CHAPTER 18

CONSTRUCTION PLAN AND COST ESTIMATE

CHAPTER 18 CONSTRUCTION PLAN AND COST ESTIMATE

18. 1 General

The following work items will be taken up in this chapter:

- Clarification of assumptions for making cost estimates
- Estimate of quantities for each prevention spot
- Examination of the unit rate for each prevention countermeasure
- Drawing up of construction costs for each prevention spot
- Drawing up of maintenance costs for each Study route

The lifespan of road disaster prevention measures, which take into account the probability of road-related disasters occurring, are as described below.

- Permanent disaster prevention measure: Effective for 20 years
- Temporary disaster prevention measure: Effective for 10 years

18.2 Cost Estimate Assumptions

Construction unit rates obtained from MTI were first reviewed and adjusted as necessary. The Study team then examined unit rates for new work items. As part of this work, the Study team requested unit rate quotations from three general contractors.

Construction costs for each prevention spot are estimated as a direct cost. Note that direct cost includes direct variable cost, which consists of costs for temporary facilities and is greatly dependent on the conditions of a particular spot. Therefore, construction cost is estimated by averaging direct costs.

18.3 Unit Rates

Unit rates for different types of work and their corresponding work items are as shown in Table 18.3.1

Unit rates, which are based on the costs derived in Chapter 7, are revised in the Feasibility Study by considering additional work items and disaster prevention measures. Note that the types of prevention measures are the same as those in Chapter 7. The revised unit rates of the work items, the additional work items and the additional measures are shown in below.

■ Work items with a revised unit rate are marked with a ○ and are as follows:
- (7) Rock-fall prevention device: Net
- (9) Riverbank protection: Concrete revetment

■ Additional work items are marked with a □ and are as follows:
- (4) Structure: Concrete cribwork
- (9) Riverbank protection: Concrete cribwork for riverbed

■ Additional measures are as follows:
- (11) Bridge structure
- (12) Box culvert

Table 18.3.1 Unit Rates

Type of Work	Work Item	Remarks	Unit	Unit Rate	Reason for Modifying Unit Rate
(4) Structure	Shotcrete	T=10cm	m^2	48.30	Vegetation is used to harmonize with a nearby natural park.
	Concrete cribwork □	0.3×0.3 @2.0m	m^2	100.00	
	Gabion mat		m^3	43.67	
(7) Rock-fall prevention device	Prevention net ○		m^2	8.53	Estimate changed to reflect prices from three local construction companies instead of just
	Barrier with gabion mat		m^3	97.49	
	Barrier with concrete wall		m^3	625.13	
(9) Riverbank protection	Concrete revetments ○		m^3	654.95	Estimate based on prices from two local construction companies was changed to one based on prices from four local construction companies.
	Gabion mat		m^3	97.49	
	Stone riprap with mortar		m^3	66.91	Concrete cribwork adopted for rapid river flows.
	Concrete cribwork for riverbed ○		m^2	39.49	
(11) Bridge structure	Steel bridge with concrete slab		m^2	406.24	Bridge is considered as an alternative.
	Gravity-type abutment		m^3	37.15	
	Reversal T-type abutment(RC)		m^3	197.26	
(12) Box culvert	Cast in place	3m×2m	m	1740.6	Box culvert type is considered as an alternative.

18. 4 Spot Specific Construction Plans

The main types of equipment used for construction at each of the disaster prevention spots are as shown in tables 18.4.1 and 18.4.2.

Table 18.4.1 Main Equipment List for Slope Damage Repair

ID. No	Type of Disaster	Type of Countermeasure	Bulldozer	Back hoe	Pick hammer	Shotcrete machine	Truck crane	Vibration roller	Jumbo Breaker	Boring machine
N001A290	R.F	Recutting + Prevention net + Drainage		○	○		○			
N001A280	R.F	Horizontal drainage								○
N001A240	R.F	Recutting + Prevention net		○	○		○			
N001B230	R.C	Recutting + Prevention net		○	○		○			
N001B170	R.C	Recutting + Drainage		○	○				○	
N001B150	R.C	Recutting + Shotcrete + Drainage		○	○	○				
N001B120	R.C	Recutting + Drainage		○	○				○	
N003B400	R.C	Recutting + Drainage		○	○					
N003B370	R.C	Recutting + Drainage		○	○				○	
N003B320	R.C	Embankment + Concrete retaining wall + Vegetation	○	○	○			○	○	
N003C230	S.S + R.C	Recutting + Cribwork +Drainage Embankment + Vegetation + Drainage	○	○	○		○	○	○	
N003E170	D.F + R.C	Dam Recutting + Drainage	○	○	○		○	○	○	
N003C150	S.S + R.C	Recutting + Drainage Embankment +Vegetation	○	○	○			○	○	
N003C140	S.S + R.C	Recutting + Drainage Embankment +Concrete retaining wall + Vegetation + Drainage	○	○	○		○	○	○	
N005A010	R.F	Recutting + Drainage		○	○				○	
N026A060	R.F	Recutting + Shotcrete + Drainage		○	○	○				
N026B140	R.C	Recutting + Horizontal drainage + Drainage		○	○				○	○
N026A150	R.F	Recutting +Drainage		○	○				○	
N026B160	R.C	Recutting + Prevention net		○	○		○			

Note) R.F: Rock-fall/collapsing; R.C: Rock collapsing; S.S: Slope Slide; D.F: Debris flow

Table 18.4.2 Main Equipment List for Bridge Damage Repair

Bridge Name		Type of Disaster	Type of Countermeasure	Bulldozer	Back hoe	Concrete breaker	Truck crane	Jumbo breaker
NIC.1	Junquillal	Bridge	Gabion mat		○		○	
	San Nicolas	Bridge	Gabion mat		○		○	
	Las Chanillas	Bridge	Concrete block		○		○	
	San Ramon	Bridge	Gabion mat		○	○	○	
	Inali	Bridge	Gabion mat Revetment +Stone masonry		○	○	○	
	Tapacali	Bridge	Gabion mat Revetment		○	○	○	
NIC.3	Guayacan	Bridge	New bridge construction	○	○	○	○	○
NIC.26	Solis	Bridge	Stone riprap with mortar Gabion mat		○		○	
	Papalon	Bridge	Stone riprap with mortar Gabion mat		○		○	
	San Juan de Dios	Bridge	Gabion mat		○		○	
	La Banderita	Bridge	Stone riprap wall Gabion mat		○		○	

Note) Bridge: Scouring of foundation

18.5 Work Quantities

18.5.1 Summary of Work Quantities

The 30 disaster prevention spots of the six routes of the Study consist of 11 bridges and 19 slopes. The work quantities for the disaster prevention spots are estimated based on the types of countermeasures adopted and the drawings in this study. A summary of the work quantities is shown in Table 18.5.1.

Table 18.5.1 Summary of Work Quantities

Type of Work	Work Item	Remarks	Unit	Quantities		
				Slope	Bridge	Total
(1) Surface drainage	Crest ditch	0.5×0.5 1:1	m	2,758	0	2,758
	Berm ditch	U-0.3×0.3	m	4,115	0	4,115
	Toe ditch		m	2,934	400	3,334
	Vertical ditch	U-0.3×0.3	m	1,321	0	1,321
(2) Horizontal drainage	Horizontal drain hole	PVC PIPE f 0.04	m	546	0	546
(3) Vegetation	Seed spraying with pump		m^2	7,551	0	7,551
(4) Structure	Shotcrete	t=10cm	m^2	3,856	0	3,856
	Concrete cribwork		m^2	711	0	711
	Gabion mat		m^3	0	490	490
(5) Structural support	Stone riprap wall		m^2	0	1126	1,126
	Gravity-type retaining wall		m^3	164	0	164
	Gabion wall		m^3	0	0	0

Type of Work	Work Item	Remarks	Unit	Quantities		
				Slope	Bridge	Total
	T-shaped retaining wall		m^3	1,077	0	1,077
(6) Earth work	Removal		m^3	0	0	0
	Rock cutting		m^3	60,011	0	60,011
	Rock pre-splitting	Rock blasting	m^3	0	108	108
	Soil cutting		m^3	40,394	0	40,394
	Embankment		m^3	27,354	3500	30,854
(7) Rock-fall prevention device	Prevention net		m^2	26,032	0	26,032
	Prevention fence		m^2	0	0	0
	Barrier with gabion mat		m^3	0	0	0
	Barrier with concrete wall		m^3	0	0	0
(8) Anchoring	Rock bolt		each	0	0	0
(9) Riverbank protection	Concrete revetments		m^3	0	2107	2,107
	Gabion mat		m^3	812	3327	4,139
	Stone riprap with mortar		m^3	0	122	122
	Concrete cribwork for riverbed		m^2	0	0	0
(10) Abutment & pier protection	Gabion foot protection		m^3	0	0	0
(11) Bridge structure	Steel bridge with concrete slab		m^2	0	500	500
	Gravity-type abutment		m^3	0	58	58
	Reversal T-type abutment(RC)		m^3	0	487	487
(12) Box culvert	Cast in place	3m×2m	m	14	0	14

18.5.2 Spot Specific Work Quantities

Work quantities for each disaster prevention spot are as shown in Table 18.5.2- Table18.5.8.

1) NIC.1

Table 18.5.2 Work Quantities for Countermeasures for Slope Damage

ID. No.	Type of Disaster	Type of Countermeasure		Unit	Quantity
N001A290	R.F	Recutting + Prevention net + Drainage	T	m^2	23,286
N001A280	R.F	Horizontal drainage	P	m	100
N001A240	R.F	Recutting + Prevention net	T	m^2	950
N001B230	R.C	Recutting + Prevention net	T	m^2	228
N001B170	R.C	Recutting + Drainage	P	m^3	36,028
N001B150	R.C	Recutting + Shotcrete + Drainage	P	m^2	252
N001B120	R.C	Recutting + Drainage	P	m^3	10,655

Note) R.F: Rock-fall; R.C: Rock collapsing; P: Permanent countermeasure; T: Temporary countermeasure

Table 18.5.3 Work Quantities for Countermeasures for Bridge Foundation Scouring

Location	Type of Disaster	Type of Countermeasure		Unit	Quantity
113+190	Bridge	Gabion mat	T	m^3	435
135+640	Bridge	Gabion mat	T	m^3	114
150+330	Bridge	Concrete block	T	m^3	288
151+850	Bridge	Gabion mat	T	m^3	86
226+890	Bridge	Gabion mat Revetment +Stone masonry	T	m^3 m^2	1,138 1,758
233+245	Bridge	Gabion mat Revetment	T	m^3 m^2	238 640

Note) Bridge: Scouring of foundation; T: Temporary countermeasure

2) NIC.3

Table 18.5.4 Work Quantities for Countermeasures for Slope Damage

Location	Type of Disaster	Type of Countermeasure		Unit	Quantity
N003B400	R.C	Recutting + Drainage	P	m^3	290
N003B370	R.C	Recutting + Drainage	P	m^3	1,676
N003B320	R.C	Embankment + Concrete retaining wall + Vegetation	P	m^3	3,168
N003C230	S.S + R.C	Recutting + Cribwork +Drainage Embankment + Vegetation + Drainage	P	m^2 m^3	638 4,934
N003E170	D.F + R.C	Dam Recutting + Drainage	P	m m^3	20 2,670
N003C150	S.S + R.C	Recutting + Drainage Embankment +Vegetation	P	m^3	9,221 16,076
N003C140	S.S + R.C	Recutting + Drainage Embankment +Concrete retaining wall + Vegetation + Drainage	P	m^3	5,408 3,176

Note) R.C: Rock collapsing; S.S: Slope Slide; D.F: Debris flow; P: Permanent countermeasure

Table 18.5.5 Work Quantities for Countermeasures for Bridge Foundation Scouring

Location	Type of Disaster	Type of Countermeasure		Unit	Quantity
119+050	Bridge	New bridge construction	P	m^2	500

Note) Bridge: Scouring of foundation; P: Permanent countermeasure

3) NIC.5

Table 18.5.6 Work Quantities for Countermeasures for Slope Damage

Location	Type of Disaster	Type of Countermeasure		Unit	Quantity (m^2)
N005A010	R.F	Recutting + Drainage	P	m^3	10,760

Note) R.F: Rock fall; P: Permanent countermeasure

4) NIC.26

Table 18.5.7 Work Quantities for Countermeasures for Slope Damage

Location	Type of Disaster	Type of Countermeasure		Unit	Quantity
N026A060	R.F	Recutting + Shotcrete + Drainage	P	m^2	3,604
N026A140	R.C	Recutting + Horizontal drainage + Drainage	P	m^3	11,495
N026A150	R.F	Recutting +Drainage	P	m^3	2,113
N026B160	R.C	Recutting + Prevention net	T	m^2	1,568

Note) R.F: Rock fall; R.C: Rock collapsing; Permanent countermeasure; T: Temporary countermeasure

Table 18.5.8 Work Quantities for Countermeasures for Bridge Foundation Scouring

Location	Type of Disaster	Type of Countermeasure		Unit	Qty
107+533	Bridge	Stone riprap with mortar Gabion mat	T	m^3	72 546
108+154	Bridge	Stone riprap with mortar Gabion mat	T	m^3	50 408
155+785	Bridge	Gabion mat	T	m^3	115
170+952	Bridge	Stone riprap wall Gabion mat	T	m^2 m^3	162 375

Note) Bridge: Scouring of foundation; P: Permanent countermeasure

18.6 Summary of Spot Specific Costs

18.6.1 NIC.1

Costs for each disaster prevention spot are as shown in Table 18.6.1- Table18.6.7.

Table 18.6.1 Construction Cost for Countermeasures for Slope Failure

ID. No	Type of Disaster	Type of Countermeasure		Unit	Qty	Cost (US$1000)
N001A290	R.F	Removal + Prevention net + Drainage	T	m^2	23,286	335
N001A280	R.F	Horizontal drainage	P	m	100	10
N001A240	R.F	Removal + Prevention net	T	m^2	950	26
N001B230	R.C	Removal + Prevention net	T	m^2	228	6
N001B170	R.C	Recutting + Drainage	P	m^3	36,028	1,590
N001B150	R.C	Recutting + Shotcrete + Drainage	P	m^2	252	27
N001B120	R.C	Recutting + Drainage	P	m^3	10,655	814
Total						2,808

Note) R.F: Rock fall; R.C: Rock collapsing; P: Permanent countermeasure; T: Temporary countermeasure

Table 18.6.2 Construction Cost for Countermeasures for Bridge Foundation Scouring

ID. No	Type of Disaster	Type of Countermeasure		Unit	Qty	Cost (US$1000)
Junquillal	Bridge	Gabion mat	T	m^3	435	42
San Nicolas	Bridge	Gabion mat	T	m^3	114	25
Las Chanillas	Bridge	Concrete block	T	m^3	288	189
San Ramon	Bridge	Gabion mat	T	m^3	86	9
Inali	Bridge	Gabion mat Revetment +Stone masonry	T	m^3 m^2	1,138 1,758	828
Tapacali	Bridge	Gabion mat Revetment	T	m^3 m^2	238 640	282
Total						1,375

Note) Bridge: Scouring of foundation; T: Temporary countermeasure

18.6.2 NIC.3

Table 18.6.3 Construction Cost for Countermeasures for Slope Failure

ID. No	Type of Disaster	Type of Countermeasure		Unit	Qty	Cost (US$1000)
N003B400	R.C	Recutting + Drainage	P	m^3	290	40
N003B370	R.C	Recutting + Drainage	P	m^3	1,676	175
N003B320	R.C	T-shaped retaining wall +Refilling+ Vegetation+ Drainage	P	m^3	3,168	239
N003C230	S.S + R.C	Recutting + Cribwork + Vegetation+ Drainage Embankment + Vegetation + Drainage	P	m^2 m^3	638 4,934	328
N003E170	D.F + R.C	Concrete dam + Box culvert Recutting + Drainage	P	m m^3	20 2,670	310
N003C150	S.S + R.C	Recutting + Drainage Embankment +Vegetation+ Drainage	P	m^3	9,221 16,076	918
N003C140	S.S + R.C	Recutting +Horizontal drainage + Drainage Embankment +T-shaped retaining wall + Vegetation + Drainage	P	m^3	5,408 3,176	749
Total						2,759

Note) R.C: Rock collapsing; S.S: Slope Slide; D.F: Debris flow; P: Permanent countermeasure

Table 18.6.4 Construction Cost for Countermeasures for Bridge Foundation Scouring

ID. No	Type of Disaster	Type of Countermeasure		Unit	Qty	Cost (US$1000)
El Guayacan	Bridge	New bridge construction	P	m^2	500	1,379

Note) Bridge: Scouring of foundation; P: Permanent countermeasure

18.6.3 NIC.5

Table 18.6.5 Construction Cost for Countermeasures for Slope Failure

ID. No	Type of Disaster	Type of Countermeasure		Unit	Qty	Cost (US$1000)
N005A010	R.F	Recutting + Drainage	P	m^3	10,760	389

Note) R.F: Rock fall; P: Permanent countermeasure

18.6.4 NIC.26

Table 18.6.6 Construction Cost for Countermeasures for Slope Failure

ID. No	Type of Disaster	Type of Countermeasure		Unit	Qty	Cost (US$1000)
N026A060	R.F	Recutting + Shotcrete + Drainage	P	m^2	3,604	316
N026A140	R.C	Recutting + Horizontal drainage + Drainage	P	m^3	11,495	904
N026A150	R.F	Recutting +Drainage	P	m^3	2,113	210
N026B160	R.C	Removal + Prevention net +Drainage	T	m^2	1,568	13
Total						1,443

Note) R.F: Rock fall; R.C: Rock collapsing; P: Permanent countermeasure; T: Temporary countermeasure

Table 18.6.7 Construction Cost for Countermeasures for Bridge Foundation Scouring

ID. No	Type of Disaster	Type of Countermeasure		Unit	Qty	Cost (US$1000)
Solis	Bridge	Stone riprap with mortar Gabion mat	T	m^3	72 546	66
Papalon	Bridge	Stone riprap with mortar Gabion mat	T	m^3	50 408	51
San Juan de Dios	Bridge	Gabion mat	T	m^3	115	5
La Banderita	Bridge	Stone riprap wall Gabion mat	T	m^2 m^3	162 375	31
Total						153

Note) Bridge: Scouring of foundation; P: Permanent countermeasure

18.6.5 Total Cost

Total construction cost for each route is as shown in Table 18.6.8.

Table 18.6.8 Total Construction Cost by Route

Objective Route	Cost (US$1000)		
	Slope	Bridge	Total
NIC.1	2,808	1,375	4,183
NIC.3	2,759	1,379	4,138
NIC.5	389	0	389
NIC.26	1,443	153	1,596
Total	7,399	2,907	10,306

US$1=C$14.4 (exchange rate as of October 14, 2002)

CHAPTER 19

ENVIRONMENTAL IMPACT ASSESSMENT

CHAPTER 19 ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

19.1 Method of EIA

19.1.1 Target Spot of EIA

The EIA covers the thirty spots specified in Chapter 14.

19.1.2 Method of EIA

The EIA assesses the level of consideration given by countermeasures to the environmental negative factors selected for each spot in Chapter 9. Validity of the method of environmental consideration is judged based on "The summary of general matters for environment observance in the construction stage" (Chapter 5 of NABCV in NIC 2000). As for items that are difficult to assess and environmental considerations under construction, it is suggested that these be compiled as carryover items to the next step.

19.2 Evaluation of Environmental Consideration

19.2.1 Resettlement

Resettlement (a hotel under construction) was originally forecast at one spot (Nic3) among the target spots. However, this was averted by revising works as shown in Table 19.2.1.

Table19.2.1 Consideration Items for Avoidance of Resettlement

Spot No.	Countermeasure	
	Initial Idea	Final Idea
N003B320	It was forecast that the hotel would fall on in the excavation line due to cutting works.	Cantilever retaining wall was adopted to ensure backfilling at the rear. .

Acquisition needs to be carried out at the spots indicated in Table 19.2.2. However, there are no spots where expropriation causes a trouble judging from present conditions of use. . And, land acquisition is done in accordance with the Nicaraguan law.

Table19.2.2 Consideration Items for Avoidance of Resettlement

NIC 1

No.	Owner of the land	Land use	Countermeasure
N001B120	No information available	Shrub and second growth vegetation	Re-cutting, Concrete frame + Cobble, Drainage, Removal of Bolders
N001B150	Paulo Gonzalez	Pasture land	Slope fairing, Shotcrete, Drainage
N001B170	Paulo Gonzalez	Pasture lands	Slope fairing, Concrete frame + Vegetation, Drainage, Removal of Bolders
N001A280	Nicasia Gutierrez	Pasture land	Re-cutting, Vegetation, Drainage
N001A290	Carlos Rodriguez	Pasture land, corn, wood	Barrier with wall, Drainage, Removal of Bolders

NIC3

No.	Owner of the land	Land use	Countermeasure
N003B400	Rafael Rayos Torres	Pasture land	Re-cutting, Concrete frame + Vegetation, Drainage,
N003B370	No information available	Pasture land	Re-cutting, Concrete frame + Vegetation, Drainage,
El Guayacan	José Antonio Hernandez Gonzalez, José Manuel Gustamante	Pasture land Family house	Re-construction of Bridge
N003B320	Roger Castillo Palma	Recreation	Cantilever Retaining Wall, Back Fill
N003C230	Francisco Frey Gonzalez	Pasture land, forest (pine)	Re-cutting, Concrete frame + Vegetation, Drainage, Re-embankment
N003E170	Erick Kuhl (dueño del hotel Selva Negra), Felipe Lopez	Horticulture	Dam, Re-cutting, Concrete frame + Vegetation, Drainage
N003C150	Jorge Salazar	Coffee plantation	Re-cutting, Concrete frame + Vegetation, Drainage, Cantilever Retaining Wall
N003C140	Manuel Lanzas Ponce	Pasture land	Re-cutting, Concrete frame + Vegetation, Drainage, Cantilever Retaining Wall

NIC5

No.	Owner of the land	Land use	Countermeasure
N005A010	Nicolas Lopez	Horticulture	Re-cutting, Concrete frame + Vegetation, Drainage

NIC26

No.	Owner of the land	Land use	Countermeasure
N026A060	Fabian y José Altamirano	Corn and others	Slope fairing, Shotcrete, Drainage
N026B140	Abraham Mairena	Pasture land	Re-cutting, Concrete frame + Cobble, Drainage
N026A150	Abraham Mairena	Pasture land	Re-cutting, Concrete frame + Cobble, Drainage
N026B160	Pedro Urritia (father and son)	Pasture land, sometime corn	Prevention Net, Removal of Bolders

19.2.2 Economic Activity

Concern was raised over the impact on economic activities at four of the spots; however, measures were taken at each spot to avert this economic impact as indicated in Table 19.2.3.

Table19.2.3 Consideration Items for Economic Activity

Spot No.	Countermeasure	
	Initial Idea	Final Idea
Junquillal (Nic1)	An influence on the service water for rice fields on the downstream side was forecast by the shutoff of water under the construction.	It is the plan to secure the service water by half-section construction.
N003B320	As mentioned in the Table 19-1.	As mentioned in Table 19-1.
N003C140	It was forecast that a coffee field under the embankment will be affected by the construction.	It is the plan to avoid an influence by the wall.
N003C150	A coffee field was confirmed at the top of the slope as a result of the site re-survey.	Influence was minimized by countermeasures matched to the existing slope as much as possible.

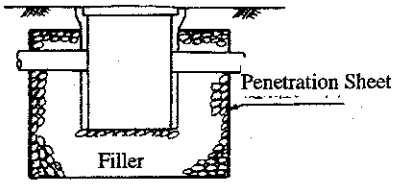
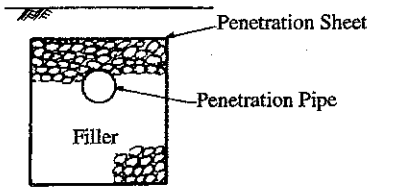
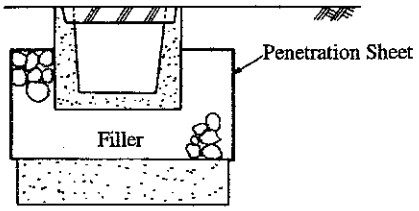
19.2.3 Ground Water

Concern was raised over the impact on three shallow wells that utilize non-artesian ground water. As for the N026B160 point, since the shallow well was found to have a depth 98-foot (about 30m) and to use artesian water, it is deemed there will be no impact. As for the remaining two points, a percolation layer existed under the thin weathering layer as a result of the geological survey. Therefore, countermeasures were devised to minimize impact on the water catchment volumes shown in Tables 19.2.4 and 19.2.5.

Table19.2.4 Consideration Items for Ground Water

Spot No.	Countermeasure	
	Initial Idea	Final Idea
N005A010	Re-cutting + Vegetation + Drainage	Concrete Frame + Vegetation + Drainage (permeation catch pit)
N026B140	Re-cutting	Concrete Frame + Cobble + Drainage (permeation catch pit)
N026B160	Judgment as use of the non-artesian water	Use of confined water.

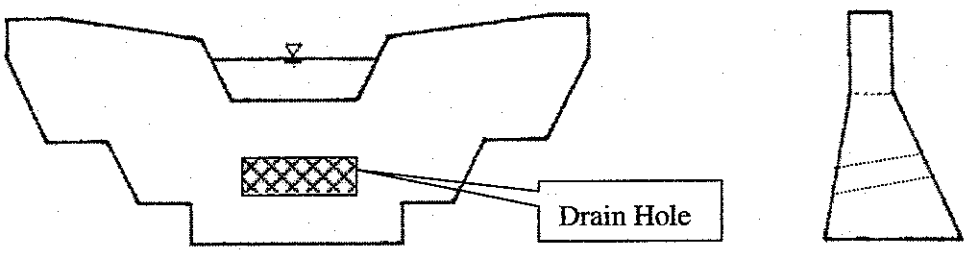
Table19.2.5 The Drainage Structure in Consideration of the Underground Permeation

e.g. Structure	General Outline
	Permeation Catch Pit Permeation catch pit is the structure composed of catch pit that it has perforations on the side and the bottom, and filling material on the circumference. And, rainwater is made to permeate from the sides and bottom to the ground.
	Permeation Trench Permeation trench is the structure composed of permeation pipe and filling material of the circumference. And, rainwater is made to permeate from the sides and bottom to the ground.
	Permeation Side Ditch A permeation side ditch is the structure composed of sides and bottom made from permeable or perforated concrete, and circumference made from filling material. And, rainwater is made to permeate from the sides and bottom to the ground.

19.2.4 Lake and River

Concern was raised over the impact on the river (river use) in one place. However, the structure was revised so that impact on river flow was avoided as shown in Table 19.2.6.

Table19.2.6 Consideration Item for River Use

Spot No.	Dam
N003E170	

19.2.5 Fauna and Flora

Concern was raised over the direct and indirect impact on the national conservation area (precious animals and plants) in the following two spots. However, it is the plan to avoid any influence as shown in Table 19.2.7.

Table19.2.7 Consideration Items for Fauna and Flora

Spot No.	Pending Issue	Measure
San Nicolas (Nic1)	There was concern that water supply to the animals will decrease due to shutoff of water by the construction to the Cerro Tomabu national conservation area on the downstream side.	Carry out construction in the dry season without resorting to water shutoff.
N003C230	Because the spot was located in Cerro El Arenal national conservation area, countermeasures had to take vegetation regeneration into consideration.	It is the plan to regenerate vegetation by doing planting in the concrete frame. (Refer to Fig. 19.2.1) The planting is carried out using native species or latent natural seedings. And, the embankment is planted with trees to harmonize with the surrounding landscape.

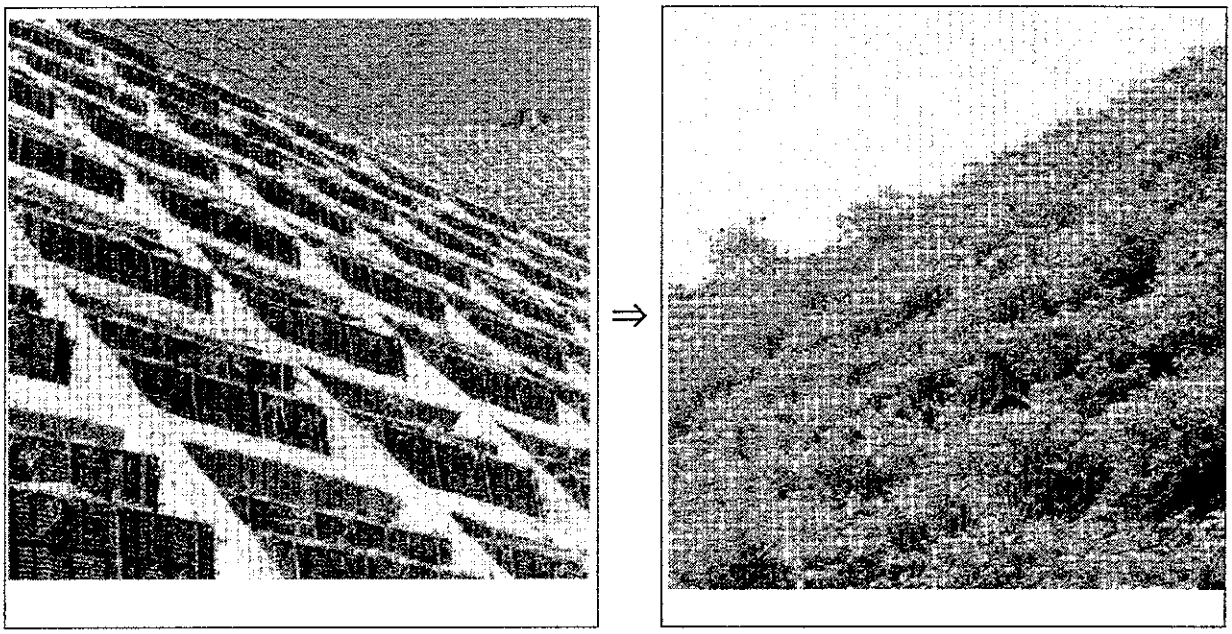
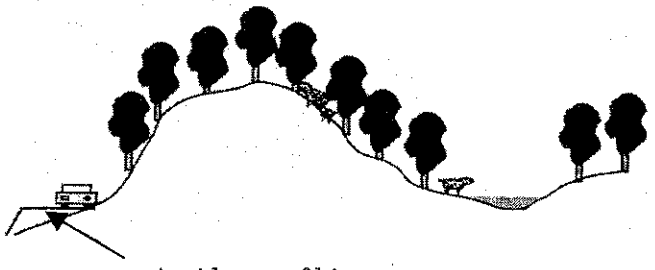
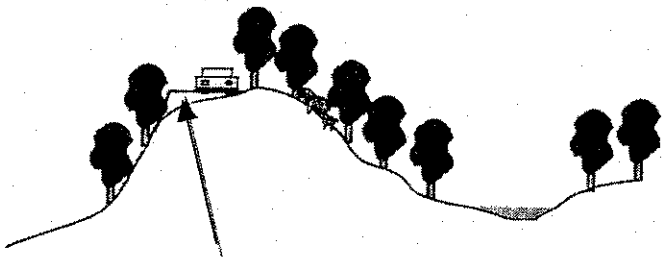
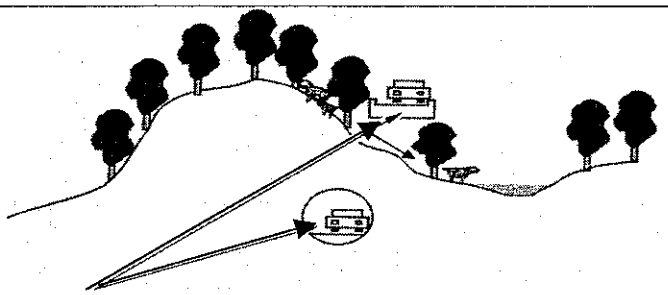
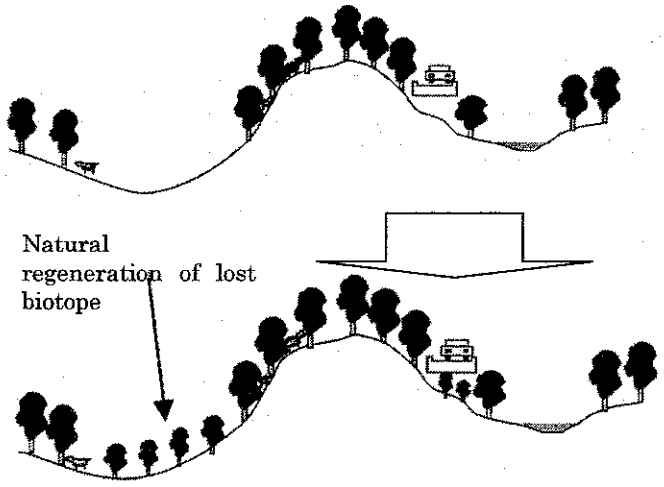


Figure 19.2.1 e.g. Planting in the Concrete Frame

As shown in Chapter 9, as for trees that are cut down by the construction, an alternative spot is secured in accordance with the mitigation measures (refer to Table 19.2.8) as for other spots as well. On this occasion, suitable species are selected to match with the surrounding environment.

Table19.2.8 Method of Mitigation

Echelon	Explanation	
Avoiding	 Avoidance of biotope	Avoidance from biotope and movement zone.
Minimizing	 Avoidance of core biotope Acceptance of the structure that minimizes impact	Avoidance from core biotope. Minimization of embankment and cut.
Balancing	 Acceptance of structure that secures he animal movement zone	An impact is made to balance in the same point.
Restoration or Compensating	 Natural regeneration of lost biotope	It alternates the impact elsewhere. An alternative spot is secured elsewhere. Unavoidable impact is compensated for. *Four tree-planting duties for one felling by the guidance of MARENA are contained here.

19.2.6 Landscape

N003C230, where countermeasures are enforced directly in the national conservation area, was made the target for careful consideration to the landscape. As was mentioned above, it is planned to take countermeasures here that give careful consideration to vegetation that matches with the surrounding natural landscape. And, vegetation of the embankment by tree plantation and lawn seed coating is planned as early as possible in accordance with progress of the construction to achieve harmony with the landscape of the circumference.

19.3 The Points to Concern for The Next Step

Concerning responsibility to the legal environment in the construction contract stage, the section 108 of NIC2000 must be referred to. And, as for the points of concern with the environment in the stage of the basic design, the detailed design and the construction, it is important to confirm the mentioned items of NABCV fully.
Concern here is only directed to items that should be considered in the construction stage, and these are evaluated by the detailed construction plan in the environment impact factors selected with IEE including the correspondence with NIC2000.

19.3.1 Living and Transportation Facilities (Refer to Nic2000 108.14, NABCV 5.1)

Effort shall be made not to influence the social infrastructure and access to work places. Moreover, the construction work must not hinder the economical activities of inhabitants.
In cases where the above points are unacceptable, a contractor must provide equal facilities to those that are affected.

19.3.2 Waste (Refer to Environmental Basic Law, Chap.3)

1) General

Generally surplus soil is used for holes around roads, gully erosion, and reclamation of borrow pits. There must be no damage to surrounding vegetation and arable land, and moreover it cannot be disposed or used to pollute rivers and the environment. Disposal on slopes is also prohibited. Landowner's permission must be obtained in advance when disposing on private land.
Waste material must be taken to the disposal site that is specified from the construction spot at once. On this occasion, the quantity and kind of the waste materials are specified, and permission must be obtained from the related organization in advance. (Note: In advance, an interview with the city mayor is given in advance to explain about the effect and the purpose of the construction.) And, consideration must be taken to ensure that conveyance of the waste

materials doesn't become an expensive cost item in the project.

As for the removed asphalt waste, it shall be recycled for use as road sub-base.

Waste oil shall be collected by a special enterprise, and carried to the treatment plant for recycling. Adjustment with these enterprises about taking back waste oil from the workshop is necessary.

The waste materials of concrete and the stone block shall be used in protection walls of embankment, slope and the erosion points. And, they can be buried in the road circumference area under the approval of the adjustment organization about the environment and the natural resources, MARENA, the cities public office and the landowner in advance. In cases of disposal inside rights of way, the permission of MTI is necessary.

2) Control Method of Waste Material

Every kind of waste must be controlled as mentioned in Table19.3.1.

Table19.3.1Control Method of Waste Material

Category	Method
Waste Oil	Waste oil such as lubricating oil and fuel is collected by special hydrocarbon handling enterprise. The contractor must adjust it properly between the nearest fuel stores of the construction site so that those enterprises may carry waste oil to the receiving refinery. 1) The contractor must prepare the workshop or the place of the oil exchange installed with a transport pipe to oil tank or waste oil collection tank. 2) That place is made waterproof, and it must be controlled fully so that waste oil may not leak outside. 3) Generally that equipment is made by masonry with overcoat. 4) The contractor must store up waste oil in secrecy containers of 55 gallons for collection by the recycling company. 5) Waste oil is used for lumber curing for the pattern frame. The precise control of the waste oil is necessary because of that.
Surplus Soil	Generally surplus soil is separated into inorganic substance and organic substance. Disposal of waste materials, surplus soil and the excavation materials is critical from the economic and environmental viewpoints. Therefore, as for specification of the place and the operation, characteristics in drainage, and physical and geographical factors must be taken into consideration fully in each place. 1) The surplus soil of inorganic substance is used for the reclamation of the area with no vegetation, gullies and bog holes. Or it used for the reclamation of bog holes collected embankment materials. 2) When any kind of waste including the surplus soil is disposed in private land, landowner's permission should be necessary. 3) It is prohibited to throw solid waste away in the flow of the water and the mountainside slope . 4) Waste materials are removed from the construction site at once, and they must be carried to the final disposal place. 5) The surplus soil of the inorganic substance must not be accumulated on unstable areas and important areas from the viewpoint of environment and agricultural production sites. When it can be carried to the disposal sites of neighboring cities, inert

Category	Method
	waste is carried under the advance understanding of the cities. Generally the layer of organic matter which forms the surface of the soil is mixed with plant waste or useful microorganisms which support the ventilation of the soil. The plant layer abounds in nutritious elements resulting from elements of the organic matter and corrosion acid. 1) A layer of organic matter has indispensable biological and physical resources as to the development of the creature activities, the natural regeneration and re-greening of the land where it was exposed. Therefore, it must be kept in the place where it is selected in advance. 2) A layer of organic matter is used for the natural regeneration of slope which is formed by construction in the construction stage. 3) A surface must be made flat with less than 2 m height to prevent that from being compacted while it keeps the layer of organic matter. 4) It is desirable to mix it with the remaining plants to increase the content of organic material or the seed.
Removed Asphalt	Generally asphalt waste materials are recycled by a contractor as roadsub-base. These waste materials are put on the reclaimed land approved by surrounding cities. Because the landscape is hurt and soil and arable land are polluted, asphalt waste materials must not be put by the side of the road. If suitable technology exists, recycling of the asphalt layer is a wonderful substitutive technology.
Removed Concrete	Generally concrete waste materials occur from removal of the existent road or the concrete blender. This debris is used for the boundary of camp yards or roads, and embankment protection. And, it can be disposed of in city-managed sites, too. Or, it can be buried in private land under the permission of landowners and MARENA, too. It is used for small drywall construction of embankment protection so that some of these waste materials may minimize the progress of the erosion.
Lumber	Generally pieces of lumber are used as the timber pile of the topographic survey. The pieces of the lumber are kept in order. Then, they are delivered for use by inhabitants around the construction site as firewood. Because it has the possibility to induce fire, it isn't suitable to burn up the lumber. It is sent to the city-managed sites and can be disposed in final disposa sites too.
Stone	Remaining crushed stone is disposed in vacant lots of excavation or cutting soil in quarries. It can also be handed over to municipal or village public offices . The stone that appeared from excavation or cutting soil can be used for the drywall for embankment protection.
Waste Water	The waste water produced in the washing process of the aggregate also makes sediment occur. This water is channeled to grit tank through the waterway, and it is used as washing water again. The mud which accumulates in the grit tank is carried regularly to the drying place, and carried to the final disposal area of surplus soil permitted in advance. As for polluted water such as that from stone washing not done under sanitary management in advance, river disposal is not permitted under any circumstances. Construction campsites must be provided with septic tanks for the sewage treatment to promote accumulation and the resolution of the mud. This mud is dried regularly, and it must be locked up in the hole specified by environment supervisor of the project.

Category	Method
Others	Cement bags discarded in concrete and masonry preparation areas are also subject to control.

19.3.3 Water Pollution (Refer to NIC2000 108.31,205)

The contractor must put all necessary plans in action to protect rivers, lakes, lagoons, ponds, swamps, bays and coast against the harmful materials of fuel and oil, bituminous materials, calcium chloride and others. Then, the plan that minimizes the precipitation of that liquid material must be integrated into that operation.
The contractor submit the program which prevents the pollution of the water effectively to the technician before the working start of the project, and the contractor must get that approval.

19.3.4 Noise and Vibration (Refer to NIC2000 108.31,NABCV 5.3)

A contractor must formulate rules and a control system concerning all work that generates noise which disturbs or causes menace to the peace and health of workers and inhabitants. Noise and vibration shall be reduced on construction sites, and sources of noise shall be removed or reduced as far as it is possible. The rough finishing of road surfaces must be avoided to reduce noise from tires in fragile environmental areas. The contractor must keep passage of large trucks as far away from areas of residence as possible, especially at night.
As for tranquil residential areas in city suburbs, machines which cause noise beyond 70 dB in Level A (the measurement of a distance 15m) can't be used from 6 p.m. until 7 a.m. However, exceptions shall be made in emergencies or when there is technician's special permission. When sterner local standards exist in comparison with this standard, local standards take precedence in all cases.

note: Level A

A-Weighted sound pressure level. It is written with L_A, and units are unified in dB.

19.3.5 Air Pollution (Refer to NIC2000 108.31,NABCV 5.3)

The following items must be observed about the air pollution.

- The motors of construction machines shall be maintained s that the discharge of carbon monoxide or the hydrocarbon is minimized.
- Avoid burning of plant waste from road site felling, root removal and plant clearing

on quarries and campsites as far as possible except where MTI or MARENA standards permit.

- Use dust collector machines in asphalt and concrete plants and other dusty plants.
- Avoid the discharge of the dust at the time of earth excavation and embankment construction by sprinkling with water to the unstable material so far as it is possible.
- Stabilize conveyance roads by sprinkling with water or additive.
- Observe the law and the applicable rules concerning the control of paints used for the construction, dilution medicine, the concrete and the curing compound for the asphalt, and so on.

These measures are strictly applicable when construction is carried out just near cities or villages. And, the special permission of MARENA must be sought before doing that work when powdered dust of at least 4.5kg scatters in the atmosphere.

19.3.6 Other Precautions

Before the execution of the construction, MTI shall submit the documents shown in Appendix-B2 to MARENA, and EIA needs and other environmental considerations shall be confirmed. After EIA and so on is carried out if necessary, environmental permission containing general and/or independent precautions about the prevention and reduction measures which a contractor should take, will be handed over to the client.

19.4 Evaluation at Present

It is judged that adequate countermeasures are being taken with respect to items that are immediately pertinent to minimization of environmental impact. Final evaluation of every site is shown in Table 19.4.1.

Table19.4.1 Evaluation of Each Spot for Environmental Impact

Enviroment Item			Stage of IEE																											
			Nic.1												Nic.3								5	Nic.26							
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Social Environment	1	Inhabitant Transfer	D*	B	D	D	D	D	B	B	B	B	B	D	D	B	B	D	A	B	B	B	B	B	B	D	B	B	B	D	D	D
	2	Economic Activity	D	D	A	D	D	D	D	D	D	D	D	D	D	D	D	D	A	D	D	D	A	D	D	D	D	D	D	D	D	D
	3	Facility for Life and Traffic	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
	4	Waste	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
Natural Environment	5	Ground Water	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	B	D	D	B	D	B	D	D	D
	6	Lake/Liver	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	B	D	D	D	D	D	D	D	D	D	D	D
	7	Fauna/Flora	D	D	D	A	D	D	D	D	D	D	D	D	D	D	D	D	D	D	B	D	D	D	D	D	D	D	D	D	D	D
	8	Landscape	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	B	D	D	D	D	D	D	D	D	D	D	D
Pollution	9	Air Pollution	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
	10	Water Pollution	B	B	B	B	B	B*	B	B	B	B	B	B*	B*	B	B	B	B	B	B	B	B	B*	B	B	B	B	B*	B	B	B
	11	Noise/Vibration	D	D	D	D	B	D	D	D	D	D	D	D	D	D	D	B	B	D	D	D	D	D	D	D	D	D	B	D	D	D
Countermeasure by Primary Survey			GW	PN	GM	GM	GM	GM	PN	PN	R+S	R+S	R+S	GM	GM	R	R	RW	R	R+R E+C W+V	D	R+R E+C W+V	R+R E+C W+V	R+S D+V	R+S	GM	R	R+S	PN	GM	GM	GM

*: Existance of Particular Condition.

Enviroment Item			Stage of EIA																											
			Nic.1													Nic.3								5	Nic.26							
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Social Environment	1	Inhabitant Transfer	B	B	D	D	D	D	D	D	B	B	B	D	D	B	B	B	B	B	B	B	B	B	B	D	B	B	B	D	D	D
	2	Economic Activity	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	B	D	D	D	D	D	D	D	D	D	D
	3	Facility for Life and Traffic	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
	4	Waste	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
Natural Environment	5	Ground Water	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
	6	Lake/Liver	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
	7	Fauna/Flora	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
	8	Landscape	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Pollution	9	Air Pollution	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
	10	Water Pollution	B	B	B	B	B	B*	B	B	B	B	B	B*	B*	B	B	B	B	B	B	B	B	B*	B	B	B	B	B*	B	B	B
	11	Noise/Vibration	D	D	D	D	B	D	D	D	D	D	D	D	D	D	D	B	B	D	D	D	D	D	D	D	D	D	B	D	D	D
Countermeasure by Fainal Survey			CW+ BR+ SD	R+S D+V	GM	GM	GM	GM	BR+ PN	BR+ PN	SF+ CF+ SD+ BR	SF+S +SD	R+C F+S D+G D+B R	GM	GM	R+C F+V +SD	R+C F+V +SD	NB	CW+ GD	R+C F+V +SD +GD +RE	D+R +CF +V+ SD	R+C F+V +SD +GD +RE	R+C F+V +SD +GD +CW	R+C F+V +SF +GD	SF+S +SD	GM	R+C F+S D+G D	R+C F+S D+G D	BR+ PN	GM	GM	GM

Note : GM (Gabion Mat) CM (Concrete Mat) NB (New Bridge) GW (Gabiaon Wall) CW (Concrete Wall) CF (Concrete Flame) R (Recutting) S (Shotcrete) PN (Prevention Net) BR (Boulder Removal) CW (Counter Weight) D (Dam) V (Vegitation) C (Culvert) SD (Surface Drainage) GD (Ground Drainage) RW (Reconstruction Wing Wall) RE (Re-embankment) SF (Slope Fairing) BP (Bank Protection)

NIC.1	
1	N001A290
2	N001A280
3	Junquillal
4	San Nicolas
5	Las Charullas
6	San Ramon
7	N001A240
8	N001B230
9	N001B170
10	N001B150
11	N001B120
12	Rio Inali
13	Rio Tapacali
NIC.3	
14	003B400
15	003B370
16	El Guayacan
17	N003B320
18	N003C230
19	N003E170
20	N003C150
21	N003C140
NIC.5	
22	N005A001
NIC.26	
23	N026A006
24	La Bandeera
25	N026B140
26	N026A150
27	N026B160
28	San Juan de Dios
29	Papaloni
30	Solis

CHAPTER 20

IMPLEMENTATION PLAN

CHAPTER 20 PROJECT EVALUATION

20.1 General

As noted in Chapter 13 the traffic benefits that would result from disaster prevention measures are evaluated by calculating the dis-benefits to traffic of a disaster occurring. It is assumed that at each site a disaster would result in the closure of that particular link in the network and the need for traffic to re-route. When traffic re-routes to avoid the closed link it potentially incurs two types of dis-benefit;

- increased vehicle operating costs due to additional distance; and
- increased passenger time costs.

These two parameters are evaluated by the JICA STRADA model by running the model for two cases : with the affected link in place (a common base), and without the link in place. The aggregate differences over the network, for each vehicle mode, of vehicle-kilometres and vehicle-hours are calculated.. These are converted to monetary benefits using the parameters developed in the Chapter 11 and set out in Table 20.1.1.

Table 20.1.1 Vehicle Operating Costs and Passenger Costs, Nicaragua 2002

Vehicle type	*Operating Cost per 1000 km, US $*	*Passenger Costs per vehicle hour*
Car	185.5	2.84
Utility	215.1	1.09
Average Bus	529.7	14.90
Light Goods	549.1	1.04
Medium Goods	768.2	1.04
Heavy Goods	878.5	0.75

Source : NIC2000 Transport Plan and year 2002 prices

The costs of disaster prevention measures are expressed in terms of the capital cost of works (assumed to be incurred in 2003) and the continued maintenance cost of the link. The costs of temporary prevention measures are assumed to recur every twelve years. Permanent measures incur a single capital cost, but annual maintenance costs thereafter. Costs of preventative measures have been revised since the Interim Report. These preliminary engineering costs, prepared in Chapter 18, have been uprated by a factor of 1.23 to give the full costs. The additional cost factors are shown in Table 20.1.2. Revised costs are set out in Table 20.1.3.

Locations of vulnerable sites are shown in Figure 20.1.1.

Table 20.1.2 Full Cost Breakdown of Countermeasures

Component	*% of Engineering Works*
Engineering works	100.0
Design	5.0
Construction Supervision	7.5
Client Costs	0.9
Transport of materials	5.0
Contingency	5.0
Total	123.4

Source : International norms

Table 20.1.3 Costs of Countermeasures by Site

Road	*Site no.*	*Site ID*	*Full Economic Cost (US $)*
NIC.1	1	N001A290	413,370
NIC.1	2	N001A280	12,339
NIC.1	3	Junquillal	51,825
NIC.1	4	San Nicolás	30,849
NIC.1	5	Las Chanillas	233,215
NIC.1	6	San Ramón	11,105
NIC.1	7	N001A240	32,082
NIC.1	8	N001B230	7,404
NIC.1	11	N001B170	1,961,965
NIC.1	12	N001B150	33,316
NIC.1	13	N001B120	1,004,427
NIC.1	18	Rio Inalí	1,021,702
NIC.1	19	Rio Tapacalí	347,971
NIC.3	24	003B400	49,358
NIC.3	25	003B370	215,940
NIC.3	26	El Guayacán	1,701,604
NIC.3	27	N003B320	294,912
NIC.3	29	N003C230	404,732
NIC.3	30	N003E170	382,521
NIC.3	32	N003C150	1,132,757
NIC.3	33	N003C140	924,221
NIC.5	35	N005A010	480,003
NIC.26	44	N026A060	389,925
NIC.26	45	La Banderita	38,252
NIC.26	49	N026B140	1,115,482
NIC.26	50	N026A150	259,127
NIC.26	51	N026B160	16,041
NIC.26	52	San Juan de Dios	6,170
NIC.26	54	Papalón	62,931
NIC.26	55	Solís	81,440
Total			**12,716,988**

Source : Tables 18.6.1 to 18.6.7, and Table 20.1.2

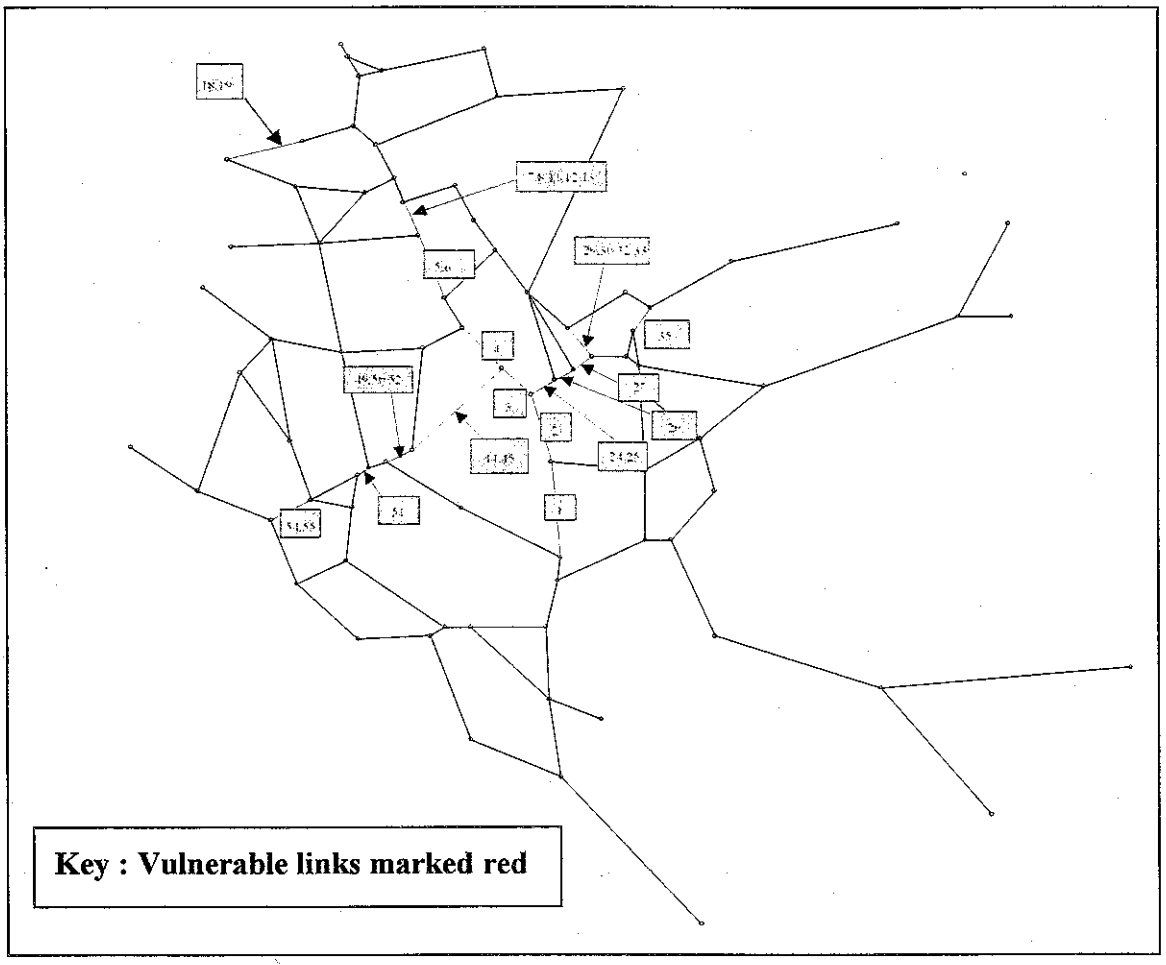


Figure 20.1.1 Locations of 30 Vulnerable Road Sites for Evaluation

Table 20.1.4 lists the parameters used in the economic evaluation.

Table 20.1.4 Economic Evaluation Parameters

Parameter	*Value*	*Source*
Discount Rate	10%	International Norm
Discount period	18 years	2003 to 2020
Maintenance cost for permanent works	2% of capital cost per year	Assumption
Implementation of counter measures	2003	Assumption
Start year of benefit flow	2004	Assumption

20.2 Economic Analysis

The economic evaluation relies on quantifying disadvantages that flow from road closures due to a natural disaster. The scale of the disbenefits is a function of the amount of traffic, and the length and quality of alternative routes available to traffic.

However, the disaster prevention spots are requested the emergency. Furthermore, it is not

able to fix the disaster occurrence probability because natural disasters occur frequently on the project roads. In Nicaragua, the "rainy" season (which includes the onslaught of typhoons) lasts from April to October. As a result of this six-month period of rains, it is unavoidable that some roads will become impassable due to land and rock slides, severe scouring of bridge foundations, etc. For this reason, it has been decided that the frequency of disasters should be derived applying past data that experienced the heaviest rains. Maximum hourly rainfall data for the past 20 years are as shown in Table 20.2.1. As the table indicates, there are variations in the figure. For example, the figure for maximum hourly rainfall in the year that experienced Hurricane Mitch is abnormally large as compared to the figures for the previous and following years. Accordingly, after much consideration, the Study has selected 200 mm/h of rain or more as the figure for when rock foundations experience cracking due to water infiltration, land and rock slides occur, etc. Based on this, it can be seen that there were seven times that this figure was exceeded over the twenty year period from 1980 to 2000, meaning that every three years a road disaster would occur at the locations requiring disaster prevention measures.

Table 20.2.1 Maximum Annual Hourly Rainfall for the Past 20 Years

Year	Amount of Rainfall (mm/h)	Comments
1980	283.3	
1981	98.9	
1982	85.1	
1983	37.3	
1984	48.5	
1985	245.9	
1986	50.1	
1987	47.5	
1988	217.1	
1989	50.0	
1990	143.6	
1991	96.3	
1992	57.6	
1993	129.4	
1994	112.4	
1995	324.9	
1996	340.4	
1997	157.7	
1998	888.4	Hurricane Mitch
1999	215.0	
2000	82.6	

In addition, as described in Chapter 18, the lifespan of disaster prevention measures shown below are reflected in investment costs.

- Permanent disaster prevention measure: Effective for 20 years
- Temporary disaster prevention measure: Effective for 10 years

The construction period required for implementing road disaster prevention measures (With Project) and the costs for road restoration when no measures are implemented (Without

Project) are as shown in Table 20.2.2. Furthermore, note that there are substantial variations in the construction period required for prevention measures depending on the scale and content of the work involved. For example, installation of the netting to prevent rocks from falling on to the surface a road requires little time, while re-cutting a slope or reinforcing embankments at certain locations will require up to two years.

The costs for road restoration for the "Without Project" case consists of the investment needed to restore a road to its previous condition prior to a disaster. In this case, it is assumed that there is no road closure, and the costs and scale for restoration work will vary depending on whether or not one lane of the existing road can be used or if a temporary detour road has to be built. For example, the use of locally available rock to deal with the scouring of bridges is an inexpensive method of restoration.

Table 20.2.2 Construction Period for Road Disaster Prevention Measures (With Project) & Road Restoration Costs (Without Project)

Item No.	Site	Construction Period (Days)	Road Restoration Costs (US$)
1	N001A290	195	2,000
2	N001A280	449	2,000
3	Junquillal	1663	1,000
4	San Nicolás	596	1,000
5	Las Chanillas	296	1,000
6	San Ramón	1023	1,000
7	N001A240	223	2,000
8	N001B230	213	2,000
11	N001B170	26	2,000
12	N001B150	204	2,000
13	N001B120	43	7,000
18	Rio Inalí	2	5,000
19	Rio Tapacalí	4	1,000
24	003B400	715	2,000
25	003B370	351	2,000
26	El Guayacán	59	1,000
27	N003B320	309	2,000
29	N003C230	44	3,000
30	N003E170	52	2,000
32	N003C150	22	2,000
33	N003C140	27	2,000
35	N005A010	33	2,000
44	N026A060	32	2,000
45	La Banderita	73	1,000
49	N026B140	32	2,000
50	N026A150	92	2,000
51	N026B160	1211	2,000
52	San Juan de Dios	198	1,000
54	Papalón	357	1,000
55	Solís	371	1,000

In the future, some of the main roads in Nicaragua will be upgraded, along with some of the minor roads. Table 20.2.3 shows the planned highway improvements, their status and indication of the effect they have on the economic analysis for this study.

Two schemes have been incorporated into the future year JICA STRADA model tests as commitments : the upgrading of the San Benito to San Lorenzo section of NIC.7, (Managua and Boaco) and the resurfacing of the Santa Cruz to San Nicolas link in Esteli. The implementation of these schemes result in lower journey times on the alternative routes to potential disasters at sites 1 and 4 respectively.

The proposed rehabilitation and improvement of the Guayacan to Jintoega link poses problems for the economic evaluation. At the time of drafting of this report, the status of this scheme is not known. It has a major effect on the benefits of disaster prevention measures on NIC.3 on the section Jinotega-Matagalpa-Guayacan. At the same time, the implementation of measures on NIC.3 will affect the economic evaluation of the Jintoga-Guayacan link. As result, a special evaluation of these sites on NIC.3 was undertaken, in which the economic benefits of disaster prevention measures vary depending when the improvements to the Jinotega-Guayacan link are carried out.

The results of the economic evaluation are shown in Table 20.2.4. In this table, it is assumed that the Jinotega-Guayacan link has not been improved.

Figures 20.2.1 and 20.2.2 show how the benefit/cost ratios of schemes on NIC.3 are affected by the opening date of the Jinotega-Guayacan link. Figure 20.2.2 reveals how sensitive are the cost benefit ratios for sites 29, 30, 32, and 33 to the opening date of improved link. Furthermore, these four sites are all within a short distance (7.2 km) on the same part of NIC.3. Consequently, it is important that all four sites are addressed at the same time, otherwise road failure at just one site would erode all the benefits of any prevention works undertaken at the other sites. The benefit to cost ratio of all four sites takes account of the benefits of maintaining the road open and the costs of all four schemes.

Table 20.2.3 Road Improvement Schemes

Funding Agency	*Road Improvement Scheme*	*Date*	*Effect on Economic Analysis*	*Note*
World Bank	Pacayita-Pacaya	July 2002	None	
World Bank	Los Sabogales-La Hermita	July 2002	None	
World Bank	Masaya-Los Flores	September 2002	None	
World Bank	El Jicaro-Jalapa	September 2002	None	
World Bank	Ocotal Jalapa	September 2002	None	
World Bank	Somoto-San Lucas	September 2002	Very minor effect on sites 18,19 (NIC.1)	*
World Bank	Santa Cruz-San Nicolas	September 2002	Effect on site 4 (NIC.1)	**
World Bank	Muhan to El Rama	May 2002	None	
Government of Japan	El Guasaule Bridge	August 2002	None	
Government of Denmark	San Benito to San Lorenzo	August 2002	Effect on Site 1 (NIC.1)	**
Government of Denmark	Yalaguina to Los Manos	November 2002	None	
BID	San Lorenzo to Muhan	October 2002	None	
OPEP	Tipitapa to Las Flores		None	
Government of Spain	Managua to Masaya to Granada	May 2003	None	
BCIE	Chinandega to Guasaule	Short –term	None	
European Union	Guayacan to Jintoega	Short-term	Major effect on sites 29,30,32,33 and 27 (NIC.3)	***
Government of Spain	Granada to Tecolostote	Medium-term	None	
Government of Spain	La Paz Centro to Villa 15 de Julio	Medium-term	Minor effect on Sites 54 and 55 (NIC.26)	*
Government of Spain	Managua to Las Nubes	Medium-term	None	
BCIE	Santa Clara to El Jicaro	Medium-term	None	
Government of Japan	Bridges at Las Banderas	Medium-term	Very minor effect on Site 1(NIC.1)	*
Government of Taiwan	Corinto to Chinandega	Medium-term	None	
Government of Taiwan	Chinandega to Potosi	Medium-term	None	
Government of Spain	Las Flores to Nandaime	Long-term	None	
Government of Venezuela	Rio Blanco to Siuna	Long-term	None	
Government of Kuwait	Siuna to Puerto Cabezas	Long-term	None	
Government of Taiwan	Acoyapa to San Carlos	Long-term	None	

*Notes : * effects negligbile; ** effects evaluated ; *** special evaluation*

Source : Ministry of Transport and Infrastructure, Development Plan for the Road Network, 2002-2006

Table 20.2.4 Result of Economic Evaluation

Site No	ID No.	Cost (US$)		Benefits($USM)		Benefits - Cost ($US)	Net Present Value ($US)	EIRR	B/C	Average	
		Total Cost (US$)	Total Discounted Cost	Total Benefits	Total Discounted Benefits					EIRR	B/C
1	N001A290	959,018	616,618	6,747,338	3,276,470	5,788,319	2,659,851	4%	5.31		
2	N001A280	16,535	14,190	516,136	454,254	499,601	440,064	44%	32.01		
3	Junquillal	120,235	77,307	2,189,560	1,091,941	2,069,325	1,014,634	12%	14.12		
4	San Nicolas	71,569	46,016	1,141,730	584,712	1,070,161	538,695	12%	12.71		
5	Las Chanillas	541,058	347,883	1,015,448	510,686	474,390	162,803	0.4%	1.47		
6	San Ramon	25,765	16,566	1,015,448	510,686	989,684	494,120	30%	30.83		
7	N001A240	74,431	47,857	1,855,991	937,770	1,781,559	889,914	19%	19.60		
8	N001B230	17,176	11,044	472,346	241,134	455,169	230,091	24%	21.83		
11	N001B170	2,629,033	2,256,222	2,670,153	2,401,084	41,120	144,861	0.3%	1.06		
12	N001B150	44,644	38,313	823,606	730,977	778,962	692,664	24%	19.08		
13	N001B120	1,345,933	1,155,072	1,589,184	1,394,328	243,252	239,256	0.5%	1.21		
18	Rio Inali	2,370,350	1,524,059	857,206	420,114	-1,513,143	-1,103,945	0%	0.28		
19	Rio Tapacali	807,293	519,064	454,892	223,324	-352,401	-295,740	0%	0.43	13.1%	12.3
24	N003B400	66,139	56,760	2,022,393	1,809,886	1,956,254	1,753,125	41%	31.89		
25	N003B370	289,359	248,326	1,023,196	910,609	733,837	662,283	4%	3.67		
26	El Guayacan	2,280,149	1,956,812	10,398,159	9,353,209	8,118,010	7,396,397	5%	4.78		
27	N003B320	395,182	339,143	531,581	468,155	136,400	129,012	69%	1.38		
29	N003C230	542,341	465,435	662,039	580,433	119,698	114,999	0.5%	1.25		
30	N003E170	512,579	439,892	785,681	696,845	273,102	256,952	1.0%	1.58		
32	N003C150	1,517,894	1,302,649	1,547,361	1,382,357	29,467	79,708	0.3%	1.06		
33	N003C140	1,238,456	1,062,837	1,276,078	1,138,202	37,621	75,365	0.3%	1.07	15.1%	5.8
35	N005A010	643,204	551,994	1,051,918	936,458	408,714	384,464	1.1%	1.70	1.1%	1.7
44	N026A060	522,500	448,406	734,632	650,901	212,132	202,494	0.8%	1.45		
45	La Banderita	51,258	43,989	188,552	161,995	137,294	118,006	4%	3.68		
49	N026B140	1,494,746	1,282,783	2,132,684	1,909,148	637,938	626,365	0.9%	1.49		
50	N026A150	347,231	297,992	475,861	418,007	128,630	120,015	0.7%	1.40		
51	N026A160	37,216	23,928	1,528,606	774,707	1,491,390	750,778	33%	32.38		
52	San Juan de Dios	14,314	9,203	466,350	236,538	452,036	227,335	26%	25.70		
54	Papalon	146,000	93,873	4,004,273	2,057,405	3,858,273	1,963,531	21%	21.92		
55	Solis	188,941	121,483	2,008,137	1,031,535	1,819,196	910,052	7%	8.49	11.7%	12.1
		19,310,546	**15,415,719**	**52,186,537**	**37,293,870**	**32,875,991**	**21,878,151**			12.8%	10.2

Source : Cost/Benefit Spreadsheets

The benefit/cost ratio for all four schemes (Sites 29, 30 ,32,and 33) taken together is relatively low and;

- Benefits of any disaster prevention works become insignificant as soon as the Jinotega-Guayacan link is improved; and
- Disaster prevention measures should not implemented if the Jinotega-Guayacan link is improved before 2006.

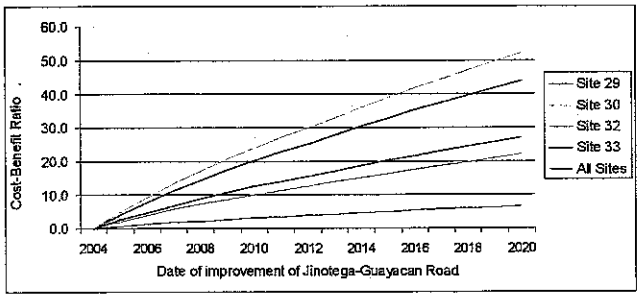


Figure 20.2.1 Impact of Jinotega-Guayacan Link on Benefits of Disaster Sites between Jintoega and Matagalpa

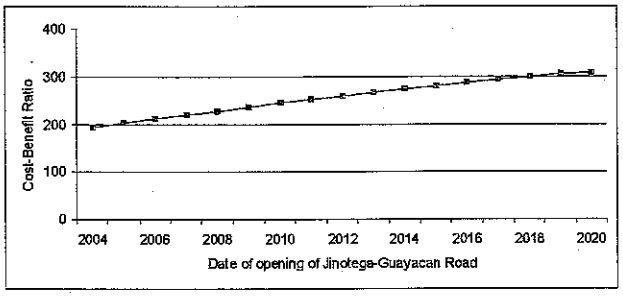


Figure 20.2.2 Impact of Jinotega-Guayacan Link on Disaster Site between Matagalpa and Guayacan

Source : Cost/Benefit Spreadsheet

The benefit to cost ratio of site 27 (shown in Figure 20.2.2) is much less sensitive to the improvement of the Jinotega-Guayacan link. This is because if the link between Matagalpa and Guayacan were closed through natural disaster, then traffic is much less dependant on the road between Jinotega and Guayacan as an alternative route.

From Table 20.2.4, there are five sites which provide 80% of the total EIRR, costing around 3% of the total cost. These high priority sites are listed in Table 20.2.54.

Table 20.2.5 High Priority Sites (EIRR) for Disaster Prevention Measures

Site No	*Site ID*	*Potential Disaster*	*Cost of prevention measures ($)*
27	N003B320	Rock Collapse	294,912
2	N001A280	Rock Fall	12,339
24	N003B400	Rock Collapse	49,358
51	N026A160	Rock Collapse	16,041
6	San Ramon	Bridge Scouring	11,105
Total			383,755

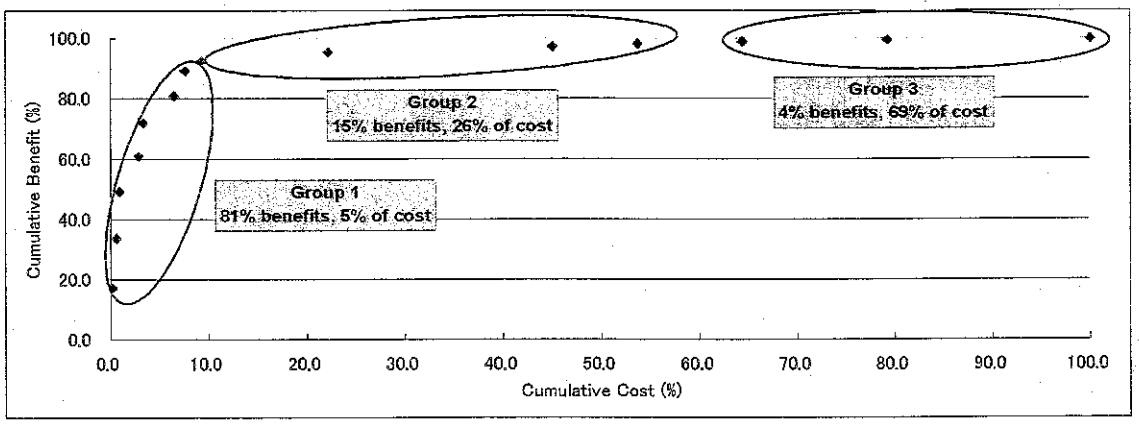
20.3 Budget Priorities

The analysis of a potential budget for disaster prevention measures has been carried out in two stages;

i) The creation of prioritised packages of work that maximise benefits, whilst minimising cost;

ii) Linking the funding packages to potential funding sources.

Table 20.3.1 and Table 20.3.2 list the schemes by ranked according to EIRR and to benefit to cost ratio. In this table the cumulative costs and benefits are listed. This data is also shown in Figure 20.3.1. The schemes can be seen to fall into three distinct groups, which indicate the priorities for investment.



Source : Table 20.2.4

Figure 20.3.1 Scattergram of Ranked Schemes by Link

The groups of EIRR are : **Priority Group 1** : Contains 12 sites. These provide 81% of the total benefits for 5% of the total cost; **Priority Group 2** : Contains 7 sites . These provide 15% of the benefits for 26% of the total cost; and **Priority Group 3** : Contains 11 sites. These provide 4% of the benefits for 69% of the total cost.

These groups therefore provide the basis for prioritising investment, and creating work packages. The schemes in each group are set in Table 20.3.3.

Table 20.3.1 Ranked Schemes with B/C

Site No	ID No.	Cost (US$)		Benefits($USM)		Benefits – Cost ($US)	Net Present Value ($US)	EIRR	B/C	Average
		Total Cost (US$)	Total Dis-counted Cost	Total Benefits	Total Dis-counted Benefits					B/C
51	N026A160	37,216	23,928	1,528,606	774,707	1,491,390	750,778	33%	32.38	
2	N001A280	16,535	14,190	516,136	454,254	499,601	440,064	44%	32.01	
24	N003B400	66,139	56,760	2,022,393	1,809,886	1,956,254	1,753,125	41%	31.89	
6	San Ramon	25,765	16,566	1,015,448	510,686	989,684	494,120	30%	30.83	
52	San Juan de Dios	14,314	9,203	466,350	236,538	452,036	227,335	26%	25.70	Priority
8	N001B230	17,176	11,044	472,346	241,134	455,169	230,091	24%	21.83	Group1
54	Papalon	146,000	93,873	4,004,273	2,057,405	3,858,273	1,963,531	21%	21.92	
7	N001A240	74,431	47,857	1,855,991	937,770	1,781,559	889,914	19%	19.60	
12	N001B150	44,644	38,313	823,606	730,977	778,962	692,664	24%	19.08	
3	Junquillal	120,235	77,307	2,189,560	1,091,941	2,069,325	1,014,634	12%	14.12	
4	San Nicolas	71,569	46,016	1,141,730	584,712	1,070,161	538,695	12%	12.71	23.8
55	Solis	188,941	121,483	2,008,137	1,031,535	1,819,196	910,052	7%	8.49	
1	N001A290	959,018	616,618	6,747,338	3,276,470	5,788,319	2,659,851	4%	5.31	
26	El Guayacan	2,280,149	1,956,812	10,398,159	9,353,209	8,118,010	7,396,397	5%	4.78	Priority
25	N003B370	289,359	248,326	1,023,196	910,609	733,837	662,283	4%	3.67	Group2
45	La Banderita	51,258	43,989	188,552	161,995	137,294	118,006	4%	3.68	
35	N005A010	643,204	551,994	1,051,918	936,458	408,714	384,464	1.1%	1.70	
30	N003E170	512,579	439,892	785,681	696,845	273,102	256,952	1.0%	1.58	4.2
49	N026B140	1,494,746	1,282,783	2,132,684	1,909,148	637,938	626,365	0.9%	1.49	
5	Las Chanillas	541,058	347,883	1,015,448	510,686	474,390	162,803	0.4%	1.47	
44	N026A060	522,500	448,406	734,632	650,901	212,132	202,494	0.8%	1.45	
50	N026A150	347,231	297,992	475,861	418,007	128,630	120,015	0.7%	1.40	
27	N003B320	395,182	339,143	531,581	468,155	136,400	129,012	69%	1.38	
29	N003C230	542,341	465,435	662,039	580,433	119,698	114,999	0.5%	1.25	Priority
13	N001B120	1,345,933	1,155,072	1,589,184	1,394,328	243,252	239,256	0.5%	1.21	Group3
33	N003C140	1,238,456	1,062,837	1,276,078	1,138,202	37,621	75,365	0.3%	1.07	
32	N003C150	1,517,894	1,302,649	1,547,361	1,382,357	29,467	79,708	0.3%	1.06	
11	N001B170	2,629,033	2,256,222	2,670,153	2,401,084	41,120	144,861	0.3%	1.06	
19	Rio Tapacali	807,293	519,064	454,892	223,324	-352,401	-295,740	0%	0.43	
18	Rio Inali	2,370,350	1,524,059	857,206	420,114	-1,513,143	-1,103,945	0%	0.28	1.1
		19,310,546	**15,415,719**	**52,186,537**	**37,293,870**	**32,875,991**	**21,878,151**			10.2

Table 20.3.2 Ranked Schemes with EIRR

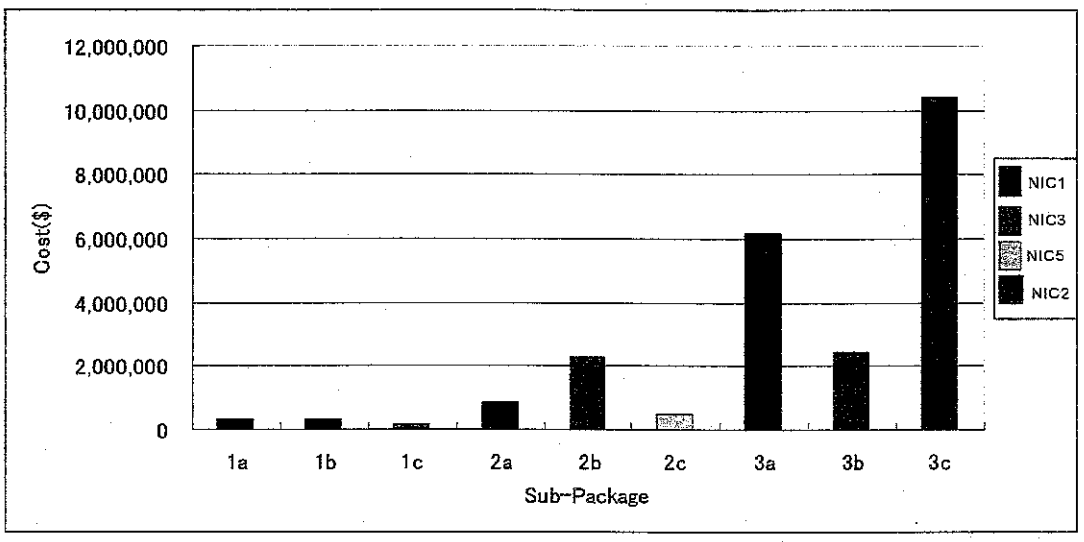
Site No.	ID No.	Cost (US$)		Benefits($USM)		Benefits - Cost ($US)	Net Present Value ($US)	EIRR	B/C	Average EIRR
		Total Cost (US$)	Total Discounted Cost	Total Benefits	Total Discounted Benefits					
27	N003B320	395,182	339,143	531,581	468,155	136,400	129,012	69%	1.38	
2	N001A280	16,535	14,190	516,136	454,254	499,601	440,064	44%	32.01	
24	N003B400	66,139	56,760	2,022,393	1,809,886	1,956,254	1,753,125	41%	31.89	
51	N026A160	37,216	23,928	1,528,606	774,707	1,491,390	750,778	33%	32.38	
6	San Ramon	25,765	16,566	1,015,448	510,686	989,684	494,120	30%	30.83	
52	San Juan de Dios	14,314	9,203	466,350	236,538	452,036	227,335	26%	25.70	Priority Group1
8	N001B230	17,176	11,044	472,346	241,134	455,169	230,091	24%	21.83	
12	N001B150	44,644	38,313	823,606	730,977	778,962	692,664	24%	19.08	
54	Papalon	146,000	93,873	4,004,273	2,057,405	3,858,273	1,963,531	21%	21.92	
7	N001A240	74,431	47,857	1,855,991	937,770	1,781,559	889,914	19%	19.60	
3	Junquillal	120,235	77,307	2,189,560	1,091,941	2,069,325	1,014,634	12%	14.12	
4	San Nicolas	71,569	46,016	1,141,730	584,712	1,070,161	538,695	12%	12.71	30%
55	Solis	188,941	121,483	2,008,137	1,031,535	1,819,196	910,052	7%	8.49	
26	El Guayacan	2,280,149	1,956,812	10,398,159	9,353,209	8,118,010	7,396,397	5%	4.78	
1	N001A290	959,018	616,618	6,747,338	3,276,470	5,788,319	2,659,851	4%	5.31	Priority
25	N003B370	289,359	248,326	1,023,196	910,609	733,837	662,283	4%	3.67	Group2
45	La Banderita	51,258	43,989	188,552	161,995	137,294	118,006	4%	3.68	
35	N005A010	643,204	551,994	1,051,918	936,458	408,714	384,464	1.1%	1.70	
30	N003E170	512,579	439,892	785,681	696,845	273,102	256,952	1.0%	1.58	4%
49	N026B140	1,494,746	1,282,783	2,132,684	1,909,148	637,938	626,365	0.9%	1.49	
44	N026A060	522,500	448,406	734,632	650,901	212,132	202,494	0.8%	1.45	
50	N026A150	347,231	297,992	475,861	418,007	128,630	120,015	0.7%	1.40	
29	N003C230	542,341	465,435	662,039	580,433	119,698	114,999	0.5%	1.25	
13	N001B120	1,345,933	1,155,072	1,589,184	1,394,328	243,252	239,256	0.5%	1.21	Priority
5	Las Chanillas	541,058	347,883	1,015,448	510,686	474,390	162,803	0.4%	1.47	Group3
33	N003C140	1,238,456	1,062,837	1,276,078	1,138,202	37,621	75,365	0.3%	1.07	
11	N001B170	2,629,033	2,256,222	2,670,153	2,401,084	41,120	144,861	0.3%	1.06	
32	N003C150	1,517,894	1,302,649	1,547,361	1,382,357	29,467	79,708	0.3%	1.06	
19	Rio Tapacali	807,293	519,064	454,892	223,324	-352,401	-295,740	0%	0.43	
18	Rio Inali	2,370,350	1,524,059	857,206	420,114	-1,513,143	-1,103,945	0%	0.28	0.4%
		19,310,546	**15,415,719**	**52,186,537**	**37,293,870**	**32,875,991**	**21,878,151**			**12.8**

Table 20.3.3 Priority Groups of Disaster Prevention Schemes

Package No.	Sub Package	Link	Site	Road	Cost (US$)
1	1a	2	N001A280	Nic1	12,339
		3	Junquillal	Nic1	51,825
		4	San Nicolas	Nic1	30,849
		6	San Ramon	Nic1	11,105
		7	N001A240	Nic1	32,082
		8	N001B230	Nic1	7,404
		12	N001B150	Nic1	33,316
	Cost				178,921
	1b	24	N003B400	Nic3	49,358
		27	N003B320	Nic3	294,912
	Cost				344,269
	1c	51	N026A160	Nic26	16,041
		52	San Juan de Dios	Nic26	6,170
		54	Papalon	Nic26	62,931
	Cost				85,142
Package 1 Cost					608,333
2	2a	1	N001A290	Nic1	413,370
	Cost				413,370
	2b	25	N003B370	Nic3	215,940
		26	El Guayacan	Nic3	1,701,604
		30	N003E170	Nic3	382,521
	Cost				2,300,064
	2c	35	N005A010	Nic5	480,003
	Cost				480,003
	2d	45	La Banderita	Nic26	38,252
		55	Solis	Nic26	81,440
	Cost				119,692
Package 2 Cost					3,313,129
3	3a	5	Las Chanillas	Nic1	233,215
		11	N001B170	Nic1	1,961,965
		13	N001B120	Nic1	1,004,427
		18	Rio Inali	Nic1	1,021,702
		19	Rio Tapacali	Nic1	347,971
	Cost				4,569,280
	3b	29	N003C230	Nic3	404,732
		32	N003C150	Nic3	1,132,757
		33	N003C140	Nic3	924,221
	Cost				2,461,711
	3c	44	N026A060	Nic26	389,925
		49	N026B140	Nic26	1,115,482
		50	N026A150	Nic26	259,127
	Cost				1,764,534
Package 3 Cost					8,795,526
Grand Total					12,716,988

Source : Table 20.2.4

The groups of schemes in Table 20.3.2 were then arranged into work packages. In each work sub-package schemes that are geographically close are grouped. This provides efficiency for the contractor. The work packages are set out in Figure 20.3.2.



Source : Table 20.3.3

Figure 20.3.2 Summary of Work Package Costs by Road