1800/2000	"	17
1200	"	10
900	"	1
Electric XD	Diesel (for use in yards)	3
	Total	41
Freight cars		
Box cars		391
open cars		93
tank cars		128
cars for metals		78
others		61
	Total	751

(Source) Empresa Nacional de Ferrocarriles.

There is a very high percentage of covered freight cars (boxcars), i.e. 52% of the total. 17% are tank cars, while open cars account for only 12% of the total.

Among the various loading capacities, 40 t cars are the most common, but recently, 50 t cars have also come into use. (Refer to Photo 5-3).

Although covered cars still include some made of wood and these are worn-out, open cars and those for the transport of wheat are all made of metal.

As shown in Fig. 5-8, the maximum limit of load heights is 4.20 m which is the same as the maximum limit of the height of the car body. Generally, open cars are used for the transport of heavy freight, but such cars are 15 m in length and 3.2m, wide and the height above the rails is about 1.1 m. Therefore, the upper limit of the load height is 3.1 m.

Open cars have load capacities of 30 t to 40 t. In cases where the load lengths exceed 15 m, it is possible in exceptional cases to connect two open cars together for a single load.

Photo 5-3 Ore Transport Wagon

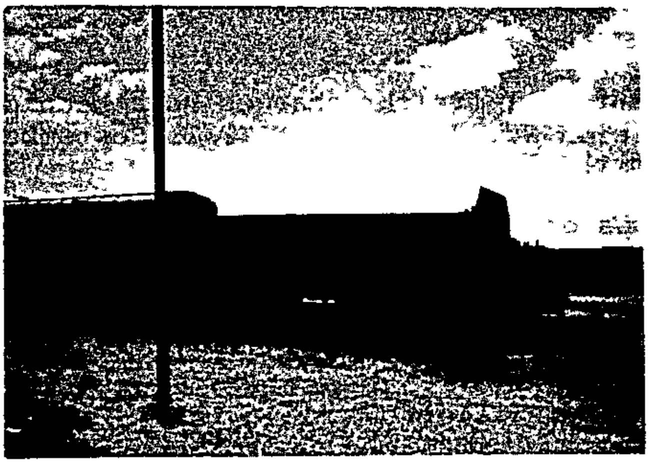
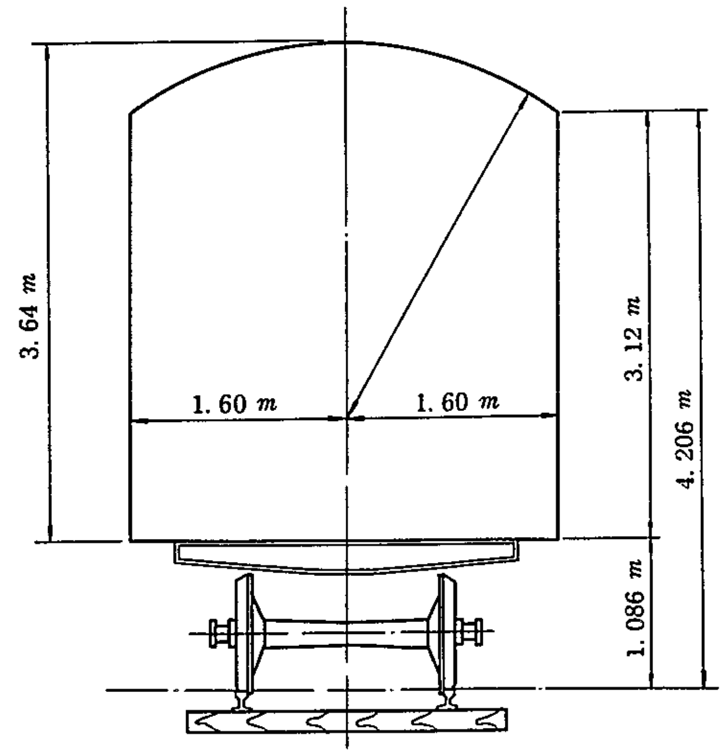


Fig. 5-8 Maximum Values of Load Cross Section



(Source) Empresa Nacional de Ferrocarriles.

2-9 Charges and Fares

2-9-1 Freight Charges

Current rail freight charges have been decided by ORETT[1] Directors' decision No. 313-79TC/ORETT/T (September 3, 1979)[1] on the basis of the following items:

1) Types of loads (small consignments, car consignments)
2) Freight dimensions (weight, quantity, volume, etc.)
3) Transport distance
4) Rate division (five sectors according to type of freight)

The charges for concentrates, liquid fuels and machinery which are the main transport items in this plan are by car consignment with respect to 1); there is no problem concerning 2); 3) is obtained from the Station Distance Table (Table 5-14); and with respect to 4), fuels and machinery are type 2 and concentrates type 4, and the rates can be determined from the Railway Charge Tables (Table 5-15 and 5-16). International transport charges and rates are given for reference in Table 5-17.

Table 5-14 Number of Kilometers Between Stations

	Matarani	San José	Vitor	Arequipa	Yura	Pampa de Arriero	Crucero Alto	Santa Lucía	Juliaca	Nicasio	Pucará	Tirapata	Ayaviri	Santa Rosa	Marangani	Sicuani	San Pablo	Tinta	Cusipata	Urcos	Oropesa	Cuzco
Matarani																						
San José	79																					
Vitor	98	19																				
Arequipa	147	68	49																			
Yura	176	97	78	29																		
Pampa de Arriero	218	139	120	71	42																	
Crucero Alto	334	255	236	187	158	116																
Santa Lucía	385	306	287	238	209	167	51															
Juliaca	451	372	353	304	275	233	117	66														
Nicasio	484	405	386	337	308	266	150	99	33													
Pucará	507	428	409	360	331	289	173	122	56	23												
Tirapata	518	439	420	371	342	300	184	133	67	34	11											
Ayaviri	542	463	444	395	366	324	208	157	91	58	35	24										
Santa Rosa	582	503	484	435	406	364	248	197	131	98	75	64	40									
Marangani	637	558	539	490	461	419	303	252	186	153	130	119	95	55								
Sicuani	648	569	550	501	472	430	314	265	197	164	141	130	106	66	11							
San Pablo	662	583	564	515	486	444	328	277	211	178	155	144	120	80	25	14						
Tinta	674	595	576	527	498	456	340	289	223	190	167	156	132	92	37	26	12					
Cusipata	709	630	611	562	533	491	375	324	258	225	202	191	167	127	72	61	47	35				
Urcos	737	658	639	590	561	519	403	352	286	253	230	219	195	155	100	89	75	63	28			
Oropeza	764	685	666	617	588	546	430	379	313	280	257	246	222	182	127	116	102	90	55	27		
Cuzco	787	708	689	640	611	569	453	402	336	303	280	269	245	205	150	139	125	113	78	50	23	

(Source) Empresa Nacional de Ferrocarriles.

Note: [1] ORETT is the abbreviation for Organismo Regulador de transporte Terrestre. It is bureau of the MTC and corresponds to the District Land Transport Bureau in Japan.

Table 5-15 Type 2 Railway Freight Charges Between Matarani and Cuzco (per ton)

(Unit: Soles)

Distance (km)	15t cars	25t cars	35t cars	Distance (km)	15t cars	25t cars	35t cars
0- 15	447	425	415	271-280	3886	3480	3292
16- 20	512	483	469	281-290	4015	3595	3401
21- 25	576	540	523	291-300	4145	3711	3509
26- 30	641	598	578	301-310	4275	3826	3618
31- 35	706	656	632	311-320	4405	3941	3726
36- 40	771	713	686	321-330	4535	4057	3835
41- 45	836	771	741	331-340	4664	4172	3943
46- 50	901	828	795	341-350	4794	4287	4052
51- 55	966	886	849	351-360	4924	4402	4161
56- 60	1031	944	903	361-370	5054	4518	4269
61- 65	1096	1001	958	371-380	5183	4633	4378
66- 70	1160	1059	1012	381-390	5313	4748	4486
71- 75	1225	1117	1066	391-400	5443	4864	4595
76- 80	1290	1174	1121	401-420	5703	5094	4812
81- 85	1355	1232	1175	421-440	5962	5325	5029
86- 90	1420	1290	1229	441-460	6222	5555	5246
91- 95	1485	1347	1283	461-480	6481	5786	5464
96-100	1550	1405	1338	481-500	6741	6016	5681
101-110	1680	1520	1446	501-520	7000	6247	5898
111-120	1809	1635	1555	521-540	7260	6478	6115
121-130	1939	1751	1663	541-560	7519	6708	6332
131-140	2069	1866	1772	561-580	7779	6939	6549
141-150	2199	1981	1881	581-600	8038	7169	6766
151-160	2328	2097	1989	601-620	8298	7400	6984
161-170	2458	2212	2098	621-640	8558	7630	7201
171-180	2588	2327	2206	641-660	8817	7861	7418
181-190	2718	2442	2315	661-680	9077	8092	7635
191-200	2847	2558	2423	681-700	9336	8322	7852
201-210	2977	2673	2532	701-720	9596	8553	8069
211-220	3107	2788	2641	721-740	9855	8783	8286
221-230	3237	2904	2749	741-760	10115	9014	8504
231-240	3367	3019	2858	761-780	10374	9245	8721
241-250	3496	3134	2966	781-800	10634	9475	8938
251-260	3626	3250	3075	801-820	10893	9706	9155
261-270	3756	3365	3183				

(Source) Empresa Nacional de Ferrocarriles

Table 5-16 Type 4 Railway Freight Charges Between Matarani and Cuzco (per ton)

(Unit: Soles)

Distance (km)	15t cars	25t cars	35t cars	Distance (km)	15t cars	25t cars	35t cars
0- 15	410	383	375	271-280	3193	2698	2546
16- 20	462	427	416	281-290	3298	2786	2628
21- 25	515	470	457	291-300	3403	2873	2710
26- 30	567	514	498	301-310	3508	2960	2792
31- 35	620	558	539	311-320	3613	3048	2874
36- 40	672	601	580	321-330	3718	3135	2955
41- 45	725	645	621	331-340	3823	3223	3037
46- 50	777	689	662	341-350	3928	3310	3119
51- 55	830	733	703	351-360	4033	3397	3201
56- 60	882	776	744	361-370	4138	3485	3283
61- 65	935	820	784	371-380	4243	3572	3365
66- 70	987	864	825	381-390	4348	3659	3447
71- 75	1040	907	866	391-400	4453	3747	3529
76- 80	1092	951	907	401-420	4663	3921	3693
81- 85	1145	995	948	421-440	4874	4096	3857
86- 90	1197	1038	989	441-460	5084	4271	4020
91- 95	1250	1082	1030	461-480	5294	4446	4184
96-100	1302	1126	1071	481-500	5504	4620	4348
101-110	1407	1213	1153	501-520	5714	4795	4512
111-120	1512	1300	1235	521-540	5924	4970	4676
121-130	1617	1388	1317	541-560	6134	5145	4840
131-140	1722	1475	1399	561-580	6344	5319	5004
141-150	1828	1563	1481	581-600	6554	5494	5167
151-160	1933	1650	1563	601-620	6764	5669	5331
161-170	2038	1737	1645	621-640	6974	5844	5495
171-180	2143	1825	1727	641-660	7184	6018	5659
181-190	2248	1912	1809	661-680	7394	6193	5823
191-200	2353	1999	1890	681-700	7604	6368	5987
201-210	2458	2087	1972	701-720	7815	6542	6150
211-220	2563	2174	2054	721-740	8025	6717	6314
221-230	3668	2261	2136	741-760	8235	6892	6478
231-240	2773	2349	2218	761-780	8445	7067	6642
241-250	2878	2436	2300	781-800	8655	7241	6806
251-260	2983	2524	2382	801-820	8885	7416	6970
261-270	3088	2611	2464				

(Source) Empresa Nacional de Ferrocarriles.

Table 5-17 International Freight Charges and Rates

(Unit: US$)

Rail charges between Matarani and Puno wharfs

Type	Consolidation	Consignment		
		15t cars	25t cars	35t cars
1st type	64.00	52.00	52.00	52.00
2nd type	40.00	33.00	29.00	27.00
3rd type	37.00	30.00	25.00	24.00
4th type	33.00	27.00	22.00	21.00
5th type	29.00	23.00	21.00	19.00

Transport fees on Lake Titicaca

Type	Puno ∿ Guaqui	Puno ∿ Chaguaya
1st type	11.00	8.00
2nd type	9.00	7.00
3rd type	8.00	6.00
4th type	7.00	5.00
5th type	6.00	4.00

Transshipment fees at Puno wharf

Type	Rate
Merchandise	1.76
Ore	1.76
Wheat	2.22

Minimum freight charges and rates

Type		Charges and rates
Ferrocarril del Sur	1st type	2.35
	2nd-5th type	1.34
Transport on Lake Titicaca		0.64
Transshipment		0.35
Departure and anchorage		1.00

(Source) Empresa Nacional de Ferrocarriles.

2-9-2 Passenger Fares

As in the case of freight charges, passenger fares have also been determined in accordance with ORETT Directors' Decision No. 313-79TC/ORETT/T (September 3, 1979). They are calculated by multiplying the distance travelled by the unit fare per kilometer between Sicuani and Cuzco, with separate fares for the steep and gentle gradient sections between Matarani and Sicuani. Fares and charges for the main sections are shown in Table 5-18.

Table 5-18 Passenger Fares Between Matarani and Cuzco

(Unit: Soles)

from AREQUIPA	1st class	2nd class	from AYAVIRI	1st class	2nd class
JULIACA	1,505	925	AREQUIPA	2,025	1,245
PUNO	1,660	1,015	JULIACA	520	320
AYAVIRI	2,025	1,245	PUNO	675	410
SICUANI	2,595	1,600	SICUANI	570	355
CUZCO	3,145	1,925	CUZCO	1,120	680

from JULIACA	1st class	2nd class	from SICUANI	1st class	2nd class
AREQUIPA	1,505	925	AREQUIPA	2,595	1,600
PUNO	155	90	JULIACA	1,090	675
AYAVIRI	520	320	PUNO	1,245	765
SICUANI	1,090	675	AYAVIRI	570	355
CUZCO	1,640	1,000	CUZCO	550	325

from PUNO	1st class	2nd class	from CUZCO	1st class	2nd class
AREQUIPA	1,660	1,015	AREQUIPA	3,145	1,925
JULIACA	155	90	JULIACA	1,640	1,000
AYAVIRI	675	410	PUNO	1,795	1,090
SICUANI	1,245	765	AYAVIRI	1,120	680
CUZCO	1,795	1,090	SICUANI	550	325

Charges

	Sleeping car	Buffet	Luxury charge
AREQUIPA ∿ PUNO	910	510	605
PUNO ∿ CUZCO	——	510	605

Fares on Cuzco - Quillabamba Line

Section	1st class	2nd class
CUZCO - HUAROCONDO	160	105
CUZCO - PTE.RUINAS	435	295
CUZCO - STA.TERESA	505	340
CUZCO - QUILLABAMBA	665	445
COMODIAD COCHE ESPECIAL		200

Section	Weekday Excursion fare
CUZCO-PTE.RUINAS-CUZCO	2,770

Lake transport

Section	Fares
PUNO - GUAQUI (Miercoles)	5.555
GUAQUI - PUNO (Viernes)	5.555

(Source) Empresa Nacional de Ferrocarriles.

3. Transport Quantities and Routes Related to Mining Development

3-1 Amounts Transported

Table 5-19 shows transport related specifications with respect to mining development.

Table 5-19 Transport Related Specifications

Mine	Atalaya	Tintaya	Corocco-huayco	Quechua	Remarks
Type of mining	Shaft mining	Open face and shaft mining	Shaft mining	Open face mining	
Construction period	in operation	1980-1982	1983-1985	1986-1988	
Operation Period	- 1985	1983-1997	1986-2000	1989-2003	
Operation level (t/day)	450	8,000	1,000	8,000	
Transport during construction (t)	-	50,000	5,000	30,000	Max. unit ø3m. 20t
Transport during operation (t/year)	12,200	212,000	28,500	141,000	
Concentrate (t/year)	9,600	152,000	20,000	92,000	
Materials (t/year)	1,000	15,000	2,500	15,000	
Fuel (t/year)	1,600	45,000	6,000	34,000	Normal use
Equipment power (kw)	1,675	15,000	5,200	15,000	÷ x 0.75
Annual electric power requirement (MWh)	6,000	90,000	20,000	68,000	
Water used (t/day)	1,500	8,800	3,000	12,500	New water only
Industrial (t/day)	1,000	7,000	2,000	11,300	
Domestic (t/day)	500	1,800	1,000	1,200	
Number of employees (person)	262	900	600	650	

As can be seen in Table 5-20, the peak values of concentrate transport will be reached every year between 1989 and 1997 when the annual amounts will reach 264,000 t. At an operating rate of 0.7, the amount transported per day during this period will be about 1,000 t.

Table 5-20 Annual Changes in Concentrate Transport

(Unit: t)

Year	Atalaya	Tintaya	Coroccohuayco	Quechua	Total
1981	9,600				9,600
1982	"				"
1983	"	152,000			161,600
1984	"	"			"
1985	"	"			"
1986		"	20,000		172,000
1987		"	"		"
1988		"	"		"
1989		"	"	92,000	264,000
1990		"	"	"	"
1991		"	"	"	"
1992		"	"	"	"
1993		"	"	"	"
1994		"	"	"	"
1995		"	"	"	"
1996		"	"	"	"
1997		"	"	"	"
1998			"	"	112,000
1999			"	"	"
2000			"	"	"
2001				"	92,000
2002				"	"
2003				"	"

Per day during best years $\frac{264,000}{365} \div 0.7$ (operating rate)

$= 1.026 \text{ t} \doteqdot 1,000 \text{ t}$

3-2 Transport Routes

3-2-1 Comparison of Routes

In consideration of such factors as the current condition of facilities and possibility of improvement, existing roads and railways can be used as transport routes. If these routes are divided into highway only routes and highway + railway routes, the routes to be compared are as follows. (Refer to Fig. 5-9.)

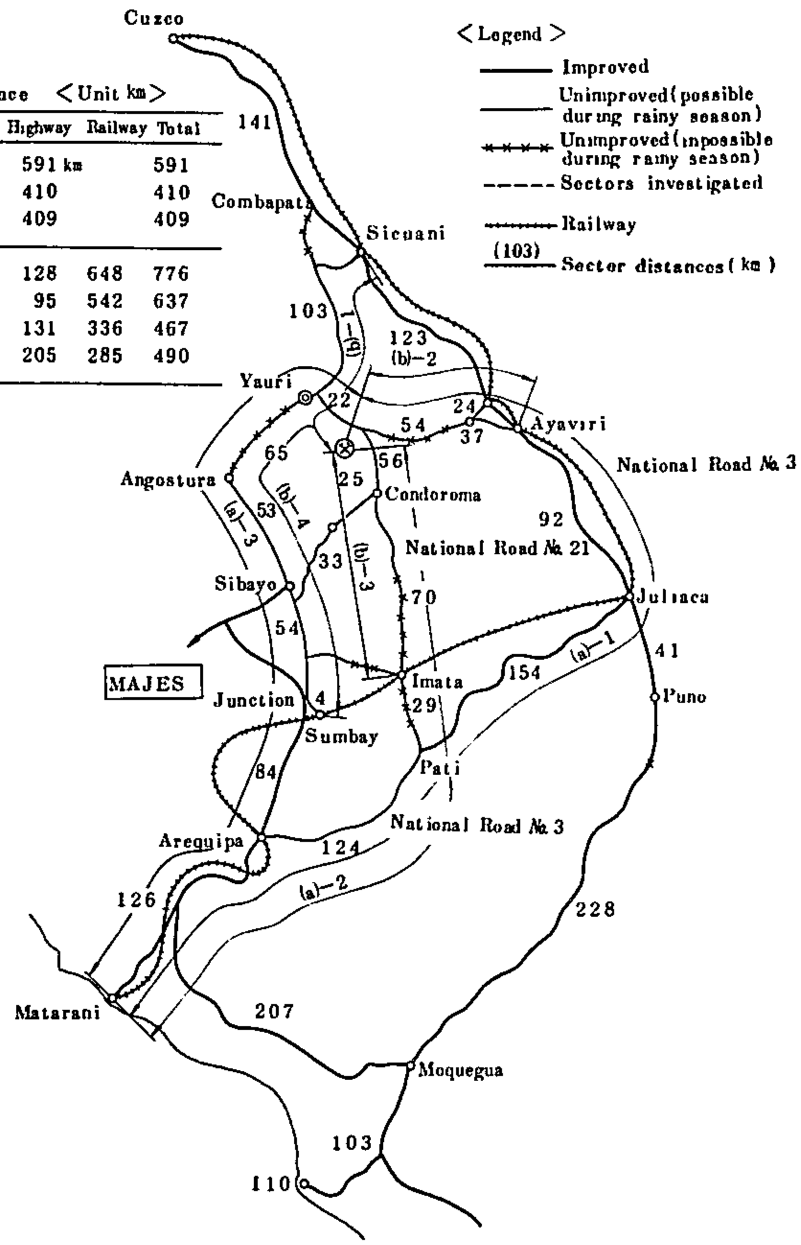
(a) Highway only routes

(1) Mines ∿ Ayaviri ∿ Juliaca ∿ Matarani Port
(2) Mines ∿ Condoroma ∿ Imata ∿ Matarani Port
(3) Mines ∿ Sibayo ∿ Arequipa ∿ Matarani Port

(b) Highway + railway routes

(1) Mines ∿ (Road) ∿ Sicuani Station ∿ (Rail) ∿ Matarani Port
(2) Mines ∿ (Road) ∿ Ayaviri Station ∿ (Rail) ∿ Matarani Port
(3) Mines ∿ (Road) ∿ Imata Station ∿ (Rail) ∿ Matarani Port
(4) Mines ∿ (Road) ∿ Sumbay Station ∿ (Rail) ∿ Matarani Port

Fig. 5-9 Current Transport Routes



Distance < Unit km >

	Route	Highway	Railway	Total
Highway onlyy	(a) – 1	591 km		591
	(a) – 2	410		410
	(a) – 3	409		409
Highways and railways	(b) – 1	128	648	776
	(b) – 2	95	542	637
	(b) – 3	131	336	467
	(b) – 4	205	285	490

3-2-2 Highway Only Routes

Among the three routes mentioned above, all of the sections are more or less completed and conditions for transport have provisionally been met with the exception of (1), the section between the mines and Ayaviri via Juliaca.

However, as is clear from Fig. 5-9, the length of route (1) is much greater than the other routes and will not be suitable as a large-scale transport route in the future. When a railway runs in parallel with a road, railway transport is better than highway transport as long as the distance is the same, and therefore, this route is not appropriate as a highway only route.

Routes (2) and (3) do not differ with respect to distances, construction costs and vehicle operating costs. They will be compared with respect to passage during the rainy season, the effect of regional development and relationship with other projects.

Route (2) has many sections in the vicinity of Imata and in the basins of the highlands which become wet during the rainy season. Even after improvements are made, it will be difficult to assure passage of large vehicles in the rainy season. However, since route (3) has comparatively good ground conditions, there should be few problems during the rainy season if improvements are made.

With respect to the results of regional development, there are almost no communities or agricultural endeavours in the vicinity of route (2), and there is little possibility of future development. On the other hand, since mines have already been developed along route (3), there are many communities, and there is possibility of future agriculture and livestock development in the Yauri Plain.

Route (3) is related to the Majes Project which involves improvement of the Sibayo ∿ Angostura section as the Angostura Dam road. Since this route also joins the trunk road of the Majes Project near Sumbay, a two-lane highway has already been completed as far as Arequipa and it is planned to use this in future.

The above indicates that, among highway only routes, route (3) is the best because of the possibility of reduced construction and maintenance through coordination with the Majes Project, and also because of the potential for more efficient utilization and management.

3-2-3 Highway + Railway Routes

Among the existing routes, route (1) is basically now complete, but is not satisfactory as a future large-scale transport route. Because the route involves long distances through mountainous areas, expensive, wide-ranging improvements would be required.

Route (2) still has several incomplete sections and fundamental improvements are necessary, but since it does not pass through many mountainous areas, the construction costs would not be much different from those required for route (1).

However, with respect to distances, route (1) is 128 km long while route (2) is only 95 km long or about 25% shorter. The length of the rail connection to Matarani Port is 648 km long in route (1), while that in route (2) is 542 km or about 15% shorter. Therefore, route (2) would result in major transport cost savings in the long run.

In the case of railway transport capacity, the steepest gradient on the line between Sicuani and Arequipa is 4.9% and even if a train is pulled by two locomotives, the transport capacity per train would be only 400 t. This is much lower than the 1,500 t capacity on the line between Ayaviri and Juliaca. Because of limitations such as those on the use of locomotives, route (2) appears to be the best.

Almost no effect on regional development can be expected with route (1), while route (2) is connected with Juliaca, the commercial center of the region, and Puno which is a trading center with Bolivia, and the effect of development would be considerable.

In comparison with highway only routes, it is clear that route (4) via Sumbay is better, but since the road section accounts for 42% of the entire route, the advantages of railway transport with respect to long distances and large-scale transport are not obtained and this route is, therefore, considered unsuitable.

The above considerations indicate that route (2) is the best highway + rail route because of such factors as future transport costs and effect on regional development.

4. Transport Plans

4-1 Section Between Mines and Ayaviri Station (95 km)

In the 95 km section between the mines and Ayaviri Station, it will be sufficient to improve existing roads and the transport capacity of ore concentrate will be a maximum of 1,000t per day. Therefore, truck transport will be used in this section since the construction of new means of transport such as light railways would only result in increased cost.

The number of concentrate transport trucks required per day will, on the assumption that 12 t trucks will be required for the coroccohuayco mine and 20 t trucks for the other mines, be as follows:

1) Tintaya mine (1983 - 1997)
   152,000/365x20 ÷ 0.7 (operating rate) = 30 trucks

2) Coroccohuayco mine (1986 - 2000)
   20,000/365x12 ÷ 0.7 = 7 trucks

3) Quechua mine (1989 - 2003)
   92,000/365x20 ÷ 0.7 = 18 trucks

4-2 Section Between Ayaviri Station and Matarani Port (542 km)

4-2-1 Transport Trains

To cope with the continuous, large-scale transport required for this project, the use of piston transport for specific trains between the loading and unloading stations will be advantageous in assuring transport and improving freight operating efficiency.

According to Table 5-5, it is possible to transport 1,500 t by one train drawn by two locomotives between Ayaviri and Santa Lucia. Since the amount of ore transported in the peak period will be 1,000 t per day, one train per day will be sufficient if extra locomotives are used in other sections with steep gradients.

4-2-2 Operating Times

Table 5-21 shows the operating times required at present between the various stations on the Matarani∿Cuzco Line. The time required between Ayavirí and Mataraní is about 15 hours, but it is necessary to add stopping times and a delay Margin of 2 - 3 hours.

Table 5-21 Time Required for Transport Between Matarani and Cuzco

Station	Distance (km)	Time required (minits)	Average Speed (km/h)
MATARANI - JULIACA			
Matarani - Arequipa	147	261	33.8
Arequipa - Yura	29	54	32.2
Yura - Pampa de Arriero	42	91	27.7
Pampa de Arriero - Crucero Alto	116	170	41.0
Crucero Alto - Sta. Lucia	51	80	38.2
Sta. Lucia - Juliaca	66	91	47.8
JULIACA - CUZCO			
Juliaca - Nicasio	33	46	43.0
Nicasio - Pucará	23	29	47.5
Pucará - Tirapata	11	13	50.8
Tirapata - Ayavirí	24	28	51.4
Ayavirí - Sta.Rosa	40	48	50.0
Sta.Rosa - Maranganí	55	91	36.2
Maranganí - Sicuani	11	16	41.3
Sicuani - San Pablo	14	18	46.7
San Pablo - Tinta	12	26	27.7
Tinta - Cusipata	35	78	26.9
Cusipata - Urcos	28	65	25.9
Urcos - Oropeza	27	60	27.0
Oropeza - Cuzco	23	58	23.8
MATARANI - CUZCO	787	1,323	35.7

(Source) Empresa Nacional de Ferrocarriles.

4-2-3 Loading Facilities

According to the results of investigations of transport routes in section 3-2-3, it is evident that the highway - rail route via Ayavirí Station is best, but there is no room for expansion of the present Ayavirí Station which is sandwiched between an urban area to the north and a cliff over 20 m in height to the south.

Therefore, a special freight station should be built 96.5 km from the starting point of Juliaca in the Cuzco direction from Ayavirí Station. (Refer to Photo 5-4.) Loading is currently performed in Sicuani Station by the method shown in Table 5-22.

Loading is currently performed in Sicuani Station by the method shown in Table 5-22.

Photo 5-4 Proposed Site of Freight Station (96.5 km nearer to the Juliaca starting point)

Table 5-22 Method for Loading Concentrate at Sicuani Station

Mine	Weight (t/day)	Type of shipment	Loading method	Time required to load one car
Atalaya	500	Bulk	Loading after temporary storage on platform or direct loading from trucks.	4 hours
Katanga	1,000	40kg bags	Loading after temporary storage on platform	2 hours

The above method, which involve unloading the freight from trucks onto the platform and then loading from the platform onto freight cars, is inefficient, and a new freight station for direct loading from the trucks onto the freight cars is desirable. Therefore, the freight station should be laid out with a shuttle and loading line with an effective length of 400 m in parallel with the main line. The platform connected to the loading line will allow for direct unloading from dump trucks onto the freight cars.

4-2-4 Unloading Facilities

Unloading of concentrate at Matarani Station is performed at an unloading site located in the center of the tracks. One side is the same height as the rail surface and the other is about 1.2 m lower. After the push-in side plates of the open wagons on the unloading line are opened, the concentrate is pushed down to the lower end of the unloading site by bulldozers, and the remainder is unloaded manually. This method is very fast and one wagon can be unloaded in about 20 minutes. (Refer to Photo 5-5.)

Photo 5-5 Ore Handling Line at Matarani Station

The unloaded concentrate is brought by bulldozer or shovel loader to a belt conveyor for loading onto ships. Since there is a good possibility of handling 1,000 t/day with respect to both the area of the collection site and the capacity of the belt conveyor, existing equipment will present no problem.

4-2-5 Freight Cars Used

At present, some covered wagons are used because there are insufficient open wagons and also because of scattering of the concentrate during transport and outflow from the wagons caused by rainwater, but since 50 t open wagons are already used for transport of Bolivian ore, the use of 50 t steel open wagons is considered as appropriate because of such factors as the low rolling stock manufacturing cost and the savings in unloading cost resulting from mechanization.

In the reconstruction plan of Ferrocarril del Sur currently under study, increases in the number of freight cars are being considered, but even without consideration of this project, the number of special freight cars will have to be increased since the present number is equivalent to only 50% of the planned transport.

Table 5-23 shows the number of freight cars required for concentrate transport annually calculated for a cycle of 72 hours including operating and unloading times and including a 10% spare car margin to allow for inspections, repairs, etc.

Table 5-23 Number of Freight Cars Required

	1983-85 (every year)	1986-88 (every year)	1989-97 (every year)
Annual concentrate transport (t)	152,000	172,000	264,000
Concentrate transport per day[1] (t)	595	673	1,026
No. of freight cars starting per day	12	14	20
No. of freight cars in operation	36	42	60
No. of freight cars required	40	46	66

(Note) 1) The amount transported per day is the value obtained by dividing the annual concentrate transport/365 by an operating rate of 0.7.

5. Comparison of Transport Costs

A comparative investigation of the transport costs was performed for highway only route (a) (3) (mines ∿ Sibayo ∿ Arequipa ∿ Matarani Port) and highway + rail route (b) (2) (mines ∿ Ayaviri Station ∿ Matarani Port) discussed in 3-2 on the basis of the road conditions shown in Figs. 5-10 and 5-11.

5-1 Highway-Only Route

The basic data used for calculating highway traveling costs is shown in Table 5-24 in accordance with ORETT Directors' Decision No.366-79TC/ORETT/T (September 30, 1979).

In the section between the mines and Matarani Port, the correction value for the 283 km between the mines and Arequipa was 2.80 for a gravel road in the mountains, and that for the 126 km between Arequipa and Matarani Port was an average of 1.1 for an asphalt road in the jungle and flatlands. Using these values, the running costs for 20 t trucks were obtained as follows:

Basic charges: $847.5 + 4.68 \times 409 \times 2 \times 20 = 78,260$ soles
Correction value: $(282 \times 2.8 + 126 \times 1.1) \times 1/409 = 2.28$
Cost per ton: $78,260 \times 2.28 \div 20 = 8,920$ soles

Fig. 5-10 Road Conditions a - 3 Route

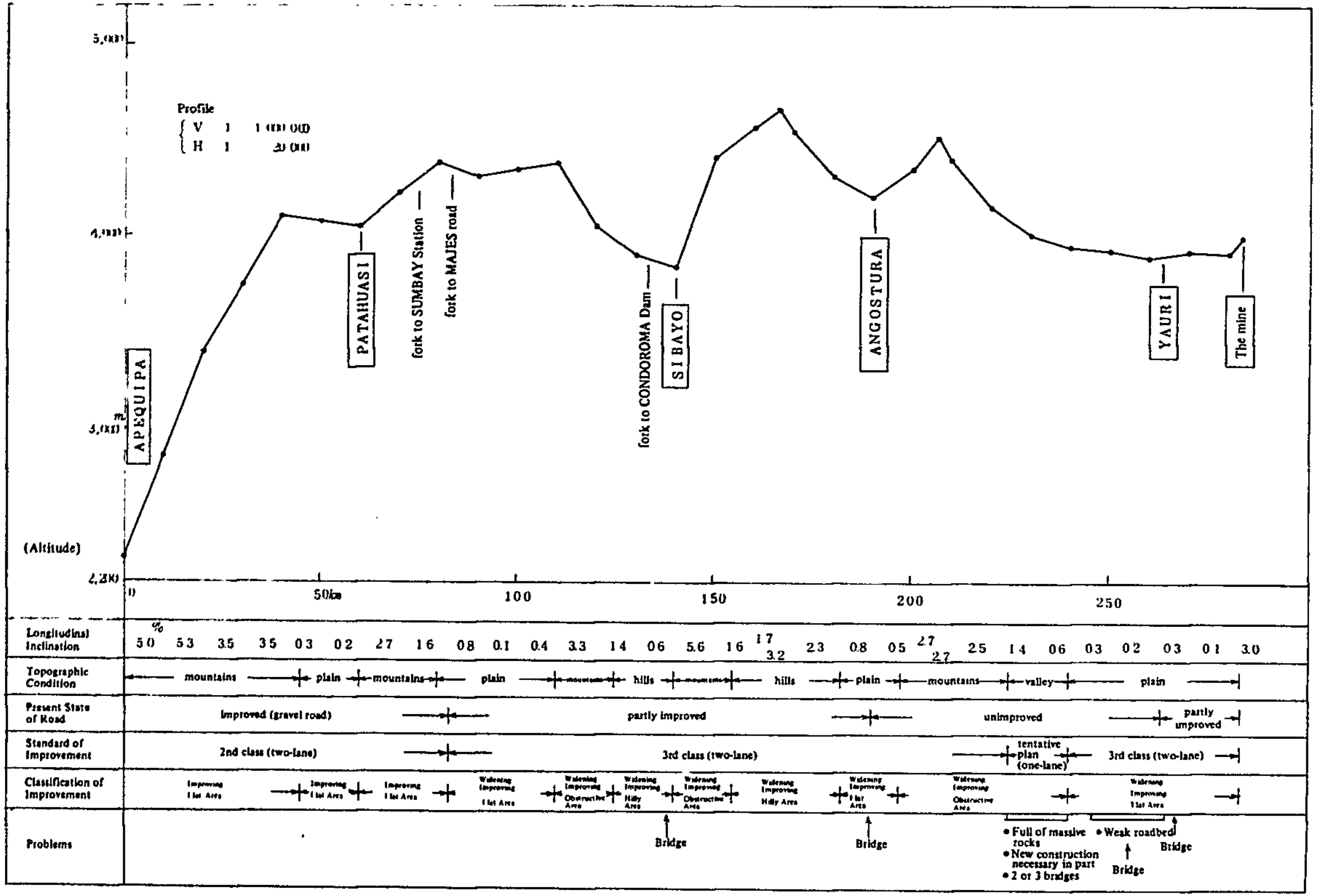
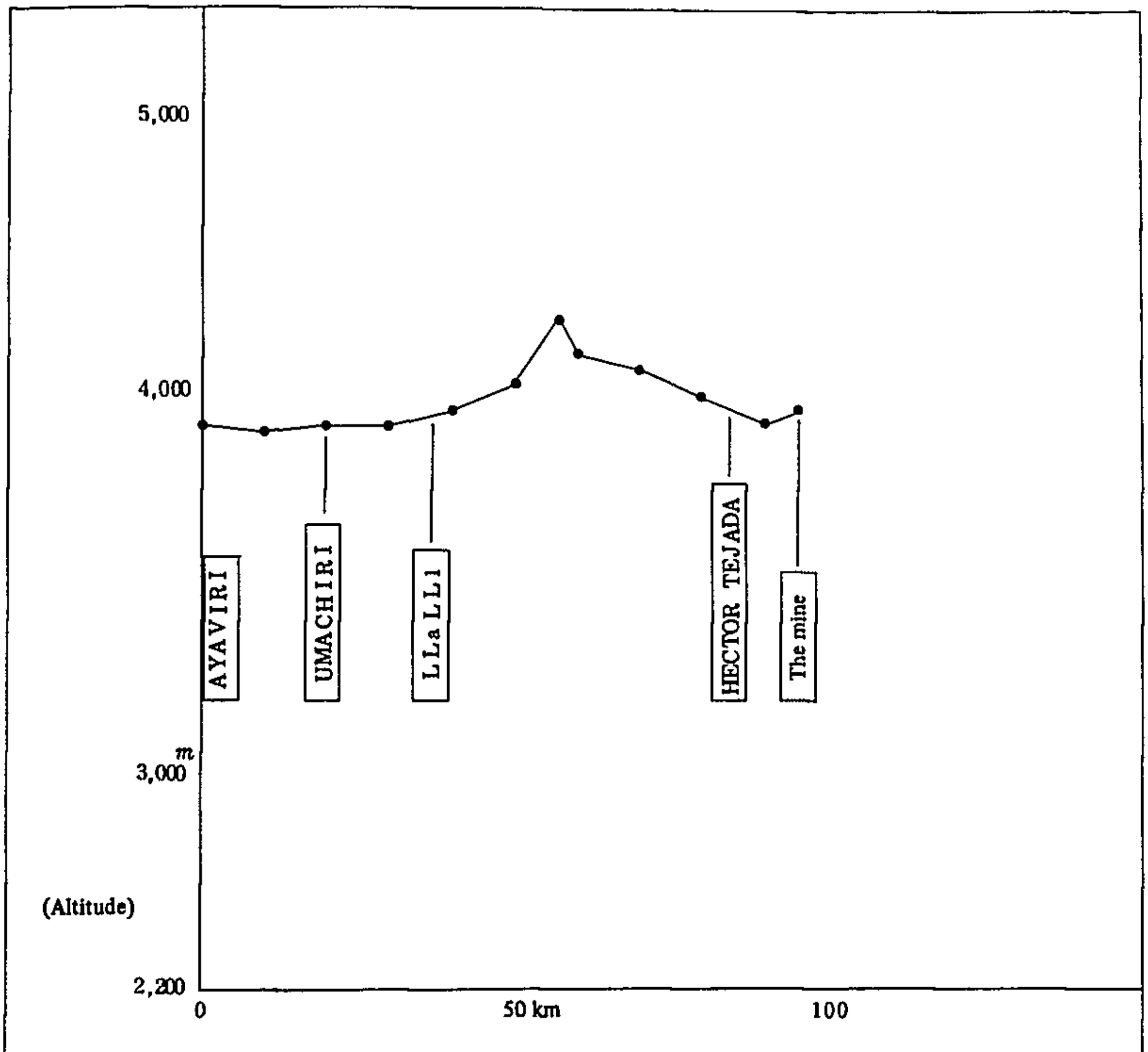


Fig. 5-11 Road Conditions b - 2 Route



Longitudinal Classification	0.2 02 0.1 05 0.8 40 5.0 04 08 08 25
Topographic Condition	Plain / Mountain / Plain
Present State of Road	Partly Improved / Unimproved
Standard of Improvement	3rd Class (two-lane)
Classification of Improvement	Improving Flat Area / Widening Improving Hilly Area / Widening Improving Obstructive Area / Widening Improving Hilly Area / Widening Improving Flat Area
Problems	Bridge, Bridge, Bridge, • Improvement of Linear Alignment, Bridge

Table 5-24 Truck Operating Costs

(Unit: Soles)

Basic charges

Traveling distance	Running costs per vehicle (Soles)
0 - 500 km	847.5 + 4.68 x L x T
500 km or more	6.55 x L x T

L: Distance travelled

T: Number of tons loaded

Correction value

Type	Asphalt coefficient	Gravel road	Unpaved
Flatland 1,000 m or less gradient 0 - 3%	1.00	1.58	2.15
Jungle 1,000 - 2,500 m 3 - 5%	1.20	2.10	2.90
Mountains 2,500 m or more 5 - 7%	1.40	2.80	3.90

(Source) Organismo Regulador de Transporte Terrestre.

5-2 Highway + Rail Route

The highway transport costs were the same as those in Table 5-24, but since the corresponding transport costs for the railway could not be obtained, freight charges were used.

A matter for future discussion is the manufacturing cost of the special freight cars for concentrate transport being born by both the railway and the mines.

In Japan, companies purchase special freight cars such as tankers and bottom-opening cars to assure transport and a system of privately-owned cars operated and maintained by the railway has developed. Such cars account for 20% of the total.

Since freight charges naturally include manufacturing and maintenance costs, in the case of privately owned cars, discount charges obtained by subtracting an amount equivalent to these costs are applied. Normally, the discount is 15%.

Therefore, in the comparison of transport costs, the usual charges on the basis of (private freight cars) + (discount charges) = (usual charges) were used for convenience.

1) Between the mines and Ayaviri Station (95 km)
   The correction value for the transportation costs

for the 95 km between the mines and Ayaviri Station was 2.80 for a gravel road in the mountains.
The costs for a 20 t truck were obtained as follows:

Basic charge: 847.5 + 4.68 x 95 x 2 x 20 = 17,480 soles
Correction value:2.80 soles
Cost per ton: 17.480 x 2.8 ÷ 20 = 2,448 soles

2) Between Ayaviri Station and Matarani Port (542 km)
Since there are four types of concentrate, the cost per ton obtained from Table 5-16 was 4,840 soles.

3) Unloading costs
The loading and unloading costs per ton according to Table 5-17 are 1.75 US$ = 430 soles. The unloading costs per ton are 430 x 2 = 860 soles.
Therefore, the total transport cost per ton between the mines and matarani port is 2,448 + 4,840 + 860 = 8,148 soles.

5-3 Comparison of Costs

The above-mentioned transport cost per ton of concentrate is 8,920 soles for the highway only route and 8,148 soles for the highway + rail route, i.e. the latter is about 8% cheaper.

In addition, as shown in Table 5-25, there is a major difference between the road construction costs, i.e. US$20.77 million for the highway only route compared with US$5.66 million for the highway + rail route. The maintenance and management costs are almost proportional to the construction costs. Therefore, the highway + rail route is more favorable with respect to cost.

Table 5-25 Comparison of Highway Construction Costs

Type of construction	Type of land	Construction cost per km	Proposed highway only route (a)-3 route		Proposed highway plus rail route (b)-2 route	
			Distance	Construction cost	Distance	Construction cost
		(Million Soles)	(km)	(Million Soles)	(km)	(Million Soles)
New road construction	Obstructed land	39.2	5	196.0	-	-
"	Hilly land	30.4	15	456.0	2	61
Widening and improvement	Obstructed land	16.9	68	1,149	8	135
"	Hilly land	14.4	28	403	23	331
"	Flatland	8.7	84	731	25	218
Improvement	Flatland	3.8	8.3	315	37	140
Total			283	3,250 (US$20.77 Million)	95	885 (US$5.66 Million)

(Note) Exchange rate as of 1978: 1US$=180 Soles
Construction Cost as of 1979: 1.15 x Construction Cost as of 1978

6. Railway Development Plans

6-1 Related Items in Plans for Reconstruction and New Line Construction

The reconstruction plan currently under investigation is concerned mainly with the replacement of worn-out rolling stock and equipment to meet demand up to 1990.

Purchase of 16 locomotives, 104 passenger cars and 250 freight cars is planned, but even without any consideration given to concentrate transport in this project, the amount transported is very large being equivalent to 50% of the reconstruction plan, and sufficient consultation and adjustment will be necessary.

Strengthening the lines by replacing 9,680 t of rails and accessories is also planned, but the resulting improvement in train speed should lead to a surplus in freight car use because of the rapid rotation of special freight cars.

Construction on the new line between Matarani and Ilo has been started and the roadbed for a distance of about 15 km between Matarani and Mollendo on this line has been completed. Plans call for opening the new line in 1980.

Currently, concentrate and general sundries are handled in Matarani Port, while fuels such as gasoline and heavy oil are handled in Mollendo Port. Since there is no railway between these two ports, special trains for fuel are operated on a line of about 87 km between La Joya and Mollendo, but transport by fuel tank cars to the mountainous areas would be facilitated if the two ports were connected.

6-2 Items Required for Execution of Project

The following items are required for the transport of concentrate and heavy oil for generators by special freight car:

1) Assurance of the necessary locomotives
2) Assurance of the necessary tank cars
3) Assurance of the necessary special freight cars
4) New construction of a by-pass line at the entrance of Juliaca Station
5) New construction of a special freight station for concentrate loading

In the case of (1), two locomotives are required to transport 1,000 t and since the required operating time between Ayaviri and Matarani is about 15 hours, it will be necessary to operate one special train each of loaded cars from Ayaviri Station and of empty cars only from Matarani Port daily.

This transport is linked in a complex way with other transport on Ferrocarril del Sur. Since an extra locomotive is required for sections with steep gradients, the required numbers of locomotives cannot be confirmed unless a careful study is made of the train timetables and locomotive operating plans, but four should be sufficient.

In the case of (2), it is planned that the power transmission network from Machu-Picchu and other power stations will be completed by 1986 when the Coroccohuayco mine will come into operation. Therefore, only the power for the Tintaya mine will have to be supplied by diesel generator.

The amount of heavy oil required for power generation in this case will be about 80 t per day and for this amount, two 50 t tank cars are needed. If one cycle is three days as in the case of the concentrate, seven wagons will be needed, six regular ones and one spare for use in the event of inspections and repairs.

At present, a considerable number of tank cars are used for transport from Mollendo Port in the direction of Sicuani and Cuzco and it should be possible to reduce the number of new tank cars required by coordination with the reconstruction and new line construction plans.

In the case of the special freight cars in (3), currently open wagons account for only 12% of the total and the 50 t open wagons for concentrate transport are all being used for transport of Bolivian ore so there are none to spare. In the reconstruction plan, consideration has been given to only 20 cars and there is no possibility that there will be any surplus of cars in the future.

Therefore, the freight cars for this project will have to be newly purchased. The number required will be 66 in the peak period.

New construction of a by-pass line in (4) is necessary because at present trains from Arequipa travelling in the direction of Ayaviri and Cuzco must double back after arrival in Juliaca Station. There is a time loss for switching the locomotive and caboose, etc. A by-pass line should therefore be newly constructed at the entrance of the station so that it is possible to by-pass Juliaca Station.

With shortened operating times of special trains in conjunction with the improvement in train speeds resulting from the reconstruction plan, it will be possible to rotate freight cars more quickly and surpluses might arise.

The new freight station in (5) will be built with a capacity of 300,000 t/year at a point 96.5 km nearer to the starting point of Juliaca from the present terminal station.

6-3 Rolling Stock and Equipment Costs

The various items required to carry out this project have been described previously. The necessary costs for various years are as shown in Table 5-26.

Table 5-26 Rolling Stock and Equipment Costs in Various Years

(Unit: 1,000 US$)

Type	Unit Price	1982		1985		1988		Total
		Number	Amount	Number	Amount	Number	Amount	
Locomotives 110 t D.E.	880	4	3,520	-	-	-	-	3,520
Tank cars 50t load	60	7	420	-	-	-	-	420
Open wagons 50t load	52	40	2,080	6	312	20	1,040	3,432
By-pass line	270	1	270	-	-	-	-	270
Freight station	600	1	600	-	-	-	-	600
Total		-	6,890	-	312	-	1,040	8,242

7. Responsibility for the Transport Facility Costs and Transport Costs

In an overall economic evaluation of the mining development, it is necessary to take transport costs into consideration, but these will include road construction costs, maintenance and management expenses, vehicle operating costs and railway charges.

7-1 Responsibility for Road Development Costs

The division of public and private responsibility for costs of road construction, maintenance and control must be decided with consideration given to the impact of road development on the region, since roads play a major role in regional development. However, at the present stage, it is very difficult to determine the appropriate proportions since no definite regional development plan has been prepared.

Therefore, the section in this case which requires road development is that from the mines to Hector Tejada and Llalli Nuevo the entire amount of which will be born by the mines since there is no great necessity for road passage at present and main development concerns the mines only.

Maintenance and management costs will be divided evenly since heavy vehicles from the mines will be major users of the road.

7-2 Responsibility for Railway development Costs

The railway facilities required for this project are shown in 6-2. However, since the transport of freight according to the demands of shippers is the task of the railways, and freight transport charges include the costs of the transport facilities, power costs and personnel expenses, the development of these transport facilities should be born entirely by the mines and this must be introduced into the reconstruction plan during the current drafting stage.

However, the volume of transport involved in this project is extremely large, being equivalent to about 50% of that in the reconstruction plan. For the shipper, it is also desirable to make thorough arrangements beforehand concerning use of the private freight car system which would be advantageous in assuring transport and would shift the costs of manufacturing the freight cars to the private sector.

This is a basic problem of railway management and no decision can be made at present. Therefore, for convenience, it is assumed that the railway will be solely responsible for development of facilities and the usual charges were used in the calculation of transport charges based on the principle of (privately owned cars) + (specified charges) = (usual charges).

7-3 Road Transport Vehicle Operating Expenses and Railway Charges

As indicated in 5-2, the road transport vehicle operating expenses from the mines to Ayaviri Station are 2,450 soles per ton and the railway charges, including unloading from Ayaviri Station to Matarani Port, are 5,700 soles per ton. Table 5-27 shows the total costs for each year and during operation of the mines.

7-4 Transport Costs

Table 5-28 shows road transport costs and railway charges required until the completion of mine operations, calculated at 1979 prices, according to public and private responsibility for road construction, maintenance and management costs as indicated previously.

8. Recommendations for Further Detailed Studies

8-1 Conclusions

This chapter has described a survey of railway development subsequent to last year's survey on highway development as part of the infrastructure of the integrated regional development study which is based primarily on development of copper mining in the Project Area.

The continuous transport of large volumes such as the ore concentrate in this project over long distances, is best performed by rail. The route consisting of 95 km of road from the mines to Ayaviri Station and 542 km of rail from Ayaviri Station to Matarani Port is 8% cheaper with respect to total road transport costs and railway freight charges and involves one third less road construction and maintenance costs than the 409 km from the mines to Matarani Port by road only. It is also advantageous in relation to energy conservation since the oil situation will become more serious in the future.

Table 5-27 Road Transport Costs and Railway Freight Charges

Year	Discount rate	Halage volume (t/year)			Mine - Ayaviri		Ayaviri - Matarani		Total Amount
	7%/year	Construction materials	Concentrates	Materials & Supplies	t/year	Amount US$	t/year	Amount US$	US$
1979	1,000								
80	0.935	16,670			16,670	158.1	16,670	464.6	622.7
81	0.873	"			"	148.4	"	436.2	584.6
82	0.816	"			"	138.7	"	407.7	546.4
83	0.762	1670	152,000	15,000	152,000	1181.4	152,000	2523	3704.4
							16,670		
84	0.712	"	"	"		1103.9	"	2926	4029.9
85	0.666	"	"	"		1032.6	"	2737	3769.6
86	0.623	10,000	172,000	17,500	172,000	1093.0	172,000	3058.4	4151.4
							27,500		
87	0.582	"	"	"		1021.1	"	2857.2	3878.3
88	0.541	"	"	"		949.1	"	2655.9	3605.0
89	0.508		264,000	32,500	264,000	1368.0	264,000	3680	5048.0
							32,500		
90	0.475		"		"	1279.0	"	3441	4720
91	0.444		"		"	1191.2	"	3216.3	4407.5
92	0.415		"		"	1117.6	"	3006.3	4123.9
93	0.388		"		"	1044.8	"	2810.7	3855.5
94	0.362		"		"	974.8	"	2622.3	3597.1
95	0.339		"		"	912.9	"	2455.7	3368.6
96	0.317		"		"	853.6	"	2296.3	3149.9
97	0.296		"		"	797.0	"	2144.2	2941.2
98	0.277		112,000	17,500	112,000	316.4	112,000	882.1	1198.5
							17,500		
99	0.258		"		"	294.7	"	821.6	1116.3
2000	0.242		"		"	276.5	"	770.6	1047.1
01	0.226		92,000	15,000	92,000	212.0	92,000	595.4	807.4
							15,000		
02	0.211		"		"	198.0	"	555.9	753.9
03	0.197		"		"	172.7	"	484.8	657.5
Total						17,835.4		47,849.2	65,684.6
				17,835.4 x 0.7 =		12,484.8	47,849.2 x 0.7 =	33,494.4	45,979.2
						Construction Materials			1,669.4
						Concentrates			40,191.3
						Materials & Supplies			4,118.5

Table 5-28 Transport Costs (1979 Price)

(Unit: 1,000US$)

	Amount	Private Share	Public Share
Construction cost	4,938	3,466	1,472
Maintenance and management cost	980	490	490
Road transport cost	12,485	12,485	-
Railway charges	33,494	33,494	-
Total	51,897	49,935	1,962

(Note)

1. The transport costs are for 20 years - the life of the road. The values are for each year from 1983 to 2003.
2. The periods of operation of the mines are as follows: 1983 - 1997 for Tintaya, 1986 - 2000 for Coroccohuayco, 1989 - 2003 for Quechua and 1978 - 1986 for Atalaya.
3. The road construction costs are based on completion of work in 1982. The centroid year of investment is 1981.
4. The maintenance and management costs are considered as 2 million soles annually.
5. The discount rate for current price conversion is taken as 7% annually.
6. The sol conversion rate used is that for 1978, i.e. 1 US$ = 180 soles.
7. The road transport costs are converted to dollars at the 1979 rate, with no increases considered.

Although this conclusion is related mainly to the mines, when consideration is given to the fact that the highway route will greatly shorten travel time between Espinar and Arequipa and the coast, as well as to the feet that a high level of development can be expected along the line, the contribution to regional development will be considerable and the rail route is better with respect to speeding up of the transport of small and medium amounts of freight.

Since more than one transport route is highly desirable because of the risk of obstructions due to such factors as natural disaster, accident, snow storm, etc., the most practical route is by road to Ayaviri Station, the nearest station to the mines, and then by rail from Ayaviri Station to Matarani Port. It is, however, also desirable to develop the road to Arequipa in conjunction with this plan.

8-2 Recommendations

This was a short-term survey limited to roads and railways. A subsequent detailed survey should deal with the following items.

8-2-1 Roads

(1) The main disadvantage of the roads in this region is that passage is obstructed during the rainy season (December - April). Since this survey was conducted during the dry season, it is absolutely necessary to perform a detailed survey of conditions prevailing during the rainy season. The Apurimac valley in particular must be carefully surveyed to correctly determine rainy season conditions since construction costs for this area will be very high and there is a possible problem of blockage of the route.

(2) With respect to the cost of road construction, inflation is extremely high in Peru and it is therefore impossible to estimate future costs. At the present stage of investigation for this plan, it is essential to make periodic corrections in costs.

(3) The highway only route is connected with the Majes Project in some way in most of the sections involved and closely coordinated planning is necessary in regard to maintenance and management.

8-2-2 Railways

The transport of ore concentrate by special trains is related in a complex way with such items as line equipment, locomotives and freight cars in use, and the plan must be related to the overall transport system.

In particular, the present Ferrocarril del Sur must be considered with respect to future overall planning, including related advances in long-term plans for railway reconstruction. Therefore, the following items must be investigated in close cooperation with the railways.

(1) Train operating conditions
The current operating conditions must be investigated and locomotive performance, rail conditions and operations within the railway premises must be clearly identified.

(2) Transport time
The time required for a special train to carry out one cycle must be calculated on the basis of investigation of improvement in speeds due to strengthening of the lines, the time saved by construction of a by-pass line at Juliaca Station and the loading time for special freight trains.

(3) Number of cars required
The number of locomotives, tank cars and special freight wagons required must be determined in coordination with increases in rolling stock in the reconstruction plan.

CHAPTER 6

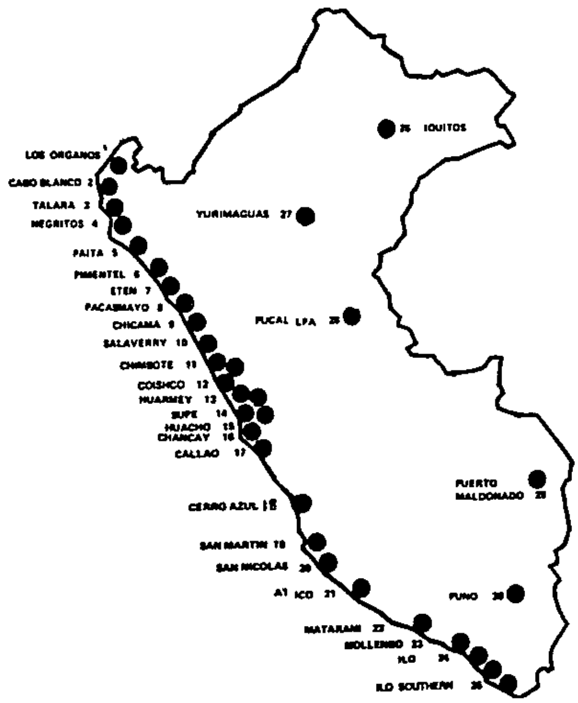
PORT AND HARBOR DEVELOPMENT

CHAPTER 6 PORT AND HARBOR DEVELOPMENT

1. Current Conditions in the Harbors of Southern Peru

There are 30 harbors in Peru, all of which are under the control of Empresa Nacional de Puertos (ENAPU). Among these harbors, Matarani and Ilo harbors in the southern part of the country are the nearest to Cuzco Department and appear promising as prospective harbors for the shipment of the ore concentrates expected to be produced by various mines in the same southern region. Fig. 6-1 shows the locations of Peruvian harbors.

Fig. 6-1 Location of Ports in Peru



(Source) Empresa Nacional de Puertos

1-1 Outline of Harbors

1-1-1 Matarani Port

(1) Historical Outline

Matarani Port, the main harbor of Arequipa Department is located in the Islay region 15 km from Mollendo.
Construction of the harbor was completed in 1942, but operations did not start until 1947 with the arrival of the ship called the Mantaro. In 1951, a railway was opened between Matarani Port and

La Joya and in 1956, grain vacuum suction equipment began operation. In 1968, a wharf for fishing boats was completed and in 1970, operation of a belt conveyor for loading ore with a total length of 530 m began.
Fig. 6-2 shows the location of Matarani Port and Fig. 6-3 shows a plan of the port.

(2) Geographical Location

Latitude: 17°00' Lat. S.

Longitude: 72°07' Long. W.

(3) Sphere of Influence and Traffic Routes

The sphere of influence of Matarani Port is the entire Department of Arequipa and parts of Moquegua, Cuzco and Puno Departments. It also serves as a window for the exports and imports of landlocked Bolivia, which has no coastline of its own. Traffic routes are as follows:

Highways: A 15 km highway to Mollendo and a 50 km highway to La Joya, which starts at a point 800 m from the port (connects with the Pan American Highway at La Joya).

Railway: A 62 km railway to La Joya where it connects with the Ferrocarril del Sur.

(4) General View of the Harbor

Matarani Port is located 8.5 nautical miles north of Mollendo Port and 465 nautical miles south of Callao Port at the base of a rocky hill. There are two breakwaters for safe mooring of ships and harbor preservation. The harbor is not very large and since the harbor entrance is narrow, there are some problems in entering and leaving the port. The water depth in the harbor is -6 ~ -29 m (Photo 6-1).

(5) Harbor Facilities

Protective Facilities: Southern breakwater

Total length: 650 m

Eastern breakwater

Total length: 145 m

Fig. 6-4 shows a cross section of the breakwaters in Matarani Port.

Mooring facilities: Quaywall with a water depth of -10.0 m (total length: 580 m). Figs. 6-5 and 6-6 show standard cross-sections of the Matarani Port quaywall.
Apron width: 20.0 m

Warehouses: No. 1 warehouse (for imports)
Shelf space: 190,000 cu.ft, floor area: 9,000t

No. 2 warehouse (for imports)
Shelf space: 160,000 cu.ft., floor area: 9,000t

No. 3 warehouse (for exports)
Area: 3,533 m^2

No. 4 warehouse (12 grain storage silos with a capacity of 11,000T)
This warehouse handles grain for domestic consumption and for import by Bolivia.

Attached warehouses: total area: 5,839 m^2

Open storage area: Total area: 42,376 m^2

Tugboats: One each of 720, 780 and 800 HP

Machinery and equipment: Tractors
22, capacities: 3,000 ~ 8,000 lbs.

Forklifts
24, capacities: 5,000 ~ 30,000 lbs.

Traveling cranes
9, capacities: 6 ~ 25t

Trucks

368	capacity:	2,000 lbs.
50	"	4,000 "
21	"	20,000 "
30	"	30,000 "
27	"	50,000 "

Scales Capacity: 100t three
Palettes: 4,500

Water supply equipment: One water storage tank of 100,000 and one of 20,000 gallons

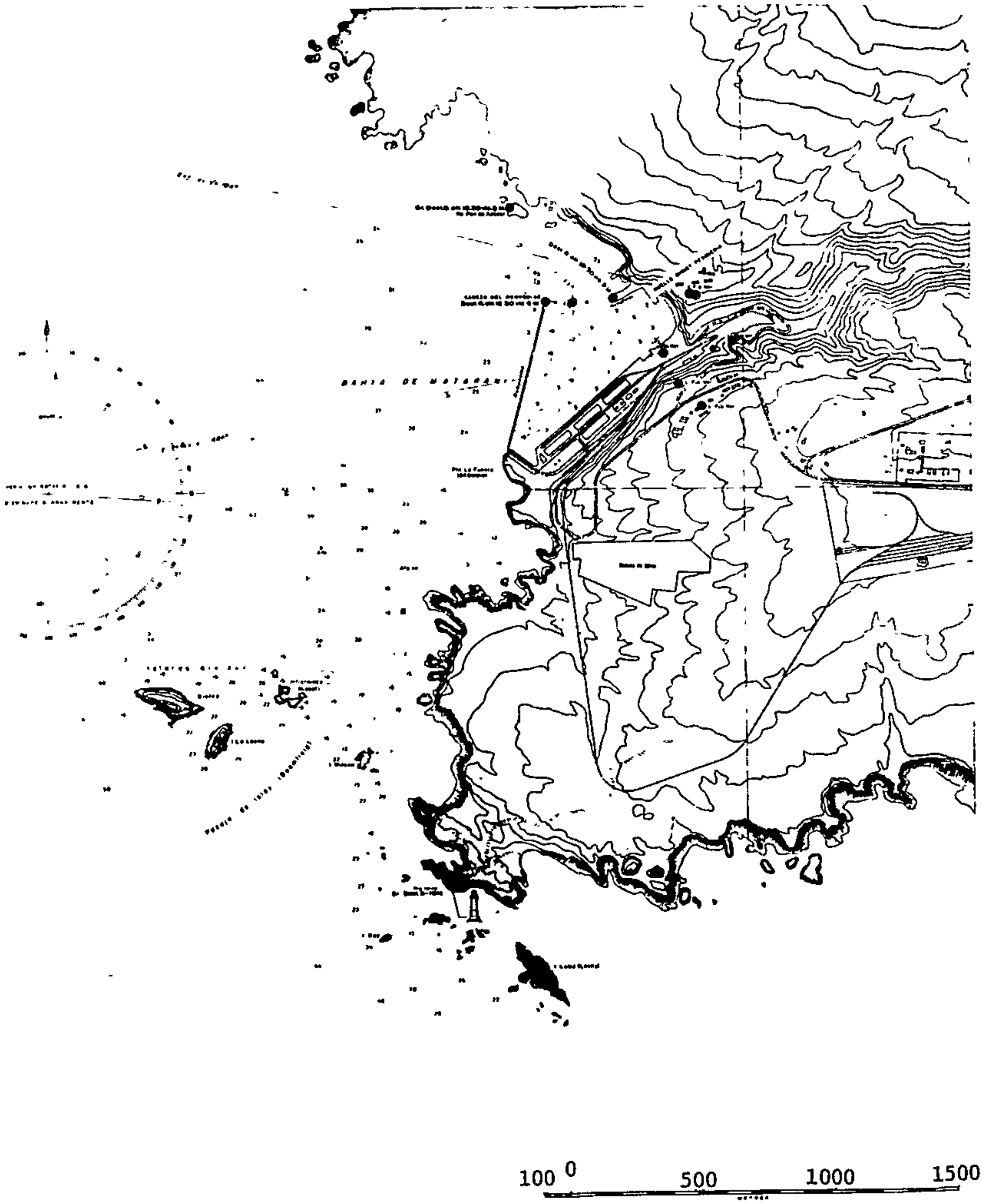
Electric power supply equipment: 600 KW diesel generator

Grain vacuum suction equipment: Two vacuum suction pumps with capacities of 100t/hour for storing grain in warehouse No.4

Ore loading equipment: Conveyor belt 530 m in length with maximum capacity of 1,000t/hour and power requirement of 500 KW and ore stockyard on the hill with an area of 72,000 m^2

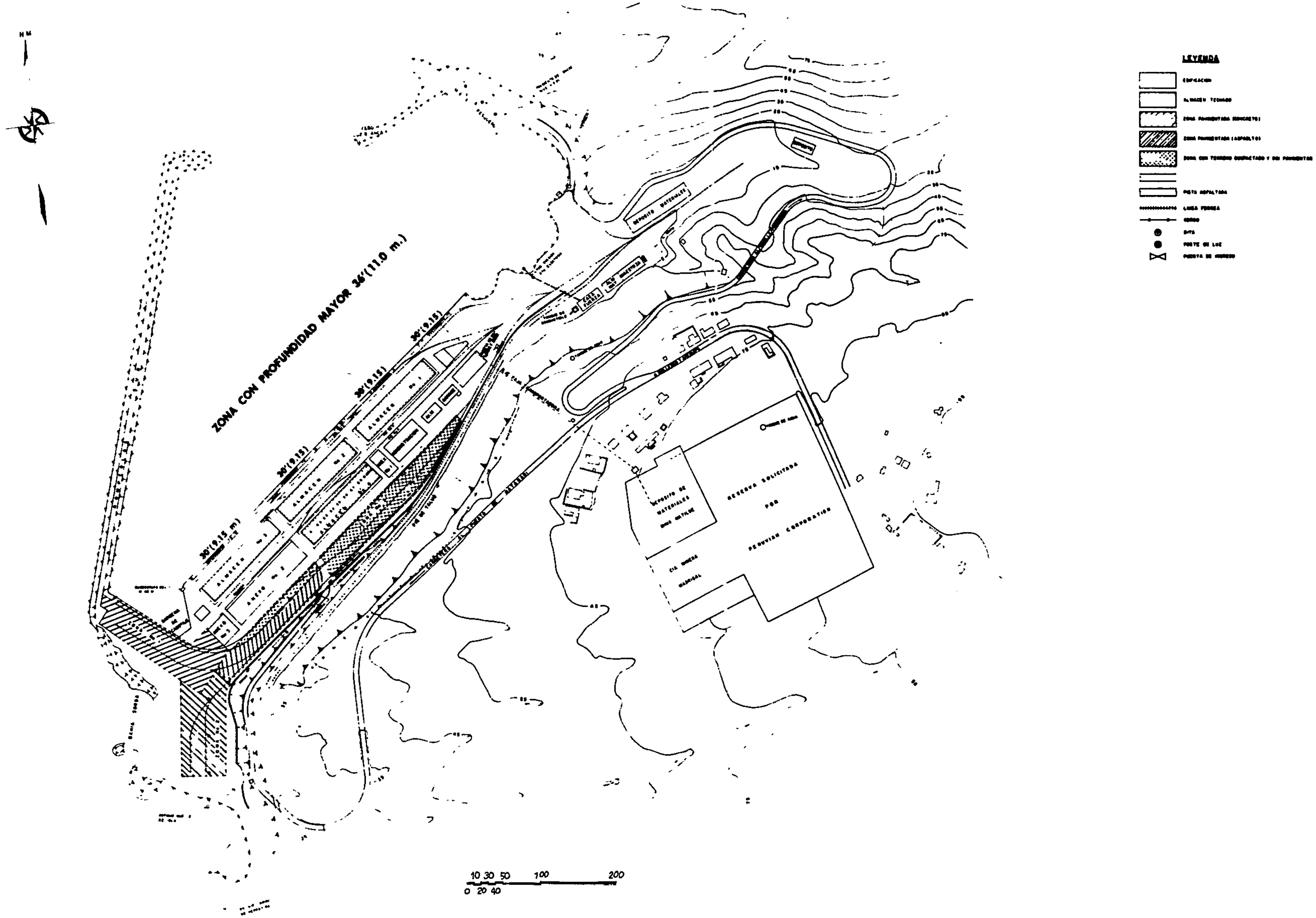
Fire fighting facilities: Modern fire fighting equipment.

Fig. 6-2 Location of Matarani Port



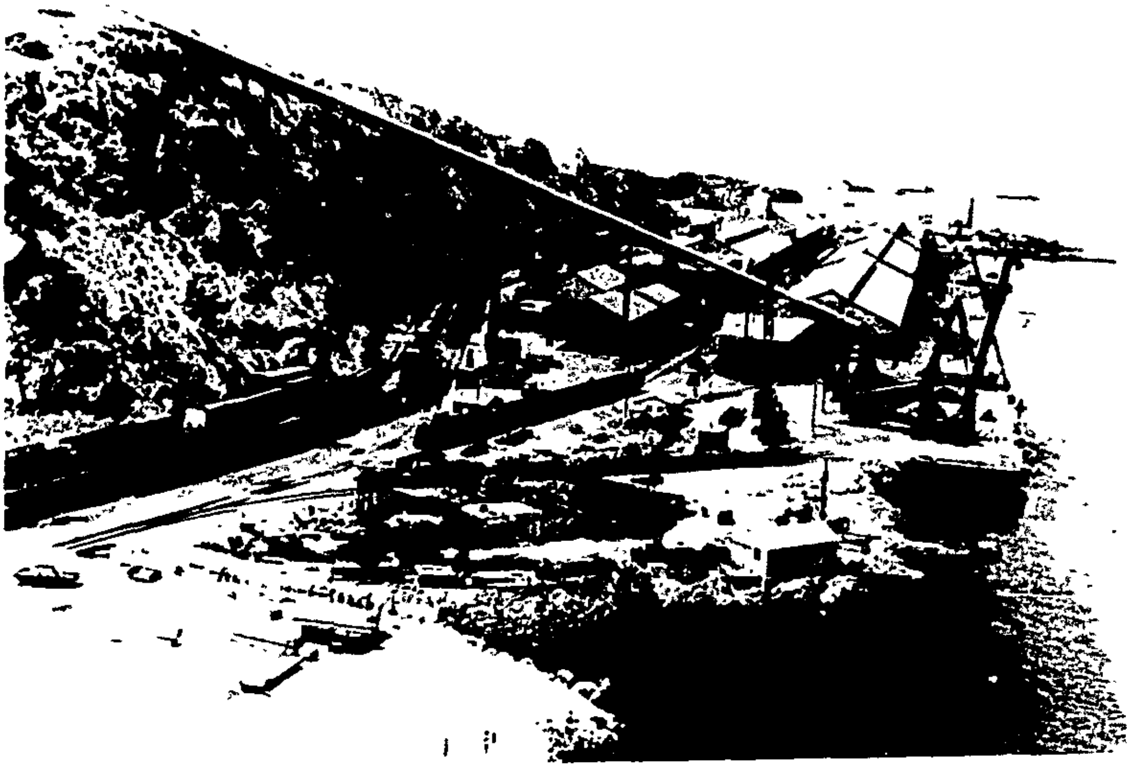
(Source) Empresa Nacional de Puertos.

Fig. 6-3 Plan of Matarani Port



(Source) Empresa Nacional de Puertos

Photo 6-1 Matarani Port



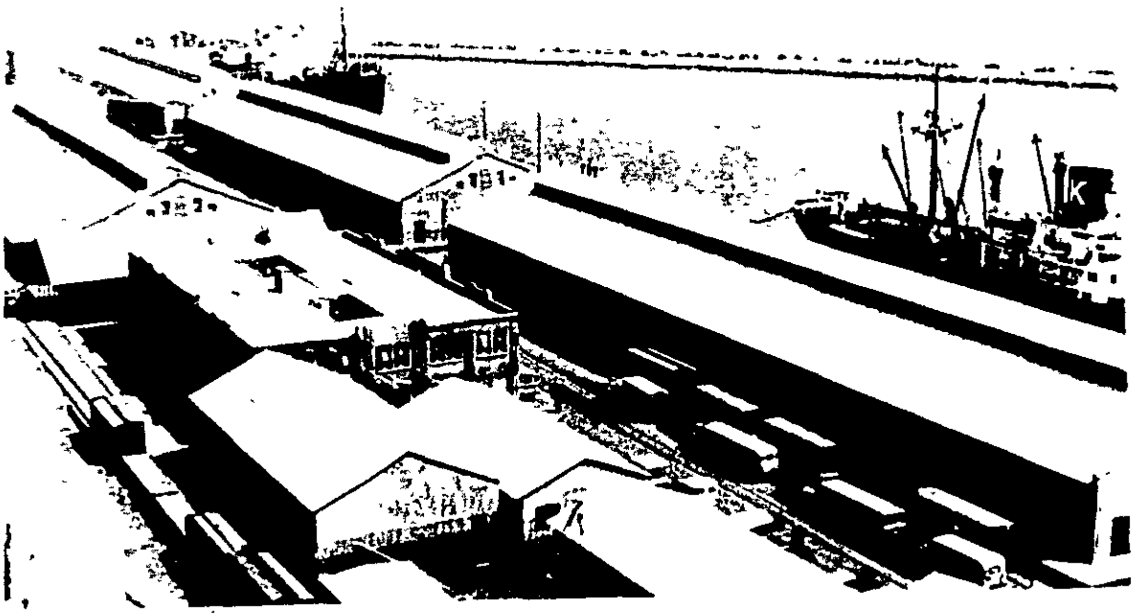
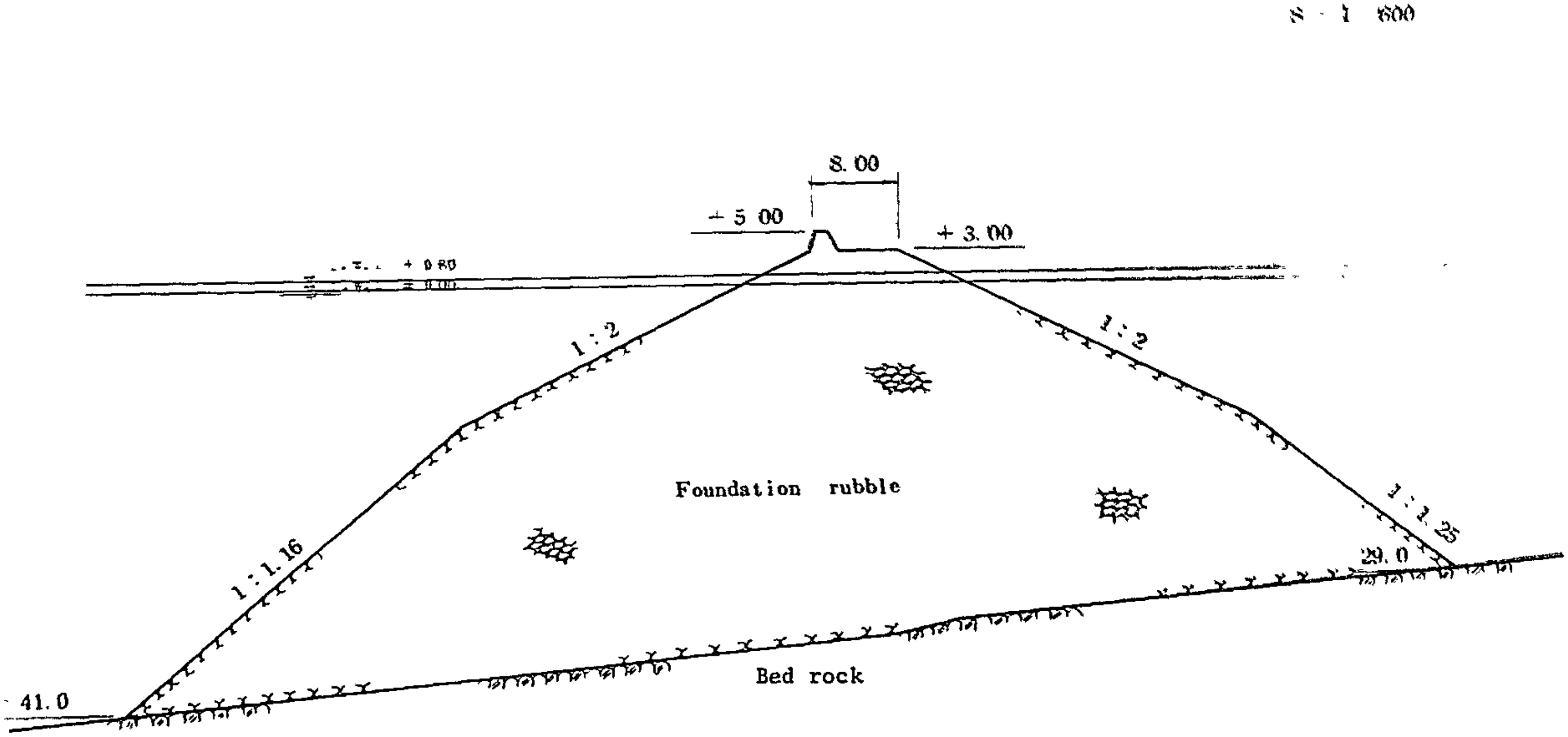


Fig. 6-4 Cross-section of Matarani Harbor Breakwater

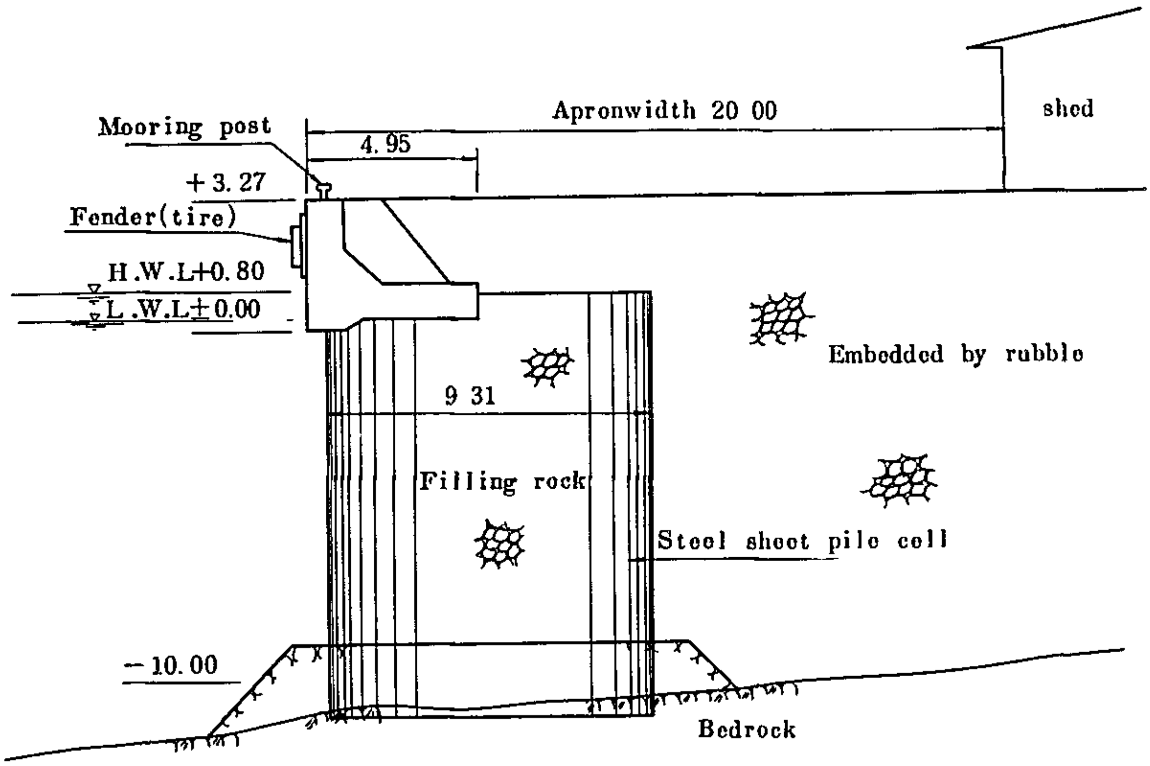


(Note) Positioned 235 m from base point (Total length : 625 m)

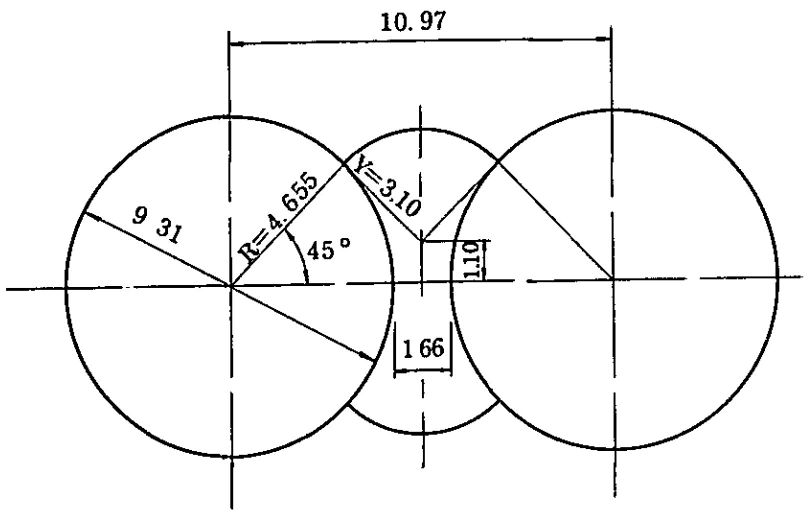
(Source) Empresa Nacional de Puertos

Fig. 6-5 Standard Cross-section of Matarani Port Quaywall (steel sheet pile cell type)

(Steel sheet pile cell type)



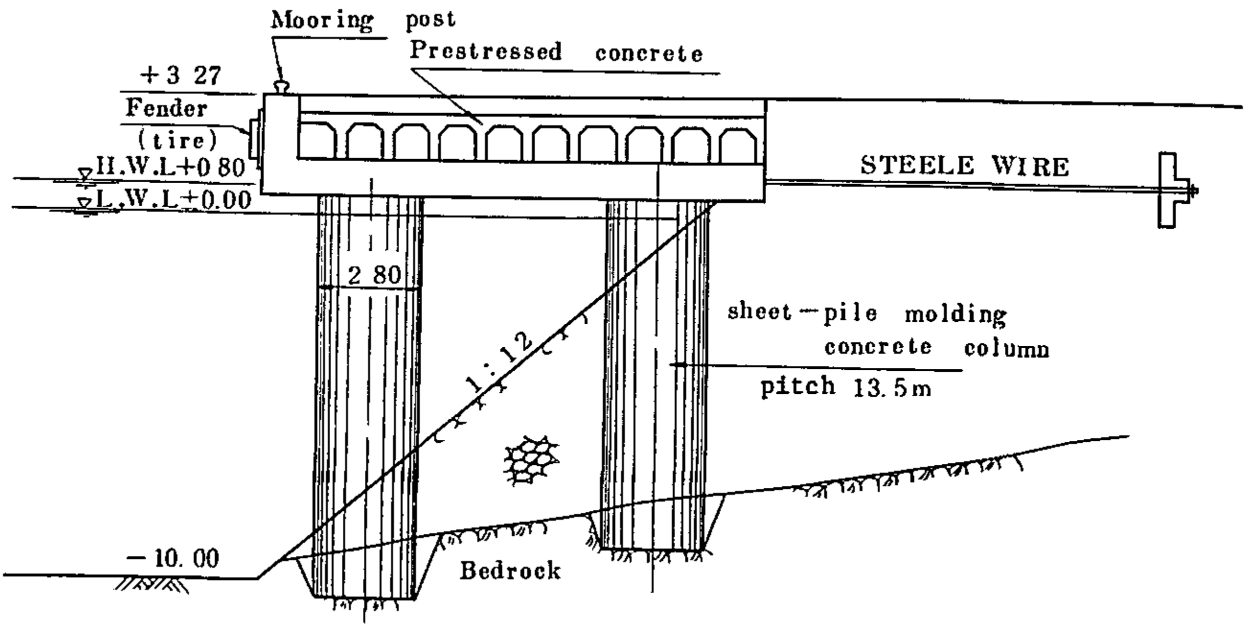
Plan of Steel sheet pile cell



(Source) Empresa Nacional de Puertos

Fig. 6-6 Standard Cross-section of Matarani Port Quay-wall (piled pier type)

S=1/200



(Source) Empresa Nacional de Puertos

1-1-2 Ilo Port

(1) Historical Outline

Ilo Port, the main harbor of Moquegua Department, is located at the southern end of the Peruvian coastline. At first, there was only a pier for launches constructed in 1887. Construction of a modern wharf was begun in 1968 and the modern harbor facilities were opened two year later on May 29, 1970. Fig. 6-7 shows the location of Ilo Port and Fig. 6-8 a plan of the harbor.

(2) Geographical Location

Latitude: 17° 38' Lat. S.

Longitude: 71° 21' Long. W.

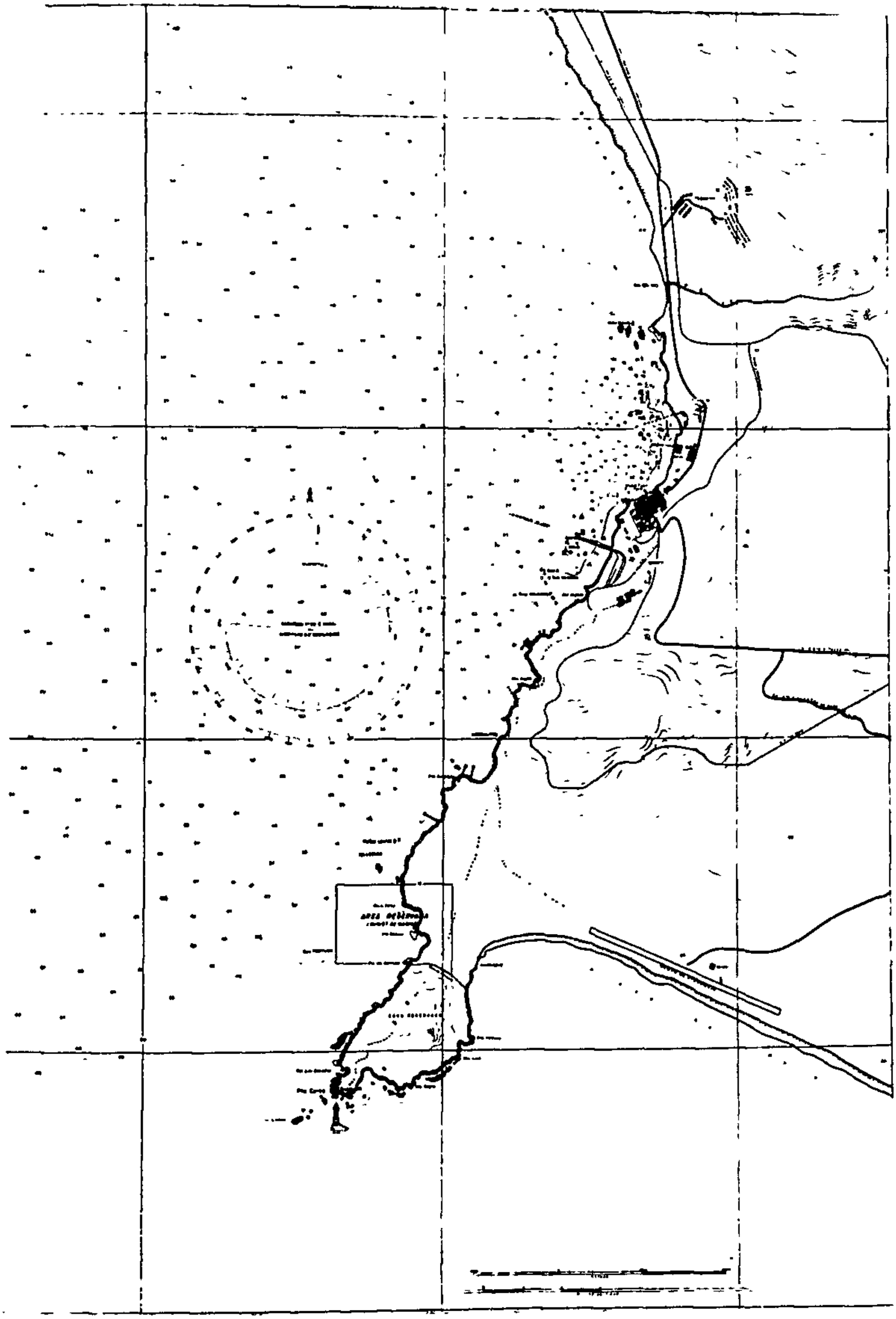
(3) Hinterland and Traffic Routes

The hinterland of Ilo Port covers all of Moquegua and Cuzco Departments and part of Puno Department. Construction of an international highway between Ilo and La Paz is planned.

Highways: Asphalt highways linking Ilo Port with Moquegua and Tacna cities and the Toquepala and Cuajone mines.

Railways: A railway linking Ilo Port with Cuajone Mine via Toquepala.

Fig. 6-7 Location of Ilo Port



(Source) Empresa Nacional de Puertos

Airports: An airport for propeller planes with a runway length of 3,000 m building of which was based on an agreement with Bolivia. It cannot, however, be used by ordinary travellers.

(4) General View of the Harbor

Ilo Port is located one nautical mile north of Coles Point and has a wharf to the south controlled by the Southern Peru Copper Corporation (SPCC) in addition to the main wharf operated by ENAPU. The harbor is a shallow inlet. Shelter against waves is provided by a group of reefs offshore to the south and there appear to be no particular man-made facilities. The water depth is -5.5 m near the coast and -55 m at a point 2.4 km offshore (Photo 6-2).

(5) Port Facilities

Mooring facilities: A T-shaped wharf 302 m long and 27 m wide with four berths. Fig. 6-9 shows a standard cross section of the Ilo Port wharf.
Berths 1-A (south) and 1-B (north)
Water depth: -10 ~ -16 m
Total length: 197 m, for imports
Berths 1-C (south) and 1-D (north)
Water depth: -5 ~ -10 m
Total length: 105 m, for coastal trade
The SPCC wharf has a length of 600 ft, a wide of 60 ft and a water depth of -37 ~ -65 ft.

Warehouses: One warehouse with an area of 1,600 m^2

Open storage areas: Total area: 33,500 m^2
Including 18,000 m^2 paved with asphalt
15,500 m^2 packed earth, unpaved

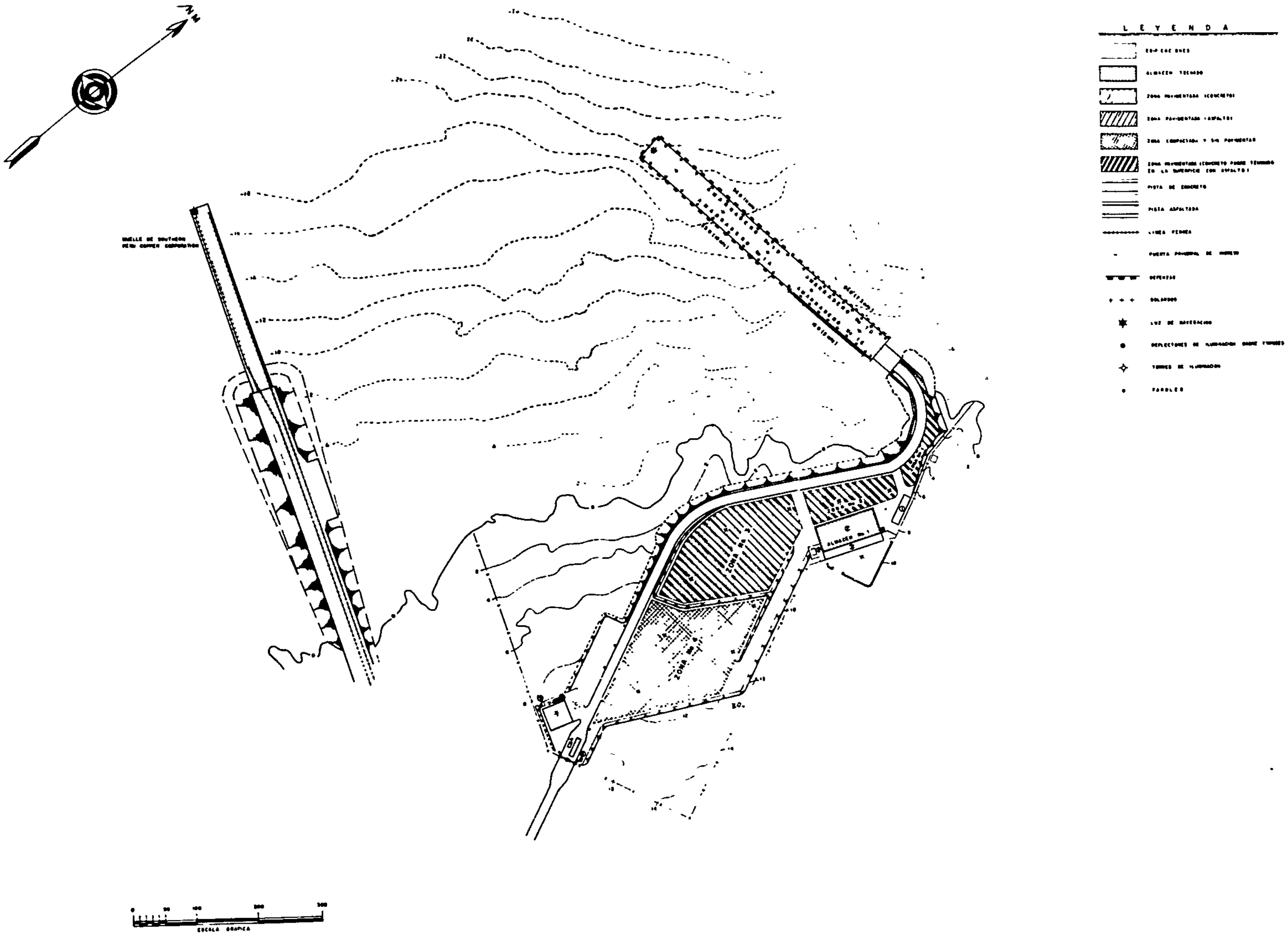
Tugboats: One 500 HP tugboat

Pipeline equipment: For loading oil and oil by-products

Machinery and equipment:
Tractors
8, capacity: 3,000 lbs
Forklifts
7, capacity: 7,000 ~ 15,000 lbs
Traveling cranes
1, capacity: 12.5t
Trucks
18, capacity: 10,000 lbs
11, capacity: 30,000 lbs
Palettes: 286

Electric power supply:
Supplied from Ilo City

Fig. 6-8 Plan of Ilo Port



(Source) Empresa Nacional de Puertos

Photo 6-2 Ilo Port

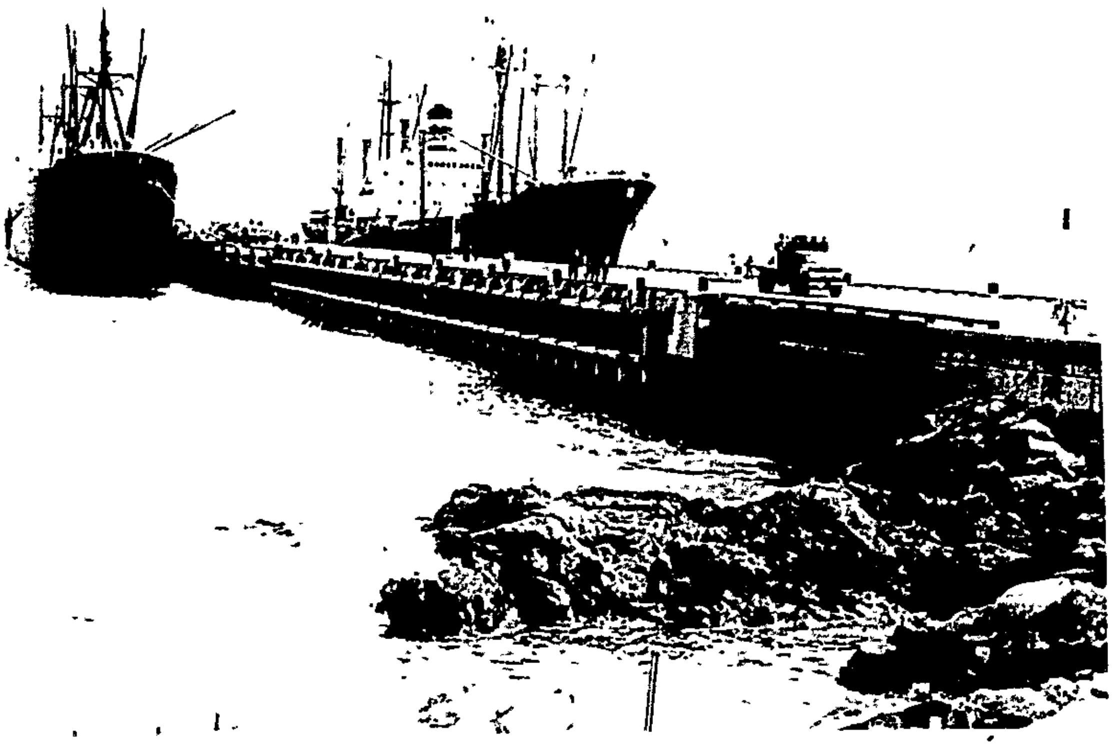
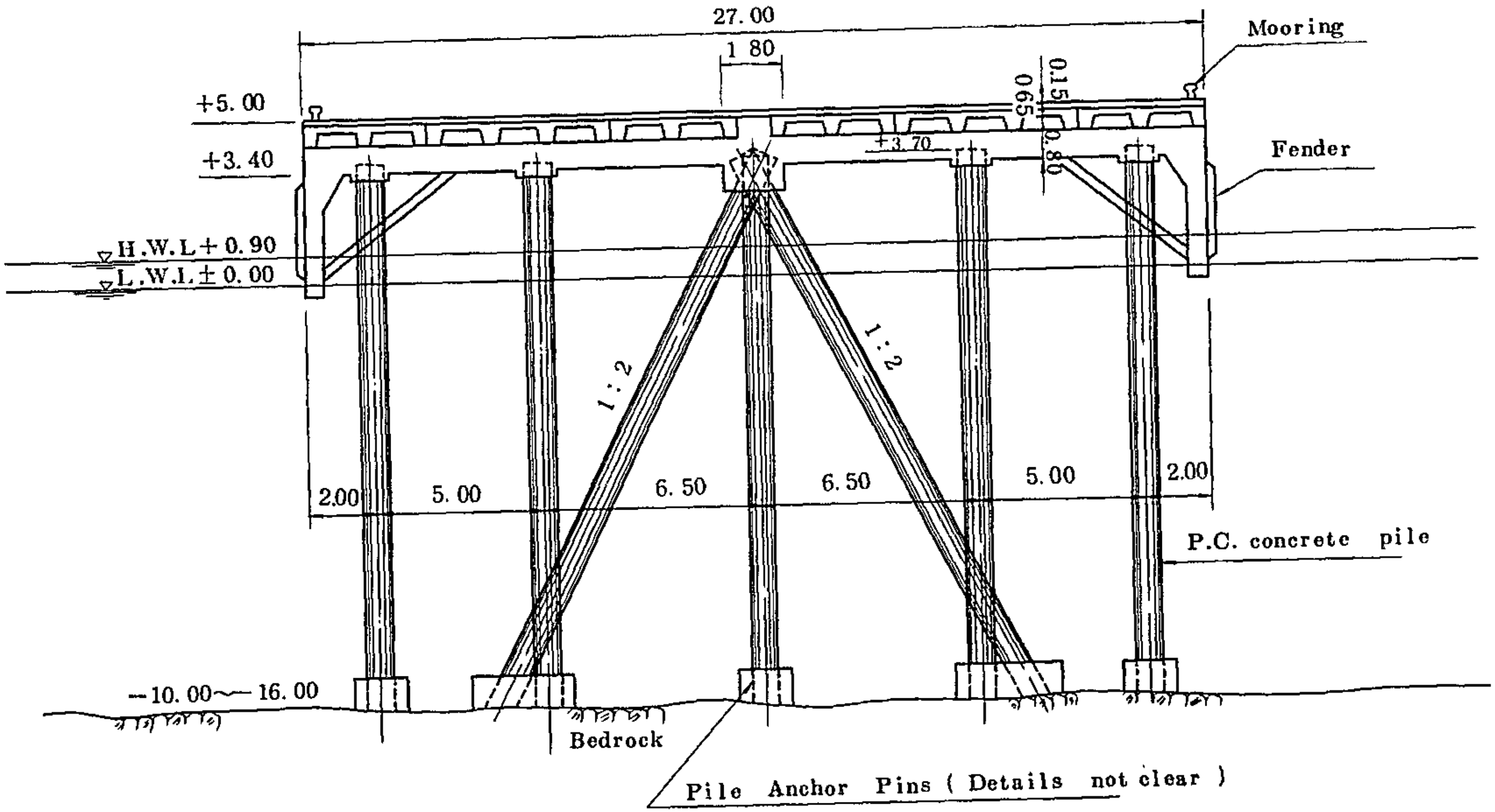


Fig. 6-9 Standard Cross-section of Ilo Port Wharf



(Source) Empresa Nacional de Puertos

1-2 Natural Conditions

1-2-1 Climate

The climate of the southern coastal region of Peru is that of the steppes (semi-desert) and the annual precipitation is less than 25 mm. The main factor which controls the climate in this region is a cold current, known as the Peruvian Current, which flows in a northeasterly direction. The average air temperature in the summer (December - February) is about 22°C, which is low for a region near the equator. The Peruvian Current makes the summer climate moderate. The winters (average air temperature: about 16°C) are not very severe. There are many cloudy days from April through October, but the clouds start to disappear in November and clear days continue from January through March. Fog occurs only rarely but sometimes happens at the beginning of summer.

1-2-2 Air Temperature

Tables 6-1 and 6-2 show maximum and minimum air temperature respectively in Ilo Port from 1954 through 1978. The air temperature is stable, with little difference throughout the year.

1-2-3 Precipitation

Table 6-3 shows precipitation in Ilo Port from 1954 through 1978. The maximum precipitation (annual precipitation; 33.2 mm) was observed in 1957. It was almost zero in other years.

1-2-4 Winds

Table 6-4 shows maximum monthly wind velocities at Ilo Port from 1954 through 1977. The maximum velocity of 20 m/sec appeared six times during the observation period. The wind blew most frequently in a southeasterly direction, with the south-southeasterly direction second, the southly and the east-south-easterly direction third in frequency.

1-2-5 Waves

The results of wave measurements are summarized as follows:

1) About 45% of the waves generated annually have heights of 1.5 m or more. The cycle is between 6 and 12 seconds in about 40% of the waves and 12 seconds or more in the remaining 5%. The direction of the waves is to the south for about 25%. Only about 1% of the waves are in a westerly direction.

2) Waves with heights of 3.0 m or more account for about 3.5% of the annual total. Their cycles are between 8 and 12 seconds for about 1.5% and 12 seconds or more for the remaining 2%. About 2% of these waves are in a southerly direction and about

Table 6-1 Maximum Air Temperatures

(Unit:°C)

Year \ Month	1	2	3	4	5	6	7	8	9	10	11	12
1954	-	-	-	-	(5) 21.6	(7) 19.8	(9) 19.1	(19) 18.2	(19) 18.7	(24) 21.8	(15) 24.0	(20) 27.1
1955	(31) 28.8	(3) 28.6	(1) 27.2	(15) 25.2	(12) 23.8	(11) 21.0	(1) 19.5	(4) 21.5	(26) 19.8	(30) 22.0	(29) 24.9	(27) 25.2
1956	(30) 26.7	(12) 27.1	(4) 26.9	(6) 23.0	(3) 21.9	(8) 19.0	(17) 18.0	(31) 18.0	(20) 19.4	(14) 21.1	(19) 22.4	(10) 23.5
1957	(3) 25.5	(3) 27.0	(30) 24.5	(1) 27.2	(16) 22.9	(2) 21.1	(4) 20.5	(9) 19.8	(18) 19.5	(9) 22.0	(11) 24.8	(31) 25.1
1958	(23) 25.4	(23) 25.9	(2) 26.5	(3) 24.7	(1) 22.9	(1) 21.5	-	-	-	-	-	-
1959	(23) 24.5	(21) 25.8	(12) 26.9	(3) 25.0	(1) 23.0	(2) 20.0	(28) 19.0	(26) 19.0	(28) 20.4	(15) 22.5	(6) 22.4	(26) 25.2
1960	-	-	-	-	-	-	-	-	-	-	-	-
1961	-	-	-	-	-	-	-	-	-	-	-	-
1962	-	-	-	-	-	-	-	-	-	-	-	-
1963	-	-	-	-	-	-	-	-	-	-	-	-
1964	-	-	-	-	-	-	-	-	-	-	-	-
1965	-	-	-	-	-	(5) 22.4	(3) 21.0	(14) 20.1	(27) 19.1	(29) 21.0	(27) 22.3	(16) 25.4
1966	-	-	-	-	(10) 22.0	(8) 19.3	(13) 18.2	(23) 18.3	(30) 19.1	(19) 21.0	(28) 24.0	(27) 24.1
1967	(30) 25.4	(11) 27.1	(16) 25.0	(18) 26.1	(8) 22.3	(1) 20.0	(7) 17.4	(7) 18.0	(24) 18.0	(28) 20.1	(23) 22.4	(22) 25.0
1968	(26) 26.0	(21) 26.1	(3) 25.1	(3) 24.1	(4) 21.0	(2) 20.4	(3) 18.3	(29) 18.3	(25) 20.0	(23) 20.4	(30) 22.4	(16) 25.1
1969	(22) 25.4	(4) 26.1	(12) 26.3	(16) 24.2	(1) 23.3	(4) 20.2	(27) 18.4	(15) 18.4	(13) 20.0	(31) 22.2	(6) 24.1	(13) 25.1
1970	(16) 26.4	(28) 26.2	(1) 26.1	(9) 24.1	(2) 23.0	(2) 19.3	(1) 18.3	(30) 18.1	(24) 19.1	(30) 20.1	(20) 22.2	(31) 25.3
1971	(9) 26.1	(21) 24.3	(3) 23.4	(1) 23.3	(5) 21.1	(4) 19.4	(31) 17.4	(19) 18.1	(28) 19.3	(28) 20.4	(28) 23.2	(29) 24.4
1972	(28) 26.2	(9) 28.0	(4) 25.3	(9) 23.3	(17) 23.6	(15) 21.2	(28) 19.2	(21) 20.0	(30) 20.4	(25) 23.2	(30) 23.5	(19) 26.6
1973	(10) 28.4	(6) 28.8	(4) 26.2	(1) 23.8	(3) 21.6	(7) 21.4	(16) 19.2	(1) 18.8	(25) 19.0	(5) 23.0	(27) 22.4	(31) 24.2
1974	(14) 26.8	(2) 26.2	(3) 25.0	(24) 24.2	(3) 21.6	(1) 20.4	(13) 19.8	(27) 19.7	(22) 19.8	(10) 20.4	(23) 24.6	(25) 25.6
1975	(23) 25.4	(3) 26.0	(4) 25.4	(27) 23.4	(8) 21.0	(13) 20.4	(15) 19.0	(5) 18.2	(23) 18.6	(28) 21.2	(22) 22.2	(27) 25.8
1976	(29) 28.2	(9) 26.2	(5) 25.4	(6) 25.2	(1) 23.0	(2) 20.4	(21) 19.0	(27) 19.6	(30) 20.0	(26) 21.8	(30) 24.8	(31) 27.4
1977	(16) 27.6	-	-	(20) 25.0	(1) 23.8	(1) 22.0	(3) 20.6	(9) 20.0	(24) 20.4	(31) 22.2	(6) 23.8	(18) 24.4
1978	(13) 26.4	(2) 26.4	(1) 26.4	-	-	-	-	-	-	-	-	-

(Source) SENAMHI

Table 6-2 Minimum Air Temperatures

(Unit:°C)

Year \ Month	1	2	3	4	5	6	7	8	9	10	11	12
1954	-	-	-	-	(14) 12.8	(20) 12.3	(13) 11.9	(9) 11.5	(4) 10.7	(2) 13.0	(1) 13.6	(4) 16.3
1955	(1) 18.8	(21) 16.0	(25) 17.1	(11) 13.7	(1) 14.2	(7) 11.0	(20) 10.1	(2) 11.0	(4) 12.0	(14) 13.5	(3) 12.6	(30) 17.0
1956	(21) 16.3	(4) 17.0	(25) 15.2	(29) 13.9	(10) 12.5	(28) 13.4	(27) 11.2	(14) 11.2	(7) 11.9	(4) 14.0	(16) 14.9	(13) 15.5
1957	(23) 15.5	(23) 17.6	(5) 17.0	(17) 16.5	(7) 17.1	(20) 15.5	(20) 14.2	(27) 13.9	(22) 14.4	(19) 15.5	(26) 16.6	(7) 16.9
1958	(31) 18.8	(2) 18.4	(30) 17.0	(12) 17.0	(28) 16.7	(19) 14.8	-	-	-	-	-	-
1959	(25) 18.5	(16) 19.0	(21) 19.4	(29) 17.7	(23) 15.0	(29) 14.0	(23) 14.0	(17) 12.2	(10) 13.8	(14) 15.0	(20) 16.0	(24) 15.0
1960	-	-	-	-	-	-	-	-	-	-	-	-
1961	-	-	-	-	-	-	-	-	-	-	-	-
1962	-	-	-	-	-	-	-	-	-	-	-	-
1963	-	-	-	-	-	-	-	-	-	-	-	-
1964	-	-	-	-	-	-	-	-	-	-	-	-
1965	-	-	-	-	-	(6) 16.3	(3) 14.4	(20) 14.0	(6) 13.3	(1) 14.3	(1) 15.1	(1) 16.3
1966	-	-	-	-	(13) 14.4	(24) 12.4	(5) 11.4	(6) 11.4	(17) 13.1	(7) 14.3	(2) 15.1	(30) 16.3
1967	(9) 17.2	(3) 15.1	(7) 17.2	(25) 15.3	(5) 14.1	(8) 13.1	(30) 13.1	(2) 11.4	(14) 11.4	(6) 13.0	(1) 15.0	(18) 15.4
1968	(2) 17.2	(21) 17.4	(22) 15.3	(17) 15.0	(24) 13.2	(27) 13.1	(4) 12.4	(14) 13.1	(11) 14.0	(19) 14.4	(2) 15.1	(4) 16.0
1969	(2) 16.3	(16) 17.3	(24) 15.2	(14) 16.4	(30) 16.2	(29) 13.3	(17) 13.2	(16) 12.3	(9) 14.2	(7) 15.0	(9) 16.4	(11) 17.2
1970	(30) 17.0	(23) 18.0	(22) 17.3	(21) 17.0	(24) 14.2	(16) 13.2	(28) 12.1	(16) 12.2	(13) 13.2	(22) 13.1	(1) 15.0	(2) 15.4
1971	(14) 16.3	(26) 16.3	(21) 15.2	(29) 15.1	(22) 13.4	(23) 13.3	(26) 11.4	(12) 12.3	(8) 13.2	(9) 13.3	(1) 14.1	(3) 15.4
1972	(17) 17.2	(28) 16.4	(27) 16.4	(21) 13.3	(12) 14.6	(23) 13.7	(25) 14.3	(25) 14.0	(29) 14.5	(5) 15.4	(30) 14.4	(3) 15.2
1973	(4) 19.4	(25) 19.8	(31) 16.1	(21) 13.4	(13) 14.4	(30) 12.4	(24) 13.2	(17) 12.2	(14) 12.0	(11) 14.0	[illegible]	(27) 15.5
1974	(3) 17.0	(16) 17.0	(22) 16.0	(11) 16.2	(14) 14.2	(28) 14.0	(26) 13.6	(5) 12.2	(11) 13.1	(7) 13.8	(1) 15.0	(3) 15.2
1975	(16) 16.7	(24) 17.4	(27) 16.0	(22) 15.4	(23) 13.0	(21) 12.6	(28) 11.8	(11) 12.3	(2) 12.6	(2) 12.8	(5) 13.4	(1) 16.3
1976	(14) 16.0	(7) 17.4	(30) 16.2	(19) 15.4	(25) 15.0	(27) 15.0	(15) 13.6	(28) 12.5	(9) 13.0	(2) 14.0	(7) 15.6	(10) 16.4
1977	(29) 18.0	-	-	(13) 16.6	(8) 16.0	(25) 14.1	(18) 14.2	(6) 12.8	(3) 14.2	(2) 14.6	(16) 16.0	(9) 16.2
1978	(19) 16.6	(28) 17.6	(30) 17.3	-	-	-	-	-	-	-	-	-

(Source) SENAMHI

Table 6-3 Precipitation

(Unit:mm)

Month / Year	1	2	3	4	5	6	7	8	9	10	11	12
1954	-	-	-	-	(1) 0.4	(2) 0.6	0.0	(2) 0.6	(6) 2.7	(3) 1.3	(2) 0.3	0.0
1955	0.0	0.0	(1) 2.3	0.0	(1) 0.2	0.0	0.0	(2) 0.6	0.0	0.0	0.0	0.0
1956	0.0	0.0	0.0	0.0	0.0	(2) 1.5	0.0	0.0	0.0	0.0	0.0	0.0
1957	0.0	0.0	0.0	0.0	(2) 3.4	(7) 11.1	(4) 3.1	(10) 12.2	(3) 3.4	0.0	0.0	0.0
1958	0.0	0.0	0.0	0.0	0.0	(2) 1.8	-	-	-	-	-	-
1959	0.0	0.0	0.0	(1) 2.0	0.0	0.0	(1) 1.2	0.0	0.0	0.0	0.0	0.0
1960	-	-	-	-	-	-	-	-	-	-	-	-
1961	-	-	-	-	-	-	-	-	-	-	-	-
1962	-	-	-	-	-	-	-	-	-	-	-	-
1963	-	-	-	-	-	-	-	-	-	-	-	-
1964	-	-	-	-	-	-	-	-	-	-	-	-
1965	-	-	-	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0
1966	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1967	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1968	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1969	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1970	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1971	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1972	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1973	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1974	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1975	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1978	0.0	0.0	0.0	-	-	-	-	-	-	-	-	-

(Source) SENAMHI

Table 6-4 Maximum Wind Velocity

(Unit:m/Sec)

Year \ Month	1	2	3	4	5	6	7	8	9	10	11	12
1954	-	-	-	-	E-6	SE-4	SE-6	SE-6	SE-5	SE-6	SE-4	SE-5
1955	SE-4	SE-8	SE-14	SE-14	SE-8	SE-6	ESE-6	ESE-7	SE-7	ESE-6	SE-6	ESE-6
1956	E-8	E-10	E-10	ESE-8	SE-6	ESE-5	ESE-6	SE-7	ESE-6	SE-6	SE-6	SSE-6
1957	SSE-7	ESE-8	ESE-8	SE-10	SSE-10	SE-10	SSE-10	SSE-10	SE-6	SE-5	S-4	SE-6
1958	SE-6	SE-6	SE-6	SE-6	SSE-5	SSE-7	-	-	-	-	-	-
1959	SE-7	SE-7	SE-5	SE-6	SE-6	S-9	SE-8	SE-9	SE-9	SE-6	SE-6	SE-7
1960	-	-	-	-	-	-	-	-	-	-	-	-
1961	-	-	-	-	-	-	-	-	-	-	-	-
1962	-	-	-	-	-	-	-	-	-	-	-	-
1963	-	-	-	-	-	-	-	-	-	-	-	-
1964	-	-	-	-	-	-	-	-	-	-	-	-
1965	-	-	-	-	-	S-11	S-14	SW-10	NE-14	SE-11	SE-14	SE-14
1966	-	-	-	-	SE-11	SE-14	SE-11	SE-20	S-14	S-11	SE-11	SE-11
1967	SE-11	SE-11	SE-14	SE-11	SE-11	SE-11	SE-14	SE-14	SE-8	SE-11	SE-11	SE-8
1968	SE-11	SE-11	SE-11	SE-11	SE-11	SE-11	SE-8	SE-11	SE-11	SE-11	SE-8	SE-14
1969	SE-11	SE-11	SE-14	SE-11	SE-14	SE-14	N-11	SE-8	SE-11	SE-11	SE-11	SE-8
1970	SE-11	SE-20	S-11	SE-11	SE-14	SE-8	SE-11	SSE-11	SSE-8	SE-11	SSE-14	SSE-8
1971	SE-14	SSE-11	SE-11	SE-14	SSE-8	S-10	SE-14	SE-14	SE-10	SE-8	SE-8	SE-10
1972	SE-10	SE-14	SE-14	SE-10	SW-10	SE-14	SE-20	SE-14	SE-10	SE-10	SE-10	SE-14
1973	SE-14	SE-10	SE-14	SE-20	SE-10	SE-10	SE-10	SE-10	SE-10	SE-8	SW-10	N-10
1974	SE-8	SE-11	SE-10	SE-10	SE-10	S-14	SW-10	SE-20	SE-10	SE-8	SE-8	SE-10
1975	SE-14	SE-14	SE-10	SE-10	SE-10	SE-10	SE-10	SE-20	SE-10	S-10	SE-8	SE-14
1976	SE-12	SE-10	SE-10	SE-10	SE-10	SE-10	SE-10	SE-14	SE-8	SE-14	SE-10	SE-10
1977	SE-10	SE-10	SE-10	SE-10	SE-10	SE-8	SE-10	SE-14	SE-8	SE-10	-	-
1978	-	-	-	-	-	-	-	-	-	-	-	-

(Source) SENAMHI

1% in a westerly direction.

1-3 Cargo Handling Costs

1-3-1 Matarani Port

Table 6-5 shows costs for handling cargo at Matarani Port.

Table 6-5 Cargo Handling Costs (Matarani Port)

(Unit: per ton by weight or volume)

Item	Imports (US$)	Exports (US$)
A. Individual or packaged general cargo		
1. Ordinary fertilizer		
a) Direct unloading	3.03	-
b) Indirect unloading	3.24	-
2. Unspecified cargo		
a) Direct unloading - loading	7.43	3.63
b) Indirect unloading - loading	7.97	3.85
3. Livestock		
Direct unloading - loading		
3.1 All types of cattle and horses, per head	0.75	0.75
3.2 All types of sheep, goats and pigs, per head	0.43	0.43
4. Fish meal		
a) Direct loading	-	3.43
b) Indirect loading	-	3.55
5. Wool		
a) Direct unloading - loading	5.19	0.90
b) Indirect unloading - loading	5.56	0.92
6. Metals		
a) Direct loading	-	0.58
b) Indirect loading	-	1.07

Item	Imports (US$)	Exports (US$)
7. Ore		
a) Direct loading	-	0.57
b) Indirect loading	-	1.06
8. Mass consumption goods		
a) Direct unloading	3.99	-
b) Indirect unloading	4.36	-
B. <u>Bulk solid cargo</u>		
1. Loading by terminal equipment or facilities		
All types of ore	-	0.90
2. Loading with user's own equipment or facilities		
1) Fish meal	-	3.26
2) Ordinary ore placed in tubs or other facilities	-	0.58
3. Indirect unloading by terminal equipment or facilities		
1) Wheat	1.05	-
2) Other grains and flour	1.05	-
C. <u>Liquid bulk</u>		
Direct unloading - loading with user's pipes or facilities		
1. Oil and oil products (In terminal operating area)	0.19	0.12
2. Unspecified liquid cargo (In terminal operating area)	2.79	0.61
D. <u>Transit cargo to and from Bolivia</u>		
1. Individual or packaged general cargo		
1) Unspecified cargo		
a) Direct unloading - loading	3.29	3.29
b) Indirect unloading - loading	3.51	3.51

Item	Imports (US$)	Exports (US$)
2. Bulk solid cargo		
1) Indirectly unloaded by terminal equipment or facilities		
Wheat	1.05	-
Other grains and flour	1.05	-
2) Directly loaded by terminal equipment or facilities		
All types of core	-	0.90

(Source) Empresa Nacional de Puertos

1-3-2 Ilo Port

The costs for handling cargo in Ilo Port are shown in Table 6-6.

Table 6-6 Cargo Handling Costs (Ilo Port)

(Unit: per ton by weight or volume)

Item	Imports (US$)	Exports (US$)
A. Individual or packaged general cargo		
1. Ordinary fertilizer		
a) Direct unloading - loading	2.19	1.35
b) Indirect unloading	2.33	1.42
2. Unspecified cargo		
a) Direct unloading - loading	3.11	1.43
b) Indirect unloading - loading	3.32	1.50
3. Livestock		
Direct unloading - loading		
3.1 All types of cattle and horses, per head	0.75	0.75
3.2 All types of sheep, goats and pigs, per head	0.29	0.29

Item	Imports (US$)	Exports (US$)
4. Fish meal		
a) Direct loading	-	1.49
b) Indirect loading	-	2.40
5. Metals		
a) Direct unloading - loading	3.11	0.59
b) Indirect unloading - loading	3.32	0.70
6. Ore		
a) Direct unloading - loading	3.10	0.58
b) Indirect unloading - loading	3.31	0.69
7. Mass consumption goods		
a) Direct unloading	1.14	-
b) Indirect unloading	1.21	-
B. Bulk solid cargo		
Direct unloading - loading with user's own equipment or facilities		
1. Fish meal	-	1.36
2. Ordinary ore placed in tubs or other facilities	-	0.46
3. Wheat	0.97	-
4. Other grains and flour	0.97	-
C. Liquid bulk		
1. Direct unloading - loading by terminal equipment or facilities		
Unspecified liquid cargo	1.26	0.90
2. Direct unloading - loading with user's pipes or facilities		
a) Oil and oil products (In terminal operating area)	0.19	0.12
b) Unspecified liquid cargo (In terminal operating area)	0.97	0.61

Item	Imports (US$)	Exports (US$)
D. Transit cargo to and from Bolivia		
All types of cargo		
1. Direct unloading - loading	1.35	1.35
2. Indirect unloading - loading	1.42	1.42

(Source) Empresa Nacional de Puertos

1-4 Calmness in the Harbors

1-4-1 Matarani Port

In the Port Directory of ENAPU, it states that Matarani Port is protected by southern and eastern breakwaters but waves are formed within the harbor and at the quay walls of the wharf. In the 1978 Annual Report of ENAPU, it mentions that a survey was performed concerning repulsion of waves within the inlet. From this statement, it would appear that the calmness in Matarani Port is not very good and therefore, the port authorities were questioned about this from various angles. Their answers can be outlined as follows:

1) There have never been any cases so far where ships could not enter or leave the harbor or where cargo handling was impossible.

2) The breakwaters have been found to overflow about once every 10 years.

3) The open seas outside the harbor are very rough in April and October, but the water inside the harbor remains very calm even at such times.

On the basis of these answers, it can be assumed that roughness inside the harbor presents no special problem. When the inside of the harbor and the open sea were observed from a launch during the site survey, it was found that the inside of the harbor was very calm when there was a swell with wave heights of about 1 m in the open sea. The reefs which form the main parts of the offshore breakwaters partially block the waves in the main southerly direction. The face line of the harbor also appears to be effective in blocking the entry of waves moving in a southerly direction. Calmness in the harbor can be considered as good.

1-4-2 Ilo Port

In the Port Directory of ENAPU, it states that Ilo Port is an open inlet and precautions must be taken against southwesterly winds. For protection against waves in Ilo Port, there is a group of reefs offshore to the south and, as indicated, the harbor is defenseless against rough seas. However, as can be seen in Table 6-4, the maximum monthly velocity of southwesterly winds has occurred only three times in 19 years and the maximum velocity at that time was only 10 m/sec, which is quite weak. Therefore, there is very little likelihood of rough seas in the southwesterly direction and it can be assumed that the waves will not be very high. The port authorities were questioned about the calmness and they answered that the wave height is about 1.5 m (considered as a significant wave height) at the front of the wharf on about three days during the three months from June through August every year and ships cannot dock at such times. The number of days on which cargo handling is impossible is only 1-2% of the total number of days in a year and the calmness in the harbor can be considered as good.

1-5 Littoral Drift

There are many cases of littoral drift along the Peruvian coast and the littoral drift at Salaverry Port is famous throughout the world. In this survey, the conditions along the southern coast and the littoral drift at Matarani and Ilo Ports were investigated by interviews and site surveys.

1-5-1 Outline of the Southern Coast

Along the southern coastline from Camana to the Chilean Border, 80 ~ 90% of the coast is rocky between Camana and Vilavila (a fishing village 50 km from Tacna) and there is almost no problem of coastal erosion in this region. There is a sandy beach for about 50 km between Vilavila and the Chilean Border and the sand is fine grained, but no erosion or deformation was seen and the coast is stable.

1-5-2 Conditions in Matarani Port

At the front tip of the breakwater, the water is very deep, i.e. -29 m, and the bottom material is rock. However, in the anchorage in the southwestern part of the harbor, the bottom material is sand and the water is very deep, i.e. -31 ~ -70 m. Therefore, there should be no movement of the sand in the anchorage. According to the port authorities, no littoral drift has ever been observed.

1-5-3 Ilo Port

The water depth at the front of the wharf is -16 m and the bottom material is rock. There is an anchorage at 750 m offshore of the wharf with a water depth of -24 m and the bottom material appears to be sand. With such a water depth, there should be no movement of the sand. The wharf in Ilo Port is of the piled-pier type and the port was constructed so that no changes would result from marine phenomena such as tidal and coastal currents. The port authorities stated that they were aware of countermeasures against littoral drift.

1-6 Amounts of Cargo Handled

1-6-1 Changes in the Amounts of Cargo Handled

The cargo handled at Matarani Port consists generally of Peruvian and Bolivian cargo. Table 6-7 shows the changes in the amounts of Peruvian cargo and Table 6-8 the changes in Bolivian cargo over the past nine years. The cargo is almost all solids such as ore, fish meal, wheat and fertilizer. Liquids such as oil and oil by-products are not included among the cargo handled at Matarani Port because they are landed via a submarine pipeline at the neighboring port of Mollendo. As can be seen from Table 6-7, there has been a gradual increase in the amount of Peruvian cargo handled. The amount of imports started to decrease from 1976, but exports showed an unprecedented increase in 1978 (75% over the previous year).

The amount of Bolivian cargo shown in Table 6-8 has generally remained at the same level and exports of mining products started to decrease slightly from 1973. The cargo handled in Ilo Port can be divided into that handled by ENAPU and that handled by SPCC. Table 6-9 shows the amount of cargo handled by ENAPU and Table 6-10 that handled by the SPCC. The largest proportions handled in both cases are liquids, but these are mainly oil and oil by-products and they are not handled via the wharf. They are landed via a pipeline and transported to points in Peru. The amount of cargo handled by SPCC showed sharp increases in 1977 and 1978. In the case of solid cargo, there have been many changes in the amounts handled by ENAPU. The amounts handled are quite small when considering the size of the wharf. The amount handled by SPCC (exports such as copper concentrate and pure copper) has tended to increase and there were remarkable increases in the quantity of exports in 1977 and 1978.

1-6-2 Shipment of Ore from Matarani Port

Tables 6-11 ~ 6-15 show ore shipment onciditons by belt conveyor at Matarani Port. These tables indicate mooring times, amounts shipped, etc., for ore handling ships entering the harbor during the four years and nine months from 1975 through September, 1979. The number of such ships entering the harbor was low in the beginning, i.e. 21 in 1975 and 28 in 1976, but there was an increases to 46 in 1977 and to 51 in 1978. The amount of ore shipped has rises from about 100,000 t/year to about 140,000 t/year. The average loading speed is as shown below. There are variations, depending on the year, but the normal speed can be considered as about 80 t/hour.

Average loading speeds

1975 : 64 t/hour
1976 : 91 t/hour
1977 : 79 t/hour
1978 : 81 t/hour
1979 : 74 t/hour

In cases where the time from the departure of one ship until the docking of the next ship is three hours or less, the next ship is considered as a waiting ship. The results of an investigation of the number of waiting ships and the number of times when two ships arrived simultaneously are shown in Table 6-16. The greater the number of waiting ships and the number of simultaneous arrivals, the more often berth overcrowding occurs. In these berths, overcrowding occurs about once a month, but this figure is low.

1-7 Control and Administrative System of Empresa Nacional de Puertos (ENAPU)

ENAPU is a decentralized public organization of the Ministerio de Transportes y communicationes (MTC) established in accordance with law No. 17526 from January 1, 1970. It is an autonomous organization with respect to administration and economics and its duties are specified in the above-mentioned law. ENAPU is managed by a board of directors with the following composition:

1) One representative of MTC (chairman of the board)
2) One representative of the Ministerio de Marina
3) One representative of the Ministerio de Industria y Turismo
4) One representative of the Ministerio de Energia y Minas (MEM)
5) One representative of the Ministerio de Agricultura y Alimentacion
6) One representative of the Ministerio de Pesqueria
7) Two experts with experience in port management appointed by MTC.

The organization is administered from a general manager's office in charge of each port. Figs. 6-10 ~ 6-13 are organizational charts of MTC, ENAPU, the Matarani Port Office and the Ilo Port Office.

Table 6-7 Amount of Goods Handled at Matarani Port (Peruvian Goods)

(Unit:t)

			1970	1971	1972	1973	1974	1975	1976	1977	1978
Solids	Export	Ore	51,986	48,269	79,543	88,526	74,406	85,245	80,166	80,985	127,150
		Fish Meal	32,190	54,471	47,687	19,316	17,039	28,741	20,483	7,381	13,693
		Coffee	7,829	9,208	12,391	12,035	5,629	9,217	7,479	7,855	9,189
		Sheep	1,486	1,452	3,285	2,794	1,685	2,130	4,445	2,217	4,292
		Sundries	4,947	3,049	4,902	9,321	4,344	2,427	6,349	4,225	20,361
	Imports	Wheat	80,721	92,672	84,776	107,552	101,712	123,516	150,302	141,924	144,922
		Fertilizer	5,316	11,928	3,287	12,340	17,025	3,048	4,865	22	2,323
		Flour	1,842	1,725	1,530	780	1,600	1,060	352	423	826
		Powdered Milk	10,680	11,474	13,364	8,724	17,467	17,531	19,421	12,859	12,777
		Cement	1,343	86	22	44	402	176			
		Machinery	3,235	2,421	2,170	7,374	14,227	19,283	9,006	11,574	15,935
		Tinplate	8,709	9,508	13,108	13,367	12,903	12,640	14,402	7,690	14
		Sundries	19,854	22,855	34,843	34,879	45,474	57,461	53,930	34,100	30,866
	Domestic Transfer	Fertilizer	7,702	3,632	4,000	4,395	1,541				
		Copper Concentrate							7,720		
		Sundries	2,697	2,561	300	236	167	8,431	46	18	
	Trans-shipment	Sundries	6,150	2,606	3,728	1,174	315	2	348	1,736	553
Subtotal			246,687	277,917	308,936	322,857	315,936	370,908	379,314	313,009	382,901
Liquids	Imports									42,562	60,621
Subtotal										42,562	60,621
Total			246,687	277,917	308,936	322,857	315,936	370,908	379,314	355,571	443,522

(Source) Empresa Nacional de Puertos

Table 6-8 Amount of Goods Handled at Matarani Port (Bolivian Goods)

(Unit:t)

			1970	1971	1972	1973	1974	1975	1976	1977	1978
Solids	Export	Ore	117,926	115,087	126,855	130,398	117,125	91,282	102,795	99,212	86,084
		Sundries	695	1,374	3,739	9,118	6,272	5,735	6,585	7,456	9,122
	Import	Flour	8,709	5,731	8,013	1,384	11,269	14,745	7,096	5,660	13,315
		Wheat	12,899	7,772	25,215	34,859	18,501	14,880	41	554	16,143
		Sundries	43,290	44,430	42,072	57,540	82,335	81,977	77,013	80,238	90,230
Total			183,519	174,394	205,894	233,299	235,502	208,619	193,530	193,120	214,894

(Source) Empresa Nacional de Puertos

Table 6-9 Amount of Goods Handled at Ilo Port (ENAPU)

(Unit:t)

Goods \ Year	1970	1971	1972	1973	1974	1975	1976	1977	1978
Total Amount	252,105 (124)	287,949 (90)	264,277 (72)	121,276 (36)	212,905 (54)	353,261 (26)	345,572 (33)	275,092 (21)	256,443 (42)
Solids	123,574 (79)	166,231 (53)	148,002 (42)	43,374 (11)	74,875 (34)	66,328 (19)	84,794 (22)	40,218 (9)	89,594 (29)
Liquids	128,531 (45)	121,718 (37)	116,275 (30)	77,902 (25)	138,030 (20)	286,933 (7)	260,778 (11)	234,874 (12)	166,849 (13)

(Note) Figures in Parenthesis Show Number of Ships Entering Harbor.

(Source) Empresa Nacional de Puertos

Table 6-10 Amount of Goods Handled at Ilo Port (Southern Perú Copper Corporation)

(Unit:t)

Total Amounts	359,494 (197)	301,239 (164)	373,658 (192)	344,862 (182)	386,918 (160)	364,676 (186)	391,175 (150)	616,498 (193)	687,817 (198)
Solids	169,056 (143)	118,590 (98)	156,516 (119)	139,785 (111)	179,894 (114)	155,949 (140)	218,207 (134)	320,709 (132)	288,631 (148)
Liquids	190,438 (54)	182,649 (66)	217,142 (73)	205,077 (71)	207,024 (46)	208,727 (46)	172,968 (16)	295,789 (61)	399,186 (50)

(Note) Figures in Parenthesis Show Number of Ships Entering Harbor.

(Source) Empresa Nacional de Puertos

Table 6-11 Amount Loaded by Belt Conveyor (1975)

Name of ship	Arrival date	Arrival time	Departure date	Departure time	Mooring time	Type of concentrate	Weight of Peruvian goods loaded (kg)	Weight of Bolivian goods loaded (kg)
HOLSTENSTEIN	08-01-75	09.15	12-01-75	07.17	94.02	ZINC	-.-	2'500.000
CALCZYSNKI	28-01-75	08.05	29-01-75	02.15	18.10	ZINC	-.-	1'500.000
SNADIECKI	08-02-75	08.40	09-02-75	01.15	16.35	ZINC	-.-	1'500.000
VENEZUELA MARU	21-02-75	09.30	24-02-75	18.00	80.30	Z.C.P.	6'120.300	-.-
TRIESERSTEIN	26-02-75	22.45	28-02-75	02.15	27.30	ZINC	-.-	2'000.000
BORDABARRI	10-03-75	12.30	11-03-75	19.40	31.10	ZINC	-.-	2'000.000
I. TUPAC YUPANQUI	09-04-75	17.30	11-04-75	08.35	39.05	Z.C.P.	4'519.600	-.-
ORTEGA	26-04-75	07.45	08-05-75	17.30	297.45	ZINC	-.-	2'500.000
SATURN	09-05-75	11.00	10-05-75	07.00	20.00	ZINC	-.-	2'150.000
ORCOMA	20-05-75	10.00	25-05-75	19.35	129.35	PLOMO	-.-	2'000.000
VALLEJO	31-05-75	07.15	02-06-75	07.45	48.30	Z.C.P.	4'313.900	-.-
SACHSENSTEIN	07-06-75	09.15	07-06-75	20.30	34.45	ZINC	-.-	2'000.000
PANETOLIKON	09-06-75	19.50	12-06-75	16.30	68.40	COBRE	10'433.400	-.-
MAREN OKOU	08-07-75	12.80	12-07-75	00.40	84.20	ZINC	-.-	5'000.000
HAITI MARU	28-07-75	15.30	02-08-75	16.15	120.45	Z.C.P.	5'696.700	-.-
AUVERGNE	28-08-75	17.10	30-08-75	01.20	32.10	ZINC	-.-	5'000.000
VALLEJO	16-09-75	07.55	18-09-75	10.15	50.20	Z.C.P.	5'709.100	-.-
CAPITAN TOHN STAVRIS	30-09-75	08.00	01-10-75	10.00	26.00	COBRE	1'936.200	-.-
KANKOKA MARU	06-10-75	07.30	08-10-75	15.25	55.55	COBRE	10'174.000	-.-
BORDABEKOA	04-11-75	09.35	06-11-75	20.20	58.45	ZINC	-.-	6'500.000
VENEZUELA MARU	28-11-75	18.45	02-12-75	06.15	83.30	Z.C.P.	6'982.900	-.-
					1'418.02		55'886.100	34'650.000

Month	Coefficient	Mooring time	Loaded weights
1	2	112.12	4'000.000
2	3	124.35	9'620.300
3	1	31.10	2'000.000
4	2	336.50	7'019.600
5	3	198.05	8'463.900
6	2	103.25	12'433.400
7	2	205.05	10'696.700
8	1	32.10	5'000.000
9	2	76.20	7'645.300
10	1	55.55	10'174.000
11	2	142.15	13'482.900
12	-.-	-.-	-.-

(Note) ZNC : Zinc
PLOMO; Lead
COBRE; Copper

(Source) Empresa Nacional de Puertos

Table 6-12 Amount Loaded by Belt Conveyor (1976)

Name of ship	Arrival date	Arrival time	Departure date	Departure time	Mooring time	Type of concentrate	Weight of Peruvian goods loaded (kg)	Weight of Bolivian goods loaded (kg)
ATLANTICO	07-01-76	13.40	09-01-76	20.50	55.10	COBRU	-.-	5'208.000
ISLA PUNA	18-01-76	07.30	18-01-76	22.00	38.30	ZINC	-.-	3'001.200
VALLEJO	04-01-76	07.00	06-01-76	05.30	46.40	Z.C.P.	3'209.000	-.-
CHARTAL	28-01-76	09.15	30-01-76	00.35	39.20	ZINC	-.-	7'200.000
HAITI MARU	06-02-76	07.35	08-02-76	02.15	42.40	Z.C.P.	5'493.800	-.-
SATURN	26-02-76	06.45	26-02-76	11.00	28.15	ZINC	-.-	300.000
VENEZUELA MARU	29-02-76	07.00	01-03-76	21.50	38.50	Z.C.P.	3'421.000	-.-
ECUADOR	13-03-76	07.40	14-03-76	06.30	22.50	ZINC	-.-	1'866.000
PRUDENTIAL OCEAN JET	27-03-76	08.00	28-03-76	00.10	16.10	PLOMO	-.-	1'050.000
VALLEJO	14-04-76	12.15	14-04-76	11.45	47.30	C.Z.P.	6'998.400	-.-
ANJOU	29-04-76	14.05	30-04-76	08.10	18.05	ZINC	-.-	4'000.000
ATLANTIC NEPTUNE	10-05-76	08.50	12-05-76	00.45	39.55	COBRE	1'801.000	-.-
AUVERGNE	18-05-76	07.50	19-05-76	17.10	33.20	ZINC	-.-	6'200.000
RIMAC	04-06-76	07.10	09-06-76	03.25	116.15	COBRE	4'511.800	-.-
I. TUPAC YUPANQUI	15-06-76	07.35	17-06-76	15.25	55.50	C.Z.P.	8'259.900	-.-
AUNIS	20-06-76	07.00	21-06-76	06.15	23.15	ZINC	-.-	3'500.000
ORBITA	01-07-76	08.00	05-07-76	17.00	105.00	PLOMO	-.-	2'400.000
VALLEJO	10-07-76	08.30	13-07-76	10.10	73.40	C.Z.P.	3'850.500	-.-
CHERTAL	14-07-76	07.50	15-07-76	17.10	33.20	ZINC	-.-	5'530.000
NOVOMOSKVCZK	17-07-76	08.15	18-07-76	22.10	37.55	COBRE	3'712.500	-.-
IRCA ROCA	22-07-76	08.15	22-07-76	19.20	11.05	COBRE	1'751.500	-.-
VENEZUELA MARU	22-08-76	07.45	24-08-76	14.30	54.45	Z.U.P.	4'500.000	-.-
MAIBAR	15-09-76	08.50	17-09-76	06.00	45.10	COBRE	3'407.000	-.-
I. TUBAC YUPANQUI	27-09-76	16.30	30-09-76	00.15	55.45	C.Z.P.	5'408.000	-.-
CHERTAL	30-09-76	07.00	01-10-76	06.00	23.00	ZINC.	-.-	2'000.000
CHERTAL	19-10-76	09.20	20-10-76	16.45	31.25	ZINC	-.-	4'000.000
VALLEJO	01-11-76	07.00	04-11-76	02.45	67.45	C.Z.P.	6'052.000	-.-
TELIO	15-12-76	06.45	18-12-76	00.30	65.45	C.Z.P.	6'768.000	-.-
					1'267.00		68'924.400	46'255.200

Month	Coefficient	Mooring time	Loaded weights
1	4	179.30	18'618.200
2	3	109.45	9'214.800
3	2	39.00	2'916.000
4	2	65.35	10'998.400
5	2	73.15	8'001.000
6	3	195.20	16'051.700
7	5	261.00	17'224.500
8	1	54.45	4'500.000
9	3	123.55	10'815.000
10	1	31.25	4'000.000
11	1	67.45	6'052.000
12	1	65.45	6'788.000

(Source) Empresa Nacional de Puertos

Table 6-13 Amount Loaded by Belt Conveyor (1977)

Name of ship	Arrival date	Arrival time	Departure date	Departure time	Mooring time	Type of concentrate	Weight of Peruvian goods loaded (kg)	Weight of Bolivian goods loaded (kg)
BAMBURY	01-01-77	08.00	02-01-77	17.35	33.35	ZINC	-.-	4'000.000
PRUDENTIAL OCEAN JET	12-01-77	19.00	13-01-77	05.40	10 40	PLOMO	-.-	1'433.000
LEAGE	12-01-77	09.40	15-01-77	17.05	79.25	Z.C.P	5'399.000	-.-
ARGOS	01-02-77	11.50	03-02-77	01.30	37.40	ZINC	-.-	7'000.000
CHOCANO	26-02-77	14.10	01-03-77	20.15	78.05	C.Z.	5'022.500	-.-
BUENOS AIRES	15-03-77	07.00	16-03-77	05.35	22.35	PLOMO	1'488.500	-.-
TELLO	23-03-77	07.05	26-03-77	02.30	67.25	Z C.P.	5'143 600	-.-
GOLDEN STAR	27-03-77	06.45	28-03-77	20.05	37.20	ZINC	-.-	10'000.000
PAIMA	14-04-77	09.10	14-04-77	23.20	14.10	PLOMO	1'569.000	-.-
SENJ	28-04-77	20.15	29-04-77	11.20	15.05	ZINC	2'500.000	-.-
ORDUÑA	26-04-77	07.00	03-05-77	05.40	166.40	ZINC	-.-	4'000.000
I. TUPAC YUPANQUI	02-05-77	07.50	04-05-77	17.15	57.25	COBRE	3'803.000	-.-
CHRISANTHEMUN	12-05-77	16.45	13-05-77	08.15	15.30	ZINC	1'266.000	-.-
LEAGE	11-05-77	12.00	12-05-77	15.10	27 10	PLOMO	1'019.000	-.-
INCA ROCA	04-05-77	18.30	05-05-77	07.00	12.30	PLOMO	1'573.200	-.-
NOVOVYATSK	06-05-77	07.50	08-05-77	15.50	56.00	COBRE	5'003.600	-.-
CHERTAL	08-05-77	07.15	10-05-77	14.55	55.40	COBRE	3'998.000	-.-
PALMA	02-06-77	07.10	02-06-77	17.30	10.20	PLOMO	1'316.300	-.-
LAGO RIÑIHUE	14-06-77	08.00	15-06-77	03.15	19.15	ZINC	2'534 000	-.-
CHOCANO	20-06-77	08.10	21-06-77	06.00	21.50	COBRE	2'798 200	-.-
INCA ROCA	06-07-77	08.50	07-07-77	14.50	30.00	PLOMO	1'424.500	- -
PAWEL SZWYDKOJ	10-07-77	06.35	14-07-77	05 10	94.35	ZINC	-.-	3'000.000
PRUDENTIAL OCEAN JET	14-07-77	07.10	15-07-77	05.30	22.20	PLOMO	-.-	997.400
MONTECRISTO	22-07-77	17.40	23-07-77	15.45	22.05	ZINC	-.-	3'400.000
I. MUAYNA CAPAC	03-07-77	08.00	26-07-77	14 35	30 35	COBRE	3'001.200	- -
BRASILIA	07-08-77	10.25	09-08-77	05.40	43.15	PLOMO	1'510.000	-.-
PALMA	09-08-77	07.20	09-07-77	18.45	11.25	PLOMO	1'337.000	-.-
ARKANDROS	27-08-77	08.00	28-08-77	00.10	16.10	ZINC	2'736.000	-.-
INCA ROCA	28-08-77	08.50	30-08-77	03.40	42.50	PLOMO	1'200.500	-.-
ANNA ULYANOVA	04-09-77	17.15	07-09-77	02.20	57.05	COBRE	5'449.000	-.-
CHERTAL	08-09-77	08.05	09-09-77	08.40	24.35	ZINC	-.-	4'300 000
CHRYSANTHEMUN	22-09-77	06.50	22-09-77	21.00	14.50	ZINC	1'702.500	-.-
HEWELVISZ	26-09-77	19.15	27-09-77	11.15	16.00	ZINC	-.-	2'100.000
PRUDENTIAL OCEAN JET	28-09-77	17.00	29-09-77	06.00	13.00	PLOMO	1'026 000	-.-
ARTICO	29-09-77	08.00	01-10-77	10.45	50.45	ZINC	2'710.500	-.-
CHIHUAHUA	03-10-77	06.30	03-10-77	17.30	11.00	PLOMO	764.000	-.-
INCA TUPAC YUPANQUI	08-10-77	09.20	09-10-77	14.10	28.50	COBRE	3'196.000	-.-
AMAZONAS	06-11-77	02.00	06-11-77	12.50	10 50	PLOMO	1'321.000	-.-
TELLO	04-11-77	06.40	06-11-77	00.10	41.30	COBRE	2'843.000	-.-
SUSANNE SKOU	13-11-77	11.45	15-11-77	19.00	55.15	ZINC	2'764.500	-.-
LAGO HUALIUUE	25-11-77	07.45	27-11-77	01.15	41.30	ZINC	-.-	4'485 500
VALLEJO	25-11-77	09.45	28-11-77	08.35	70 50	COBRE	2'501.000	- -
TUMI	10-12-77	10.45	11-12-77	03 20	16 35	PLOMO	1'873.000	-.-
LAGO HUALAIHUE	17-12-77	00.15	17-12-77	14.00	13.45	ZINC	-.-	543.950
BAYERSTEINS	18-12-77	07.05	19-12-77	05.00	21.55	ZINC	-.-	3'100.000
PRUDENTIAL OCEAN JET	19-12-77	11.45	21-12-77	07.00	43 15	PLOMO	2'379.200	-.-
					1'683.05		84'172.800	48'359.850

Month	Coefficient	Mooring time	Loaded weight
1	3	123.40	10'832.000
2	2	115.45	12'022.500
3	3	127.20	16'632.100
4	3	195.55	8'069.000
5	6	224.15	16'662.800
6	3	51.25	6'648.500
7	5	199.35	11'823.100
8	4	113.40	6'783.500
9	6	176.15	17'288 000
10	2	39.50	3'960.000
11	5	219.55	13'915.000
12	4	95.30	7'896.150

(Source) Empresa Nacional de Puertos

Table 6-14 Amount Loaded by Belt Conveyor (1978)

Name of ship	Arrival date	Arrival time	Departure date	Departure time	Mooring time	Type of concentrate	Weight of Peruvian goods loaded (kg)	Weight of Bolivian goods loaded (kg)
HILARI B	16-01-78	18.35	19-01-78	07.20	60 45	COBRE	9'877.000	-.-
TUMI	30-01-78	16 25	31-01-78	06.00	11.35	PLOMO	1'840.000	-.-
I HUAYNA CAPAC	31-01-78	07 00	01-02-78	06.10	23 10	COBRE	3'357.000	-.-
BOLESLAW CHROSET	07-02-78	08.40	08-02-78	20.20	35.40	COBRE	2'084.000	-.-
PRUDENTIAL OCEAN JET	10-02-78	07.30	12-02-78	05.30	46.00	PLOMO	814.200	-.-
MONFORT	14-02-78	06 40	15-02-78	10 00	27.20	ZINC	-.-	3'000.000
INCA ROCA	15-02-78	11 00	16-02-78	15.05	28.05	PLOMO	1'297.500	-.-
I. TUPAC YUPANQUI	17-02-78	20 00	19-02-78	12.00	40 00	COBRE	5'036.000	-.-
BASHI MARU	24-02-78	21 00	26-02-78	15.40	18 40	COBRE	1'455 700	-.-
CLIVIA	26-02-78	10.00	27-02-78	11.00	25 00	ZINC	1 955.500	-.-
SANTOS	20-03-78	07.30	21-03-78	06.00	22 30	PLOMO	818.000	-.-
B.A P ILO	24-03-78	13.45	26-03-78	13.30	47.45	ZINC	-.-	4'637.000
TUMI	05-04-78	10 30	05-04-78	18 25	08 25	PLOMO	1'174.900	-.-
REVENSWOOD	09-04-78	08 45	11-04-78	08 00	47 15	PLOMO	-.-	735.000
VALLEJO	13-04-78	06.45	15-04-78	10 10	51 25	COBRE	3'072.200	-.-
GARCILAZO	17-04-78	07.20	17-04-78	23 38	16 18	COBRE	1'713.000	-.-
IREMES GRACE	28-04-78	16.50	03-05-78	06.00	109.10	ZINC	9'400.000	-.-
NOTIS	05-05-78	07.15	06-05-78	22 10	38.55	FRANKEITA	-.-	3'060.000
ORBITA	31-05-78	18 15	05-06-78	15 05	20 50	ZINC	1'118 000	-.-
PALMA	10-06-78	10 30	13-06-78	02 30	64 00	PLOMO	2'141.000	-.-
I TUPAC YUPANQUI	13-06-78	10.45	15-06-78	01 15	38 30	COBRE	3'561.000	-.-
PRUDENTIAL OCEAN JET	17-06-78	18.00	20-06-78	02.45	56 45	PLOMO	1'040.000	-.-
SACHSENTEIN	20-06-78	07.10	21-06-78	05.00	21 50	FRANKEITA	- -	2'106.000
I CAPAC YUPANQUI	27-06-78	12 00	28-06-78	10 05	22 05	ZINC	2'803.300	-.-
AZAIKA	10-07-78	09 45	11-07-78	04 15	18.30	COBRE	1'504 000	-.-
B A P. ILO	04-08-78	15 50	06-08-78	18 25	50 35	ZINC	-.-	4'500.000
DELTA BOLIVIA	06-08-78	20 00	07-08-78	16.50	20 50	PLOMO	2'355.000	-.-
ALEMANIA	07-08-78	07.20	08-08-78	06 40	23 20	COBRE	1'546.000	-.-
SCANEASTERN	08-08-78	08 45	10-08-78	16.00	55.15	ZINC	-.-	11'450.000
BUENOS AIRES	10-08-78	17 10	11-08-78	06.15	13.05	PLOMO	1'149.000	-.-
PALMA	10-08-78	08 00	12-08-78	13 30	53.30	ZINC-PLOMO	5'550.000	-.-
VALLEJO	31-08-78	[illegible]	02-09-78	12 00	43.45	COBRE	6'060.900	-.-
ARTICO	04-09-78	08.00	05-09-78	13.00	29 00	COBRE	2'410 500	-.-
SABOGAL	04-09-78	06 45	05-09-78	22.10	39 25	COBRE	1'064.000	-.-
CHYSANTEMUN	15-09-78	08 00	16-09-78	21 35	37 35	ZINC	1'485.500	-.-
BRASILIA	20-09-78	12 05	21-09-78	16.00	27.55	PLOMO	1'086.500	-.-
ATLANTIC NEPTUNE	29-09-78	13 00	30-09-78	16 50	27.50	COBRE	2'096 000	-.-
EIBE OLD NOORT	02-10-78	07 50	02-10-78	23.00	15.50	COBRE	2'531.000	-.-
MIESCO I	16-10-78	07.20	18-10-78	00.30	41 10	ZINC	-.-	3'200.000
LAJA	17-10-78	20 40	18-10-78	07.55	11 15	PLOMO	1'647.000	-.-
SADDO MARU	20-10-78	06 50	20-10-78	22.40	16.30	ZINC	1'502.500	-.-
DEL RIO	01-11-78	21 45	03-11-78	04.55	31.10	PLOMO	-.-	1'398.000
I TUPAC YUPANQUI	10-11-78	13.45	11-11-78	23.20	33.35	COBRE	2'428.000	-.-
TELIO	12-11-78	01.10	12-11-78	21.25	20 15	COBRE	1'168.000	-.-
LONGAVI	13-11-78	08.00	13-11-78	23 00	15 00	PLOMO	2'232.000	-.-
MONFORT	17-11-78	14 00	18-11-78	17.00	27 00	ZINC	-.-	5'384.000
I HUAYNA CAPAC	30-11-78	07.00	01-12-78	15 00	32 00	COBRE	1'822 000	-.-
VALLEJO	03-12-78	08.45	04-12-78	05.45	21 00	ZINC	2'835.000	- -
ATLANTICO	15-12-78	08.15	17-12-78	04.00	43 45	COBRE	2'818 000	-.-
NIKOLA TESLA	16-12-78	08 25	18-12-78	02.15	41.50	ZINC	2'500.000	-.-
DEL ORO	16-12-78	06 25	20-12-78	18 30	108 05	PLOMO	1'545 000	-.-
					1'781 08		104'695.200	39'470.900

Month	Coefficient	Mooring time	Loaded weight
1	3	95 30	15'074 000
2	7	220 45	16'442.900
3	2	70.15	5'455.000
4	5	232.43	16'096.000
5	2	59.45	4'178.000
6	5	203 10	11'651 300
7	1	18 30	1'504 000
8	7	260 20	32'610 900
9	5	161.45	8'143.500
10	4	84 45	8'880.500
11	6	159 00	14'432 000
12	4	214 40	9'698 000

(Source) Empresa Nacional de Puertos

Table 6-15 Amount Loaded by Belt Conveyor (1979)

Name of ship	Arrival date	Arrival time	Departure date	Departure time	Mooring time	Type of concentrate	Weight of Peruvian goods loaded (kg)	Weight of Bolivi goods loaded (kg,
FRIESENSTEIN	04-01-79	06.30	04-01-79	21.05	14.35	COBRE	2'040.000 Kls	-.-
IWCA ROCA	13-01-79	06.45	16-01-79	06.05	70.10	PLOMO	1'866.000	-.-
TELLO	01-02-79	07.55	12-02-79	09.30	265.35	COBRE	5'667.000	-.-
MARESMA	05-02-79	09.20	07.02-79	16.55	55.35	ZINC	2'765.000	-.-
ANWO VENTURE	08-02-79	07.30	10-02-79	11.50	52.20	ZINC	4'750.000	1'575.000 Kls.
IMPORDA	06-03-79	19.20	08-03-79	18.20	47.00	COBRE	1'983.000	-.-
SANTO PIONER	17-03-79	17.55	18-03-79	08.10	14.15	PLOMO	2'498.000	-.-
SABOGAL	19-03-79	17.25	22-03-79	12.30	66.05	COBRE	4'405.200	-.-
DEL SOL	27-03-79	17.00	28-03-79	09.35	16.35	PLOMO	1'929.000	-.-
ATLANTICO	06-04-79	11.30	07-04-79	14.10	26.40	ZINC	2'788.000	-.-
BRISBANE	28-04-79	21.00	30-04-79	09.35	57.35	PLOMO	1'711.000	-.-
LAGO RINIHUE	20-05-79	07.35	20-05-79	22.20	14.50	ZINC	2'080.000	-.-
SYMI	17-06-79	17.30	19-06-79	05.30	36.00	PLOMO	2'324.100	-.-
OROTON	24-06-79	06.15	24-06-79	16.05	9.50	PLOMO	-.-	1'100.000 Kls.
JAMAICA MARU	25-06-79	13.30	26-06-79	05.10	15.40	COBRE	2'036.000	-.-
B.A.P. ILO	25-07-79	07.20	28-07-79	04.15	68.55	COBRE	7'052.300	-.-
AL TANVIR	05-08-79	08.25	06-03-79	11.15	26.50	ZINC	1'882.000	3'008.000 "
AVON	09-08-79	14.00	12.-08-79	16.45	74.45	COBRE	8'559.400	-.-
CLOVER	18-08-79	18.45	21-08-79	04.50	58.05	COBRE	1'542.000	-.-
AL TANVIR	07-09-79	14.40	10-09-79	06.00	63.20	ZINC	3'568.000	8'642.000 "
ELDANIA	10-09-79	08.00	11-09-79	02.10	18.10	ZINC	3'503.500	-.-
ATLANTICO	24-09-79	09.00	25-09-79	05.45	20.45	COBRE	1'975.000	-.-
VALLEJO	18-09-79	16.30	19-09-79	16.35	24.05	PLOMO	1'800.000	-.-
					1,117.40 hrs.		68'724.500 Kls.	14'325.000 Kls.

Month	Coefficient	Loaded Weight
1	2	3'906.000 Kls.
2	3	14'757.000 "
3	4	10'815.200 "
4	2	4'499.000 "
5	1	2'080.000 "
6	3	5'460.100 "
7	1	7'052.300 "
8	3	14'991.400 "
9	4	10'846.500 "
	23	83'049.500 Kls.

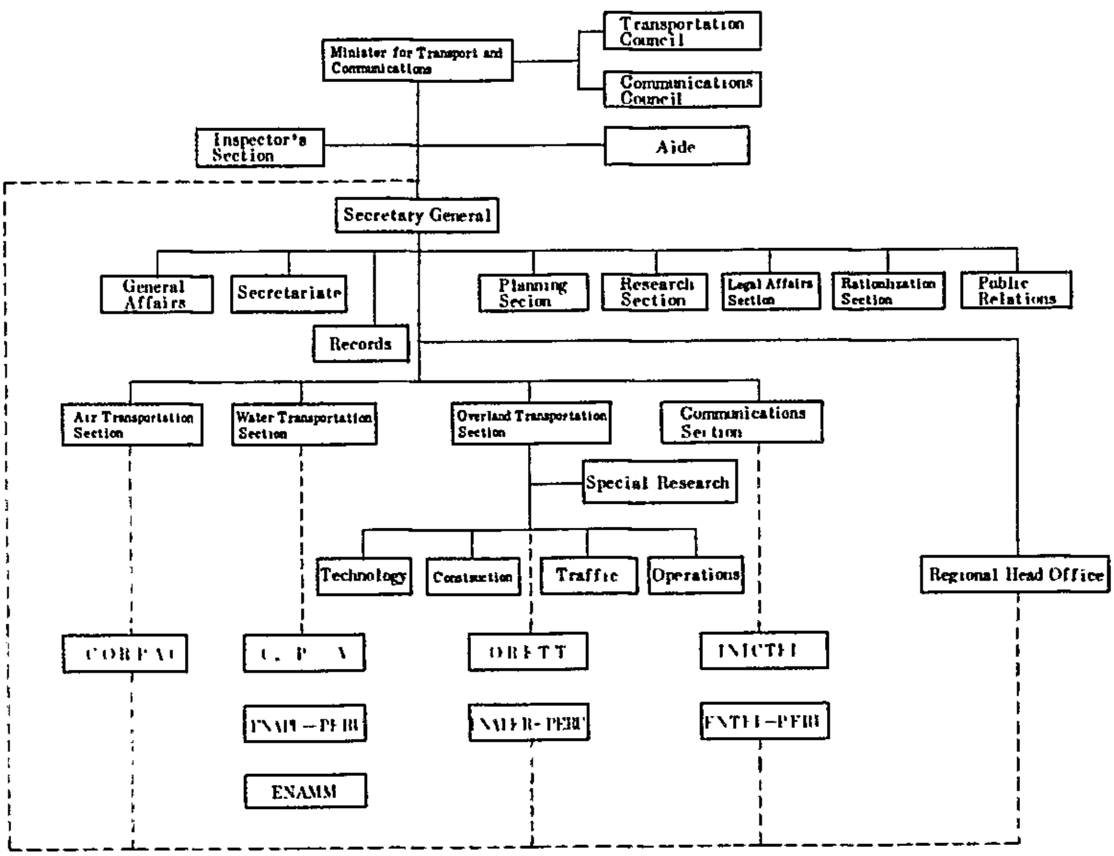
Source) Empresa Nacional de Puertos

Table 6-16 Number of Waiting Ships and Simultaneous Arrivals

Year	Shipments	No. of Ships entering port	No. of waiting ships	No. of simultaneous arrivals	Cases of overcrowding
1975	90,536	21	0	0	0
1976	115,179	28	0	0	0
1977	132,533	46	4	3	7
1978	144,165	51	6	5	11
To Sept., 1979	83,050	23	1	3	4

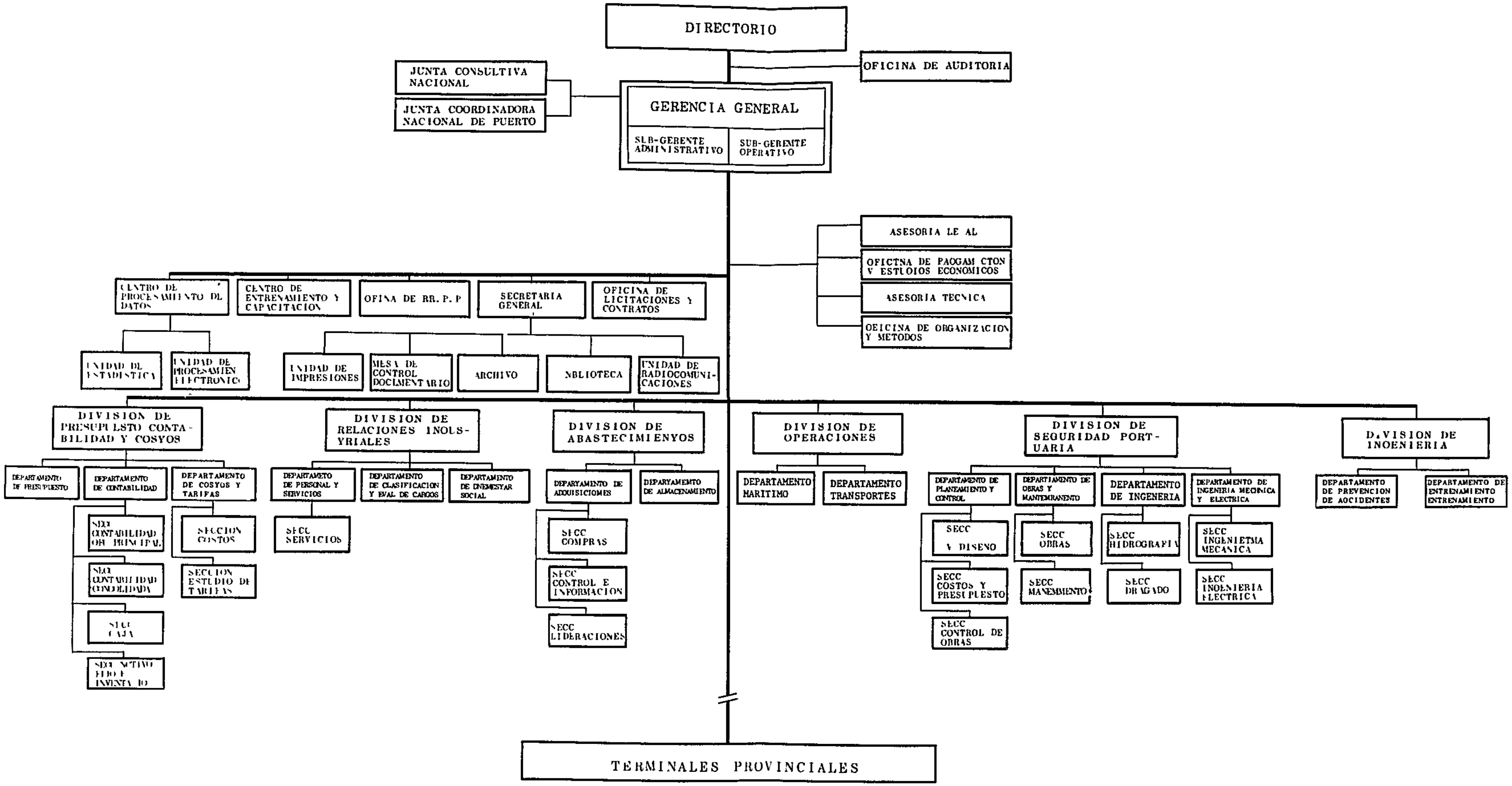
(Source) Empresa Nacional de Puertos

Fig. 6-10 Organization Chart of M.T.C. (Central)



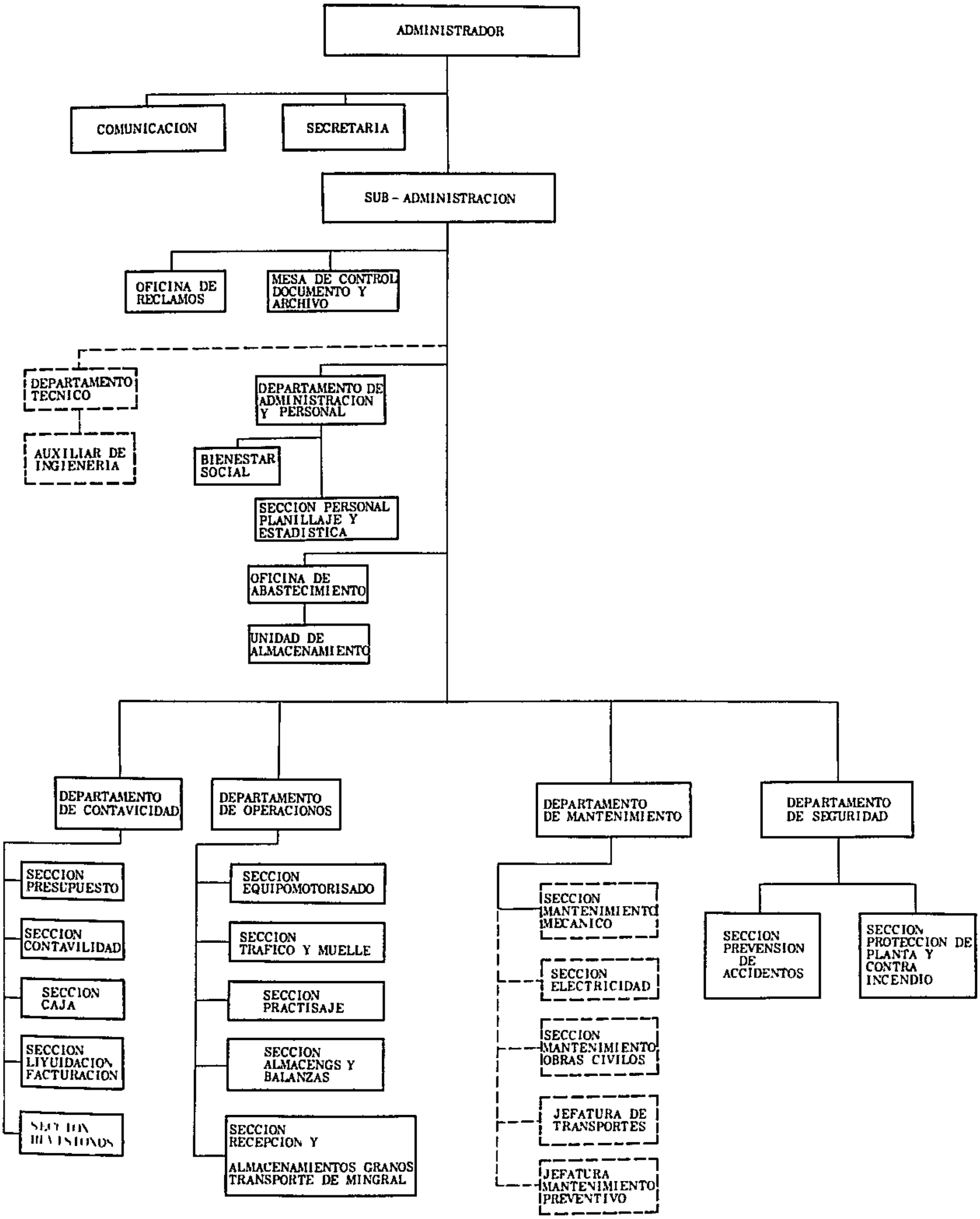
(Source) Ministerio de Transportes y Comunicaciones

Fig. 6-11 Organization of ENAPU



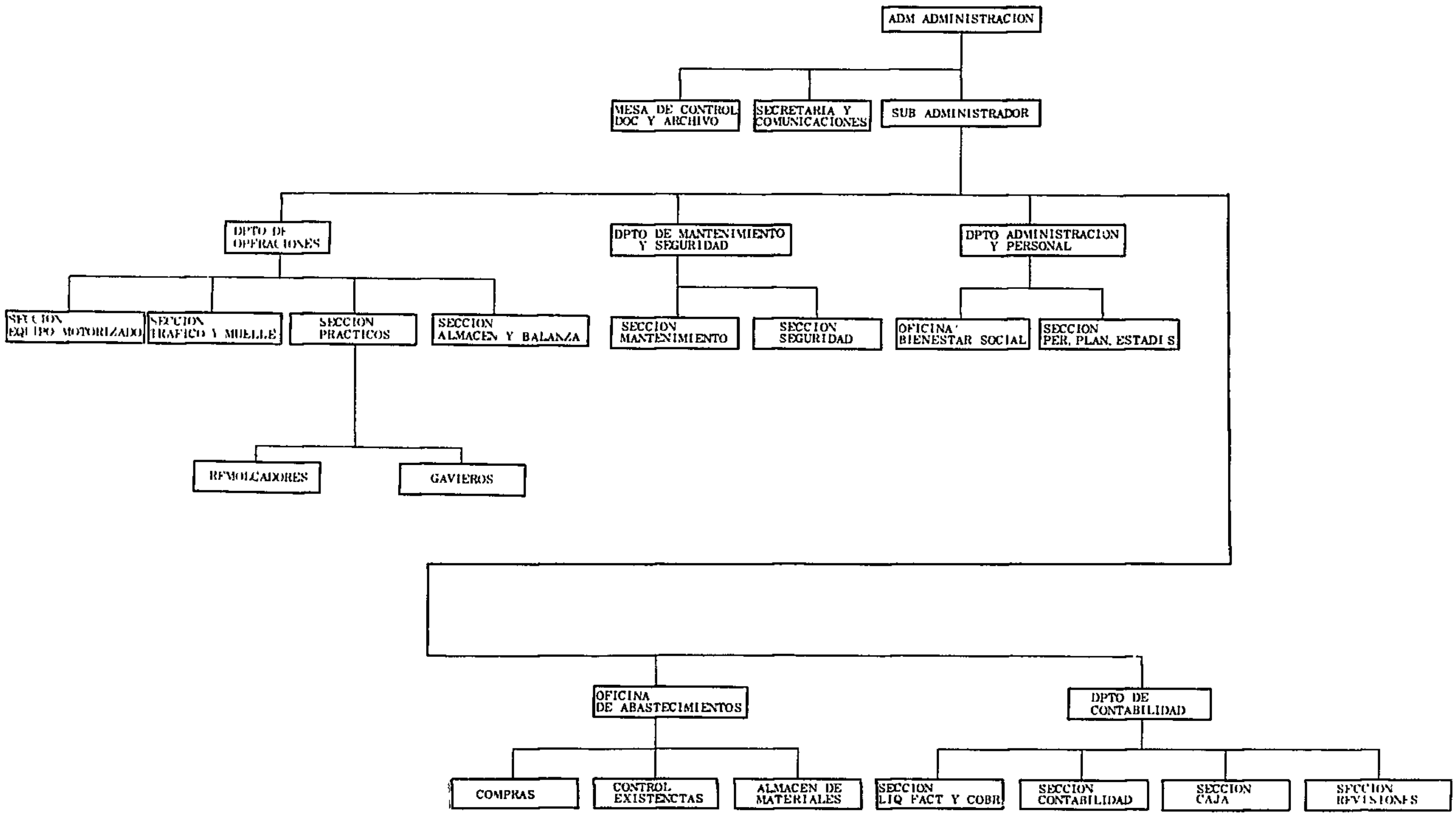
(Source) Empresa Nacional de Puertos

Fig. 6-12 Organization of Matarani Port Office



(Source) Empresa Nacional de Puertos

Fig. 6-13 Organization of Ilo Port Office



(Source) Empresa Nacional de Puertos

2. Estimates of Future Cargo Handled at the Ports

The results of interviews with port authorities (at the ENAPU office in Callao Port, and the Matarani and Ilo Port Offices) were not sufficient to estimate the cargo which will be handled at Matarani and Ilo Ports in the future. Fig. 6-14 shows a graph of the cargo handled at each port since 1970. The Peruvian cargo at Matarani Port expanded 1.8-fold in nine years and if the rate of expansion is the same in future, the amount should reach 600,000 t/year by 1985. There have been no major changes in the Bolivian cargo handled in Matarani Port over the past nine years and the figure has remained at about 200,000 t/year. The same tendency was also seen for solid cargo handled by ENAPU (cargo handled at the wharf) at Ilo Port and the figure has not exceeded 100,000 t/year. If this trend continues, the amount of Bolivian cargo handled at Matarani Port and the solid cargo handled by ENAPU at Ilo Port should not vary much in the future and remain at about 200,000 t/year and 100,000 t/year respectively.

3. Government Development Plans for the Two Ports

3-1 Matarani Port

Cargo handled in Matarani Port is increasing gradually every year and existing facilities will probably not be able to meet future demands. To cope with such conditions, ENAPU is considering expansion of Matarani Port and the English consulting firm of Liversey and Henderson has presented a master plan for such expansion. At the present stage, it is impossible to determine the contents of this plan in detail, but it does involve expansion to the south of the present location. Matters such as the period for execution of this plan appear to be very indefinite.

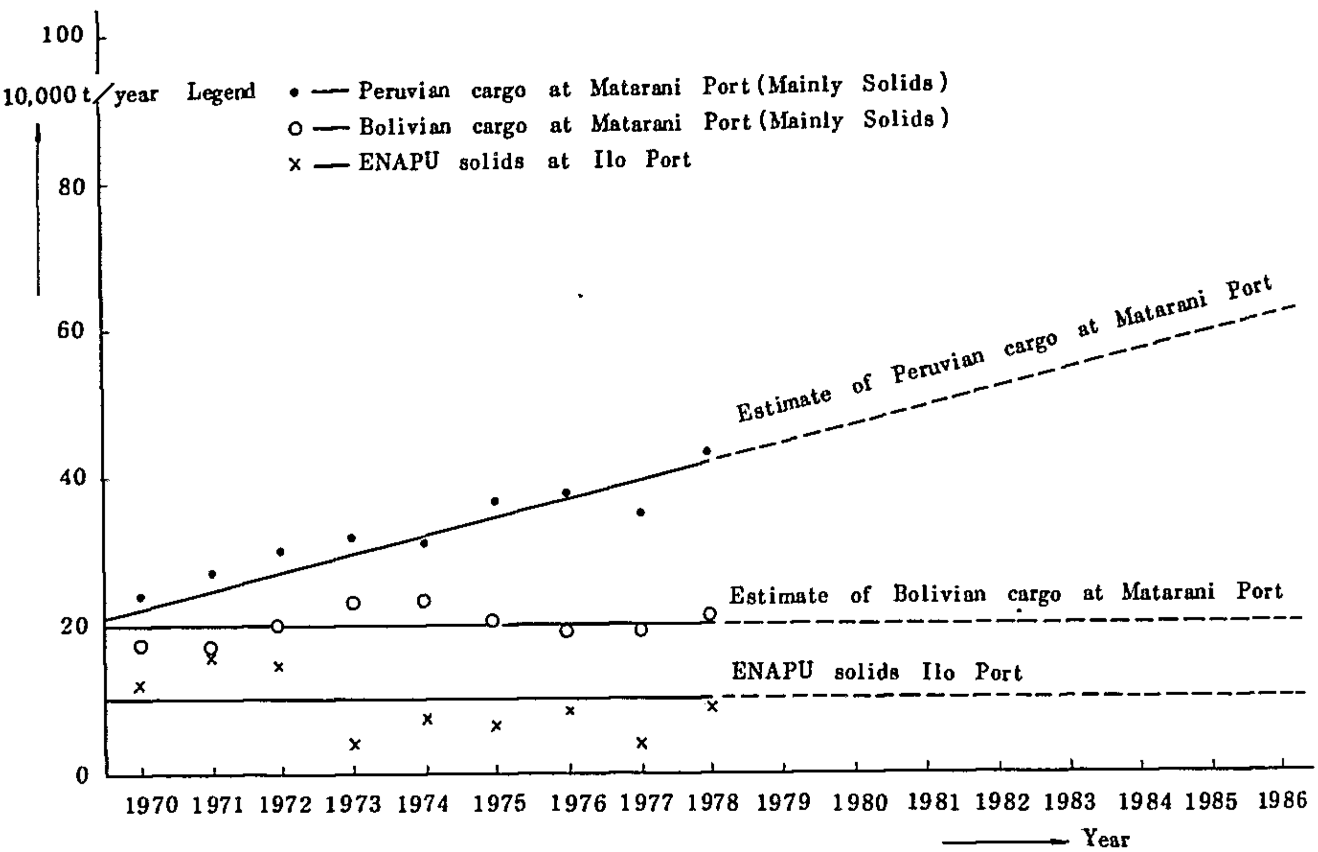
3-2 Ilo Port

The amount of solid cargo handled via the wharf under the control of ENAPU has remained at about 100,000 t/year over the last 9 years and the current capacity is still far from being reached. The port authorities consider that it will be possible to handle mining products such as concentrates and semifinished products at this wharf. A plan for construction of a railway siding on the wharf is being considered and an investigation is underway concerning the possibility of such a siding.

4. Increase in Cargo in Conjunction with Mining Development

Table 6-17 shows the estimated amounts of concentrate shipped each year in conjunction with the development of mines in the southern part of Cuzco Department. The total amounts shipped by the four mines will result in a direct increase in the cargo handled at the port concerned. During the peak period (1989 - 1997), the total amount shipped will reach 264,000 t/year.

Fig. 6-14 Changes in Amounts of Cargo Handled



(Source) Empresa Nacional de Puertos etc.

Table 6-17 Increases in Goods

(Unit:t)

Year \ Mine	Atalaya	Tintaya	Coroccohuayco	Quechua	Total
1980	9,600				9,600
1981	9,600				9,600
1982	9,600				9,600
1983	9,600	152,000			161,600
1984	9,600	152,000			161,600
1985	9,600	152,000			161,600
1986	9,600	152,000	20,000		181,600
1987	9,600	152,000	20,000		181,600
1988		152,000	20,000		172,000
1989		152,000	20,000	92,000	264,000
1990		152,000	20,000	92,000	264,000
1991		152,000	20,000	92,000	264,000
1992		152,000	20,000	92,000	264,000
1993		152,000	20,000	92,000	264,000
1994		152,000	20,000	92,000	264,000
1995		152,000	20,000	92,000	264,000
1996		152,000	20,000	92,000	264,000
1997		152,000	20,000	92,000	264,000
1998			20,000	92,000	112,000
1999			20,000	92,000	112,000
2000			20,000	92,000	112,000
2001				92,000	92,000
2002				92,000	92,000
2003				92,000	92,000

5. Suitability of These Ports for Shipment

The suitability of Matarani and Ilo Ports for shipment of concentrate has been evaluated by a comparison of such items as transport methods, stockyards, loading facilities and loading wharfs.

5-1 Matarani Port

5-1-1 Estimates of Future Concentrate Shipments

Table 6-18 shows the amount of mining product shipments (from Tables 6-7 and 6-8) and amount of concentrates shipped by belt conveyor (from Tables 6-12 ~ 6-16). Concentrate is only one type of mining product, but it accounted for a very high proportion of mining products and in 1977, reaching 74% of the total. Although total shipments of mining products have remained at about 200,000 tons for the last nine years, concentrate shipments have tended to increase every year and this increase should continue in the future. However, since there are no accurate methods of estimation and little data are available,the estimates here have been based on concepts of convenience. Since the shipments will not increase unless the mines are developed, the estimates for the two years until 1980,when development will first start in the south of Cuzco Department,are based on concentrate shipments for 1975 ~ 1978 (past data). Estimates up to 2003 were made by adding

Table 6-18 Mining Product Shipments

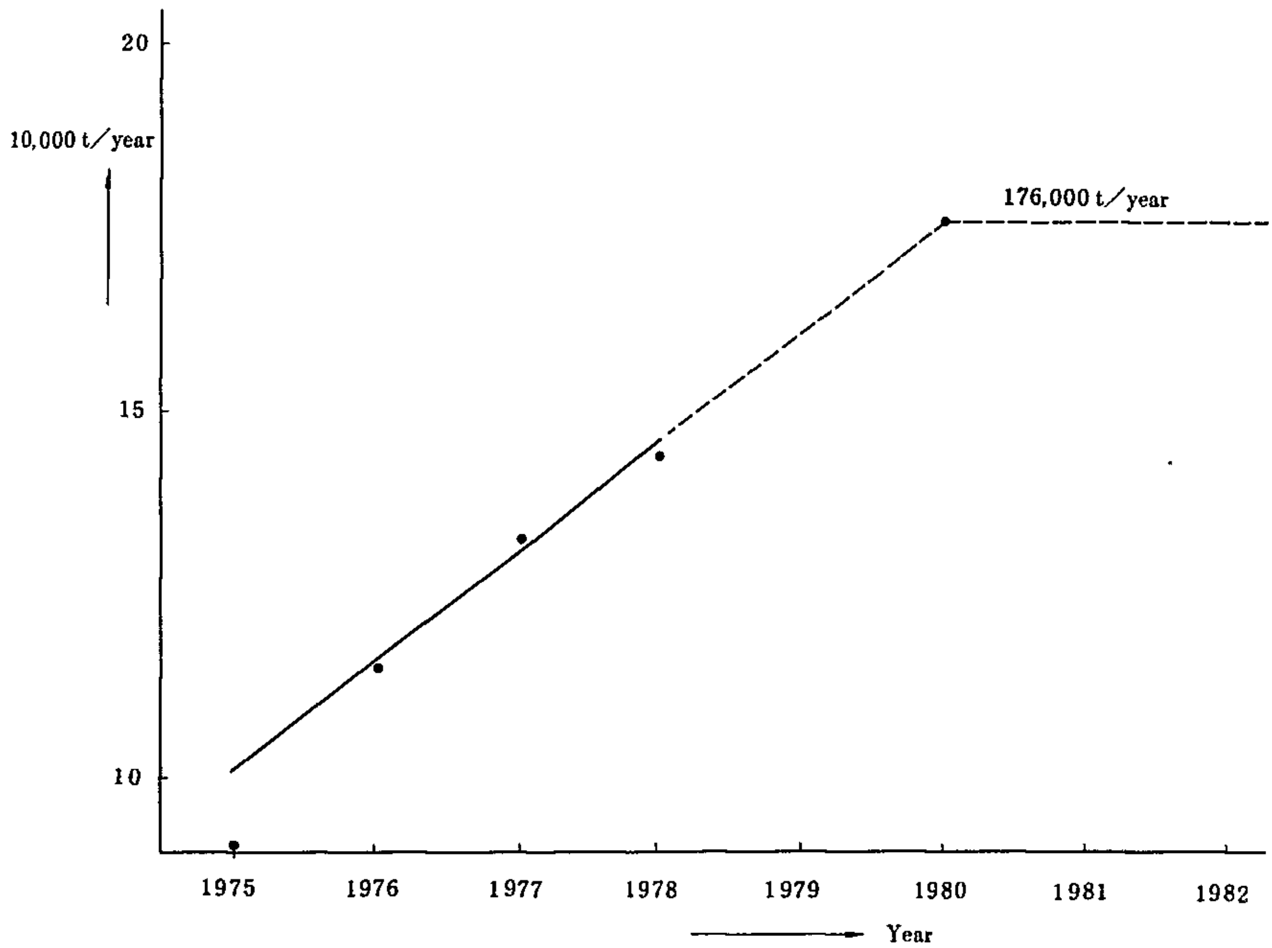
(Unit:t)

Year	Mining product shipments (A)			Concentrate shipments (B)			(B/A)
	Peruvian	Bolivian	Total	Peruvian	Bolivian	Total	
1970	51,986	117,926	169,912	-	-	-	-
1971	48,269	115,087	163,356	-	-	-	-
1972	79,543	126,855	206,398	-	-	-	-
1973	88,526	130,398	218,924	-	-	-	-
1974	74,406	117,125	191,531	-	-	-	-
1975	85,245	91,282	176,527	55,886	34,650	90,536	0.51
1976	80,166	102,795	182,961	68,924	46,255	115,179	0.63
1977	80,985	99,212	180,197	84,173	48,360	132,533	0.74
1978	127,150	86,084	213,234	104,695	39,471	144,166	0.68

(Source) Empresa Nacional de Puertos

only increases in shipments from the mines in the southern part of Cuzco Department, based on the hypothesis that there will be fixed amounts of shipments from other mines after 1981. From Fig. 6-15, the estimate of shipments from existing mines in 1980 is 176,000 t/year.

Fig. 6-15 Forecast of Concentrate Shipments Based on Previous Data



(Note) B values in Table 6 – 18

(Source) Empresa Nacional de Puertos etc.

The total of these values and those in Table 6-17 become the estimate from 1980. Table 6-19 shows the estimates of concentrate shipments from 1980 to 2003.

For further investigation, these concentrates are all considered as being loaded on ships by belt conveyor via the stockyards.

5-1-2 Methods of Transport to the Port

In the survey on the development of the national railways in this project, it was found that transport costs would be cheaper for a route using both road and railway transport from the mines to Ayaviri station and on to Matarani Port than for the all highway route from the mines to the Matarani Port via Sibayo and Arequipa. The most efficient transport to Matarani Port uses the Ferrocarril del Sur through Arequipa and La Joya.

5-1-3 Stockyard

The top of the hill is under the control of the Empresa Nacional de Ferrocarriles (ENAFER). The area is 71,000 m^2 and storage capacity is 36,000 t. At present, the stockyard is divided into large areas for the use of Minero Perú and Bolivia. Each of these areas is subdivided in accordance with the type and amount of ore, as required. The cargo of Minero Perú tends to be mainly copper and lead concentrates, while that of Bolivia is mostly zinc concentrate. According to ENAPU, these areas are not strictly fixed and it is possible to handle larger amounts of concentrate if rotation is performed smoothly. There should be no problem with storage when the concentrate from the mines in the southern part of Cuzco is added. The piling height for the concentrate is about 5 m and to prevent dust, constant sprinkling is performed. A steep face gradient of 1:0.3 is maintained, therefore. From Table 6-19, the maximum concentrate shipments will be 36,700 t/month for 1989 - 1997, therefore, the stockyard will have a capacity of about one month's concentrate. It appears that the scale of the stockyard is sufficient. Two bulldozers (capacity: 2t) are used for movement of the concentrate within the stockyard and capacity will be sufficient if one more bulldozer is added (three are used in Callao Port).

5-1-4 Belt Conveyor

The hill and wharf are connected by a 530m belt conveyor. The concentrate brought to the stockyard is loaded onto ships using this belt conveyor. Transport capacity is 1,000 t/hour and power consumption is 500 KW. This conveyor was manufactured by Add Coal Corporation Ltd. in Canada and went into operation in 1970. The life span is 30 years and it can still be used for another 20 years. One to two operators are required for 24-hour operation. No speical defects have been found so far with the exception of occasional clogging of the hopper caused by spray water used to prevent dust. The transport capacity is sufficient to handle increases in concentrate shipped and it should be possible to use the belt conveyor until 2003 when the life of the mines is expected to end. (Photo 6-3)

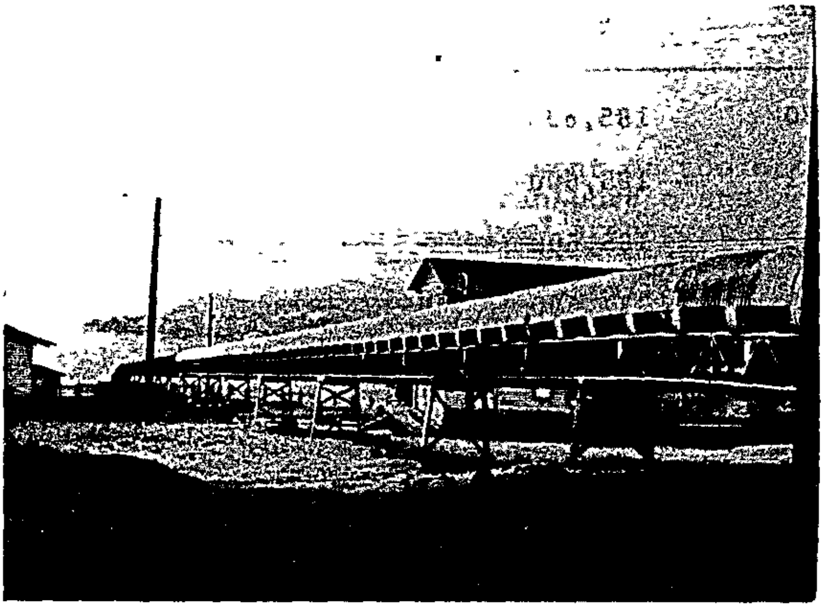
Table 6-19 Estimated Values of Concentrate Shipments

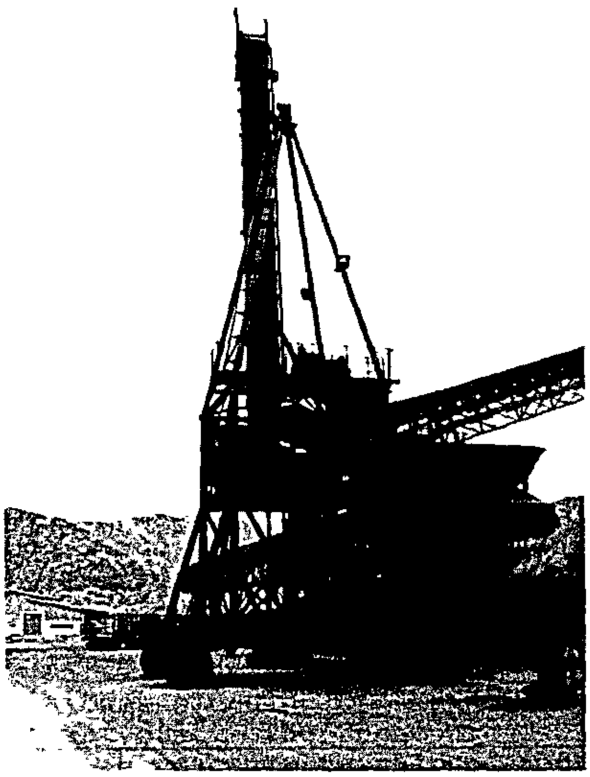
(Unit:t)

Year	Estimated values (t/year)	Estimated values (t/month)
1980	185,600	15,500
81	185,600	15,500
82	185,600	15,500
83	337,600	28,100
84	337,600	28,100
85	337,600	28,100
86	357,600	29,800
87	357,600	29,800
88	348,000	29,000
89	440,000	36,700
90	440,000	36,700
91	440,000	36,700
92	440,000	36,700
93	440,000	36,700
94	440,000	36,700
95	440,000	36,700
96	440,000	36,700
97	440,000	36,700
98	288,000	24,000
99	288,000	24,000
2000	288,000	24,000
01	268,000	22,300
02	268,000	22,300
03	268,000	22,300

(Source) Empresa Nacional de Puertos etc.

Photo 6-3 Belt Conveyor at Matarani Port





5-1-5 Loading Quaywall

The wharf at Matarani Port consists of a quay wall with a water depth of -10m. The total length is 580m. Steel sheet pile cell type, construction is used as shown in Fig. 6-6, for berths 1 ~ 3 (total length: 450m). Berth 4 (total length: 130m) near the harbor entrance is of the concrete piled pier type, as shown in Fig. 6-7. Berths 1 ~ 3 were completed in 1942 and berth 4 was added in two stages (90m and 40m) later. The terminal point of the belt conveyor is at berth 4 and ore shipment is carried out only at berth 4. Possible loading range using the belt conveyor is 80 ~ 85m out of the total length of the quay wall and one to two shifts are required for large ships. Concentrate can also be loaded at berth 3 and in such cases, special containers are used and loading is performed with a derrick crane installed on the ship. However, loading efficiency in such cases is very bad and it can be used only for small ships. From the exterior, no remarkable changes were noted in berths 1 ~ 4 and since there are few earthquakes in the region, there should be no structural problems. As shown in Table 6-5, there has been only one instance of overcrowding per month in 1978 for shipments of 144,000t. If this rate is used, overcrowding can be estimated as occurring 440,000/144,000 = about three times a month during the peak shipment period between 1989 and 1997. In extreme cases, there are ports where all of ships entering the harbor are waiting, and overcorwding about three times a month would appear to be in the permissible range.

5-2 Ilo Port

5-2-1 Estimates of Future Concentrate Shipments

Since no mining products are handled at the wharf controlled by ENAPU, the shipments for these investigations are considered to be all or part of the cargo increases shown in Table 6-17.

5-2-2 Transport Route to the Port

Consideration has been given to the existing transport route from the mines to Ilo Port via Ayaviri Station and Matarani Port, but the road portion between Matarani and Ilo Ports adds costs and the route is not economical when compared with shipment from Matarani Port.

5-2-3 Stockyard and Belt Conveyor

At present, no preparations have been made, but sufficient land is available.

5-2-4 Loading Quaywall

The quay-wall width a water depth of -10 ~ -16 m is a jetty type wharf, 302 m in length and 27 m width consisting of four berths. Docking of large ships is possible.

5-3 Conclusions

Matarani Port is nearer to the mines than Ilo Port and the transport costs to Matarani Port will be cheaper. The existing facilities at Matarani Port such as the stockyard, belt conveyor and quay wall will be able to accommodate future increases in shipments with respect to both quantity and time and there should be no problems. Ilo Port has not yet handled any mining products and there are no facilities for handling bulk materials such as concentrates. Considerable investment would be required to provide such facilities and there is no valid reason for choosing Ilo Port at this time. Therefore, it is considered that Matarani Port is most suitable as the port for shipment of concentrates from the mines in the southern part of Cuzco State. Ilo Port can be considered as a substitute port when unexpected conditions occur at Matarani Port and it can not be used. It should be sufficient if preparations are made at such times.

6. Recommendations for Further Detailed Studies

From the results of this survey, it appears that Matarani Port has sufficient capacity to receive increased cargo in conjunction with mining development. However, conclusions will have to be based on a detailed survey of shipping facilities such as the stockyard, belt conveyor and quay wall, and this will require an even more detailed survey than the present one. In particular, the belt conveyor must be investigated with respect to such items as structural problems and life span. The nominal transport capacity of the belt conveyor is 1,000 t/hour, but actual results using the conveyor (obtained by dividing the amount loaded by the mooring time) are very low, i.e. 80 t/hour and the cause of this must be made clear in order to improve efficiency.