which have V-shape valleys with steep slopes.

3) Geology

a) Altiplano
The Oruro-San Pedro-Paria in the Altiplano area is formed by sediments that glaciers carried away from the Andean range, and by sediments formed by volcanic activities of the Tertiary Period. The Altiplano area is densely covered by those sediments and seems like an inland sea.

b) Los Andes Eastern Zones
The Paria and Suticollo areas, located in the eastern Andes has a geological structure composed mainly by strata from the Palezoic Era such as the Ordovician, Silurian and Devonic periods; these stratum are weakened in many parts due to organic movement foldings and eolian erosion, etc.

c) Cochabamba Basin
The Suticollo and Cochabamba areas are a basin of the Andes formed by alluvial soils. The stratum in this area, as in the Altiplano, are composed of continental type sediments.

(3) Natural Disasters

The major natural disasters in the study area consist of landslides, dislodged masses from gorges, river sediments, dislodged sediments, and erosion along river banks. These natural disasters greatly affect existing railway operations.
The Oruro-Cochabamba Line experiences disasters frequently, especially along the steep gradients along the Tacopaya, Chull Mayu and Arque rivers (actually these are a single river which has different names).

Many tributaries flow into the Tacopaya, Chull Mayu and Arque rivers, and their basin is formed by steep slopes and weathered rock that produces landslides.
The above conditions easily generate landslides together with high volumes of sediments that run into the main river, both of which elevate river beds.
Earthquakes seldom occur in Bolivia.

3-2 ENVIRONMENTAL CONDITIONS

It is important to ensure that this project has no negative effects on the environment nor on the livelihood of the region.
The railway improvement plan of this project is small scale and is on an existing line. Therefore, there should be no environmental or social ploblems.

(1) Environmental Impact Assesment in Bolivia

Bolivia enacted General Environmental Law No. 9 in April 1992. This law stipulates that before implementing any development project it is necessary to evaluate the environmental impact and effect on the livelihood of inhabitants so as to prevent the execution of inadequate projects that might cause damage.

(2) Environmental Situation along the Proposed Route

The environmental situation of the Aguas Calientes - Irpa Irpa area, where the railway is to be improved, is as follows :

1) Living conditions of inhabitants in the area

* Housing and productive activities
  There are few communities living between the railway stations. Nearby the stations there are some schools, churches and hospitals that provide basic public services.

* Land property and water rights.
  People living along the railway own the land, and the Bolivian army is in charge of reale state registration. Water usage is decided by a government authority in the area.

* Means of transportation
  The mode of transportation used by communities living in the area is the railway system, the subject of this project. It should be noted that people nearby communities utilize the railway as a local road for their activity purposes.

2) Flora and Fauna

The area along the river is pasture used for grazing farm animals. Since the area has little rainfall, plants are prevented from growing. Trees are not able to grow in this environment, with the exception of some eucalyptus trees that have been planted.

3) Pollution

The results of studies on the atmosphere, noise, vibration, water quality, etc. are not available for the area. However, the small-scale nature of the project will not cause any to environmental problems.

4) Other provisions for the area

The area is not included in any other development plans, such as those for national parks, protected areas, etc.

(3) Environmental Items to Be Considered

It is believed that this project will have no negative effects on the environment. However, it is necessary that the following items be considered in the execution of the project:

1) Movement of inhabitants

The optimum route was selected, and the relocation plan was designed so as to avoid the severing of communities as much as possible. However, some households will have to move, and preliminary agreements with these families will be nesessary.
To solve this problem, flexible solutions will be applied that do not involve monetary compensation for relocation.

2) Noises and vibrations

During the period of construction work, noise from machines and dynamite explosions will probably cause disturbances. However, taking into account that there are only a few households along the railway, it is expected that the disturbances will have a minimal inpact. However, it is necessary to negotiate with people close to the construction sites and to obtain their understanding prior to the beginning of work.

3) Occurance of Disasters

Landslides and erosion caused by construction will be much smaller than that caused by nature. However, appropriate measures must be applied to avoid such problems, and the safety of constructing soil embankment and cuts in the area must also be considered.

4. ROUTE PLAN

4-1 CONSIDERATIONS FOR ROUTE SELECTION

(1) Sections that run parallel to the river needing improvement will have a 20 to 40-year life span.
The route basically will be relocated towards the mountains, taking into consideration topography and the ascent of the river bed .

(2) Existing sections of track not prone to disaster will be used as is, such as those more than 5m from a river bed.

(3) Bridges, box tunnels and covers will be used to protect the railway against disasters in areas where significant dislodged masses are expected.

(4) The cost of improvement work shall be kept as low as possible and project planning will include measures for easy maintenance. The construction of long tunnels, which might increase construction costs is avoided.

(5) Designs will be easy to implement. For track that has to be relocated, safety will be ensured while work is being performed near the railway.

4-2 MAIN CRITERIA FOR ROUTE SELECTION

(1)	Design speed	V=80 Km/h
(2)	Min. curvature radius	R=120m (may be reduced to R=100 as topography requires)
(3)	Max. gradient	i=30‰ (without considering curvature resistance) In stations: considering maneuvers i=less than 3.5‰ not considering maneuvers i=less than 15‰
(4)	Length of transitional curve	More than L=250 Co (Co: real cant)
(5)	Vertical curve radius	More than R=2,000 m (may be reduced to R=1,000 if topography requires)
(6)	Length of straight line between curves	Longer than L=20m
(7)	Effective length of line at the stations	Longer than L=300 m

4-3 SELECTION OF THE OPTIMUM ROUTE

The Aguas Calientes ~ Irpa Irpa section will be divided into 20 sections. Sections to be improved will be odd numbered and sections to be used as is will be even numbered. Figure 4-1 shows the selection process of the optimum route. After evaluating the railway's conditions, the first alternative plans for sections ①, ⑦, ⑪ and ⑬ were established. Then, as the second alternative plan, each two routes for the improvement sections ⑪ and ⑬ were also established.

Regarding second route alternatives, after evaluating the technical, environmental, transportation, economic-financial factors, and holding discussions with the Bolivian counterparts, the results obtained indicate that the optimum route for Section ⑪ is Route C and for Section ⑬ Route A. Figures 4-2 through 4-5 show the general plans for the optimum route.

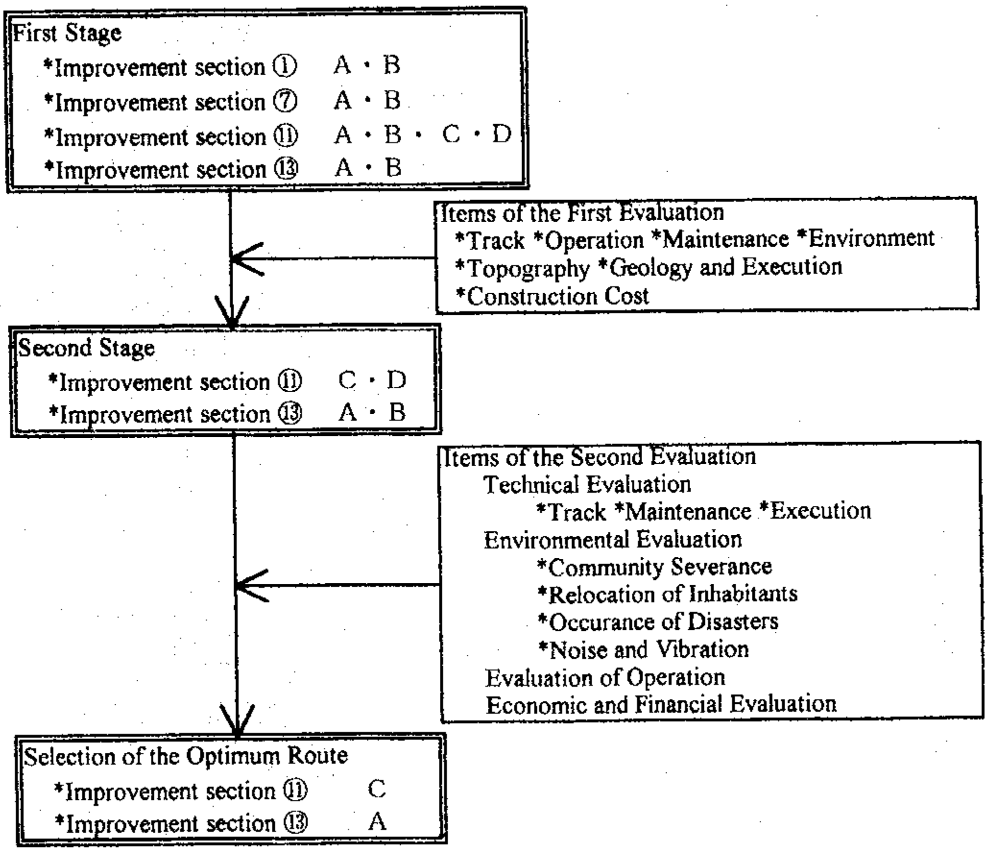


Figure 4-1 Flow for the Selection of the Optimum Route

Plano del Trazado de Via entre Aguas Calientes e Irpa Irpa

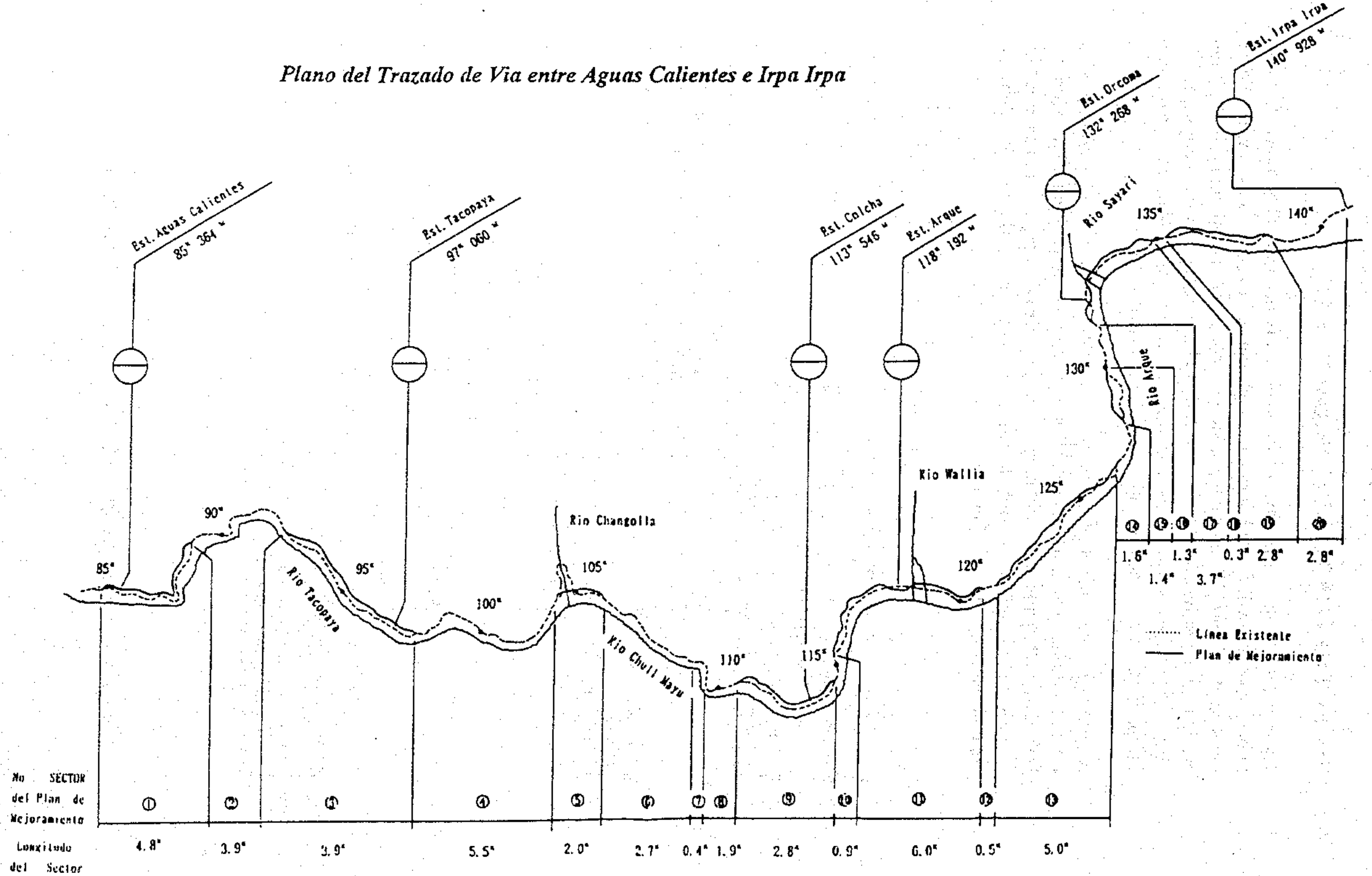


Figure 4-2 Improvement Plan for the railway line between Oruro and Cochabamba

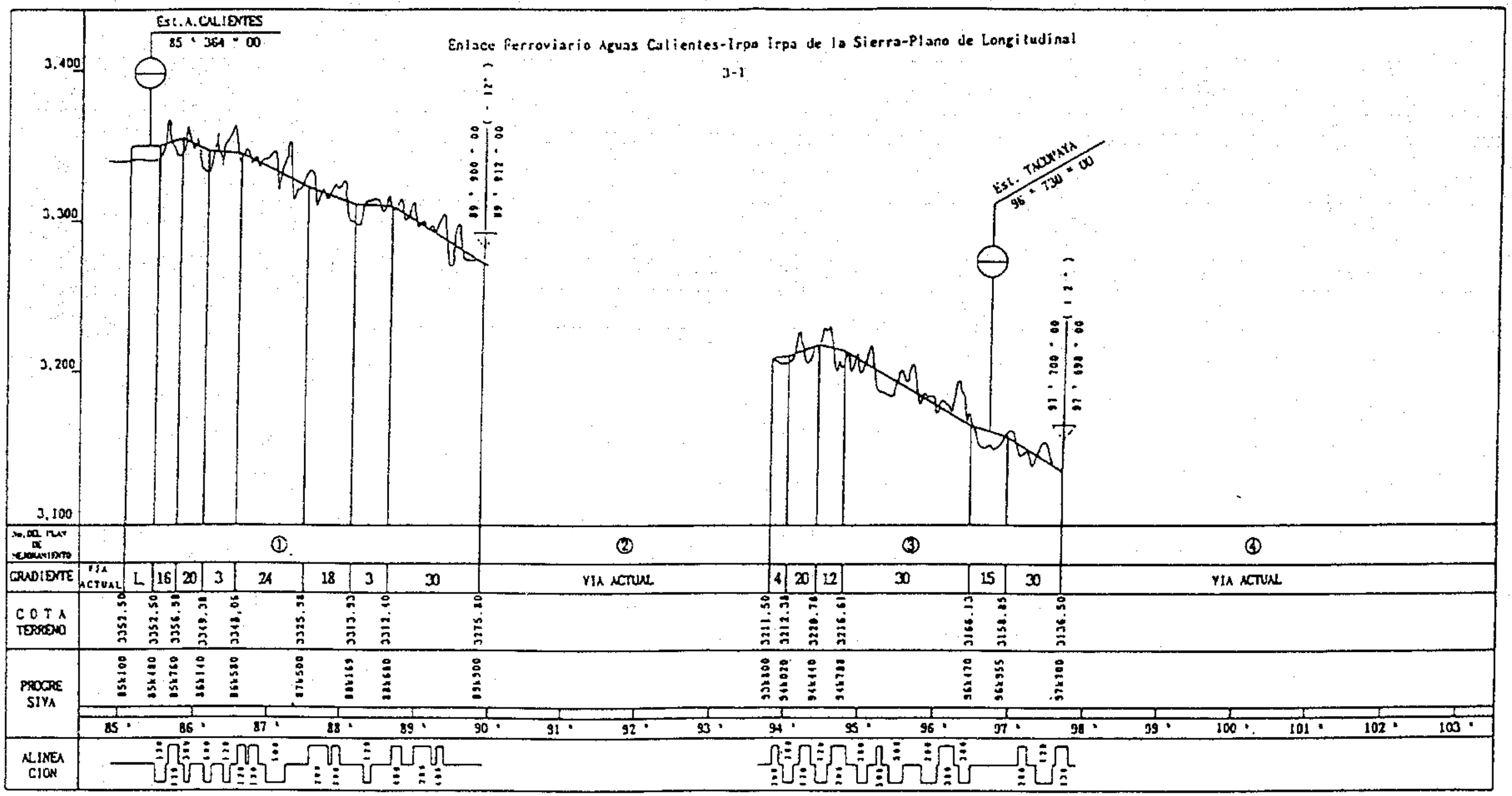


Figure 4-3 Profile of the Route Improvement Plan for the Oruro - Cochabamba Line (1)

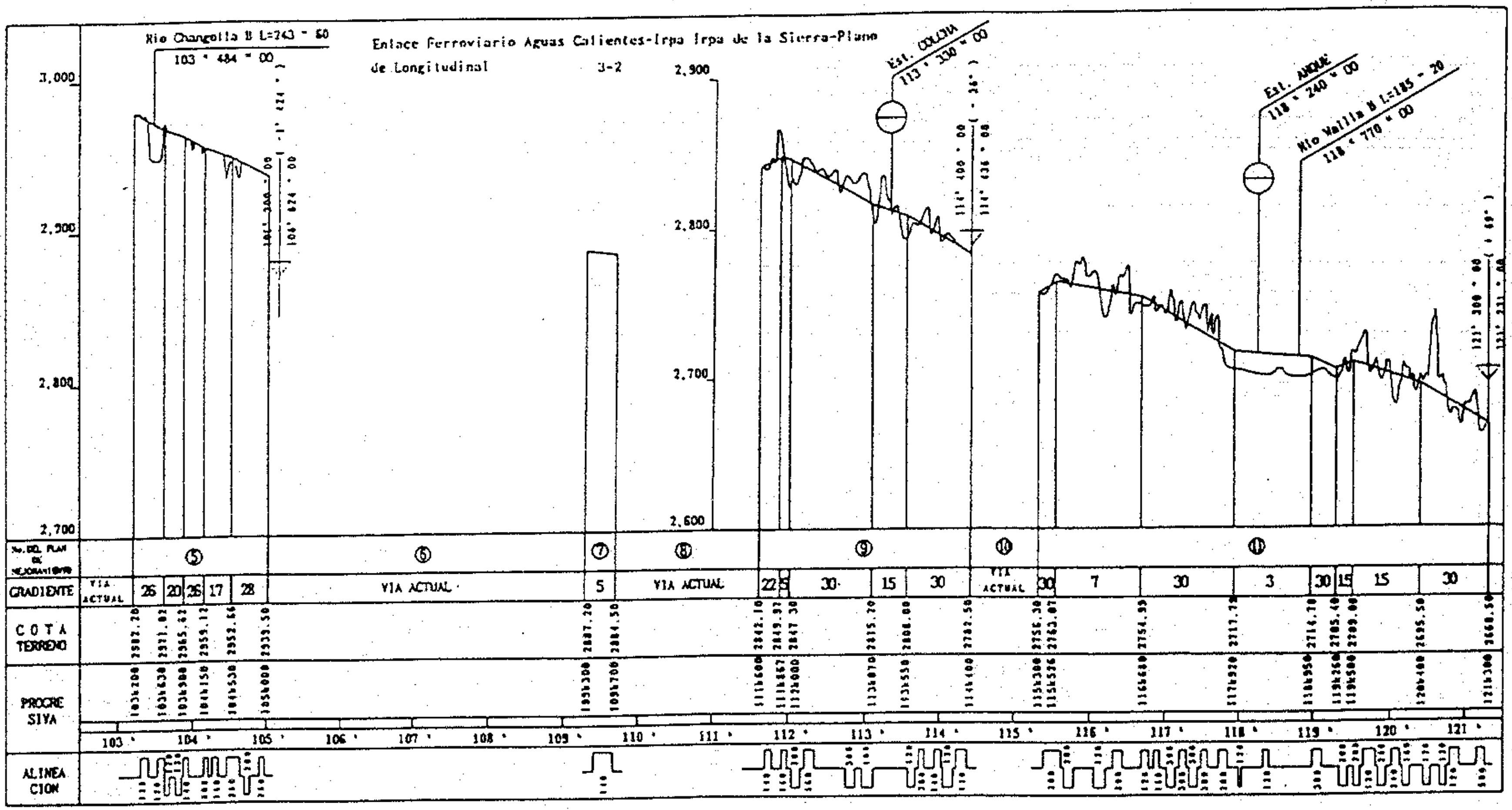


Figure 4-3 Profile of the Route Improvement Plan for the Oruro - Cochabamba Line (2)

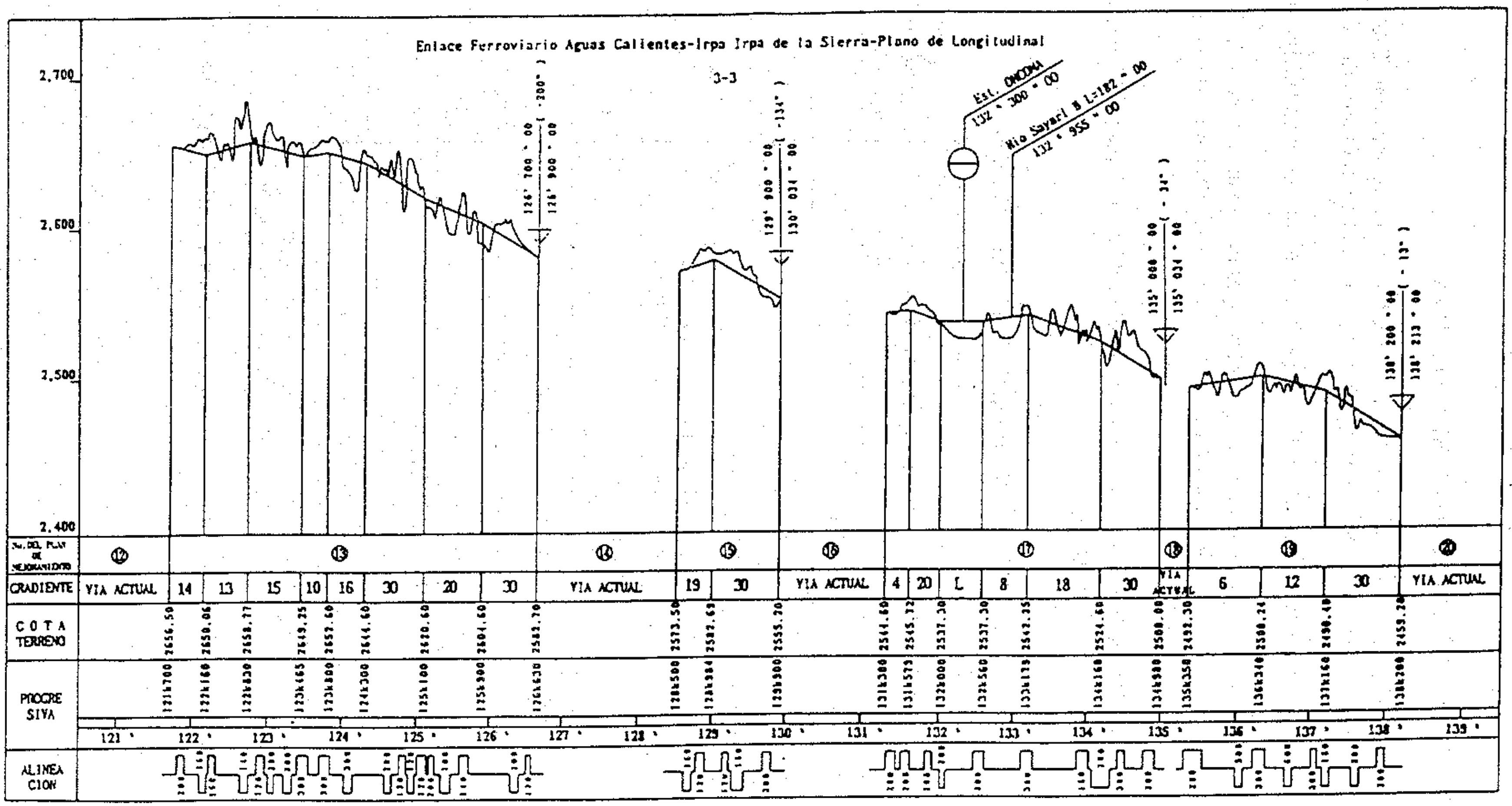


Figure 4-3 Profile of the Route Improvement Plan for the Oruro - Cochabamba Line (3)

4-4 RESULTS OF THE ROUTE SELECTION

The results of the route selection for the improved sections are shown in Table 4-1, which describes the condition of the railway and the length of structures.

To decrease construction costs the following two considerations were analyzed:

Case A. Re-utilization of existing steel bridges in Yapacaní Line, which is out of operations and services and whose resumption is not provided yet.

Case B. No re-utilization of existing steel bridges in Yapacani Line (new steel bridges).

TABLE 4-1 SUMMARY OF RAILWAY IMPROVEMENT

MAJOR ITEMS	RESULTS OF THE SELECTION	TOTAL LENGTH IN PERCENTAGE
Length of Railway to be Improved	32.85 km	
Maximum Gradient	30‰=12,548 m.	
Minimum Radius of Curvature	R=100m = 2 sites	
Gradient at Stations	Aguas Calientes (L), Tacopaya (15‰), Colcha (15‰), Arque (3‰), Orcoma (L)	
Total length of Cuts	Case A : 14,613m. Case B : 14,652m.	44.5%
Total length of Embankments	Case A and Case B : 15,252m.	46.4%
Total length of Box Tunnels	Case A and Case B : 1,380m. 9 sites	4.2%
Mountain Tunnels	Case A and Case B : 110m 1 site	0.3%
Total length of Bridges	Case A : 1,535m 76 sites. Case B : 1,496m 76 sites.	4.6%
Houses to be affected	Case A and Case B : 152 houses	
Land area affected and to be purchased	Case A and Case B : 33,250 sq.m (housing) Case A and Case B : 99,200 sq.m (farming land)	

Note: The longest bridge of the improvement sections is Changolla with L=243.60 m.

5. DEMAND FORECAST

5-1 METHODOLOGY OF FORECAST

(1) Flow chart

Figure 5-1 shows the demand forecast flow for passenger and freight transportation utilizing the four-step estimation method.

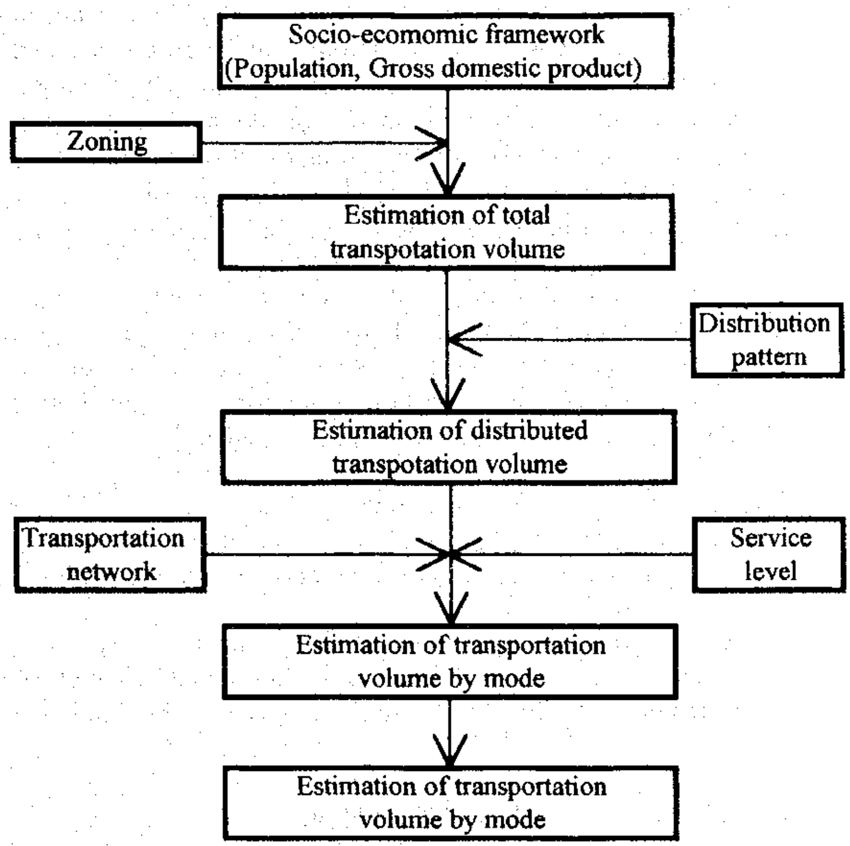


Figure 5-1 Flow of Transportation Demand Forecast

(2) Forecasting Year : 2000, 2010 and 2020

(3) Forecasting object and mode :
Passengers : railway, buses, airplanes
Cargo : railway, trucks
Note : Air cargo was excluded because of its negligible share.

(4) Forecasting of the total transportation volume
The number of passenger trips per year/person (trip number) across the border of each department is assumed to be constant. Then, the total number of passengers per year in the future is calculated from multiplying the trip number by the estimated population growth. The present number of railway, road and air trips is 1.30 trip/person/year.

Regarding freight forecasting, 12 basic commodities were taken into account to estimate the production/consumption in each department, and the volume differences between these are considered as transported volume across a department (production volume or concentrated volume); differences between production and consumption in total Bolivia correspond to export or import volume of those commodities. Freight volume for the future is assumed to be proportional to GDP growth for each projected year.

(5) Forecasting of the distributed transportation volume
The distributed transportation volume is calculated under the gravity model to which are applied trip production/concentration and distance in each zone, and then origin-destination (OD) tables are elaborated with the convergence calculation under the Frator method.

(6) Forecasting of the transportation volume by mode
The volume transported by each mode is calculated utilizing a logit model that incorporates the fares and tariffs and scheduled speeds for each mode.

(7) Forecasting of the transportation volume by railway line
The transportation volume for each line is obtained by the OD table in the above (6) being assigned to the minimum route of the railway network.

5-2 SOCIO-ECONOMIC FRAMEWORK

During the first half of the nineteen-eighties, the Bolivian economy underwent an acute economic crisis with extremely severe inflation. However, the situation changed rapidly with the New Economic Policy in 1985 and the economy has improved gradually towards growth. The actual GDP in recent years is shown in Table 5-1.

The socio-economic framework for the demand forecast was set as described in Table 5-2 by modifying the GDP growth rate in each sector in the "Strategy for

Economic and Social Development 1989 - 2000" with the actual results in Table 5-1. Table 5-2 contains also the estimated population prepared by INE based on the data of the National Census, June 1992.

TABLE 5-1 ANNUAL CHANGE IN GDP BY SECTOR(1987 - 1993)

(Unit : Bolivianos in 1980 price)

Sector \ Year		1987	1988	1989	1990	1991	1992	1993
Industry	Agriculture, Forestry and Fishing	25,337	25,951	25,604	25,097	26,911	25,683	27,164
	Petroleum and Gas	6,950	7,189	7,503	7,780	7,950	7,956	8,002
	Mining (Metallic and non metallic)	5,401	7,617	9,545	10,560	11,358	10,975	11,655
	Manufacturing	14,087	14,852	15,374	16,250	17,333	17,917	18,111
	Construction and Public Works	2,637	3,019	3,218	3,297	3,364	3,855	4,012
	Sub total	54,412	58,628	61,244	62,984	66,916	66,386	68,944
	(%)	48,73	51	51,86	51,92	52,96	51,5	51,66
Services		10,821	10,919	11,179	11,526	12,012	12,918	13,493
	(%)	9,69	9,5	9,47	9,5	9,51	10	10,11
Other Services (Commerce,Administration and others)		44,150	43,589	43,868	45,279	45,886	48,387	49,771
	(%)	39,54	37,92	37,14	37,32	36,32	37,5	37,3
Indirect Import tax		2,276	1,827	1,811	1,527	1,527	1,207	1,239
	(%)	2.04	1,59	1,53	1,26	1,21	0,94	0.93
Total		111,659	114,963	118,102	121,316	126,341	128,896	133,447
	(%)	100	100	100	100	100	100	100.00

Notes: 1987 - 1993 Provisional figures
1987: Currency denomination (10^6 Pesos = 1.0 Boliviano)

TABLE 5-2 PROJECTED VALUES FOR GDP AND POPULATION GROWTH

(Unit : %/year)

		1994		2000		2010		2020
	Agriculture and Stock Farming		3.4		1.9		1.9	
	Mining and Metal		11.1		6.2		6.2	
	Manufacturing		5.8		3.7		3.7	
	Petroleum		8.0		4.5		4.5	
	Electricity, Gas and Water supply		14.2		6.0		6.0	
	Transportation and Communications		5.4		3.5		3.5	
	Construction		5.8		4.6		4.6	
	Services		2.2		2.2		2.2	
	Gross Domestic Product (GDP)		4.6		3.0		3.0	
Population	Estimated value(1,000 pers.)	7,414*		8,329		10,229		12,193
	Rate of Increase		2.35		2.08		1.77	

* : Estimated value for 1995

5-3 ZONING AND FUTURE TRANSPORTATION NETWORK

(1) Zoning

Bolivia was divided into 18 zones (basically a zone for a department, with only the Santa Cruz department being divided into 10 zones because of its large area), and bordering countries were divided into 4 zones, for a total of 22 zones in all.

(2) Future Transportation Network

Table 5-2 shows the transportation network for the year 2020 for the railway and road network.

Regarding the airline network, direct flights between department capital cities are assumed to be operating in all target years.

RAILWAY ROAD

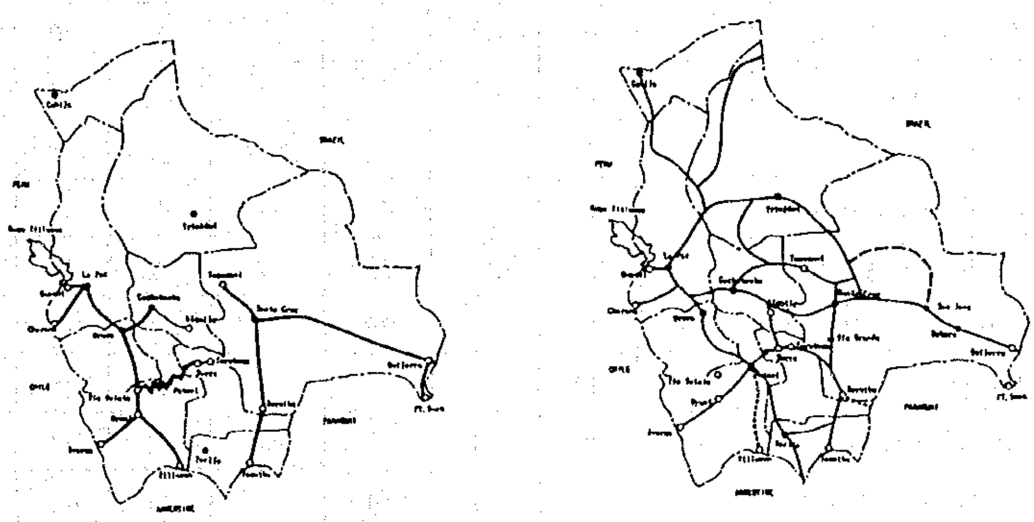


Figure 5-2 Transportation Network for the Year 2020

5-4 SERVICE LEVEL (travel time and fares)

(1) Travel time

1) Railway

SCHEDULED SPEED OF RAILWAY

(Unit: km/h)

Trains / Section \ Year	Passenger				Freight			
	Actual	2000	2010	2020	Actual	2000	2010	2020
La Paz - Oruro	60	62	62	62	33	51	51	51
Oruro - Rio Mulato	57	57	62	62	25	25	52	52
Rio Mulato - Uyuni	47	62	62	62	32	53	53	53
Uyuni - Tupiza	35	35	62	62	26	26	41	41
Tupiza - Villazón	35	35	62	62	29	29	40	40
La Paz - Guaqui	49	49	49	65	26	26	26	44
La Paz - Charaña	51	52	52	52	25	41	41	41
Oruro - Cochabamba	41	42	42	42	19	33	35	35
Cochabamba -Aiquile	21	21	21	21	22	22	22	22
Rio Mulato - Potosí	45	39	39	39	21	21	21	29
Potosí - Sucre	39	39	39	39	28	28	28	29
Uyuni - Avaroa	40	40	40	68	42	42	42	43
Santa Cruz - Quijarro	42	74	74	74	27	44	44	44
Santa Cruz - Yacuiba	43	43	74	74	29	29	38	38
Santa Cruz -Yapacani	-	-	-	-	22	22	22	22

2) Road

DATA ON TRAVEL TIME CALCULATIONS FOR ROAD TRANSPORTATION

	Average running speed (km/h)				Rest time	Time spent in: Cargo loading/unloading			
	Topography	Paved	Gravel	Soil		Sstation name	2000	2010	2020
Bus	Highlands	80	50	40	15 min/1h travel time	Santa Cruz	8	8	8
	Mountains	45	35	25		Cochabamba	8	8	8
	Plains	80	60	40					
Truck	Highlands	60	45	30	10 min/1h travel time, add 1h per trip /4h travel time add 1h per trip /8h travel time add 8h per trip/12h travel time	Tupiza	36	36	8
	Mountains	40	30	20					
	Plains	60	45	30		Villa Monte	36	36	8

3) Air

Air Travel time

Flight time (hr)	Access time (hr)	Waiting time (hr)
0.00108 x L + 0.293 L= distance (km)	1.0	1.5

(2) Fares and Tariffs

1) Railway
   Fare for 1 passenger (US$)=0.00950 x L (km) +0.0058
   Tariff for 1 ton of cargo (US$) = [0.0491 x L (km) + 4.62] x 0.9
2) Road
   Fare for 1 bus passenger by bus (US$) =0.0245 x L (km) - 1.95
   Tariff for 1 ton of cargo by truck (US$) =0.0491 x L (km) + 4.62
3) Airline
   Fare for 1 passenger (US$) = 0.0922 x L (km) + 9.241

5-5 RESULTS OF DEMAND FORECAST

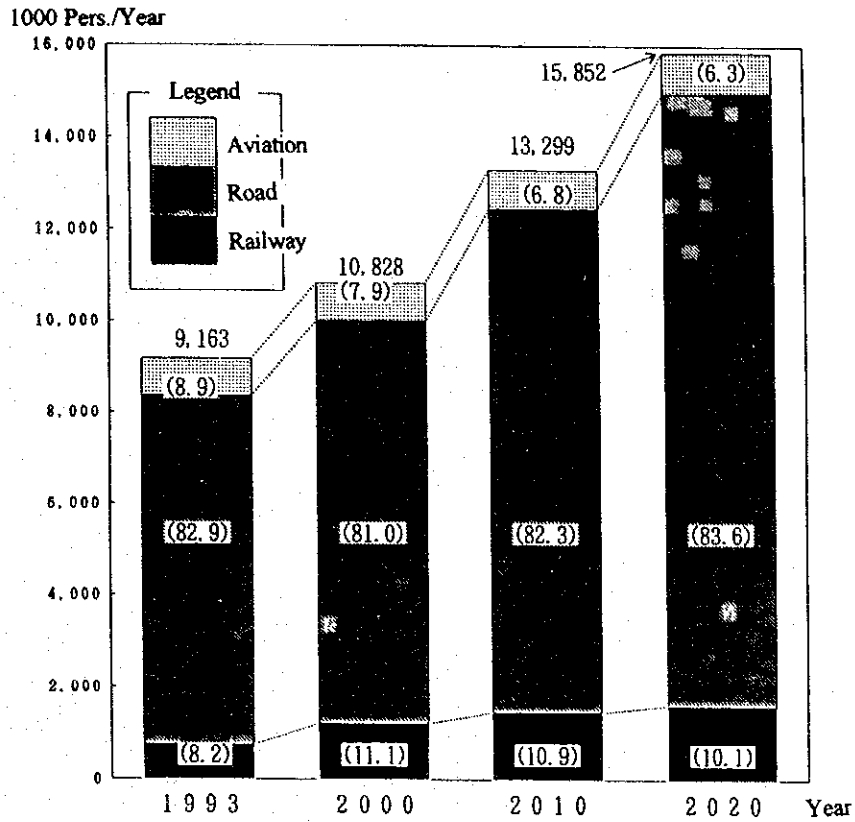
Figure 5-3 and 5-4 show the estimated transportation volume and the shares for each mode. The railway passenger share will increase slightly to 10~11% from the current figure of 8.2%. The share of railway cargo will remain between 40 ~ 50%, of which 90% is exports/imports. Link transportation volume of passengers and cargo is shown in Figure 5-5 and 5-6, respectively.

Railway transportation volume between Oruro and Cochabamba is shown in Table 5-3. By 2020, passenger transportation will have increased to four times and freight transportation to six times the present level. If improvements are not executed, decrease to 80% is forecasted.

TABLE 5-3 SECTIONAL RAILWAY TRANSPORTATION VOLUME BETWEEN ORURO AND COCHABAMBA

		Year 1993 Record	Improvements executed (WITH)			Improvements not executed (WITHOUT)		
			2000	2010	2020	2000	2010	2020
Passenger transportation (pass/year)	Oruro - Cochabamba	21,530	56,268	77,800	92,789	49,628	65,897	77,200
	Cochabamba - Oruro	21,135	57,601	78,406	92,563	51,610	67,116	71,551
	Total	42,665	113,869	156,206	185,352	101,238 (88.9)	133,013 (85.2)	148,751 (80.3)
Freight transportation (1,000tons/year)	Oruro - Cochabamba	75.5	178.3	269.4	399.3	157.2	228.2	332.1
	Cochabamba - Oruro	124.5	563.9	779.7	989.8	505.5	638.4	807.4
	Total	200.0	742.2	1049.1	1,389.1	606.7 (89.3)	866.6 (82.6)	1,139.5 (82.0)

( ): Ratio (in %) to the improvements executed



Note : As the difference of the "with" and "without" cases is small, only the"with" case is shown.

Figure 5-3 Result of Passenger Transportation Volume by Year

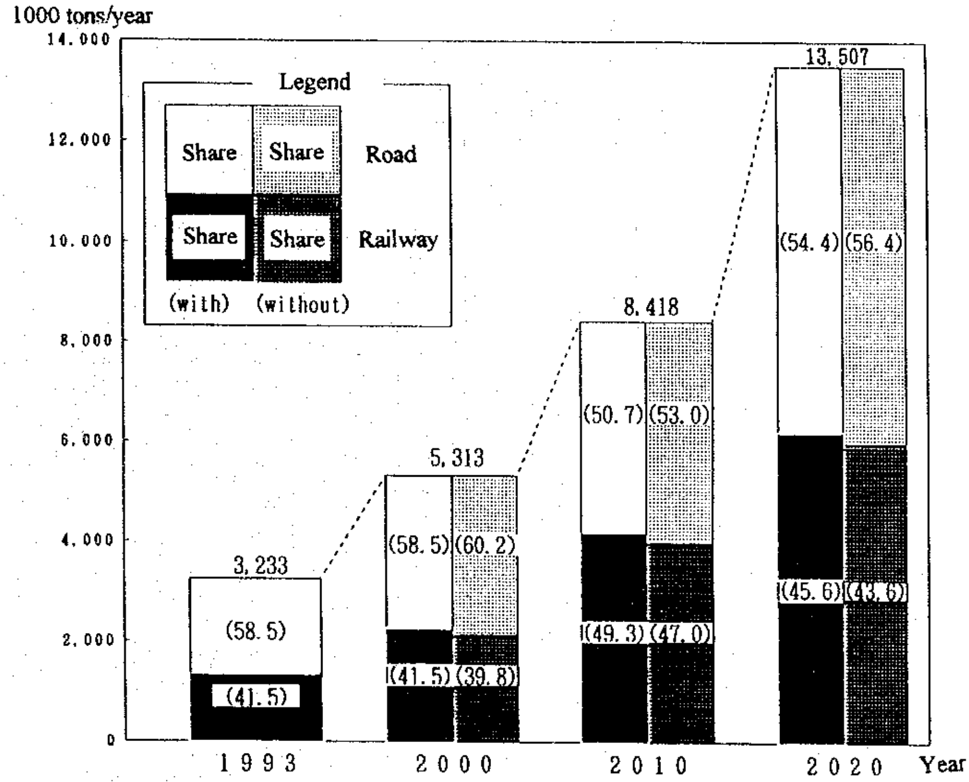


Figure 5-4 Result of Freight Transportation Volume by Year

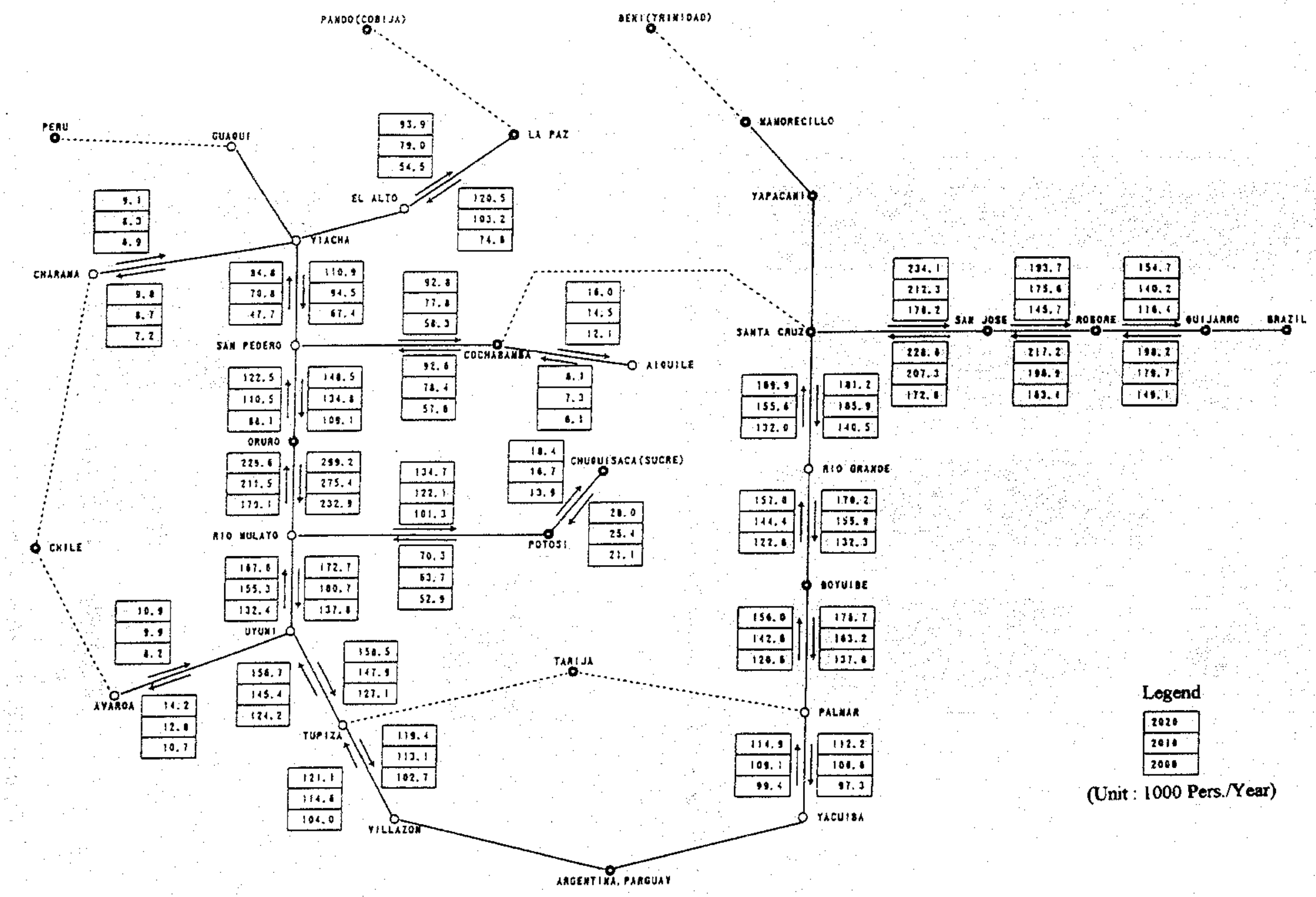


Figure 5-5 Link Volume of Railway Passenger Transportation (with)

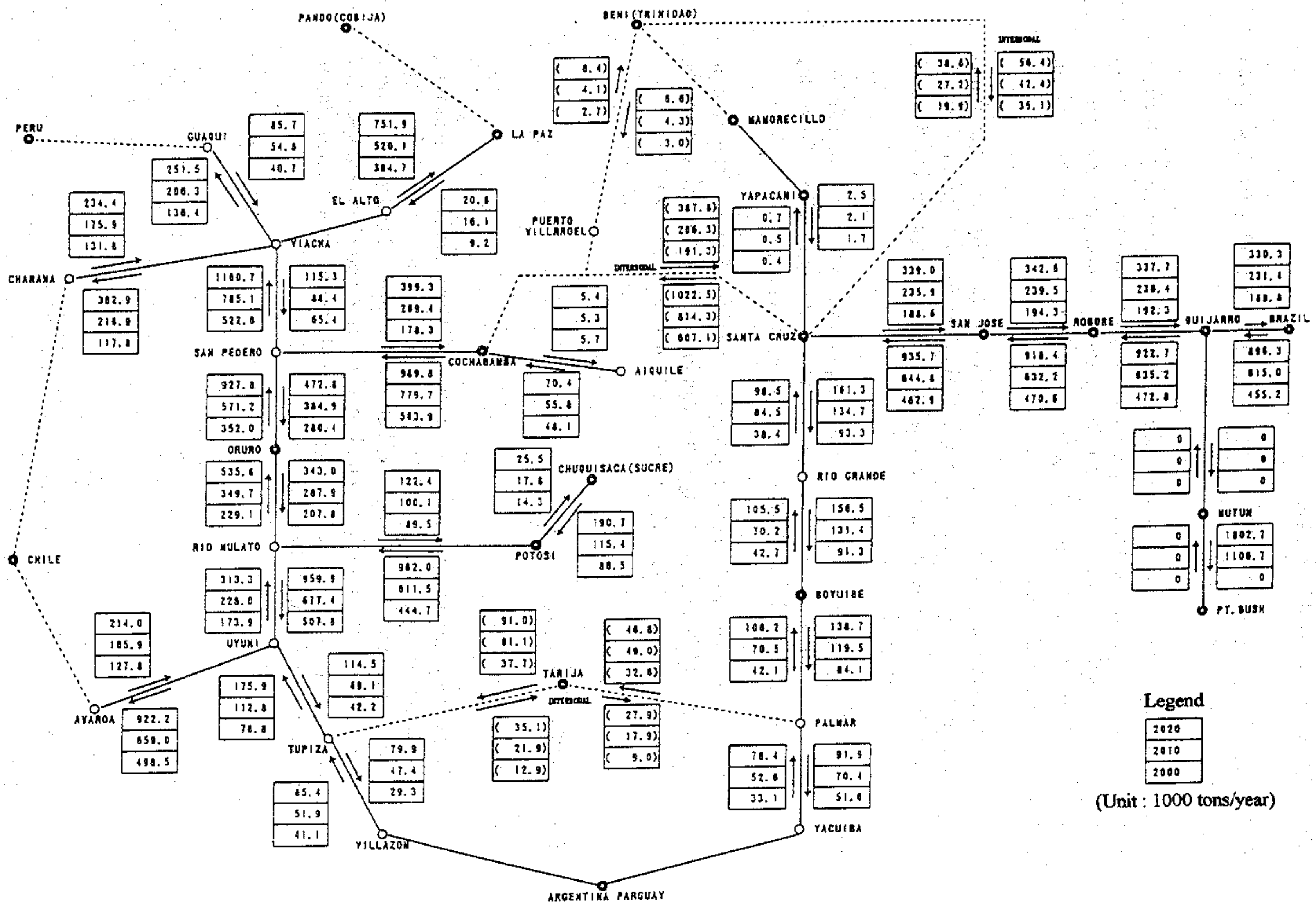


Figure 5-6 Link Volume of Railway Freight Transportation (with)

6. TRANSPORTATION PLAN

6-1 CONCEPT FOR PREPARING TRANSPORTATION PLAN AND BASIC CONDITIONS

In transportation, what is most important is safety. If there are no accidents, service is steady, the trains are not delayed, and ENFE can offer reliable service to passengers and freight forwarders. To carry out a transportation plan, the efficient utilization of both personnel and rolling stock is a major consideration to attain sound operation and service.

(1) On the Oruro-San Pedro section, the maximum speed for passenger trains should be 95km/hr and for freight 75km/hr. As for the San Pedro-Cochabamba section, the maximum speed for passengers should be 80km/hr and for freight 65km/hr.

(2) To maintain safe operation, the existing train ticket system will remain. As for the existing permissive block system on the San Pedro - Tolapalca section, it should be modified to an absolute block system.

(3) A new side track will be constructed at Cona Cona Station. The existing side track at Changolla and Higuerani stations will be taken away. Thus the minimum track capacity of this route will increase from 9 to 23.

6-2 TRANSPORTATION PLAN

(1) Passenger trains

To promote the demand and convenience of passengers, an express train and local ordinary train (both DC) will make one round trip per day. The express train will serve the demand between La Paz-Cochabamba via Oruro, while the local train will operate between Oruro and Cochabamba. The number of cars per train will be increased according to transportation demand (see Table 6-1).

TABLE 6-1 PASSENGER TRAIN OPERATION PLAN

Type of train	Transportation capacity (1 direction)								
	Year 2000			Year 2010			Year 2020		
	N°. of cars per train	N°.of seats	Trans-portation cap/ year	N°.of cars per train	N°.of seats	Trans-portation cap/ year	N°.of cars per train	N°.of seats	Trans-portation cap/year
Express	3	164	42,000	4	228	58,000	4	228	58,000
Local	2	120	31,000	2	120	31,000	3	184	47,000
Total	5	284	73,000	6	348	89,000	7	412	105,000
Demand forecast	Downbound Train 56,268 Passenger			Downbound Train 77,800 Passenger			Downbound Train 92,789 Passenger		
	Upbound Train 57,601 Passenger			Upbound Train 78,406 Passenger			Upbound Train 92,563 Passenger		

(2) Freight trains

The freight train operates between Oruro and Cochabamba, and the locomotive is a 1000 DEL. Hauling capacity for an upbound train is 600 tons, with only the Buen Retiro-La Cumbre section using a double locomotive to haul a train, while for a downbound train hauling capacity will be 800 tons. Table 6-2 shows the plan for freight trains.

TABLE 6-2 FREIGHT TRAIN OPERATION PLAN

Upbound and Downbound train	Transportation capacity per train			Tons that can be transported yearly					
				Year 2000		Year 2010		Year 2020	
	Hauling Capacity	Average number of cars to be hauled	Tons transported per train	N° of trains	Annual transp/ cap.	N° of trains	Annual transp/ cap.	N° of trains	Annual transp/ cap.
Upbound	600 t.	13.3	360 t.	5	657× 1,000 tons.	6	788× 1,000 tons.	8	1,051× 1,000 tons.
Downbound	800 t.	18	420 t.	5	767× 1,000 tons.	6	921× 1,000 tons.	8	1,228× 1,000 tons.
Demand forecast	Cochabamba - Oruro			563,878 tons.		779,737 tons		989,780 tons	
	Oruro - Cochabamba			178,274 tons.		269,408 tons		399,342 tons.	

Figure 6-1 shows an example of a train diagram for the year 2020.

Figure 6-1 Train Diagram for the year 2020 (Plan)

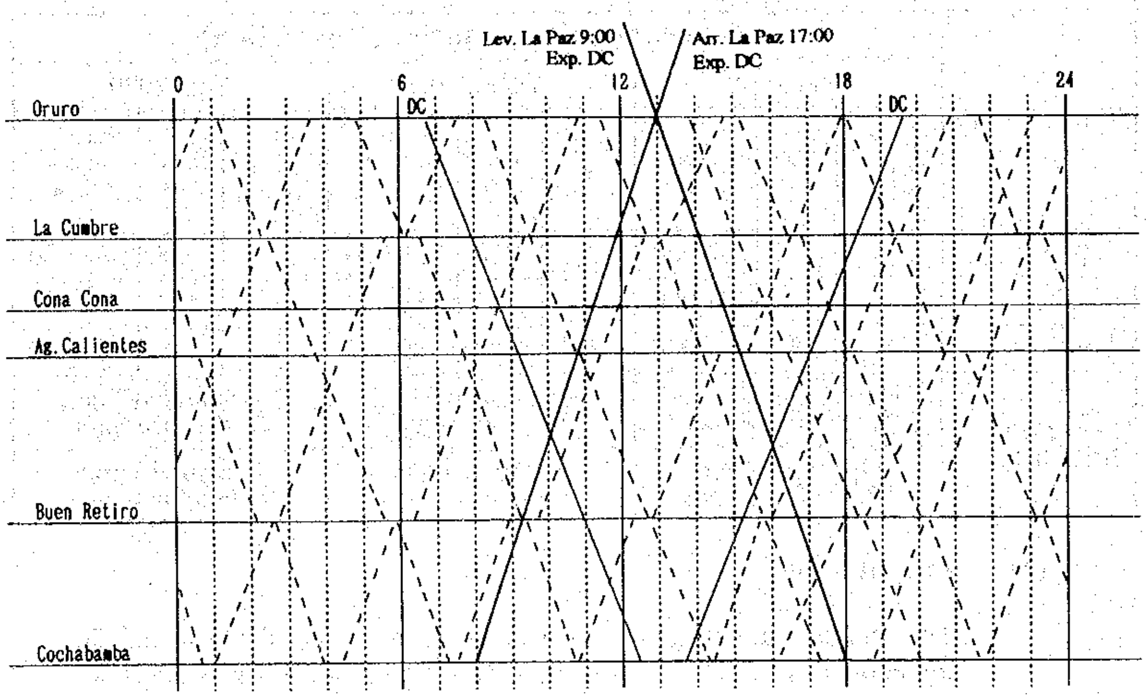


Table 6-3 shows the train schedules and scheduled speeds. Freight trains for the year 2000 are forced to adopt speed restrictions, but for the year 2005, when all improvement work will be completed, all speed restrictions will be eliminated.

TABLE 6-3 OPERATION TIMES AND SCHEDULED SPEEDS, (ORURO-COCHABAMBA LINE)

Train type		Upbound Downbound	Operation times Hr:min	Stop time Min.	Travelling time Hr:min.	Scheduled speed km/h
Passenger train	Express	Downbound	4 : 53	7	5 : 00	42,2
		Upbound	4 : 52	6	4 : 58	42,4
	Local	Downbound	4 : 57	26	5 : 23	39,2
		Upbound	5 : 07	50	5 : 57	35,4
Freight train	Year work completed	Downbound	5 : 14	38	5 : 52	35,9
		Upbound	5 : 30	42	6 : 12	34
	Speed restrictions	Downbound	5 : 33	46	6 : 19	33,4
		Upbound	5 : 47	52	6 : 39	31,7

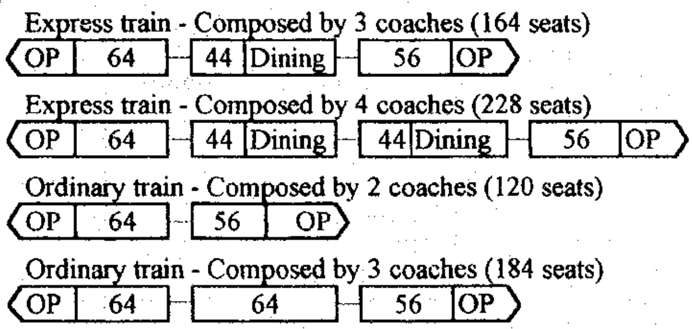
Note : Stopping stations: Express train 3 stations; ordinary train 21 stations.
Freight train will stop at La Cumbre and Buen Retiro, etc.

6-3 PLAN FOR ROLLING STOCK

(1) Rolling Stock

1) Diesel Car

All the coaches will have traction power and there will be a driver's cabin at each end of a train. Figure 6-2 summaries train composition.



References:
OP = Driver's cabin
Numbers indicate number of seats

Figure 6-2 Train composition of diesel cars

2) Locomotive

Diesel electric locomotives (DEL) type 1000 will be used. When operations are performed with a double locomotive, multiple unit control will be employed.

3) Wagon

Wagons will be the same as those used in the Andean Network.

(2) Number of Rolling Stock Needed and Plan to Increase Their Number.

Table 6-4 indicates the number of rolling stock needed for the Oruro-Cochabamba Line, the increases in rolling stock in the future, and the investment costs.

All the rolling stock are expected to be used throughout the Andean network. However, the need for new rolling stock may diminish with efficient use and appropriate inspections, repairs and maintenance.

It is recommended that ENFE consider replacing worn out rolling stock and that it emphasize improvements in efficiency during inspection and repair activities. It is desirable that a plan for rolling stock be drawn up as soon as possible.

TABLE 6-4 ROLLING STOCK REQUIRED AND AMOUNT OF INVESTMENT FOR THE ORURO-COCHABAMBA LINE

Year	No. of Rolling Stock			Increase of Rolling Stock			Investment amount (x mil US$)
	Locomotive	Diesel car	Wagon	Locomotive	Diesel car	Wagon	
1992	3	5	284 (254)				
2000	9	6	650 (552)	6	1	298	27,120
2005	10	6	901 (766)	1		214	10,960
2008	10	7	901 (766)		1		800
2011	11	7	975 (871)	1		105	6,600
2017	13	7	1,148 (976)	2		105	9,000
2018	13	8	1,148 (976)		1		800
Partial increase of wagons				10	3	722	
Unit price (US$ mil)				2,400	800	40	
Investment amount (US$ mil)				24,000	2,400	28,880	55,280

Note : In the column Wagons under ( ) do not include number of private wagons.

7. PLAN FOR FIXED FACILITIES

7-1 STANDARDS

Standards used in the "Fixed Facilities Plan" are as follows:

Construction gauge	As shown in Figure 7-1
Rolling stock gauge	As shown in Figure 7-1
Width of formation	5.20 m (Figure 7-2)
Train live load	Cooper E-40 (Figure 7-3)

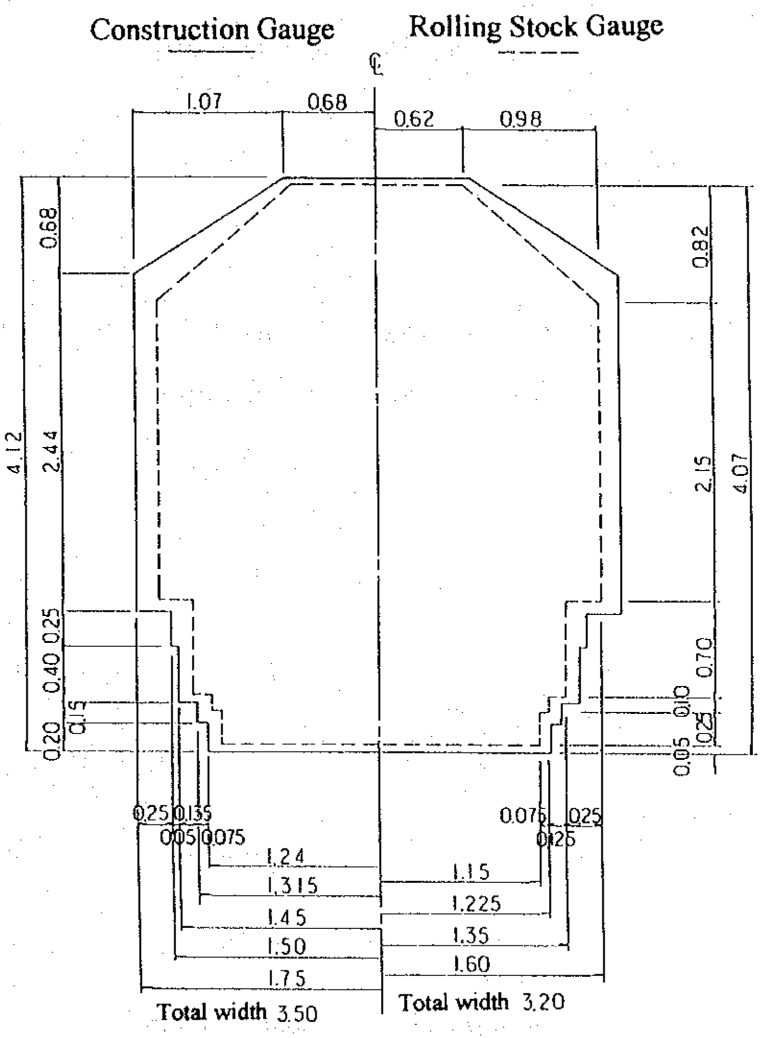
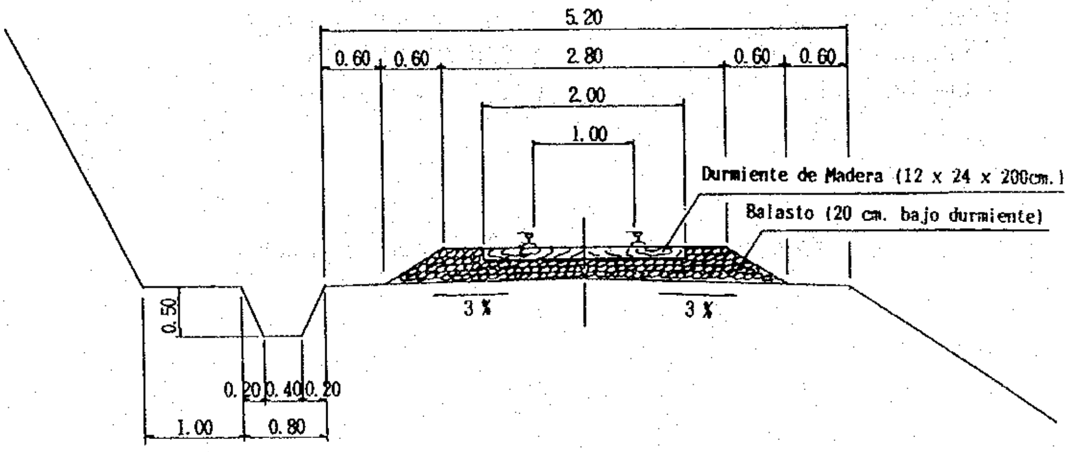


Figure 7-1 Construction Gauge and Rolling Stock Gauge



Note: In order to maintain the gauge tie plates will be fixed with curve radius of R≦200m.

Figure 7-2 Road Bed Structures

(COOPER E-40)

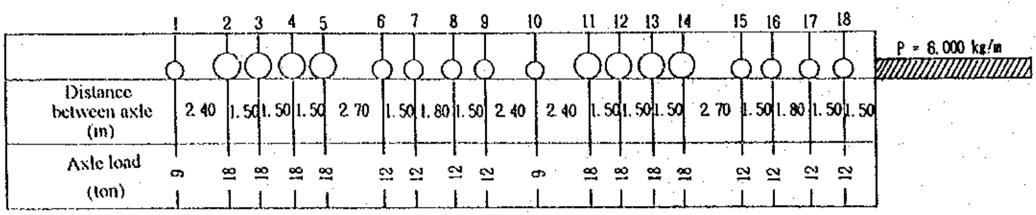


Figure 7-3 Live Load of Trains

7-2 STRUCTURES

The results obtained from surveys and discussions held with the Bolivian counterparts will be reflected in the Structure Plan. Safety, economy, work execution, administration and maintenance will be considered thoroughly. Basically, the plan adopts soil structures (cuts and embankments), which ENFE has sufficient experience. At crossings with rivers and river gorges, bridges or box tunnels will be used depending on the distance from the track to the ground.

Also, on those sites where embankments or cuts would be of a large scale, a mountain tunnel will be planned after performing a study on the geological condition.

(1) Cuts and Embankments

1) Cut sections

The gradient of a slope face is decided by the soil : 1 : 0.2 for shale and 1 : 0.5 for talus.

2) Embankment sections

The gradient of an embankment varies mainly with the materials. The materials of embankment sections will consist of soil and sand from cuts and river beds, with the inclination being 1:1.5 up to a height of 9m. In the case of the height being 9m or more, the inclination is eased in accordance with the height. In addition, to prevent landslides, 1.50m berms will be considered.

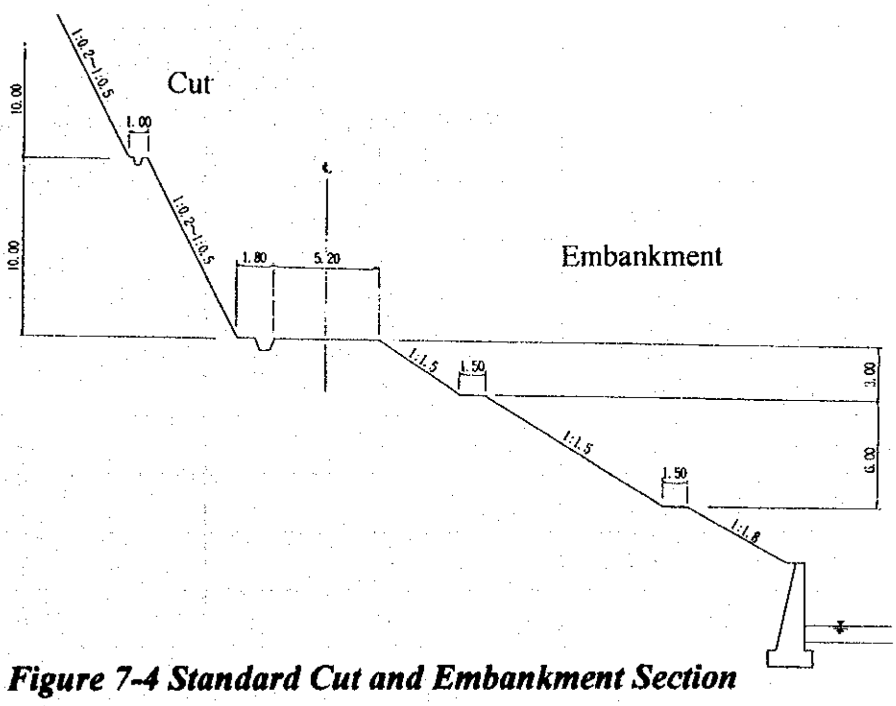


Figure 7-4 Standard Cut and Embankment Section

(2) Bridges

The super structures of existing steel bridges will be used to reduce construction costs. Existing steel bridges will be used from the Cochabamba Line after relocating the route, together with steel bridges from the Yapacani Line and steel super structures stored at warehouses in Oruro. As for the existing steel bridges of the Yapacani Line, two cases are examined : re-utilization or no re-utilization.

1) Re-utilization of existing steel bridges

Table 7-1 shows the proportions of existing and new steel bridges needed for the above-mentioned two cases.

TABLE 7-1 PROPORTION OF REUSE AND NEW STEEL BRIDGES TO THE TOTAL NEEDED.

	Number of Steel Bridges			Proportion of Re-utilization (%)
	Reuse	New	Total	
Re-utilization from Yapacani Line	73	7	80	91
No reutilization from Yapacani Line	52	28	80	65

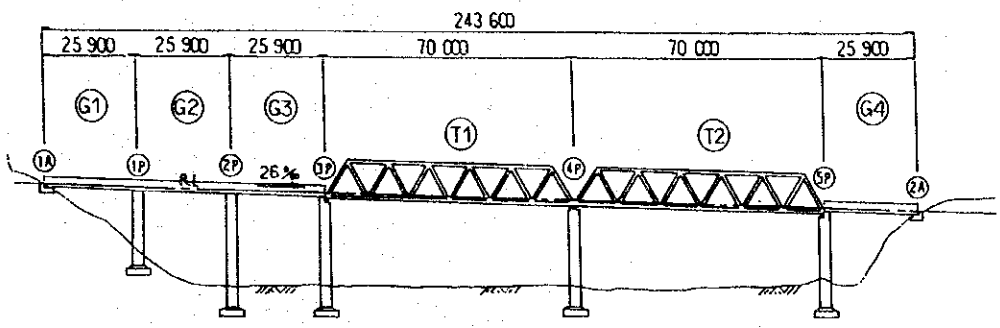
2) Classification of bridges by the length.

Classification of bridges by length is shown in Table 7-2

TABLE 7-2 CLASSIFICATION OF BRIDGES

Length	Number of bridges	
	Re-utilization from Yapacani Line	No re-utilization from Yapacani Line
L ≦ 10 m	43	52
10m < L ≦20m	12	10
20m < L ≦30m	15	8
30m < L ≦50m	1	1
50m < L ≦100m	2	2
100m < L ≦200m	2	1
200m < L ≦250m	1	2
Total	76	76

The longest bridge is for the Changolla River as shown in Figure 7-5. Improvement Plan ⑤ includes 8 bridges to be put up by ENFE.



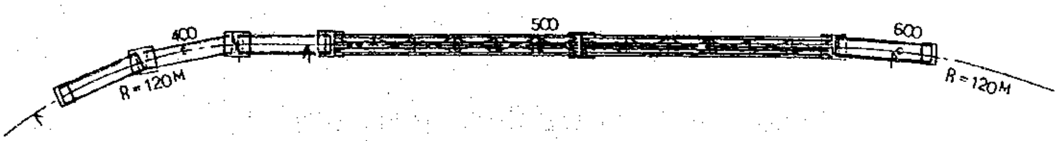


Figure 7-5 Bridge Scheme for the Changolla River

(3) Tunnels

Box and mountain tunnels are decided according to land conditions and the height of earth covering. The classification of tunnels by length is shown in Table 7-3.

TABLE 7-3 TUNNEL CLASSIFICATION BY LENGTH

Tunnel length	Number of tunnels	
	Box	Mountain
L ≦ 50m	2	-
50m < L ≦ 100m	2	-
100m < L ≦ 150m	2	1
150m < L ≦ 200m	1	-
200m < L ≦ 300m	1	-
300m < L ≦ 400m	1	-
Total	9	1

Figures 7-6 and 7-7 show the standard sections for the two tunnel types. For a typical tunnel section, a lateral pedestrian passage of 0.70 m width is planned on one side.

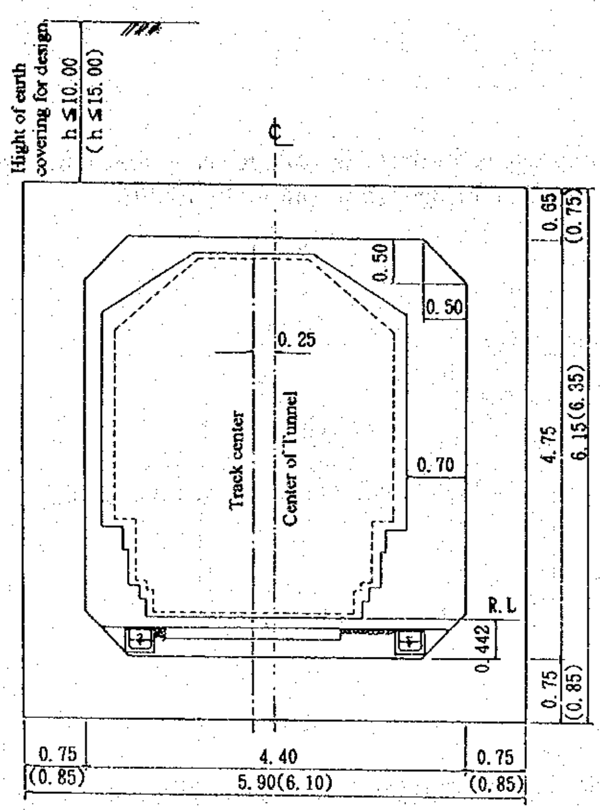


Figure 7-6 Standard Box Tunnel Section

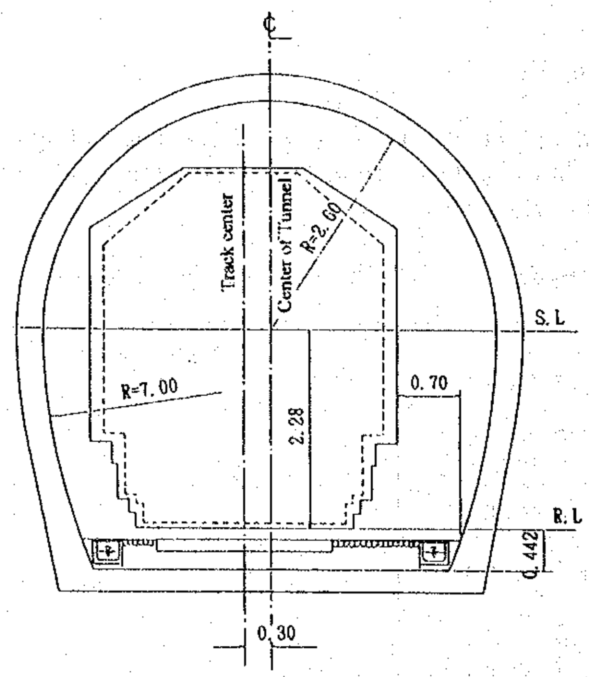


Figure 7-7 Standard Mountain Tunnel Section

7-3 TRACK

The Oruro-Cochabamba Line originates at San Pedro Station, or one station away from Oruro Station, and passes through Aguas Calientes Station (85km364m). From Aguas Calientes Station up through Irpa Irpa (140km928m), this area is prone to disasters. The line then continues to Cochabamba Station (204km850m) and ends at Aiquile Station (419km649m).

(1) Track condition

Except for the section where disasters are frequent, the maintenance status of the track meets the minimum requirements for existing train operation, but the road bed needs to be improved using ballast to attain safe train operation.

Besides sections experiencing disasters frequently, some other sites along the rivers reveal road bed deterioration due to flooding and an elevation in the river beds. Also, there are sections where protective work is in danger of collapsing due to the effect of water flows.
Figure 7-8 shows railway sites where accidents, due to deficient facilities, occurred on the Oruro-Cochabamba Line during 1990-1993. It should be noted that most of the accidents occurred on the new route section, especially on those sections located between the 66km ~ 80km and 145km ~ 153km markers. These sections are mountainous and the track layout is in very poor condition.

(2) Track maintenance

For the Oruro-Cochabamba Line, the Oruro District Office is in charge of maintaining the track up until the 85km marker, and the Parotani District performs maintenance work up to Tin Tin. In order to cover disaster-prone sections, these offices have relatively many maintenance staff as a total of the Western Division. However, the number of staff per track length is a very small 0.22 ~ 0.25 person / km.

On the other hand, it should be mentioned that actual track maintenance practices are limited to elementary care and most of the maintenance equipment is old. There are very few measurement tools, and maintenance staff do not know how to use them properly.

To solve these problems, the modernization of track maintenance training is urgently needed. It is recommended that a railway specialist in track maintenance be invited from a foreign country.

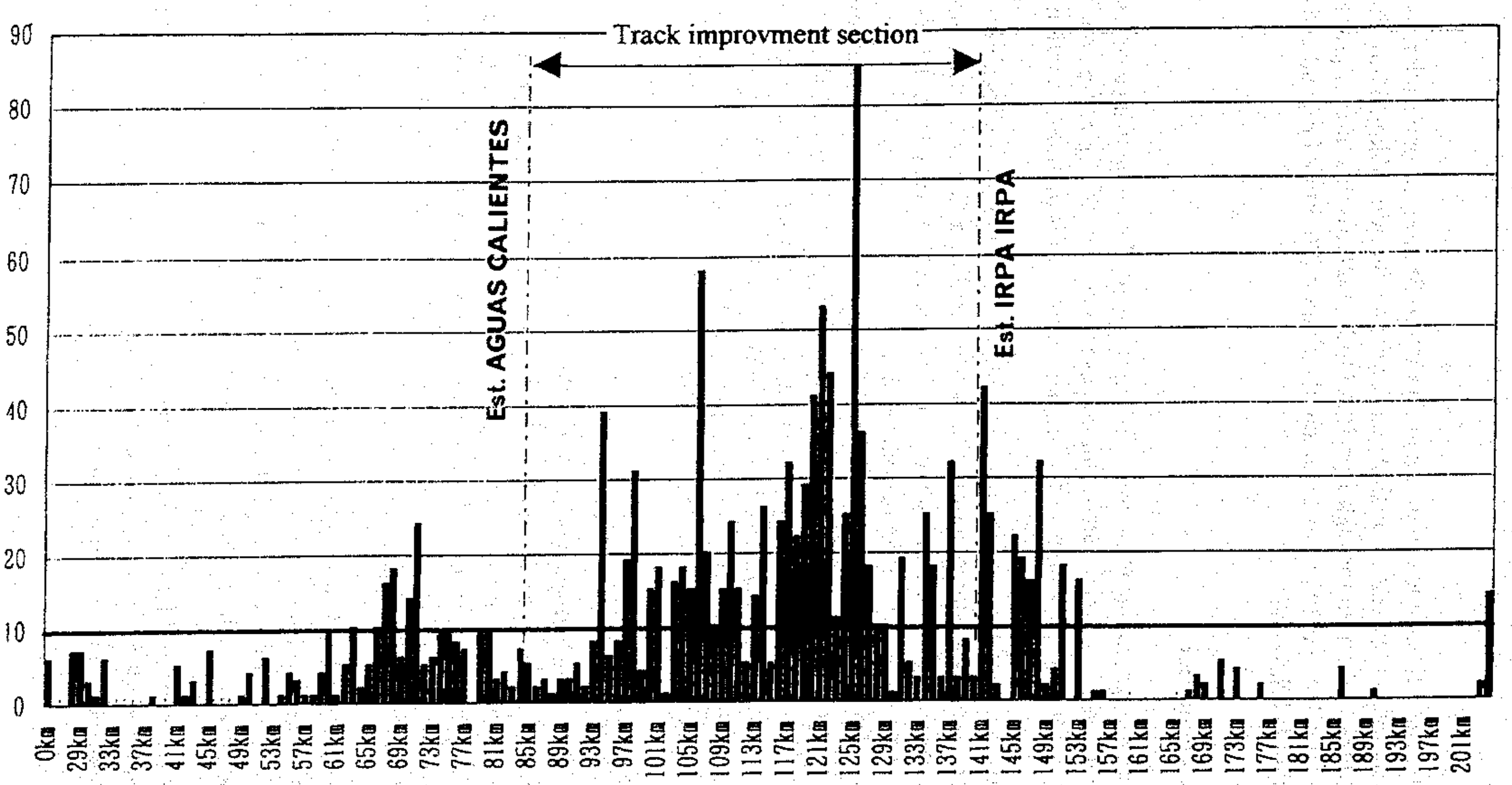


Figure 7-8 Total Number of Accidents and Track Failures during 1990-1993

(3) Track Improvement Plan

Table 7-4 describes the track structure standard for the sections where modifications are to be introduced, i.e. between Aguas Calientes and Irpa Irpa with a length of approximately 55km and on 14km of other sections where accidents and derailment are frequent. Table 7-5 shows those sections where many accidents occurred.

TABLE 7-4 TRACK STRUCTURE STANDARDS

Item	Content
Type of rail	Heavier than 75 lb / yard
Switch	Bigger to No.8 (normal switch)
Type & Quantity of sleepers	Wooden sleeper Normal section 1,500 pce/km Curve section 1,567 pce/km (R≦600m)
Kinds of Ballast and Thickness	Gravel thickness of 200mm or more

TABLE 7-5 SECTIONS REGISTERING MANY ACCIDENTS

Section	Track length (km)	Accident (times)
63 ~ 64 km	1	10
66 ~ 69 km	3	46
70 ~ 72 km	2	38
Improvement section	(55)	(974)
141 ~ 143 km	2	67
145 ~ 149 km	4	103
151 ~ 152 km	1	18
153 ~ 154 km	1	23
Total	14 km	305 times

(4) Plan for Improving Track and Maintenance Equipment

The existing track has a soil bed and the appropriate machinery and maintenance equipment for ballast has not been allocated. According to proposed improvements, machinery and equipment will be introduced to the group in charge of the Cochabamba Line maintenance, as described in Table 7-6. However, these proposed improvements will not produce a definite solution for the unforeseen disasters that occur yearly during the rainy season. Landslides and fallen or loose rocks on the tracks, under bridges, or on box tunnels, etc., make it necessary to have appropriate heavy machinery to move all kinds of large materials.

TABLE 7-6 PLAN FOR THE PROVISION OF MACHINERY AND EQUIPMENT FOR MAINTENANCE.

Machinery and Equipment	Type	Oruro district	Parotani district	Remarks
Screw spike	Hydraulic	2 units	4 units	with electric engine
Track chisel	Electric	1 units	2 units	with generator
Drill		1 units	2 units	with generator
Welder	TERMIT	1 set	2 sets	
Power tamper	4 sets.	2 sets	4 sets	with generator
Bulldozer	CAT - D7G		5 units	
Neumatic tractor	CAT - 814		2 units	
Excavator	CAT - 966		2 units	

7-4 STATIONS

(1) Improvement Plan for Stations

Facilities on the Aguas Calientes-Irpa Irpa section have not been modified nor improved since the opening of the section, even though the motive power was changed. It is suggested to eliminate all facilities which are not actually needed.

A minimum effective length of 300m of track is needed for station yards, especially in those yards frequently used. Since the route for the Aguas Calientes-Irpa Irpa section will be modified, some stations will be closed and moved to new locations. At the Changolla and Higuerani stations, side track will be closed.

Figure 7-9 shows the improvements for stations located between Aguas Calientes and Irpa Irpa.

(2) Improvement of Cona Cona Station

The track capacity of the La Cumbre-Aguas Calientes section is not appropriate and should be improved so as to ensure larger track capacity for transportation between the San Pedro-Cochabamba section. Figure 7-10 illustrates an improvement plan for this station.

(3) Intermodal Installation

Considering the existing situation that there is no connection between the Western Network (Andean) and the Eastern Network to carry freight throughout Bolivia, specific facilities for freight transfer are being constructed at the Cochabamba and Santa Cruz (Guarachi) stations. In Cochabamba, as the locomotive depot was demolished, a study was done to change it into an area for freight handling facilities. Table 7-11 shows the improvement plan.

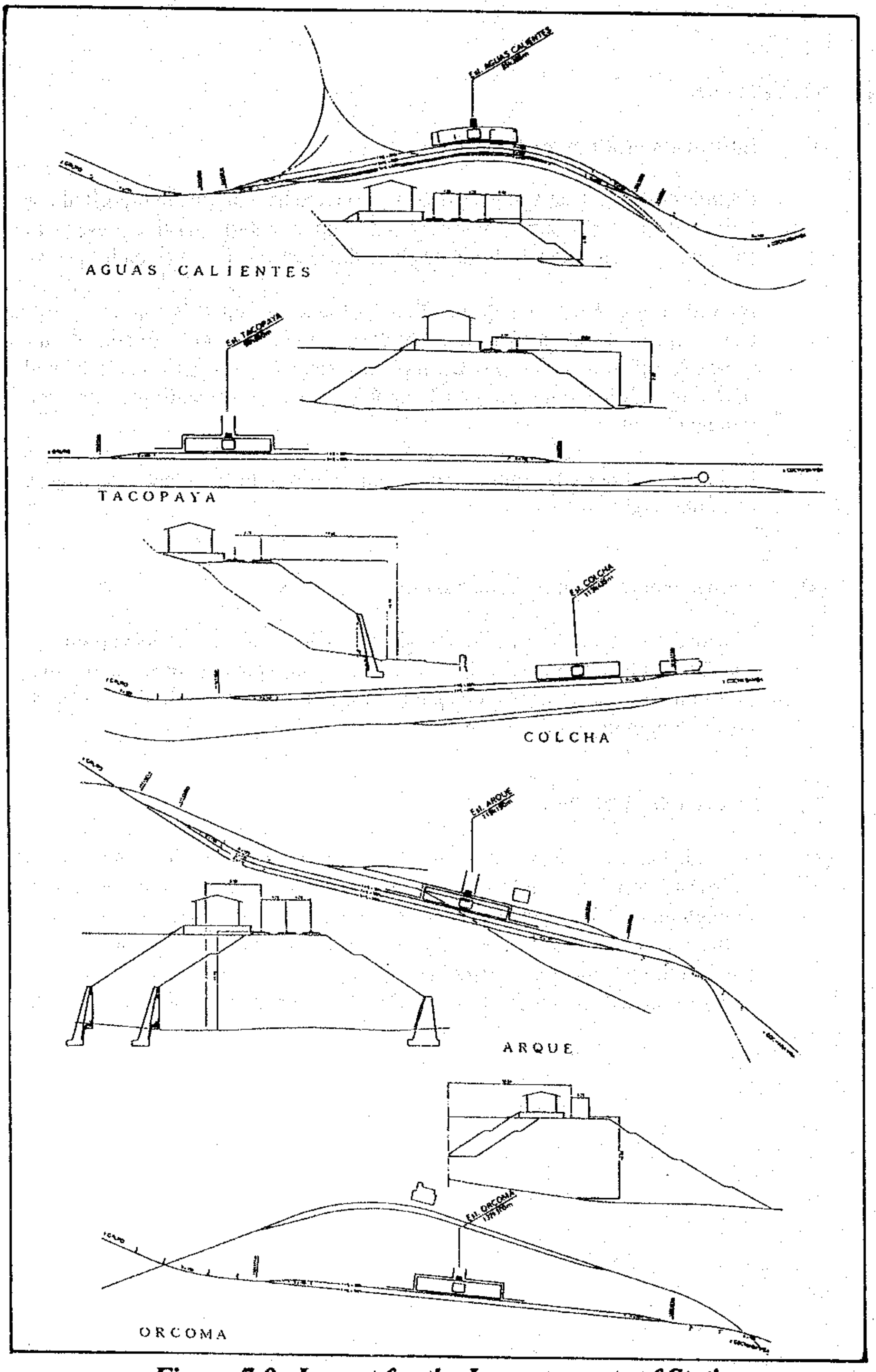


Figure 7-9 Layout for the Improvements of Stations

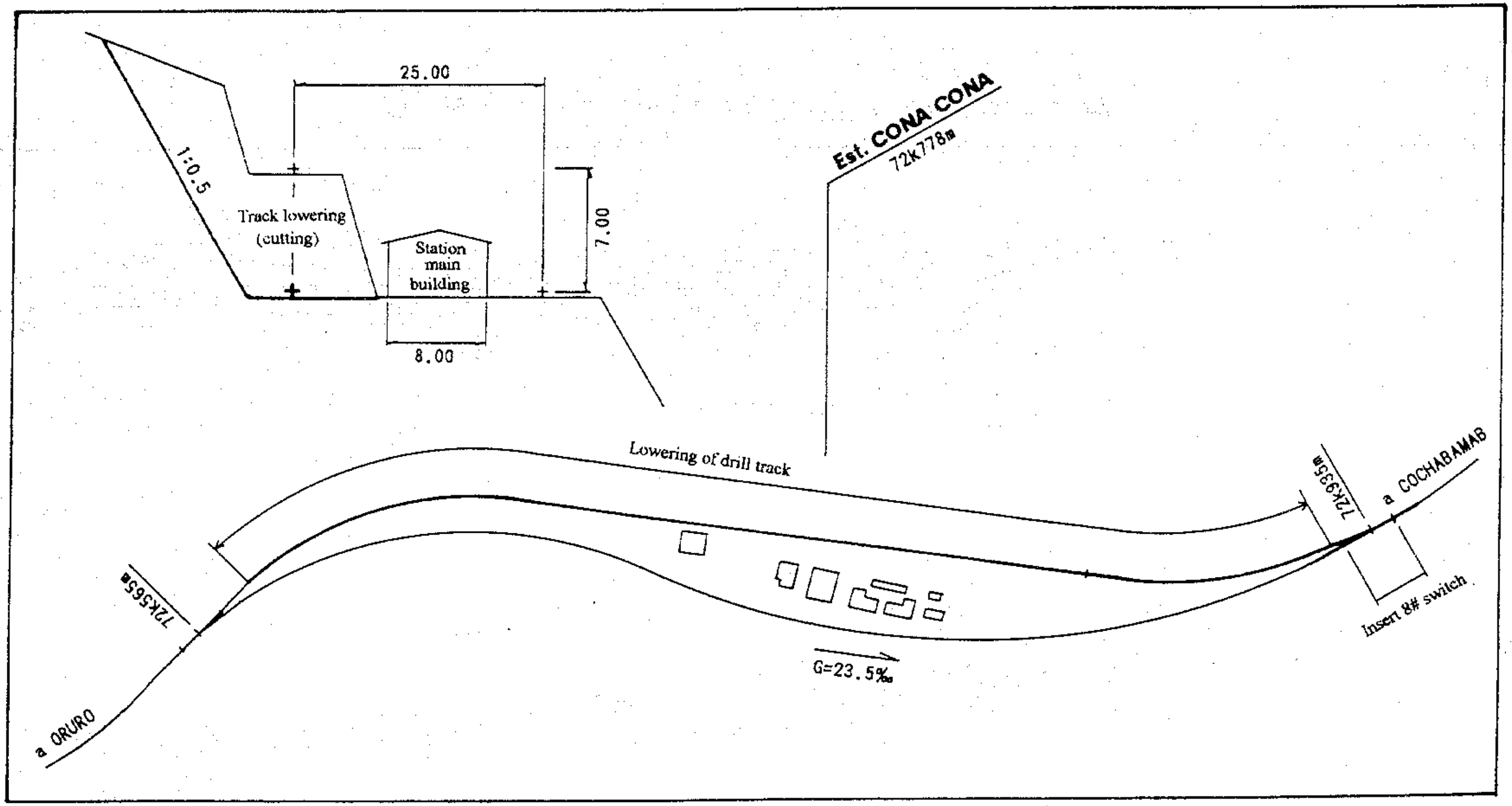


Figure 7-10 Layout for the Modification of Cona Cona Station

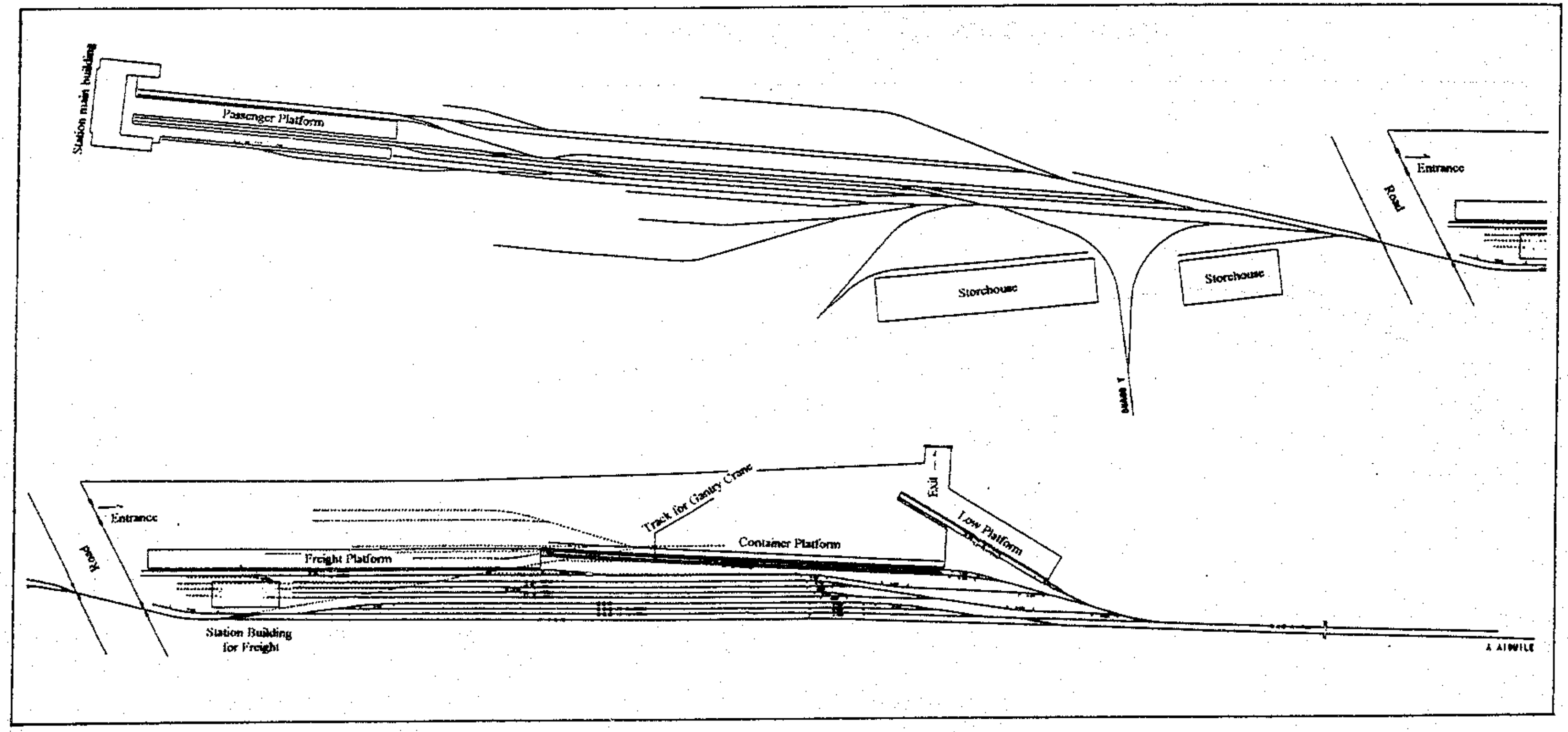


Figure 7-11 Track layout in Cochabamba Station Yard

7-5 SIGNALLING AND TELECOMMUNICATIONS

There is almost no signalling between Oruro and Cochabamba. For the indicators showing the direction of switches either open or close, and at the railway crossing other indicators showing the position are installed respectively.

Safety and traffic information is transmitted by a telecommunications system with open wiring and high-fidelity radio (HF).

Under World Bank assistance, a new plan for VHF radio communications is being designed for the Oruro-Cochabamba section. This system will consist of wireless communications between trains.

For the Aguas Calientes - Irpa Irpa section, it is possible to improve train control using the existing facilities, if the number of trains and the utilization of the facilities are taken into consideration. However, planning will include only facility changes as needed when route is modified.

(1) Indicators

Point indicators will be moved as required at stations where modifications are made. Existing indicators will be kept as they are when there is no route change.

(2) Telecommunications facilities

On sections where modifications are made, telecommunications lines with open wiring will be moved to the sites that are safe and adequate, to protect them from landslides and to improve control and maintenance.

For new routes, the open wiring will be placed alongside the mountains at the best locations possible.

(3) Relocation of Signalling and Telecommunications

Table 7-7 shows the signalling and telecommunications materials and equipment needed because of modifications due to route relocation.

TABLE 7-7 Quantities of Relocation

Installation name	Contents	Quantity	Remarks
Signalling	Switch indicator	17 sets.	
Telecommunications	Open wires	35.5 km.	
	Telephones	20 units	

8. ADMINISTRATION AND OPERATIONS PLAN

8-1 ORGANIZATION AND PERSONNEL

(1) Organization

The organization of ENFE is composed of the Central Office, the Andean Bureau and the Oriental Bureau. However, the board of directors at the Central Office decides ENFE's policies as a whole. The Andean Bureau and the Oriental Bureau operate as an executing agency under a decentralized system, but their organization differs from that of the Central Office.

ENFE, historically, developed its activities in La Paz and it has its headquarters there. The Andean Bureau also has its management office in La Paz. At present, it is necessary to have an organizational scheme suited for ENFE as a whole, designed in a simple and functional way.

(2) Personnel

ENFE staff in 1990 numbered 7,190 individuals. In 1993, that was 5,254 because of ENFE's down-sizing. The reduction represented a 25% decrease in three years. Table 8-1 shows the decrease in staff management for 1992-1993 by sector.

TABLE 8-1 ENFE PERSONNEL DECREASES BY SECTOR

(annual averages)

Region	Occidental			Oriental		
Year / Sector	1992	1993	Difference	1992	1993	Difference
Administrative Proportion	544.4 14.8%	494.6 14.5%	- 49.8	258.6 13.8%	263.6 14.6%	5.0
Operative Proportion	3,126.3 85.2%	2,920.4 85.5%	- 205.9	1,611.1 86.2%	1,575.0 85.7%	- 36.0
Total	3,670.7	3,415.0	- 255.7	1,869.6	1,838.6	- 31.0
TOTAL ENFE				5,540.3	5,253.6	- 286.6

The staff reduction at the Oriental Bureau is lower than that of the Andean Bureau. In fact, the number of personnel for administration at the Oriental Bureau has even slightly increased. Of course, we cannot evaluate the contents of the personnel cuts here. However, the proportion of administrative personnel in ENFE is over 14%, which is high compared with major private railway companies in Japan.

8-2. ADMINISTRATION AND OPERATIONS COSTS

(1) Items and Basic Units

Administration and operations costs consist of eight items, and each item is divided into personnel and material costs. Personnel cost refers to number of persons needed, and material cost refers to the units shown in 1) through 8) below.

1) General Administration : number of personnel.
2) Maintenance Administration : Coach-km
3) Transportation Administration : Transportation volume
4) Track Maintenance : Coach-km
5) Signaling and Telecommunications : Train-km
6) Maintenance of Rolling Stock : Coach-km
7) Transportation cost : Transportation volume
8) Train operation cost : Coach-km.

(2) Calculation of Administration and Operations Cost

Administration and operations costs are calculated according to transportation and personnel plans. Table 8-2 shows the personnel needed for the Oruro and Cochabamba services. Table 8-3 shows basic units applied, and Table 8-4 illustrates the results obtained from calculations.

TABLE 8-2 PERSONNEL PLAN

Year	2000	2010	2020
Operation sector	433	465	481
Administration Sector	49	52	54
Total	482	517	535

TABLE 8-3 BASIC UNIT

(Unit: Bolivianos)

Item	Basic Unit
Personnel Cost	20,257/per. (Num.of personnel)
Material Cost	
General Administration	15,607/per. (Num.of personnel)
Maintenance Administration	0.096/km (Coach-km)
Transportation Administration	2,723,000/pers·ton/km (Transportation Volume)
Track Maintenance, (year 2000) (after year 2010)	0.055/km (Coach-km) 0.045/km (Coach-km)
Signaling and Telecommunications	0.069/km. (Train-km)
Maintenance of Rolling Stock	0.174/km (Coach-Km)
Transportation	5,368,000/per ton·km (Transportation Volume)
Train Operation	0.453/km (Coach-km)

TABLE 8-4 ADMINISTRATION AND OPERATIONS COSTS

(Unit: Thousand Bolivianos)

Item \ Year		2000	2010	2020
Number of staff personnel (persons)		482	517	535
Volume of transportation (1,000 persons·ton·km)		176,829	249,120	326,001
Coach-km (thousand km)		11,960	14,379	19,018
Train-km (thousand km)		1,077	1,231	1,539
Personnel Cost		9,764	10,473	10,838
Material Cost	General Administration	7,522	8,069	8,350
	Maintenance Administration	1,152	1,385	1,832
	Transportation Administration	482	678	888
	Track Maintenance	660	641	848
	Signaling & Telecommunications	75	86	107
	Maintenance of Rolling Stock	2,078	2,498	3,304
	Transportation cost	949	1,337	1,750
	Train operation cost	5,412	6,507	8,606
	Total Material Cost	18,330	21,201	25,684
Grand Total		28,094	31,674	36,522

8-3 EDUCATION AND TRAINING

It is necessary to implement education and training programs for each sector, as follows, to execute the improvement plan smoothly and to operate the railway without obstacles after the execution of this project.

(1) Transportation

Presently, ENFE's most critical problem is frequent traffic accidents such as derailment. Training will focus on safety education, technical education, VHF communications system, etc., to achieve good performance in traffic and communications activities.

(2) Fixed facilities

The present track maintenance of ENFE is far from satisfactory. Training activities for foremen will be carried out to improve track maintenance and administration standards. This should be complemented by updating existing manuals, procedures and working methods.

Works records for structural maintenance should be established so as to have detailed information on individual structures. These records should contain information and data on the state, control and maintenance of structures.

9. IMPLEMENTATION PLAN

9-1 INVESTMENT COST

(1) Premises for Calculating Investment Cost

The following items are considered as premises for calculating the investment cost.

1. Investment cost is calculated for cases A and B.

   Investment cost for Case A : Steel bridges (W=1,300 ton approx.) from the Yapacani Line to be re-utilized. Removal and transportation costs of the same is included.

   Investment cost for Case B : If steel bridges are not re-utilized, investment cost is calculated for newly manufactured bridges.

2. Construction costs are calculated by dividing them into foreign and local currency portions and converted to U. S. dollars.

3. Costs consist of labor, materials, rental, overhead expenses, etc. and are calculated by item.

4. Costs are calculated in September 1994 prices and any price increase is not considered.

5. Exchange rates are as follows:
   US$ 1 = Bs. 4.65 (Bolivian currency)
   US$ 1 = Y. 100 (Japanese yen)

6. All machinery, equipment, material, etc. will be calculated in CIF prices.

7. Labor costs for all work items are calculated as part of the local currency portion.

8 The utilization of national products will be done as much as possible.

9. For unforeseen expenses in work execution, a 10% contingency fee will be added to the construction costs.

10. Indirect costs include the topographical survey, geological studies, engineering costs I and II. Engineering I includes detailed design costs for structures, which accounts for 4% of the civil construction works, track and building cost. Engineering II covers the supervisory services on work sites, which accounts for 10% of direct costs (excluding land and contingency costs.)

11. Table 9-1 shows machinery for maintenance and for civil works. These costs are included in the investment costs.

12. Figure 9-1 shows the composition of investment costs.

TABLE 9-1 MACHINERY FOR MAINTENANCE & CIVIL WORKS

Machinery for maintenance		Machinery for civil works	
Bulldozer	Screw Spike	Track motor car	Concrete plant
Tractor	Rail saw	Flat car	Concrete pump car
Shovel	Rail drill	Wagon for ballast	Concrete delivery ca[r]
Tie tamper	Rail welder		

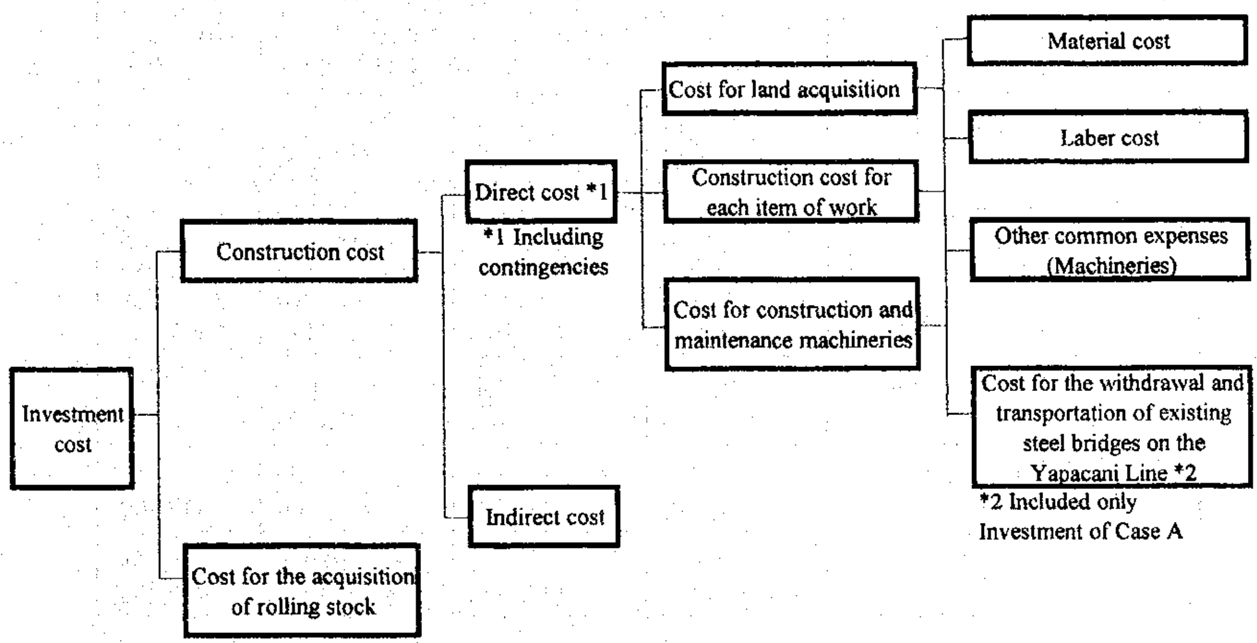


Figure 9-1 Composition of Investment Costs

(2) Calculation for Investment Cost

1. Investment cost for Case A : If steel bridges from the Yapacani Line are used, the total investment cost will be US$ 141 million, including the cost of rolling stock. Of this total, US$ 86 million will be for the installation of fixed facilities (i.e. US$ 50 million for Phase I and US$ 36 million for Phase II.)

2. Investment cost for Case B : If steel bridges from the Yapacani Line are not used, the total investment cost will be approximately US$ 147 million, including the cost of rolling stock. Of this total, US$ 92 million will be for the installation of fixed facilities (US$ 53 million for Phase I, and US$ 39 million for Phase II).
   The investment costs are shown in Table 9-2 .

TABLE 9-2 INVESTMENT COST

Unit :US$ 1000

Item	Sector	Investment Cost	Phase I 1996 ~ 2000	Phase II 2001 ~ 2005	After 2006
Investment Cost for Case A	Fixed facility Cost	85,833 (30,614)	49,503 (20,266)	36,330 (10,348)	- -
	Rolling stock Cost	55,280 (55,280)	27,120 (27,120)	10,960 (10,960)	17,200 (17,200)
	Total Cost	141,113 (85,894)	76,623 (47,386)	47,290 (21,308)	17,200 (17,200)
Investment Cost for Case B	Fixed facility Cost	91,641 (36,128)	52,556 (23,265)	39,085 (12,863)	- -
	Rolling stock Cost	55,280 (55,280)	27,120 (27,120)	10,960 (10,960)	17,200 (17,200)
	Total Cost	146,921 (91,408)	79,676 (50,385)	50,045 (23,823)	17,200 (17,200)

The figures without ( ) are the sum of the foreign and local currencies.
The figures in ( ) indicate costs in foreign currency.

9-2 INVESTMENT SCHEDULE

(1) Criteria of the Schedule

To decide the investment schedule, it is assumed that ENFE will begin the necessary procedures with the appropriate agencies in 1996, after the conducting of this feasibility study.

It is also assumed that a preliminary study (survey, geographical study and detailed design), which must be done prior to the construction of this project, will start around the middle of 1996, and that Phase I will finish at the end of 1997. Work will begin with high priority sections in 1998 and finish in 2000, with roadbed and track work being completed for five sections about 16km in length.

Phase II will start in the year 2003 and continue until 2005, and it will finish roadbed and track work for the remaining five sections totalling about 17km in length.

(2) Investment Schedule

A table of the investment schedule is shown in Table 9-3.

Table 9 - 3 Table of Imvestment Schedule

(Unit : US$ 1,000)

Item / Year	Phase I					Phase II					Cost for Case A	Cost for Case B
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total	Total
Various procedure by ENFE												
Preliminary Study (Survey, Geological study, Detailed design)											3,521 (2,460)	3,720 (2,668)
Supervision of Construction											6,824 (2,346)	7,291 (2,788)
Roadbed Work I (Section⑤, ⑦, ⑨, ⑪, ⑬.St.ConaCona)											35,964 (14,040)	38,627 (16,610)
Roadbed Work II (Section①, ③, part of④, ⑮, ⑲)											19,569 (2,647)	22,039 (4,887)
Track Work I											7,662 (3,479)	7,662 (3,479)
Track Work II											12,109 (5,495)	12,109 (5,495)
Electrical Work											193 (148)	193 (148)
Acquisition of Rolling Stock											55,280 (55,280)	55,280 (55,280)
Cost for Case A Total	510	790 (790)	14,956 (7,904)	19,654 (5,360)	40,713 (33332)	1,227 (685)	457 (457)	8,215 (1,423)	17,798 (4,838)	19,593 (13,905)	141,113 (85,894)	
Cost for Case B Total	510	862 (862)	14,488 (8,036)	22,033 (7,282)	41,783 (34,205)	1,281 (739)	492 (492)	8,739 (1,953)	19,329 (6,197)	20,204 (14,442)		146,921 (91,408)

10. ECONOMIC ANALYSIS

10-1 OBJECTIVE AND METHODOLOGY OF ANALYSIS

The objective of this chapter is to carry out an analysis and evaluation from the economic point of view in regard to investment efficiency for the improvement project. Two cases will be examined : Case A, which re-utilizes steel bridges from the Yapacani Line, and Case B, which dose not re-utilize these bridges. Here the investment cost and various benefits are evaluated by applying the following indexes.

Indexes for evaluation : Net Present Value (NPV)
Economic Internal Rate of Return (EIRR)

Benefits are generated from the year 2001. The analysis period extends until the year 2030, and the discount rate is 12% / year.

10-2 INVESTMENT COST

Based on the investment costs in the foreign and local currency portions mentioned in Chapter 11, and the transfer items such as customs duties and taxes, the investment cost (economic price) is calculated as shown in Table 10-1 below.

TABLE 10-1 TOTAL INVESTMENT AMOUNT

Unit : thousand US$ (1994 prices)

	Market Price	Economic Price
Case A	196,850	157,632
Case B	203,474	162,723

*Investment period : 1996-2030 (excludes interest)
*Includes re-investment for facilities after life cycle.

10-3 CALCULATION OF BENEFITS

The benefits of this project are generated from the difference in the economic costs for the case when the project is executed (with) and not executed (without). In this economic analysis, the following benefits are taken into consideration in the calculations.

1. Reduction of the total transportation cost by road and railway
   Railway transportation costs per unit (passenger/km, ton/km) after the execution of this project will be lower than road transportation. The difference between the total costs of railway and road transportation in the with and without cases generates benefits.

2. Benefits in reducing the travel time
   The reduction of travel time is considered a benefit for passengers as well as for cargo. This benefit is calculated by multiplying the unit time value by the reduction in travel time for both cases.

3. Benefit in reducing the maintenance costs of roads
   After the railway system is improved, transportation volume will shift from the road to the railway. Thus the reduction in road maintenance costs due to less road traffic is estimated as a benefit.

4. Savings of rehabilitation costs caused by disasters on the Oruro-Cochabamba Line. After the execution of the improvement plan, it is expected that rehabilitation works will not be practically needed. Assuming that the average rehabilitation costs for the past 7 years can be eliminated, this cost is included as a benefit.

5. Loading / unloading cost of cargo in the inter-modal system
   In the case of railway transportation, the costs for loading and unloading to / from trucks is generated at Cochabamba and Santa Cruz and are added as negative benefits.

6. Summary of benefit amount
   Benefits are obtained from the difference in the with and without cases for all the above items. The total amount of the benefits is shown in Table 10-2.

TABLE 10-2 AMOUNT OF BENEFITS

Unit : thousand US$ / year (1994 price)

Year	2000 (2001)	2010	2020
1. Benefits from reduction in transportation cost (cargo)	7,483	13,853	21,944
Benefits from reduction in transportation cost (passenger)	47	118	226
2. Benefits from reduction in travel time (cargo)	1,233	1,799	2,155
Benefits from reduction in travel time (passenger)	77	104	130
3. Reduction in maintenance costs for roads	642	1,067	1,646
4. Saving of rehabilitation costs for disasters	67	67	67
5. Benefits of inter modal loading / unloading of cargo	-146	-351	-477
Total amount of benefits	9,403	16,657	25,691

Note : 1) Benefits for the year 2000 are generated in the starting year 2001, after the completion of improvement work (2000)
2) The benefits indicated above are the same for Case A and B.

10-4 RESULTS OF ANALYSIS

The economic internal rate of return (EIRR) is 13.24% for Case A and 12.69 % for Case B. In Table 10-3, the net present value (NPV) and the EIRR for Case A and B up to the year 2030, with a discount rate of 12%, are shown. These EIRRs are above 10%, which is said to be a benchmark of the World Bank, that is, the two cases are economically feasible for execution.

Regarding to the NPV for both cases A and B, the benefits are bigger than the expenses. If we compare the two cases, the NPV of Case A is US$ 5.8 millions with a discount rate of 12%, while the NPV of Case B is US$ 3.4 millions, or only 60% of that of Case A.

The difference in the EIRRs and NPVs of cases A and B is due to a larger initial investment of US$ 5.1 millions. This means that the amount of the initial investment greatly affects the results. Consequently, to improve the efficiency of the project, it is necessary to make efforts to decrease the initial capital costs.

TABLE 10-3 RESULTS OF ECONOMIC ANALYSIS (Discount rate 12%)

Unit : US$ thousands

	Case A	**Case B**
a. Total investment amount	157,632	162,727
b. Total investment amount after discounting	56,155	58,592
c. Total benefits	603,467 (Same for A and B)	
d. Total benefits after discounting	61,981 (Same for A and B)	
d-b: Net Present Value (NPV)	5,826	3,389
Economic Internal Rate of Return (EIRR)	13.24%	12.69%

10-5 SENSITIVITY ANALYSIS

A sensitivity analysis was made for the three cases below.

Case 1 : An increase of 10% in the total investment amount.
Case 2 : A decrease of 10% in the total transportation demand.
Case 3 : An increase of 10% in the total investment amount and decrease of 10% in the total transportation demand.

The results of the sensitivity analysis are shown in Table 10-4. A 10% increase in total investment reduces approximately by 1.2% the EIRR in both cases. A reduction of 10% in benefit (demand) reduces approximately by 1.3% the EIRR in both cases. If both conditions occur at the same time, there is a reduction of approximately 2.4%. A 10% increase in total investment and a 10% decrease in transportation demand results in a 20% increase in investment or a 20% reduction in transportation demand. Even in this case, the EIRR is still higher than 10%. Consequently it can be stated that any case is economically feasible.

TABLE 10-4 RESULTS OF SENSITIVITY ANALYSIS

	Case A	Case B
	EIRR (%)	EIRR (%)
Increase of 10% of total investment amount	12.04	11.53
Reduction of 10% of benefit (demand)	11.92	11.41
Increase of 10% of total investment amount + reduction of 10% of benefit	10.79	10.31

10-6 OTHER BENEFITS

In addition to the above mentioned benefits,the following additional benefits are also expected :

1. Decrease in derailments (the current annual average is 500 times on the improvement section), level crossing accidents and the number of death and injuries.

2. Employment of people living in the execution area.
   A total 40,000 person · months will be employed. Expected employment over ten years will be an average of 330 persons per year.

3. New employment opportunities after the project is completed.
   ENFE will increase its personnel for track, workshops, administration, etc.

4. Shift of traffic from road to railway will alleviate environmental contamination, and will reduce road traffic accidents.

10-7 EVALUATION

In this project the benefits are higher than the costs and the EIRR is about 13%, which exceeds the 10% which is said to be a bench mark of the World Bank. The employment and economic effects generated by this project will not extend only to the project area, but also to the national economy. As regards environmental effects, it can be said that the railway is better than the road.

This project will be economically appropriate and useful.

11. FINANCIAL ANALYSIS

11-1 OBJECTIVE AND METHODOLOGY OF ANALYSIS

In order to analyze how much improvement of financial standings can be expected and whether sound operation is possible or not after the execution of the project, the financial internal rate of return (FIRR) is calculated.

11-2 MAJOR PREMISES

(1) Analysis Period and Currencies Utilized

Profitability is studied by performing an analysis on the increase in investment amount, funding, revenues and costs considered over the life of the project until the year 2030. It is assumed that revenues and administration and operations costs will annually increase equally for the years 2000 ~ 2010 and 2010 ~ 2020. Thereafter, no such increases will occur until the end of the project's life. The analysis is made in United States dollars.

(2) Investment Cost

An analysis will be made for Case A, which re-utilizes steel bridges from the Yapacani Line, and Case B which does not re-utilize these bridges. Market prices will be utilized for the analysis, but for imported equipment and materials market prices will be CIF prices plus 29.31%, the expenses and duties for imports and the VAT (value-added tax). After the durable life of the equipment, re-investment of the same amount as the initial investment is necessary. Table 11-1 shows the total investment amount during the project life including the re-investment.

TABLE 11-1 TOTAL AMOUNT OF INVESTMENT

(Unit : US$ Thousands)

Execution Plan	Foreign Currency	Local Currency	Total
Case A	141,023	55,828	196,850
Case B	147,962	55,512	203,474

(3) Source of Finance

For the necessary financing for the initial investment of the foreign currency portion, it is assumed that Bolivia will utilize loans available to it from international organizations with the conditions of 3% interest per annum, a maturity of 30 years with a 10-year grace period and a semi-annual equal installments over 20 years.

After obtaining the foreign currency loan for the initial investment, all other costs of investment, financing and operation will be obtained by funding in local currency. The funding scheme will be as follows.

Case 1: Total amount with internal funding and from the Government with no interest.

Case 2: Loans from financial organizations with a 4.5% interest per annum.

(4) Revenues

Passenger volume is divided into through passengers and those getting on/off within the Line. Passenger fare is calculated by multiplying the fare by the passenger for each travel distance. Freight traffic is calculated as all cargo is transported through the Line. Passenger fare and cargo tariff will be in U.S. dollars. In addition, other miscellaneous revenues will be included in the analysis.

11-3 RESULTS OF ANALYSIS

Table 11-2 shows the revenues and administration and operations costs. Table 11-3 is the major indexes of the analysis.

TABLE 11-2 REVENUES, AND ADMINISTRATION & OPERATIONS COSTS ORURO-COCHABAMBA LINE

(Unit : US$ Thousands)

Items \ Year	1992	2000	2010	2020
Revenues	4,119	10,869	15,357	20,294
(Idem. Increase to 1992)		6,750	11,237	16,175
Administration & Operations costs	3,744	7,204	8,122	9,365
(Idem. Increase to 1992)		3,459	4,377	5,620

TABLE 11-3 INDEXES OF THE ANALYSIS

(Unit : US$ Thousands)

Construction Cost	Case A		Case B	
Funding	Case 1	Case 2	Case 1	Case 2
Financial Internal Rate of Return (FIRR)	3.31 %		3.09%	
The First Year of Annual Surplus	2009	2018	2010	2024 (Note)
The Year of Offset of Accumulated Deficits	2014	After 2031	2016	After 2031
Peak Balance of Foreign Loan	90,101		97,245	
Peak Balance of Local Loan	44,047	96,737	46,886	113,449

Note:After the surplus in the year 2020, deficits occur again in the years 2022 and 2023.

For all the indexes, Case A is better than Case B, but the differences are not significant. The FIRR in both cases is between 3.31% and 3.09%, which cannot be considered high. However, in Funding Case 1, the FIRR is higher than the financial costs, so there will be no problem in executing the project.

On the other hand, in Funding Case 2, this project will be very difficult, and it will be necessary to seek better funding sources both for the local and foreign currency portions.

As regards revenues and expenses, in Funding Case 1, the differences between cases A and B are not significant. Annual results will turn into profit and the accumulated deficit will be set off during the project life.

On the other hand, in Funding Case 2, annual results will turn into profit later and will be unable to offset the accumulated deficits during the project life.

The difference of funding gives larger effects than the difference of the costs.

11-4 SENSITIVITY ANALYSIS

For the funding of cases A and B, a sensibility analysis is made for the following three cases:

Case 1 : An increase of 10% in the total investment amount.
Case 2 : A decrease of 10% in the total transportation demand.
Case 3 : An increase of 10% in the total investment amount and a decrease of 10%in the total transportation demand.

Table 11-4 shows results of this analysis.

TABLE 11-4 RESULTS OF SENSITIVITY ANALYSIS

(Unit : US$ Thousands)

Case	Basic Case	Sensitivity Analysis		
		Case 1	Case 2	Case 3
Construction Cost	Case A			
FIRR	3.31%	2.73%	1.90%	1.40%
The First Surplus Year The Year Accumulated Deficits Are Offset	2009 2014	2012 (Note1) 2018	2014 2024	2015 2029
Peak Foreign Loan Balance	90,101	99,111	90,101	99,111
Peak Local Loan Balance	44,047	58,376	72,689	91,816
Cost of Works	Case B			
FIRR	3.09%	2.52%	1.72%	1.24%
The First Surplus Year The Year Accumulated Deficits Are Offset	2010 2016	2012 2020	2014 2026	2018(Note2) after 2031
Peak Foreign Loan Balance	97,245	106,969	97,245	106,969
Peak Local Loan Balance	46,886	66,776	80,325	100,216

Note 1 : After the surplus of 2010, a deficit will occur again in the year 2011.
Note 2 : After the surplus of 2016, a deficit will increase in the year 2017.

The reduction in total demand (sensitivity analysis Case 2) has a larger effect than an increase in the total investment amount (sensitivity analysis Case 1).

11-5 STUDY FOR THE INVESTMENT VOLUME

Under the conditions of the analysis, after foreign funding is obtained for the project, the annual amount of capital and interest to be paid will not exceed the amount of the capital and interest of the loan to be paid by ENFE.

Consequently, this project is within the scope of ENFE's past investment volume. It can be stated that financially it is a feasible program .

Even if taking into account the fact that there are several other urgent programs for ENFE, the priority of this project is high. But other improvement investments are important for ENFE as well, it is desirable to obtain soft funding in foreign currency as well as in local currency. Also, it is advisable to reduce the investment cost as much as possible.

11-6 EVALUATION

The financial internal rate of return (FIRR) of the improvement project for the Oruro-Cochabamba Line is not high. However, if funding with an interest rate of 3% for foreign loans and with no interest for local funds is possible, the project has a reasonable level of feasibility. However, if the total local cost has to be covered with an interest rate of 4.5%, the project can be defined as difficult.

This project cannot bear large variations in investment and demand, but it is not large compared to ENFE's past investments. It is important to seek soft funding as much as possible.

12. CONCLUSIONS AND RECOMMENDATIONS

12-1 CONCLUSIONS

(1) Project Summary

The Oruro-Cochabamba Line, which is a part of Bolivia's export corridor, experiences annually heavy rains that paralyze railway traffic for long periods of time. The improvement plan is directed at this section and intends to provide a better ability to cope with disasters and to allow prompt rehabilitation, in order to ensure reliable and safe transportation throughout the year.

The improvement plan covers the Oruro (San Pedro)-Cochabamba Line, which has a route length of approximately 204km. The 55km section between Aguas Calientes and Irpa Irpa is the site where accidents are most frequent. During Phase I of the study, a topographic map was made and Phase II covers the relocation of the route and its related works for this 55km.

On the Aguas Calientes - Irpa Irpa section, there are ten sections of 33km in length where disasters happen most frequently, and a plan for the relocation was performed.

To decrease costs, it was planned to utilize existing steel bridges from the Yapacani Line (21 bridges). For this work, two cases were examined.

1) Re-utilization of the existing steel bridges on the Yapacani line
2) No re-utilization (new steel bridges)

Based on the result of these studies, ENFE shall decide the number of bridges to be re-utilized from the Yapacani Line.

The improvement plan will be carried out in two phases. Phase I will deal with the most urgent five sections, which are approximately 16km in length and will be finished by 2000. Phase II will handle the other remaining five sections approximately 17km in length, which will be finished by end of year 2005.

The investment amount required, on the basis of costs as of September 1994, is as follows :

1. Re-utilization of steel bridges from the Yapacani Line
   The total amount is US$141 millions, including the cost of rolling stock. US$86 millions will be for fixed facilities (US$50 millions for Phase I, and US$36 millions for Phase II).

2. No re-utilization of steel bridges from the Yapacani Line (new steel

bridges)
The total amount is US$147 millions, including the cost of rolling stock. US$92 millions will be for fixed facilities (US$53 millions for the Phase I and US$39 millions for Phase II).

The outline of the improvement plan is summarized as follows :

1) Aguas Calientes-Irpa Irpa section out of Oruro-Cochabamba Line.

a) The route will be relocated towards the mountains and the track will be improved. It consists of 10 sections of approximately 33 km. In this area, there is little height difference between the track and bed of the river flowing parallel to it, which is the cause of frequent flooding.

b) Track will be protected against debris flows with bridges, box tunnels, etc., to avoid dislodged masses.

c) As a result of route relocation, it will be necessary to improve the five stations at Aguas Calientes, Tacopaya, Colcha, Arque and Orcoma. In addition, side track at Changolla and Higuerani will be closed taking into account track capacity.

d) On the 10 sections of track approximately 22km in length where there are no route changes, the track will be improved.

2) Oruro-Cochabamba Line, except the section 1) : Oruro-Aguas Calientes and Irpa Irpa-Cochabamba sections

a) The track will be improved where the accidents and derailments are most frequent (14km).

b) At Cona Cona Station, a new side track will be introduced for train crossings, taking into consideration the capacity of the track.

(2) Evaluation of the Project

1) Technical Aspect

a) Route

Several alternative routes were projected considering the actual track condition, magnitude and frequency of disasters, topographic conditions, etc. A comprehensive evaluation was made as regards those alternative routes. Detailed discussions were held at each step with the Bolivian counterparts to analyze the alternatives and discard those considered as not adequate, and special attention was given to analyzing sites prone to disasters. Finally, the most adequate route was selected, as the improvement plan for the Aguas Calientes-Irpa Irpa section.

b) Fixed facilities

Work on fixed facilities for the new route were considered on the basis of ENFE's technical capacity and execution experience. Cut and embankment are planned for 91% of the new route, in which ENFE has much experience.

As for civil structures, long bridges need geological surveys using drilling. Besides, there is only one mountain tunnel (where ENFE has little experience), which will be only 110m long and the geological conditions are good. Electrical work consists mainly of moving communication cables because of the relocation of the route.

The civil and electrical work mentioned above will not present any difficulties.

c) Train operation and rolling stock

Train operation is programmed according to the transportation plan based on demand increases. Existing speed restricted sections will be improved by upgrading track, restoring the original scheduled speed. A new side track will be constructed at Cona Cona Station, and two existing side tracks at Changolla and Higuerani will be closed. Thus, it is expected that transportation will be better regulated throughout the whole Oruro-Cochabamba Line.

The plan for increasing rolling stock is accessary to meet demand and cope with the train operation plan for the Oruro - Cochabamba Line.

2) Environmental aspect

Although there are several rural communities along the railway route, there should be no problems as the route has been selected so as not to sever communities and to avoid housing movements, etc. If a household is to be moved, this will be done after careful precautions.

The improvement project will be executed in a mountainous area and will involve vibrations and noise near community areas. However, careful measures will be taken during work to avoid creating disturbances, and there should be no problems.

Finally, there are no developmental restrictions due to such things as archaeological ruins and cultural patrimony.

Thus, impacts on the environment will be negligible.

3) Economic aspect

The economic internal rate of return (EIRR) of the project is 13.24% if steel bridges on the Yapacani Line are re-utilized, and is 12.69% if new steel bridges are used. These rates are believed to be over the benchmark of the World Bank, the Asian Development Bank and other international funding organizations.

This project would be even more economically appropriate and useful if the indirect socio-economic benefits generated by employment, the elimination of traffic accidents, the reduction of environmental contamination, etc., were taken into account.

4) Financial aspect

The financial internal rate of return (FIRR) of the project is 3.31% if steel bridges on the Yapacani Line are re-utilized, and is 3.09% if new bridges are used. These rates are not high for ENFE. It should be necessary to obtain funding from international organizations or through bilateral agreements between governments at the lowest interest rates possible for the foreign currency portion. On the other hand, if government subsidies or soft loan financing is available for the local currency portion, there should be no specific problem in executing the project.

5) Overall evaluation (conclusion)

This project, which includes the relocation of a route, is technically possible and has a negligible impact on the environment.

From the national point of view, the EIRR is 13.24% ~ 12.69%. Taking into account the indirect benefits to be attained, this project is feasible for the national economy. As regards the financial aspects of the project, its FIRR is 3.31% ~ 3.09%, which has a reasonable level of feasibility if soft loan agreements for funding are available.

From the overall point of view, this project is an adequate plan for the Los Andes range topography, where the railway has been damaged by disasters causing traffic stoppages for long periods of time; technical, environmental, economic and financial evaluation has been studied as feasible.

The execution of this project will provide reliable transportation service between Oruro and Cochabamba, which will contribute to the social and economic development of Bolivia.

To execute this project, it is necessary to improve hardware, such as structures and rolling stock, as well as software, such as the development of human resources through education and training activities for transportation control and the maintenance of existing equipment and installations.

12-2 RECOMMENDATIONS

In executing the project, the following items are recommended to make it more effective.

(1) Consulting, Discussions and Provisions with Related Organizations

1) It is necessary that all organizations involved in matters related to water and land policies make all efforts to implement actions to eliminate the origin of disasters along the railway. Experience has shown that the magnitude and frequency of disasters are significant on the Oruro-Cochabamba Line, and this problem should be eliminated.

2) Because of the actual track capacity, the side tracks and stations at Changolla and Higuerani are planned to be closed. However, if here is demand, these two stations should handle passengers and cargo.

(2) Environmental Considerations and Smooth Execution of Work

1) Since some houses have to be moved due to the new route, it is recommended that the Project be carefully promoted to attain necessary understanding from the households and communities in the area.

2) Regarding noise and vibration caused by the execution of work, the understanding of residents should be gained through a careful explanation of the project.

3) The design and execution works should use cut and embankment in consideration of their sound stability in guaranteeing the safety of trains and the surrounding areas.

4) It is necessary to plan the smooth execution of work by taking into consideration the whole process, from the geographic surveys to the detailed design, which shall be done prior to the work, as well as the re-utilization plan of existing steel bridges and purchasing plan of new bridges.

5) It would be effective to invite railway specialists from a foreign country with advanced technology, to stay in Bolivia and carry out technology transfer to ENFE engineers and to give necessary advice for follow-up work.

(3) Reduction of Investment Cost

1) It is recommended that the re-utilization plan for steel bridges be reviewed for both networks, the Oriental and Occidental, in order to reduce construction costs by promoting their re-utilization.

2) The rises in the river beds of the Rio Sayari, Rio Wallia etc., which cross the railway route, were mainly measured based on hearings. However, in the future, it is recommended that actual measurements be made to make better plans and reduce costs.

3) As regards the purchasing of rolling stock for the Oruro-Cochabamba Line, only this line was considered. Actually, rolling stock utilization should be for the whole Andean network, and efficiency in utilization, inspection and repair should be considered from that viewpoint. Then, it might be possible to consider a reduction in the purchase of rolling stock. It is recommended, therefore, to study the rolling stock of the entire Andean network, including the improvement of workshops, separately in other related programs as soon as possible.

4) For the provision of rolling stock, machinery and other equipment, efforts should be made to guarantee indispensable quality and the most reasonable prices.

5) It is important for ENFE to obtain funding for this project at the lowest interest rates possible.

(4) Maintenance and Operation Control

1) It is acknowledged that even after the project execution, and during the rainy season, disasters will continue to occur, causing dislodged masses over the box tunnels. Consequently, it is necessary to perform an continual maintenance of structures.

2) A track maintenance system should be established to avoid accidents and derailments, and also to maintain rail joints that constitute the weak points of the track, and to clean and clear side drains to avoid road bed damage on cut sections.
This project proposes the improvement of 69km of track by utilizing ballast on sections where accidents are frequent. In the future, ballasted track should be considered not only for the Oruro-Cochabamba Line, but also for all lines.

3) To realize this project, it is necessary to improve such software as operation control, increase the availability of rolling stock, maintain track and structures, educate and train personnel, etc., in addition to

investment in hardware such as rolling stock and fixed facilities. This improvement of software should not only be for the Oruro - Cochabamba Line, but for the entire ENFE as well.
It would be effective to invite railway specialists from a foreign country with advanced technology to stay in Bolivia and to promote software technology.

4) If ENFE is to be capitalized, as is now being studied, all of the proposed work should be reviewed, including the organization for work and maintenance.

5) Transportation capacity with existing facilities on the Oruro - Cochabamba Line will reach their limit by the year 2020, according to the demand forecast.
If further big increases of transportation volume is expected in the future, a study to improve hardware to increase transportation capacity will be necessary.

6) As regards the connection between the Oriental and Occidental networks, intermodal transportation between Cochabamba and Santa Cruz should be executed in parallel with the current project to guarantee reliable transportation. In addition, in the long term, and on the basis of accurate calculations of international demand by potential users of the inter-oceanic bridge, the connection of these two networks should be studied including prospective transportation capacity.

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