17.2 Preliminary Bridge Design

17.2.1 Design Conditions for Bridges

The design conditions set prior to the preliminary design of the bridges are shown below. The conditions are based on design and construction data collected in Panama and interviews with local designers.

1) In Panama, AASHTO's standard specifications for Highway Bridges are applied to the design of bridges. The same specifications are applied in this study, but conditions peculiar to Panama may also be set if necessary (see the following items).

2) AASHTO's highest value of HS20-44 is adopted as the design live load for the bridges because the study section is part of an important primary road in Panama and traffic on the Panama-Colon Highway is heavy.

3) A study conducted by the University of Panama revealed that earthquakes measuring around 4 on the Richter Scale have occurred although Panama is not a seismically active country. Since this falls under the category of Zone II($0.09<A<0.19$) as defined in the AASHTO specifications, it is concluded that an acceleration coefficient of $A=0.15$ can normally be used.

4) Since Panama is in the tropical zone, an annual temperature range of 21 C to 38 C is assumed for the design. As for the assumed wind load, 80km/hr is considered to be sufficient.

5) AASHTO specifies that the minimum clearances in the horizontal and vertical directions should be equal to the roadway width and over 4.267 meters (14ft.), respectively. For the horizontal direction, for this study, the AASHTO minimum clearance is adopted, and for the vertical direction, a minimum clearance of 5.0 meters is adopted, considering the actual traffic conditions in Panama.

6) For widths of bridge cross section elements, the values obtained from the preliminary road design are used:

a) Highway bridge: General section

* The 4-lane dual carriageway is adopted. Each lane is 3.65 meters wide.
* The median strip is 10.0 meters wide.
* The right shoulder is 3.0 meters wide and the left shoulder is 1.5 meters wide. If the length of the bridge is 50 meters or more, the right and left shoulders are 1.8 meters and 1.2 meters wide, respectively, for reasons of economy.
* The cross slope of the road surface is 2 percent.

b) Highway bridge: Connection with Corredor Norte

* There are two up lanes and two down lanes. Each lane is 3.65 meters wide.
* The median strip is 10.0 meters wide.
* The right shoulder is 1.8 meters wide, and the left shoulder is 1.2 meters wide.
* The cross slope of the road surface is 2 percent.

c) Overbridge: Interchange

* There are one up lane and one down lane. Each lane is 3.65 meters wide.
* The median strip 1.0 meters wide.
* The right shoulder is 3.0 meters wide, and the left shoulder is 1.5 meters wide.
* The cross slope of the road surface is 2 percent.

d) Overbridge: Access road bridge

* There is one lane. The lane is 2.7 meters wide.
* Both the right and left shoulders are 1.8 meters wide.
* The cross slope of the road surface is 2.0 percent.

7) The strength requirements for major materials are set as shown in Table 17.2.1, in consideration of the strength values commonly used in Panama.

Table 17.2.1 Strength of Materials

Concrete	For Slab	fc = 315 kgf/cm
	For Prestressed	fc = 350 kgf/cm
	For Substructure	fc = 210 kgf/cm
Reinforcing bar	(Grade 40)	fv =2800 kgf/cm
Prestressing Steel	(Grade 270)	fv = 161 kgf/mm
Structural Steel	(M -183)	fu =4000 kgf/cm

Note:
fc: Specified compressive strength of concrete at 28 days
fv: Specified yield strength of reinforcement
fu: Minimum tensile strength

17.2.2 Design Policy

(1) Basic Design

The bridges in the Study Section include viaducts, river bridges and lake bridges. The overbridges in the Study section include interchange bridges and access road bridges.

The viaducts are designed so that clearance requirements can be satisfied if there is grade separation. Even if there is no grade separation, viaducts may be planned in cases where the design road height makes embankments uneconomical or there are obstructions.

River bridges are planned, as a general rule, according to the following rules, which are observed in Panama. Tube are provided if the catchment area is smaller than 350x10 meters, culvert are planned if it is from 350x10 meters up to less than 900x10 meters and bridges are planned if it is 900x10 meters or more.

The lake bridges are provided because the highway is to cross over Lake Gatun near its shore. The overbridges include interchange bridges connecting the up and down lanes, which is necessary because a trumpet interchange is planned, and access road-bridges to take the place of the existing crossing roads that would otherwise be cut off by the proposed road.

Generally, in designing a bridge, it is necessary to take account of not only the performance of the completed bridge in consideration of such conditions as site topography and alignments, but also environmental (e.g., landscaping), maintenance, and other nonperformance requirements. At the same time, it is also necessary to evaluate the safety, constructible, and economy of the entire structure (superstructure + substructure) so that such parameters as the type of structure and span length can be optimized.

In this study, the climate of Panama and local construction practices, in addition to the above general requirements, were taken into consideration and design policies for the superstructure, substructure, and foundation were formulated separately.

(2) Superstructure

Generally, superstructures of bridges can be classified as those for reinforced concrete bridges and those for prestressed concrete bridges having a span of up to about 20 meters while prestressed concrete structures and steel structures are applicable to both short and long spans.

A study on desirable material for the superstructures of the planned bridges in the study section indicated that prestressed concrete is the most desirable for the following reasons.

a) All of the three bridges now under construction in Panama (Arraijan Bridge, etc.) are made of prestressed concrete (AASHTO-PCI), and their spans are 30 meters or less. In view of the practices in recent construction projects, prestressed concrete bridges are common in Panama.
b) Since Panama is in a tropical country, steel is vulnerable to corrosion during the hot and humid rainy season. Steel bridges, therefore, are not suitable for use in such an environment.
c) Panama has a sufficient capacity for concrete production.
d) Panama has the technology to construct long-

span prestressed concrete bridges like the Rio Chiriqui Bridge (span length: 50+96+50=196m).

The types of prestressed concrete bridge that are considered to be the best-suited to the study section are shown in Figure 17.2.1 (Type A,B, and C). Important considerations in applying these three types of bridge are listed below.

a) Type A is an AASHTO-PCI girder structure applicable to spans of up to 30 meters. The girders assemblies on land is erected using truck cranes, and girder assemblies in river sections or other areas inaccessible to truck cranes are erected using erection girders.
b) Type B is a prestressed concrete box girder structure applicable to spans of 30 to 50 meters and both simple and continuous girders. Girders assemblies on land are erected with fixed false work. If false work cannot be used (e.g., in rivers), the incremental launching method is used.
c) Type C is a prestressed concrete box girder structure applicable to spans of 50 to 150 meters. Bridges of this type are continuous rigid-frame structures whose intermediate supports are integral with the piers. This type of bridge is erected by the cantilever method under which girder segments are erected as cantilevers projecting from the piers.
d) Since the highway has a wide median strip, the up lanes and down lanes on all of the above three types of bridges should be separated.
e) In determining the bridge and span lengths, economy and constructionally should be taken into consideration. The location of the substructure should be determined on the basis of a careful study of the relationships between topographic and geologic conditions and bridge structure.

Bridge deck works are planned as follows: concrete railings have been adopted in consideration of economy, construtibliity, durability, safety, and ease of maintenance. The bridge deck pavement has not been planned in accordance with common practices in Panama considering the wear of concrete slabs, reinforcement will be covered with 5 cm thick concrete.

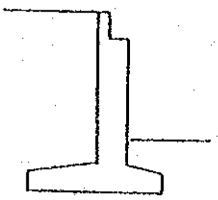
(3) Substructure

Topography and geology are the most important considerations in planning the substructure of a bridge. On the basis of the results of field surveys conducted in Panama and data on recent construction projects, the design policies for the substructures of the bridges planned in the Study section were established as follows as shown in Figure 17.2.1.

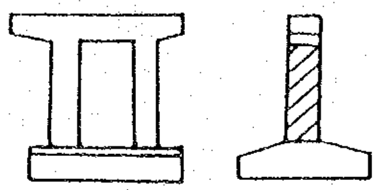
a) Commonly used inverted-T-shaped abutments should be used, and their heights should be up to about 10 meters.
b) If piers are to be constructed not in rivers but on dry

land as the piers of viaducts, an economical-shape should be used. If piers are to be built in rivers, oval cantilever piers should be used. In the former case, however, if the proposed road is narrow and piers need to be tall, rectangular cantilever piers may be used.

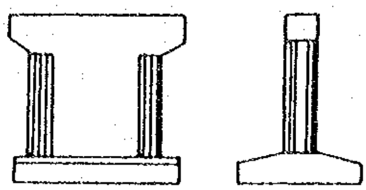
c) The location of the substructure of a bridge must be determined through the evaluation of various factors such as the size of the bridge, topographical and geological conditions, and harmony with the landscape in the surrounding area.



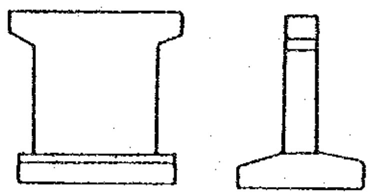
1) Inverted T Shaped Abutment



2) Shaped Rigid-Frame Pier



3) Oval Cantilever Pier



4) Rectangular Cantilever Pier

Figure 17.2.1 Types of Substructure

(4) Foundations

On the south side of the line connecting Lake Madden and Colon City in the study section are Tertiary or older formations. The flatlands along the Pacific and the Caribbean overlie Quaternary alluvia. According to a geological survey, at most of the sites of the planned bridges, there is clays soil at depths of 10 meters or less, and basalt formations underlie the clays soil. These basalt formations are high bearing capacity for supporting bridge foundations. In the planning of bridge foundations, the following policies were drown up based on the to field surveys conducted in Panama, recent construction data and the peculiarities of the construction sites.

a) As a general rule, mat foundations should used if the bearing layer is at a depth of 5 meters or less, and prestressed concrete pile foundations if the bearing layer is at greater depths.
b) Some of the piers of the bridge at Lake Gatun will have to be constructed in the lake. Lake Gatun is 3 to 8 meters deep at the construction site. The construction of footings on the lake-bed requires the use of cofferdams, and the size of temporary structures needed to construct footings increases with the depth of water. Since multicolumn pile foundations are economical and practical if the water is deep. In this study a water depth of 5 meters is considered to be the minimum depth for the installation of multicolumn pile foundations.
c) Generally speaking, multicolumn pile foundations, which have footings above the water surface, require scaffolding, while cofferdams do not. Pile foundations are easy to construct because the piles (steel tubes) can be driven in from temporary piers or ships.

17.2.3 Designs

(1) Type of Bridge

The proposed type of bridges are shown in Table 17.2.2.

Table 17.2.2 Number of Bridges Planned by Type of Bridge
(Unit; Volume)

Type	Alcalde diaz	Sabanita	Total
Viaduct	1	1	2
River Bridge	5	6	11
Lake Bridge	0	4	4
Overbridge	4	6	10
Total	10	17	27

(2) Major Bridges

The details and background of the plans for some of the 27 bridges that have been provided in the design are given below. The bridges described below have been chosen from each of the four types of bridges listed in Table 17.2.2.

1) Viaduct: Santa Barbara Interchange Bridge

A viaduct located at the starting point of this study in the Alcalde Diaz area. Connected to the Corredor Norte, this bridge forms a diamond interchange together with the existing Panama-Colon Highway which the bridge crosses.

Since the 2-lane Panama-Colon Highway is about 15 meters wide, it was thought that this bridge could be safely supported by a single span of AASHTO-PCI girders. A standard prestressed concrete pile foundation is planned because the bearing layer is 7-10 m below ground level.

2) River bridges

a) Quebrada Ancha Bridge

This bridge crosses over a swamp near the Rio Gatun in the Sabanitas area. This long river bridge is in view of the design height of the proposed road and the depth of the valley. A continuous rigid-frame structure is adopted since the piers have to be tall and the bridge needs to be long. The bearing layer is 7 meters below ground level, but because of the size of the piers which require deep excavation, a mat foundation is used to reduce costs.

b) Rio Gatun Bridge

This is a river bridge that crosses over the Rio Gatun about 1 kilometers upstream from Lake Gatun in Sabanitas area. The river is wide and the bridge is long, but the design road height is not so great and the piers do not need to be high. Since the River bed is rather flat, there is much space, outside the deepest area, where the piers can be constructed. In view of the required span length over the deepest part of the river and the total balance, a continuous box girder structure is adopted. Since the bearing layer is 6-11 m below ground level, a standard prestressed-concrete pile foundation is used.

3) Lake bridge: Lago Gatun No.3 Bridge

This is one of the four bridges planned over Lake Gatun in the Sabanitas area. Although the road surface is about 10 meters above Lake Gatun, the bridge's length of 300 meters makes it look rather flat. Since the depth of the lake at the construction site is around 8 meters, it will be difficult a place where it is difficult to construct a foundation. Therefore, multi-column pile foundations are adopted, and, because of their structural characteristics, AASHTO-PCI girders have been adopted to reduce the reaction of the superstructure. The bridge needs many piers, but that will effect the sense of flatness, create a some of rhythm, and making a bridge in harmony with the landscape in the surrounding area.

4) Overbridge: Alcalde Diaz Interchange Bridge

This bridge, which will be constructed at the Alcalde Diaz type of Interchange in Alcalde Diaz area, is necessary because a trumpet interchange is planned. Since the proposed road will have a wide median strip of 10m, piers can be constructed in the median strip area, too. Though the bridge must be long because it has to span the proposed road, AASHTO-PCI girders are considered to be strong enough if a two-span structure in used. Considering the size of the bridge and geological conditions, a mat foundation is suitable for it.

If an overbridge passes over the proposed road diagonally, it may have to be so long that the two-span AASHTO-PCI girders mentioned above cannot be used. It is decided that, in such cases, a prestressed concrete continuous box girder structure would be used.

Table 17.2.3 Proposed Bridge Type in Alcalde Diaz

Area	Bridge Name	Station No.	Brige Length (m)	Bridge Type
ALCALDE DIAZ	SANTA BARBARA INTERSECTION BRIDGE	A 0 + 0	30	A Type
〃	SAN AGUSTIN OVERBRIDGE	A 1 + 430	60	A Type
〃	LA ROTONDA OVERBRIDGE	A 2 + 590	60	A Type
〃	RIO LAS LAJAS BRIGE	A 2 + 980	120	B Type
〃	QUEBRADA GONZALILLO BRIDGE	A 3 + 380	40	B Type
〃	ALCALDE DIAZ INTERCHANGE BRIDGE	A 9 + 110	60	A Type
〃	MARIO LUIS OVERBRIDGE	A 9 + 250	60	A Type
〃	QUEBRADA LA CABIMA BRIDGE	A13 + 575	30	A Type
〃	QUEBRADA EL MARANON BRIDGE	A13 + 995	30	A Type
〃	FINCA PANAMA OVERBRIDGE	A15 + 60	60	A Type
〃	CALZADA LARGA INTERCHANGE BRIDGE	A15 + 580	60	A Type
〃	RIO CHILIBRILLO BRIDGE	A16 + 667.5	125	A Type + B Type
〃	DENOS AIRES BRIDGE	A19K+ 750	50	A Type

Table 17.2.4 Proposed Bridge Type in Sabanitas

Area	Bridge Name	Station No.	Brige Length (m)	Bridge Type
SABANITA	RIO DUQUE BRIDGE	S 0 + 265	90	A Type
〃	RIO AGUA SUCIA BRIDGE	S 3 + 205	50	B Type
〃	QUEBRADA ANCHA BRIDGE	S 9 + 205	170	C Type
〃	RIO GATUN BRIDGE	S10 + 582.5	275	B Type
〃	OVER BRIDGE	S12 + 330	60	A Type
〃	〃	S14 + 50	60	A Type
〃	〃	S15 + 150	60	A Type
〃	QUEBRADA EL PINO BRIDGE	S15 + 832.5	315	B Type
〃	QUEBRADA LOPEZ BRIDGE	S16 + 265	150	B Type
〃	SABANITA INTERCHANGE BRIDGE	S16 + 530	80	B Type
〃	SAN JORGE OVERBRIDGE	S17 + 400	60	A Type
〃	SAN ANDRES OVERBRIDGE	S17 + 850	60	A Type
〃	LAGO GATUN No. 1 BRIDGE	S17 + 990	100	B Type
〃	OVER BRIDGE	S19 + 350	60	A Type
〃	LAGO GATUN No. 2 BRIDGE	S20 + 242.5	115	B Type
〃	LAGO GATUN No. 3 BRIDGE	S20 + 540	300	A Type
〃	LAGO GATUN No. 4 BRIDGE	S21 + 465.5	90	A Type
〃	COCO SOLO VIADUCT	S24 + 980	540	A Type

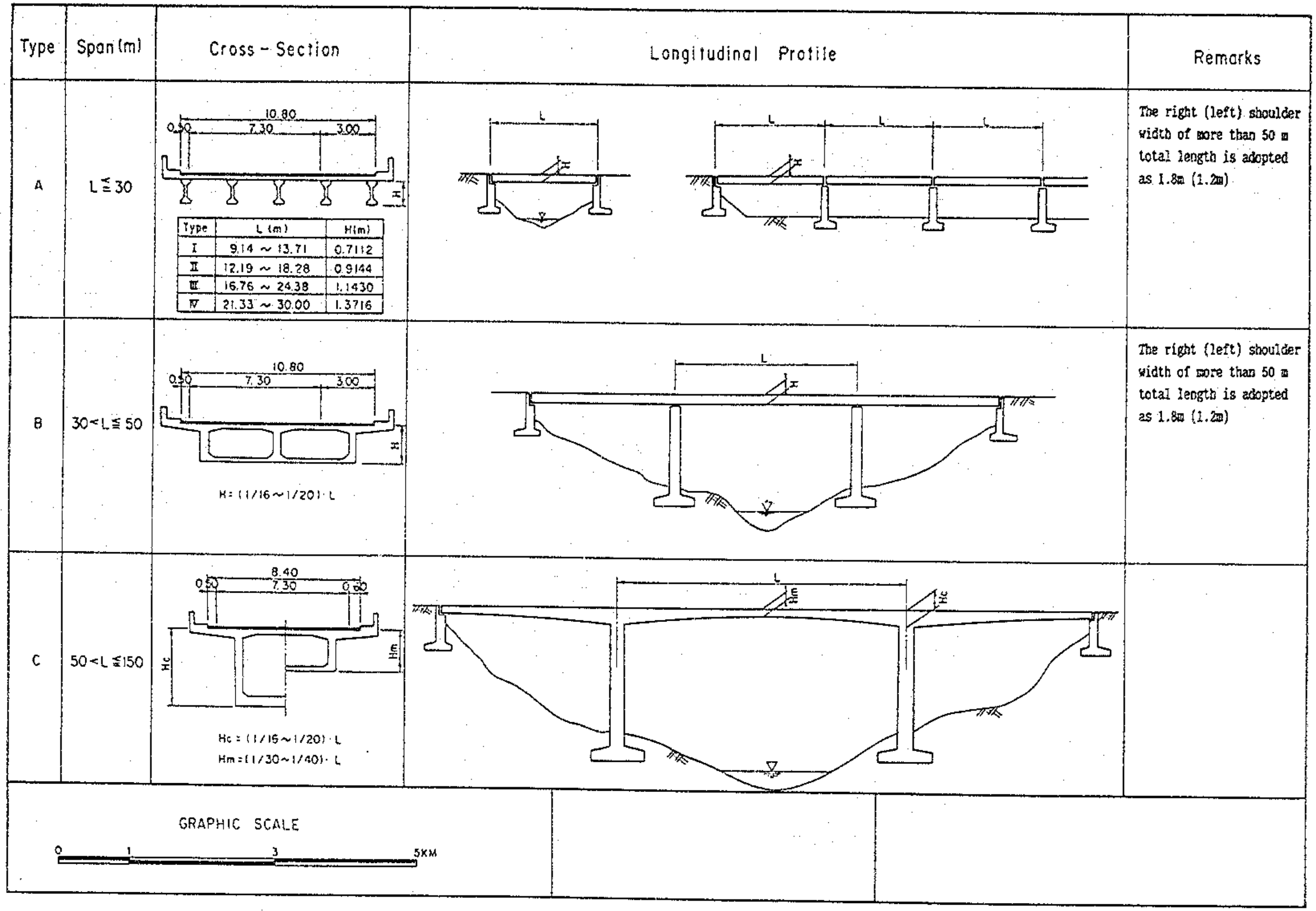


Figure 17.2.2 Type of Bridge

17.3 Road Maintenance Plan

The road maintenance system has three goals, to ensure "traffic safety", "smooth traffic flow", and "driver comfort" through efficient and economic operation. The functions of the road maintenance system are as follows:

a) To maintain a safe and smooth traffic flow on the highway.
b) Prevent conditions such as traffic accidents and traffic congestion which affect traffic flow.
c) Recover normal traffic flow as quickly as possible from traffic accident and traffic congestion conditions.

17.3.1 Organization

The future highway network may require an adequate highway maintenance system in future. Until that time, MOP must determine how best to manage the highway maintenance system. For the interim, it is recommended that MOP try to strengthen the existing organization.

17.3.2 Basic Plan for Maintenance.

(1) Flow of Highway Maintenance

In order to keep highway maintenance at acceptable service levels, its component operations have to be carried out in a regular and systematic manner. This must be consistent with the requirements of its organization and in accordance with the established procedures. While the details may vary slightly between tasks, the overall procedural routine must be followed.

(2) Highway Maintenance Operation System

1) Maintenance operations system

Highway maintenance covers various activities related to inspections, maintenance and repairs. It requires swift and appropriate action to keep the highway constantly open to traffic. The following items have to be clarified in order to implement the maintenance operations system:

a) Communications (instructions, responses, duties, decisions and coordination) system between headquarters, regional division office, main maintenance center and maintenance offices.
b) Extent of activities and responsibility of each office. MOP should be responsible for highway maintenance activities ,carried out by itself or on a contract basis depending on the nature of the work.

Maintenance on a contract basis should be gradually increased to cope with MOP personnel limitations and to raise the technical expertise of contractors.

2) Equipment and workshops

The number and type of maintenance equipment required on every maintenance operations. It is also necessary to consider whether the work will be done by MOP itself or on a contract basis to determine the numbers and types of these facilities.

3) Database and management system

A database and management system is indispensable for the highway maintenance. One of the most important activities in this is to collect reliable data; in particular as-built drawings and documents, including design reports, construction records and historical records. These records must include inspectors' observations of extraordinary damage, the work carried out and the interference to traffic, particularly in relation to vehicular accidents and their causes.

4) Planning for highway maintenance operations

Highway maintenance consists of many types of work for which the scope and scale are both very great and not very clear. Therefore, it is important to prepare a detailed work plan for each category of work in advance so that the implementation of similar work may be carried out effectively. Since inspections, maintenance and repairs will be performed on a highway on which there is traffic, it is necessary that there be coordination between the maintenance office and MOP. It is also necessary that notice be given to the traffic police office in advance and that public announcements are made to highway users.

5) Operations system during unusual conditions

Incidents disrupting the smooth flow of traffic on the highway can be divided into "man-made incidents" (traffic accidents, vehicle breakdown, dropped objects, spilled loads, fires, road maintenance activities) and "natural incidents" (unusual weather such as heavy rain, fog, strong winds and earthquakes).

It is of primary importance to prevent as far as possible the occurrence of traffic accidents, or slope slips, for example, in the case of heavy rainfall. If an incident has occurred, measures must be taken to prevent the spread of damage and secondary incidents. This can be achieved by activating the communications system and passing on information quickly to the traffic control room and road users, assessing the nature and seriousness of the incident and deciding the appropriate countermeasure to take.

In principle, disaster prevention systems define three levels of contingency: "Attention", "Warning" and "Emergency" in accordance with the seriousness of the incidents.

a) Attention;

This contingency is set up in the case of unusual weather conditions. Liaison personnel must be stationed in the maintenance office, and when necessary, contact the main maintenance center in order to organize personnel and materials.

b) Warning;

This contingency is set up when unusual weather conditions became worse, incidents have occurred in places, or traffic flow is disrupted because of such incidents.

Personnel must be stationed in the main maintenance center and maintenance office. If necessary, personnel, materials and equipment should be at the site ready to make an immediate response to any change in the circumstances.

c) Emergency;

This contingency is set up when a major disaster has occurred. The entire resources of the organization are mobilized to cope with the disaster. Persons to direct and supervise the operations should be stationed at the main maintenance center and maintenance office and if necessary, requests may be made to other authorities concerned for assistance.

17.3.3 Highway Maintenance Operations

(1) Planning of Highway Maintenance

Highway maintenance operations programs will be made for maintenance on an annual, monthly and weekly basis, considering the priority of the work, available resources, past work records, road inventories, traffic volumes, meteorological data, etc.

(2) Implementation of Highway Maintenance

Highway maintenance will be carried out, in careful consideration of traffic regulations, traffic safety and circumstances along the highway, to cause minimum interference to traffic and public utility equipment under parts of the highway. The following are considered to be necessary for the implementation of highway maintenance.

a) Coordination with police office
b) Safety during maintenance and repairs
c) Public announcements
d) Coordination with public utility offices
e) Meetings with and instructing road maintain offices

(3) Highway Maintenance Tasks

1) Inspections

Roadway inspections are one of the most important activities carried out by MOP. From them, can be known the condition of the road surface as well as traffic conditions. There are three types of inspection as follows:

a) Routine Inspection

Routine inspections look for damage to the road surface and other unusual conditions on the highway. They also cover road utilization with respect to the safety aspect of road structures and smooth traffic flow.

These inspections are normally done visually from a moving patrol car, are occasionally supplemented by observations made on foot and normally utilize two or more trained inspectors, one of them a qualified engineer.

b) Periodic Inspection

Periodic Inspections are detailed inspections on road structures and facilities such as asphalt pavement, drainage, bridges and slopes, and are normally made on foot. Periodic inspections are conducted by a specially trained team of inspectors, made up of both engineers and non-engineers.

c) Special Inspection

The special inspection is a supplementary inspection conducted in addition to the routine and periodic inspections described above, when required, to look for possible damage due to storms, heavy rain or other unusual conditions.

2) Maintenance and repairs

The many kinds of maintenance and repair work included in highway maintenance operation, are as follows;

a) Road cleaning
b) Vegetation control
c) Maintenance of traffic safety and control facilities

* Guardrails & guard pipes
* Anti-dazzle plates
* Traffic signs
* Roadway lighting
* Traffic markings
* Delineators
* Kilometer posts
* Others

d) Maintenance on pavement
e) Maintenance and repairs to bridges
f) Repairs to other structures

* Drainage
* Slopes
* Walls
* Others

g) Prevention and repair of damages caused by natural disasters

18 ENVIRONMENTAL IMPACT STUDY

18.1 Policy of the Environmental Impact Study

As a result of the road network Master Plan study two sections were selected as the priority for the feasibility study: Alcalde Diaz Section (former Segment B) and Sabanitas Section (former Segments D and F).

After the evaluation of the Alternative plan, an environmental impact study should be required in the feasibility study to avoid environmental problem.

There are many kinds of methodology of environmental study such as Chesklist, Overlay, Network, Cost-Benefit etc. Among them, checklist method is considered to be adapted for this study considering the nature of the project and the study stage. The flow of the study is shown in Figure 18.1.1.

The environmental items where some impact is predicted in the initial environmental study are selected as the items for the environmental impact study in the feasibility study. Those are listed in Table 18.1.1 Large or moderate impact is predicted for some items and any impact is not obvious for some other items in the initial environmental study.

The contents of the survey of present condition for each environmental item is shown in the Table 18.1.1, too. The contents are decided as a result of a discussions between JICA Study Team and MOP considering the result of the initial environmental study.

Some countermeasure for avoiding or mitigating the impact is examined. For examining the countermeasure, objectives of conservation is established, which is described in chapter 18.4. It is also helpful to judge if environ mental consideration in the planning policy mentioned in chapter 17.1 is enough to avoid or mitigate the impact or if additional countermeasure is required.

The study followed after the lineation drawn on maps in scale of 1/5,000.

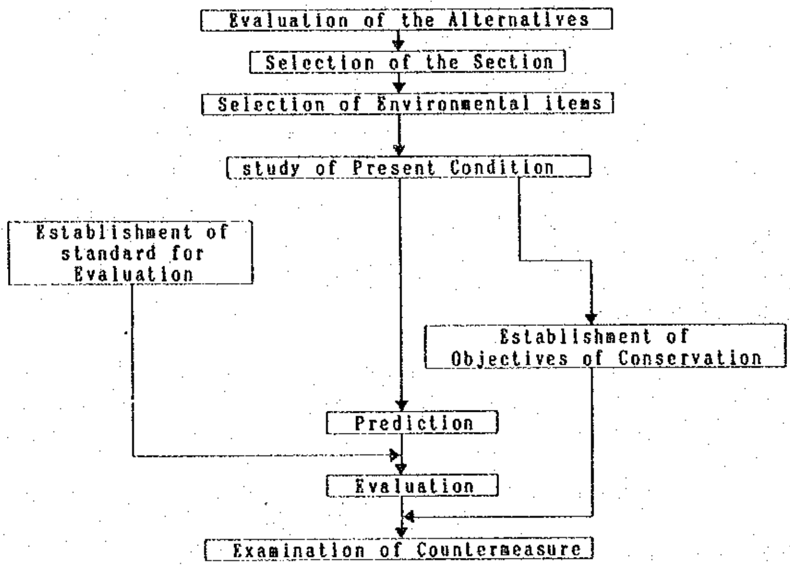


Figure 18.1.1 Flow of Environmental Study

Table 18.1.1 Initial Evaluation and Present Condition Study

Items	A	S	Contents of the Study
Vegetation	−	◎	distribution of forest and other type of vegetation distribution of precious vegetation
Fauna	−	○	distribution of endangered species distribution of important habitat
Soil Erosion	−	○	potential of erosion
Resettlement	◎	○	number of household for resettlement
Economic Activities	△	△	number of industry for resettlement
Public Facilities	△	−	number of public facility for resettlement
Safty & Split of Community	○	○	crossing section with local road location of settlement to be cut off
Cultural Property	△	△	distribution of cultural property
Air pollution, Noise Vibration	○	−	existing data for present pollution distribution of densely populated area
Water Pllution	−	◎	existing data for present pollution distribution of water intake

A: Alcalde Diaz Section
b: Sabanitas Section

Evaluation in Initial Environmental Study
◎: Large or Moderate
○: Slightly
△: Uncertain
−: Nil or Negligible

18.2 Present Condition

18.2.1 Vegetation

(1) Survey Method

The method for vegetation cover was based on interpretation of aerial photographs taken in the dry season of 1993 at a scale of 1:10,000. Doubts arose over interpretation, these were clarified by field trips.

(2) Present Condition

Present vegetation cover is shown in Figure 18.2.1 and 18.2.2. Of the total road length, of 46 kilometers, 13.9 kilometers is covered by pasture and grasses. Shrubs or degraded vegetation cover 12.1 kilometers. Secondary forest are found along 12.0 kilometers. Settled areas and households are along 8.0 kilometers. Almost all pockets of secondary forest lie in Sabanitas Section. In the Alcalde Diaz Section, trees the sporadic.

Table 18.2.1 Length of Vegetation Types

Vegetation Type	Area (Km)
Grasslands	13.9
Secondary Forests	12.0
Rastrojo or Shrubs	12.1
Farms and Settlements	8.0

Many of the terrain to be crossed by the Project is deforested and now is covered by pastures for livestock or by an aggressive exotic grass Saccharum Spontaneum, which is not eaten by cattle. In the dry season the pastures and grasslands burn creating huge fires and smoke. Some of these fires are lit on purpose others are the product of accidents.

Pockets of secondary forests concentrate between Coco Solo and the Chagres River in the Sabanitas Section. These forested sections coincide with areas having the steepest terrain with the highest precipitation.

In the secondary forests, some trees are eliminated, possibly for forestry uses. The forests have recuperated and trees as high as 15 or 20 meters can be found, mostly consisting of rapid growth species such as:

a) Guarumo	Cecropia peltata
b) Guarumo pava	Didimopanax morototoni
c) Mao	Vochissia ferruginea
d) Roble	Tebehia pentaphylla

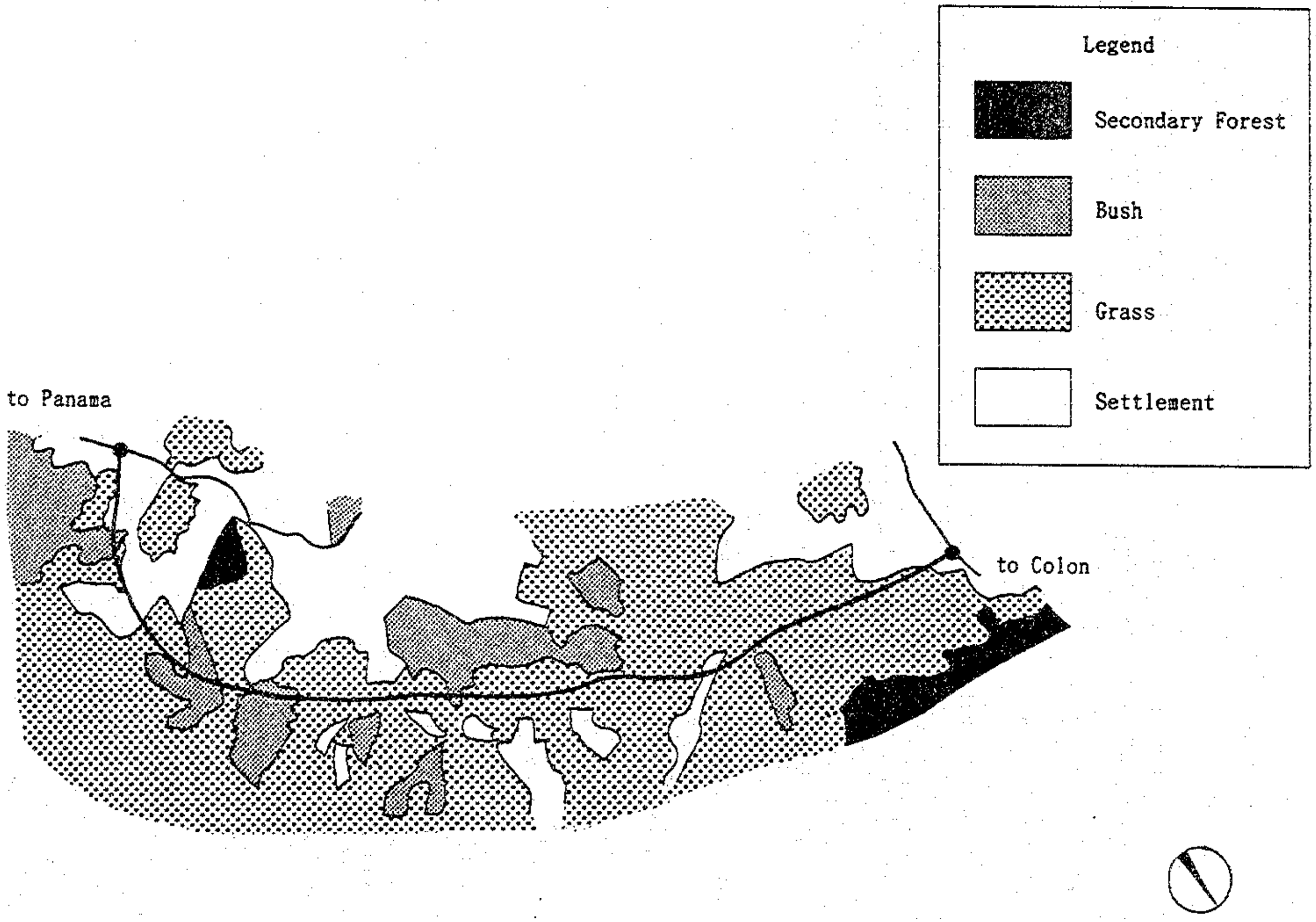


Figure 18.2.1 Vegetation Cover in Alcalde Diaz Section

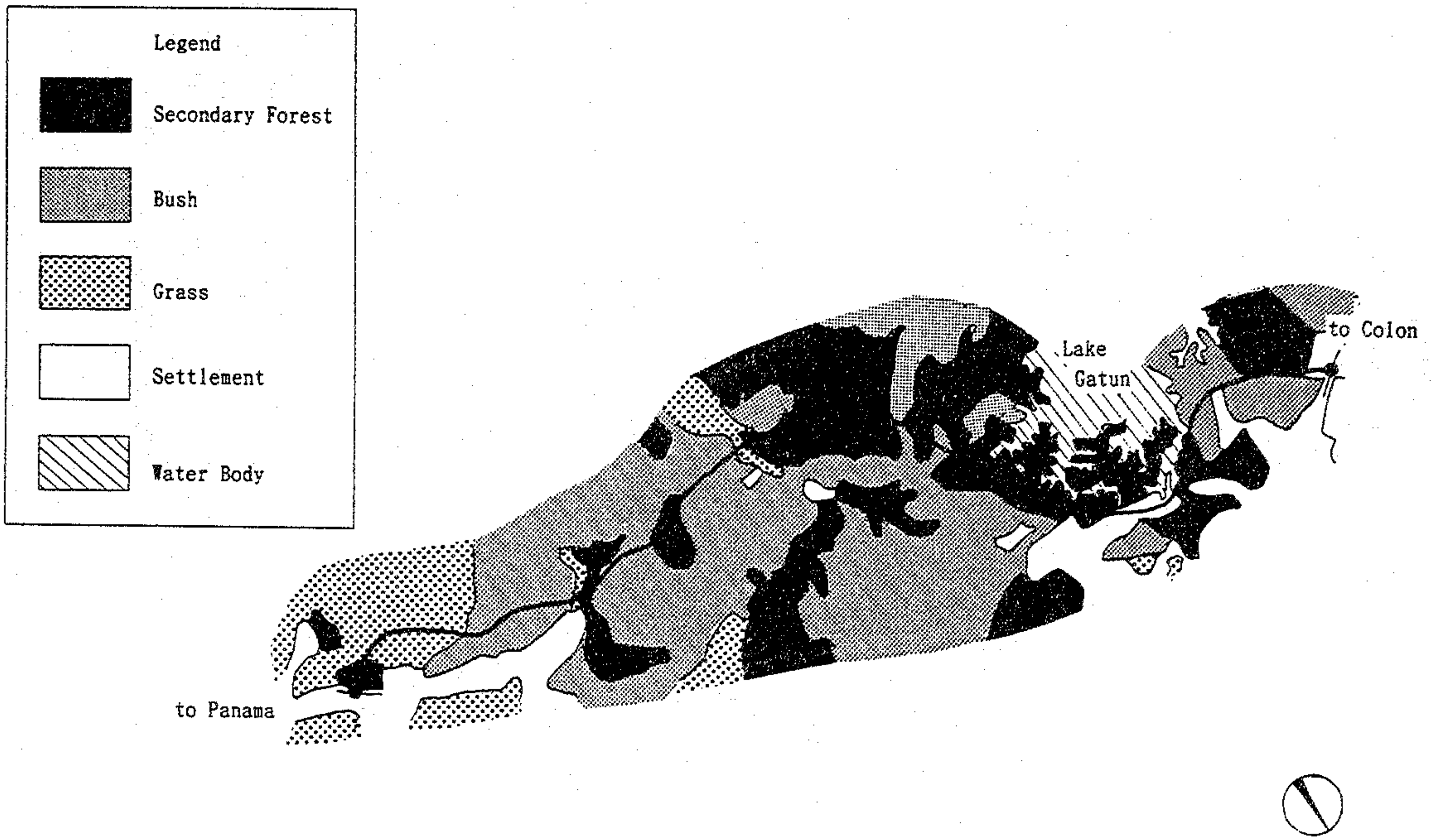


Figure 18.2.2 Vegetation Cover in Sabanitas Section

e) Guacimo colorado	Lubea semanii
f) Jobo	Spondias momhin
g) Almacigo	Bursera semarouba
h) Amarillo	Terminalia amazonia
i) Laurel	Cordia alliodora
j) Balso	Ochroma lagopus
k) Vara santa	Triplaris sp.
l) Cortezo	Apeiba tiborbou
m) Panama	Sterculia Apentala
n) Canillo	Miconia argentea
o) Anona	Anona sp.
p) Arcabu	Zanthoxylum exelsum
q) Espave	Anacardium exelcum

Secondary forests also contain different species of palm trees. Other sections of the route are covered by "rastrojo", areas where the vegetation cover is mostly shrubs and grasses.In rural settlements farmsteads commonly have home gardens, formed by a wide diversity of tropical fruit trees.

18.2.2 Fauna

(1) Survey Method

Given the brief period allowed for this study,this part of the study is based on existing bibliography, aerial mosaics and complemented, when necessary, with field visits and interviews with people living along the area of the Project.

(2) Present Condition of Habitats and Fauna

Along the Study Area, three different habitats are found: open, forested and aquatic.

1) Open Area Habitats

These are deforested areas mostly covered by pastures, grasses, shrubs, crops or occupied by settlements. Most of areas along the proposed route are open habitats, covered by Saccharum spontaneun and other type of trees such as Ficus, Psidium, Chrysophyllum, Inga, Genipa, Enterolobium, Diphysa, Mangifera, Anora, Byrsonima, Spondias, Cochlospernum, Bactris and Jatropha.

Most species of fauna found in the open habitats are not under threat of extinction, although some birds in this category are observed crossing open areas in route to foraging areas or in migration route. Among these species are: Pionus mestrus, Brotogeris jugularis, and some species of Falconiforms. Some species of the Trochilidae family use shrub areas for foraging.

2) Forest Habitats

The main forest areas in the Study Area are within the national parks. There are minor forests along the Sabanitas section.

Also small gallery forests are located along the streams and rivers in sectors heavily intervened by man.

Natural forests are the main habitat for most species under threat of extinction. The habitat of these species lie between existing parks. In the case of the Chargres National Park most species remain within the protected forests and do not tend to move towards the heavily disturbed areas southeast of the park such as Chilibre and Calzada Larga.

Chagres Camp is another minor forested habitat found along the Study Area. It is located on the shores of Alhajuela Lake and covers about 300 hectors. Given the major alteration of forest cover outside the parks and the sustained pressure on some species of fauna from hunters, most of the fauna is forced to remain within the national parks and other protected areas and some species are strictly limited to the more remote parts of these areas. Therefore, it can be stated that the fauna of Soberania, Inter-oceanico, Camino de Cruces, Charges and Parque Metropolitano will not be directly affected by the Project.

Among the fauna listed by CITES and found in the Study Areas mentioned above are:

a) Reptiles:

Crocodylus acutus	Caiman crocodylus

b) Birds:

Harpia harpyja	Pionus menstruus
Otus cholib	Brotogeris jugularis
Tyto alba	Amazona farinosa
Sarcoramphus papa	Amazona autumnalis
Leucopternis albicollis	Amazona ochrocephala
Spizaetus ornatus	Pionopsitta hacematotis

Approximately 20 species of the Trochilidae family, others of the Falconiforms and the order Strigiforms.

a) Mammals:

Aloutta palliata	Phantera onca
Athles geoffroyi	Myrmecophaga tridactyla
Aotus pardalis	Tamandua mexicana
Felis pardalis	Bradypus variegatus
Felis yagouaroundi	Agouti paca
Felis concolor	

b) And many other species.

The Lake Gatun Recreation Park has 348 hectors and it is located beside the northern end of the Sabanitas Section. It is the only protected area that will be affected by the project. Information on the fauna of this park is limited. It has only two park rangers with no motorcycle or motorvehicle for patrolling.

Between Limon and Sabanitas in the Sabanitas Section the main forest habitats are small pockets of secondary growth. All substantially altered. There are also combinations of shrubs and farms where forests have been eliminated and fruit trees planted in the patios. In such altered habitats one can find some species listed CITES, which are protected by Panamanian law, but which however are not found in the INCN Red Data Book of species in danger of extinction. The species are:

a) Mammals:

Bradipus variegatus	Aotus trivirgaus,
Tamandua mexicana	Dasypus novemcintus,
Choloepus hoffmanni	Agouti paca,
Dasyprocta punctata	Nasua narica.

b) Birds:

Pionus menstruus	Brotogeris jugularis

Several species of the family Trochilidae and some species of the Falconiform order.

c) Reptiles:

Boa constrictor

The remainder of the Study Area contains few small pockets of very altered secondary forests. In some sectors small tracts of gallery forests are found. In these places fauna is not threatened except for a few birds of the Trochilidae family and the order Psittaciformes.

It should be mentioned that in forest habitat there can be found large number of birds, mammals, reptiles, amphibians and insects which are not in any of the endangered species lists or protected by law. Many migratory birds also use these forest habitats while on their journey.

3) Aquatic Habitats

These are constituted of swamps, lakes, streams and rivers. The major aquatic habitats are lakes Gatun and Alhajuela, the Chagres and Gatun Rivers. A smaller habitat is Lake Las Cumbres, close to Panama City.

Aquatic habitats are very important for fauna. Here reptiles such as Caiman crocodylus, Crocodylus acutus,and mammals, such as the Hydrochaeris can be found. These species in forests surrounding these habitats. Several migratory species of birds use these habitats in their migrations from North or South America and vice versa.

Among the endangered species found in these aquatic habitats are the Caiman crocodylys and some of the bird species already mentioned. The aquatic habitats along the Project are concentrated in the Chagres and Gatun Rivers and branches of Gatun Lake.

18.2.3 Soil and Soil Erosion

(1) Survey Method

This study is based on topographical maps at a scale of 1:50,000. As well as on maps of Panama's rural cadastre for soil and water at a scale of 1:20,000, using maps No.14pw,14pe, 14ne,15me,15mw and 15nw with field visits.

(2) Existing Conditions

1) Climate and Precipitation

According to Koppen's climate classification, the Project crosses two climatological zones: wet tropical, characterized by rainfall over 2500 millimeters yearly; and tropical savanna which has an annual precipitation of less than 1800 millimeters.

According to maps of precipitation distribution the Study Area is located in an area where total annual rainfall ranges from 1810 to 2884 millimeters as measured at the meteorological stations at Chilibre, Las Cumbres and Buena Vista.

2) Geology and Soil

According to the Panama Altas of 1988 the geology along the Project Area is as follows: sedimentary rocks from the cenozic era from the Upper tertiary (limestone, sand, clays), lower tertiary (limestones, limonites, lutites); there are igneous rocks from the Mesozoic and Cretaceous eras (lava, basalt, andesites and pumicitic volcanic ash).

According to the soil map of Panama's rural cadastre soil texture is fine clay and skeletic clay.

3) Existing Erosion Problems

In recent years the government has established several soil conservation projects in the watershed. Furthermore, many portions of the highway still have a vegetative cover mainly of secondary forests,bush,as well as pastures and grassland. These secondary forests and different types of pastures and grasses provide adequate protection against soil runoff due to precipitation.

The worst soil related problems are found in settled areas where man has severely disturbed the ground cover.

After 49 years, the sedimentation rates for the Lake Alhajuela Basin, according to the hydrometorological section of the Panama Canal Commission(1983), was 4.7 percent. Therefore,for the canal watershed as a whole it was estimated at 3.8 million tons of soils. According to a Isaza(1984)in the area of the proposed highway, the erodabilty potential estimated at between 1100 and 1800 tons of soil per hectare per year.

4) Type of Erosion Along the Proposed Route

Our study of existing data divides the Project into four different categories of potentials for soil erosion (see Fig 18.2.3).

Category 1:

These terrains have a moderate to low natural potential for erosion. According to topographical maps,4 sectors of the Project, with a length of 5.3 kilometers, fall within this category. These terrains have an almost flat topography and slopes from less than 3 percent up to 8 percent. This category has the least susceptibility to erosion risks and site are presently mostly covered by grasses and pastures.

Category 2:

Approximately 6.3 kilometers of soils in the Project fall into this category. The landscape is flat to almost level, with slopes ranging from 3 to 8 percent. These soils are found in the alluvial plains of rivers and streams. Paradoxically it is precisely here that the worst erosion occurs due to the large quantity of human settlements. If proper urbanization and planning measures had been carried out,there would be little erosion today because they have low natural susceptibility.

Category 3:

This category includes land with little to moderate natural or geological erosion, less than half of the A horizon has been lost. There are four such sectors of the road with a total length of 10.4 kilometers in this category. The layout of the land is undulating ,with slopes from 20 to 45 percent. The terrain consists of small hills derived from igneous or sedimentary rocks. Presently,they have good vegetative cover,mainly shrubs and grasses protecting the soil from erosion during the rainy season.

Category 4:

This soil erosion category includes lands that have low to moderate natural and geological erosion. However, half of horizon A the topsoil has been eroded. According to topographical maps 24.0 kilometers of the proposed highway falls into this category. These are broken terrains with steep slopes ranging from 20 to 75 percent. The local landscape consists of high hills made of igneous and sedimentary rocks. Usually,they have good vegetation cover, either secondary forests, bush and grasses. All of which provide effective protection against soil loss.

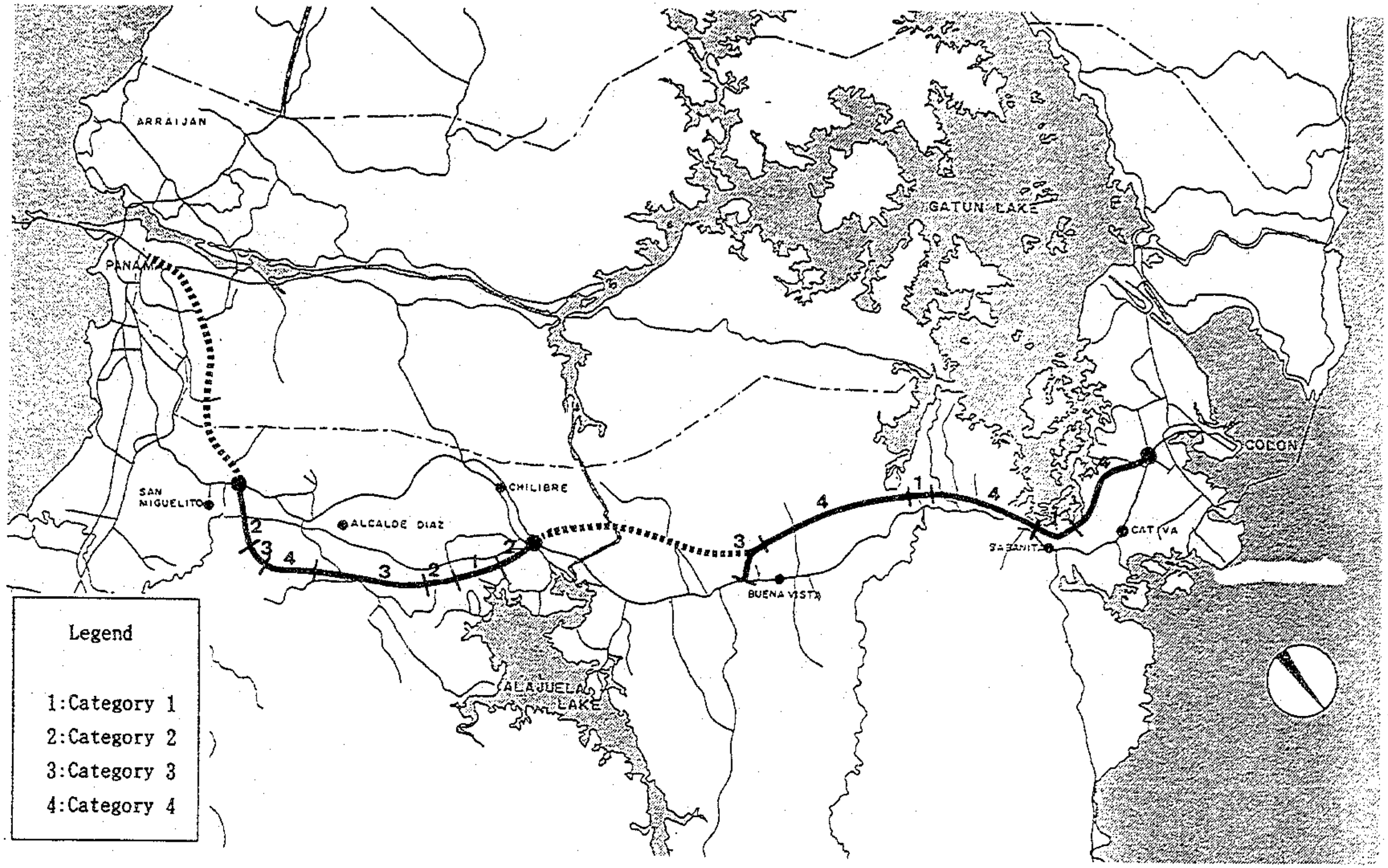


Figure 18.2.3 Four types of soil Erosion Possibility

18.2.4 Settlement and Population

(1) Survey Method

The method of this study is as follows: first, all inhabited sites are located with maps of 1:50,000 scale and later at a 1:5,000 scale. Additionally, the latest aerial photographs (1993) of the project area are used. Then,all settlements along the route are visited during two field trips to clarify doubts and look closer at specific structures and communities affected by the Project. The specific objective of this part of the study is to identify how many physical structures are located within 100 meters wide right of way of the road, 50 meters on each side of the proposed road center.

(2) Settlements and Structures

On the axis of the Project 16 human settlements are located. Some are old communities where families have lived for generations. Their attachment to their home makes it difficult to estimate the emotional or non material value people place on these properties. Other settlements date back 40 years and are made of immigrants from other parts of the country seeking better opportunities in the cities of Panama and Colon.

According to the national census the population density varies substantially along the proposed road. In the province of Panama the road will pass across the "corregimientos" of Las Cumbres with a density of 533 inhabitants per km2 and Chilibre where population density is barely 28 inhabitants per km2. In the province of Colon the proposed road cuts across the "corregimientos" of Buena Vista, 65 persons per km2, Cativa, 909 persons per km2, and Sabanitas at 1002 inhabitants per km2.

This study identified that a total of 141 settlements located within the road's 100 meter wide right of way. Of these 132 are family dwellings: They are single households not apartments. Families have gradually built their houses over the years. Most houses are small and built with cement blocks and zinc roofs. It is difficult to estimate the non material value of these properties.

Only nine structures are not households. These consist of one church, an elementary school, a Catholic seminary, a kindergarten, a furniture shop, a small country store, two factories and one warehouse. The location of these 9 structures is mapped in Figure 18.2.4.

The most important work place to be removed is at the end of Alcalde Diaz Section. It is a heavy equipment company called Empresa "Gruasy Equipos S.A" employing 60 workers.

In addition of these settlements the proposed road cuts across 31 existing local roads. Their importance is varied. Some are roads connecting remote village to the existing highway.

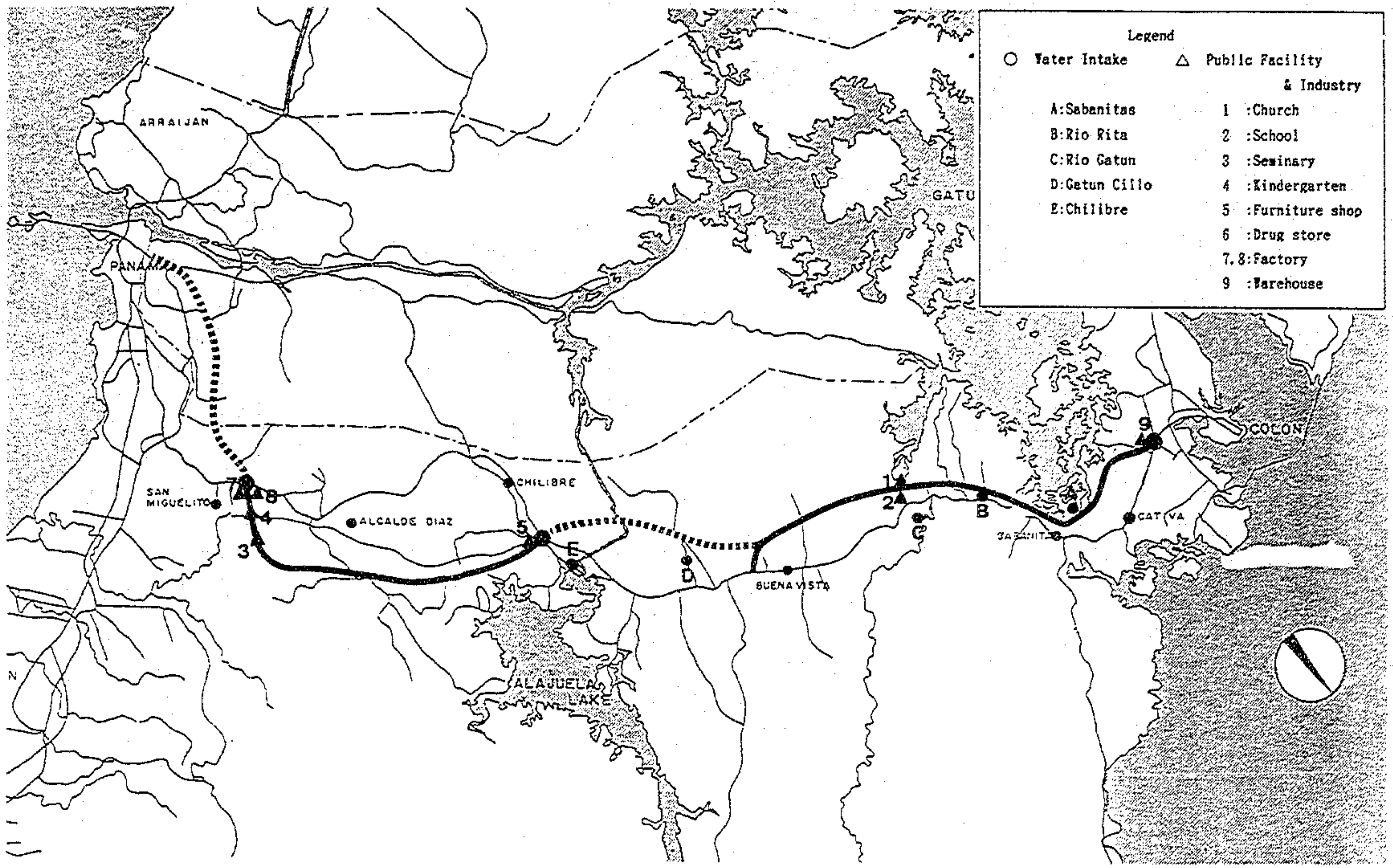


Figure 18.2.4 Distribution of Public Facilities and Industries

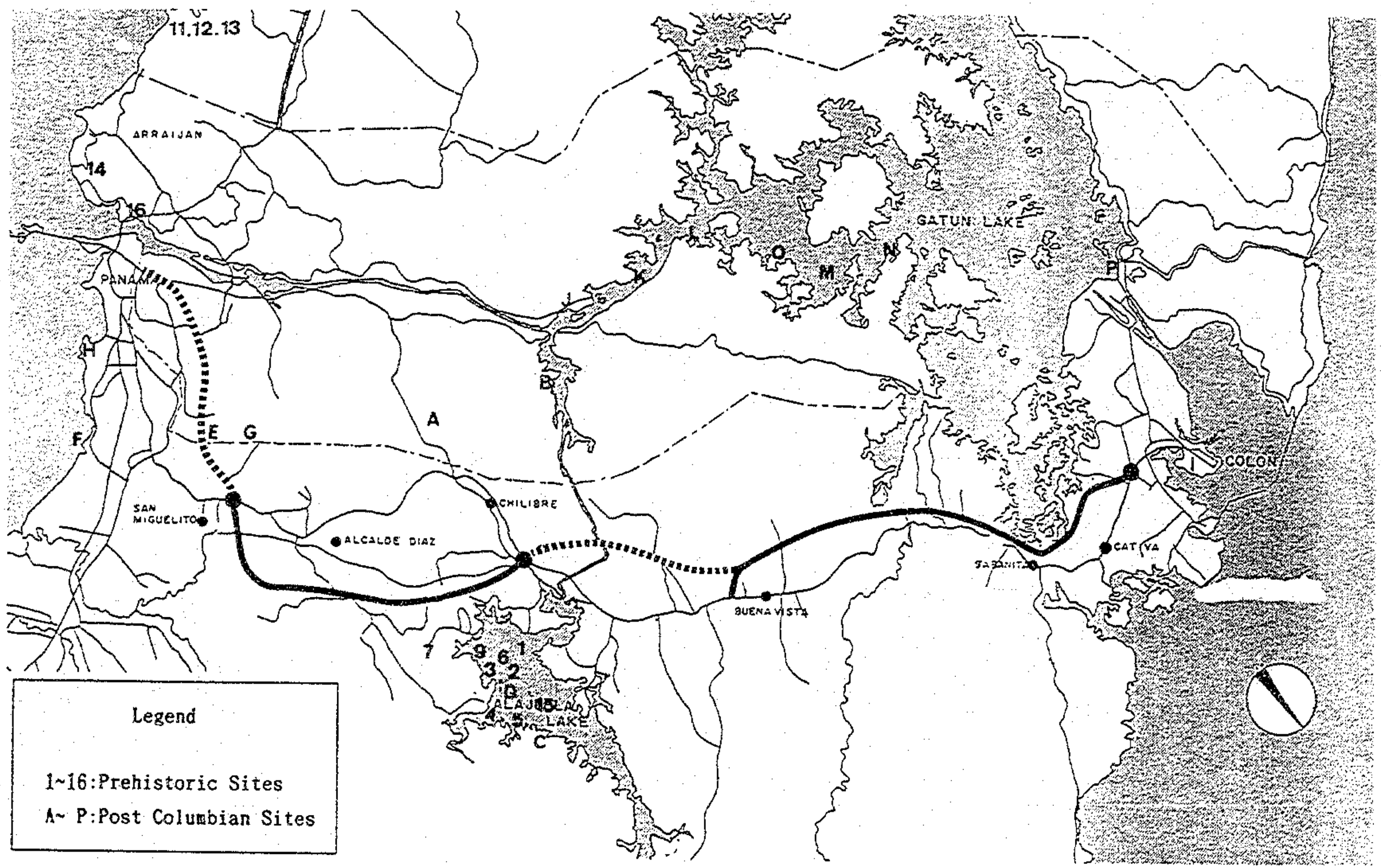


Figure 18.2.5 Distribution of Cultural Property

18.2.5 Cultural Property

(1) Survey Method

The identification and location of archaeological and historical sites listed is prepared based an extensive bibliographical search and personal communication with experts.

(2) Location of Sites and Present Condition

1) Prehistoric Sites

The prehistoric sites are divided into six periods of habitations.

Period 1-Paleo Indian Sites 9000 B.C.:

a) Isla Marcelito-----(1)
b) Isla Macapele------(2)
c) Butler-------------(3)
d) La Loma------------(4)
e) San Juan-----------(5)
f) Wes Tieno----------(6)

The most important artifacts of the Paleo-Indian Period in eastern Panama have been found in the basin of Lake Alhajuela. These artifacts consist of Cloves points. Stone flakes from prehistoric work sites also found. The lithic technology of these stone points belongs to bands of hunters and gatherers of late pleistocene megafauna.

Period 2-Early Preceramic(8000-5000 B.C.):

a) Isla Macapele-----(2)

Some bi-facial points were found in Lake Alhajuela which can be dated to the early Holocene. In the bay of Parita similar artifacts are tentatively assigned to the Early Preceramic period.
Period 3-Late Pre Ceramic (5000-3000B.C.):

a) Calzade Larga-----(7)
b) Aguas Buenas------(8)

In Calzada Larga a probable late preceramic site is located. It is a lithic site similar to those of Cerro Mangote and Monagrillo. On the other hand in Aguas Buenas, Cruxent located the site of a lithic workshop which belongs to the pre-projectile point occupation.

Period 4-Early Ceramic(3000-900B.C.):

a) There are no reported sites for this period.

Period 5-Middle Ceramic(900-100B.C.):

a) Isla Carranza------(9)
b) Panama Viejo-------(10)
c) Veracruz-----------(11)
d) Chumical-----------(12)
e) Playa Venado-------(13)
f) Palo Seco----------(14)

At the site of Isla Carranza,Cooke obtained a date from 70B.C. to 155 for a carbon sample found in an old filled waterhole.

Period 6-Late Ceramic(500 A.D. to the conquest):

a) Panama Viejo-------(10)
b) Palo Seco-----------(14)
c) Lago Alhajuela(several sites)-----(15)
d) Farfan--------------(16)

In eastern Panama,outside of the Study Area, evidence for this period is recovered at the Miraflores site. A group of tombs are also dated between 685 and 895 A.D.. Typical ceramic ware consists of bottles and trays with red point. Similar artifacts are reported for Farfan and Palo Seco.

Another distinctive ceramic style post 500/600 A.D. known as votive ware is recognized on the Pacific Coast and at some sites in the Chagres Basin.

2) Post Colombian Sites

Some of these historical sites are abandoned due to different circumstances and have became ruins,such is the case of the old Spanish road system across the isthmus and Panama la Vieja. Other historical sites were destroyed,partially or totally, by construction of the canal as is the case of Fort Gatun, the Old Royal Custom House, known as Venta de Cruces and Venta de Chagres,and the towns of the old railroad line which emerged during the days of the old California Gold Rush railroad across Panama. A few historical sites are continuously occupied such as the old quarter or "casco viejo" of Panama City and the Port of Colon.

The following sites do not organized around the historical time periods mentioned above (Colonial,New Granadian,Republican) because most present evidences of occupation that overlap these historical periods or sequences.

a) Camino de Cruces
b) Venta de Cruces
c) Camino Real
d) Venta de Chagres
e) Aljibe(Technological University site)
f) Panama La Vieja
g) La Palangana
h) Casco Viejo de Ciudad de Panama

i) Colon
j) Gorgona
k) Mamey
l) Tabernilla
m) Buena Vista
n) Bohio Soldado
o) Frijoles
p) Fuerte Gatun and Gatun Trenches

The above mentioned a)-d):

No exact date exist for the initial construction of the colonial transisthmian routes and their custom houses or "ventas". Their construction by the Spanish crown was motivated by the need to link Panama City on the Pacific shore to the Atlantic port of Nombre de Dios. The official exploration of the possible route across the isthmus was ordered in 1526 by Pedro de los Rios,then Governor of Panama.

In 1534, a royal decree or cedula authorized the proposed road across Panama. The catalytic event for construction of the road was the discovery and conquest of Peru, which had taken place 2 years before, and the need to get the bullion across Panama for shipment to Spain via the Port of Havana. Panama City was linked by the Cruces Trail to Venta de Cruces on the Chagres River. From Where the trip continued down river to the Atlantic Coast,to the Fort of San Lorenzo.

According to descriptions from 1628, the village consisted of 45 houses and numerous stores and even a monastery.

The other overland trail was The Royal Road,that linking old Panama City to the Caribbean port of Nombre de Dios. After the foundation of Portobelo in 1597, this port became the terminal for the route and Nombre de Dios was abandoned.

By the early 18th century accounts give the impression that the trail had been laid with cobblestones from nearby rivers.

During the first half on the 19th century,the Cruces Trail was used intensively until the interoceanic railroad was constructed. Along the route there are numerous vestiges of abandoned settlements. A few sites in both transisthmian roads are studied to illustrate different aspects of the techniques and materials used in their construction.

The above mentioned e):

This site was discovered recently in the new campus of the Universidad Tecnologica de Panama(UTP). There is a well associated with a cattle hacienda dating to the late 19th century.

The above mentioned f):

This monumental site is one of the most important sites of Colonial Spanish America. It is in a critical state of abandon-

ment and it is necessary to undertake an urgent and complex task to conserve and restore it.
The above mentioned g):

These are the ruins of a colonial chapel was excavated by Luis Almanza. It constitutes part of a larger settlement along the old Spanish transisthmian route.

The above mentioned h):

After the destruction of Old Panama by Henry Morgan, the inhabitants moved the city a few leagues from the original site, in the shadow of Ancon Hill. The historical interest of the old quarter of the new city lies in its uninterrupted archaeological and historical testimony spading from the colonial period to the present.

The above mentioned i):

This city was born out of the construction of the first interoceanic railroad of the Americas in 1850-1855. Originally called Apinwall by the North Americans it was qiuen its present name by the New Granadian government in 1852. As a historical site its main interest is the architecture dating to the end of the 19th and early 20th century.

The above mentioned j)-o):

These old towns arose along the interoceanic railroad: Gorgana, Maney, Tabernilla, Buena Vista, Bohio and Frijoles. Most now lie under the waters of Gatun Lake formed by damming the Chagres River during construction of the canal.

The above mentioned p):

These were built in the second half of the 18th century on the Chagres River, some 8 miles upstream from Fort San Lorenzo.

18.2.6 Air Pollution, Noise and Vibration

(1) Survey Method

In Panama there are no data on air and noise pollution, nor on vibration caused by traffic. A review is carried out of both the limited number of isolated studies and legal rules relating to these environmental matters.

(2) The Current Pollution Situation

1) Noise

Data on noise generated by traffic has led to increase interest from the authorities and the general public. Increased noise levels in Panama City led to the enactment of measures such as

Municipal Decree 95 as on September of 1992, forbidding excessive noise by transport in the capital.

Rising levels of noise stimulated creation of an inter-institutional commission against noise which carried out a technical report on noise levels caused by transport and damages to public health.

2) Air Pollution and Vibration

There are no data on air pollution and vibrations in the country, nor on there causes or consequences.

18.2.7 Water and Water Contamination

(1) Survey Method

Data on water contamination in Panama is scarce since there is very little research on this matter. However, some institutions carry statistical registries on water quality that represent changes on the concentration of some water related parameters. These institutions are IDAAN, INRENARE, the Institute of Hydraulic Resources and Electrification (IRHE), the University of Panama and the Technological University.

(2) Present Conditions of Water and Water Contamination

1) Water Quality

Data from IRHE(Table 18.2.2) shows water quality in the following five river sites along the Project.

The available data reflects the presence of high water turbidity caused by soil erosion in the watersheds of those rivers mentioned above.

In densely inhabited areas, garbage collection systems operate poorly and given cultural patterns of the people, large volumes of garbage are found beside streams and rivers. This is the main cause of deterioration of water quality. Along the Project 27 percent of the population still uses latrines.There are no sewage treatment plants. Thus demographical growth, lack of sanitation infrastructure and poor cultural habits have lead to a steep rise in the contamination of surface waters.

There is no specific information on contamination caused by urban and maritime transport. It is estimated that ships navigating the canal spill some 200 tons of oil yearly.

Table 18.2.2 Data on Water Contamination

Items		Chilibrillo	Agua Sucia	Agua Buena	Chilibre	Gatun
PH		8.26	7.61	6.36	6.85	7.73
Alkalinity	(mg/l)	116	78	48	112	76
CO2	(mg/l)	8	0	0	0	0
C 1	(mg/l)	4.2	3.0	3.8	3.6	5.0
Ca	(mg/l)	41.2	26.3	10.9	16.7	18.1
Mg	(mg/l)	-	3.05	3.03	3.89	6.41
Hardness	(mg/l)	118	78	40	58	72
Nat +	(mg/l)	5.8	6.5	5.3	9.4	6.7
K +	(mg/l)	0.90	1.03	1.09	1.04	0.84
Cu +	(mg/l)	0.1	0.1	0.1	0.1	0.1
Fe	(mg/l)	0.096	0.158	0.214	0.363	0.127
NO 3	(mg/l)	0.066	0.202	0.354	0.000	0.181
NO 2	(mg/l)	0.021	0.050	0.015	0.000	0.013
PO 4	(mg/l)	0.104	0.154	0.154	0.060	0.091
SO 4	(mg/l)	4.7	8.0	0.9	2.8	2.6
NH 3	(mg/l)	0.047	0.130	0.002	0.066	0.034
Fe total	(mg/l)	0.242	0.171	0.360	34.2	0.625
Turbidness		5.50	0.1	33.0	130.0	27.0
Conductivity		210	155	82	136	143
S/S	(mg/l)	173	154	122	444	157
Total	(mg/l)	15.5	19.70	14.4	29.0	23.60
Oxygen	(mg/l)	7.90	6.80	6.62	6.53	7.00
COD	(mg/l)	0.78	1.96	2.74	3.53	1.76
BOD 5	(mg/l)	1.10	0.90	0.40	-	1.0

2) Garbage

According to the report of CIASNA, the Comite Inter Institucional de Agua, Saneamiento y Medio Ambiente, Panama City produces some 932 tons of garbage daily of which 70 percent are collected. This leads to the accumulation of garbage in streets,roads and empty lots. In the rainy months the frequent rainfalls carry the garbage into nearby streams and rivers and thence to the lakes increasing pollution.

The city of Colon is a most worrisome. In the city and its outskirts an impressive amount of fly infected garbage lies uncollected and rotting. Part of the problem is the lack of funds by the municipality of Colon. The other cause is the low level of environmental awareness of the population and the non-enforcement of the existing regulations. The existing highway near Colon has become a longitudinal garbage dump.

3) Water Plants and Sources

Along the proposed road the most critical area from the standpoint of water quality is in the northern end of Sabanitas section, where the proposed road hugs the coast of Gatun Lake, a few hundred meters from the inlet of the Savanitas Water Plant.

The Sabanitas plant is a crucial installation. It provides water for all the new neighborhoods on the outskirts of Colon, the city's fastest growing area. The plant processes 6 million gallons daily to supply 35,000 people, but demand grows at 7 to 10 percent annually. There are plans to double its capacity in the next 5 years to 12 million gallons daily.

The water inlet is located in a narrow inlet of Gatun Lake about 100 meters wide with hardly any current because no stream or river runs into it.

Water quality of this arm of Gatun Lake is excellent. Water production costs are 27 cents per 1000 gallons. According to IDAAN the parameters of the fresh water at the Sabanitas Water Inlet have a PH of 7 to 7.5,total hardness is excellent at 60 kilogram per liter and a turbidity of 0.6NTU. These indicators are within the limits established by the Pan-American Health Organization / World Health Organization. Presently 5 milligrams per liter of sulfate are used at an annual cost of $15,000. Water contamination aby organic matter varies with the rainfall between 0 and 120 colonies per 100ml.

In addition to the Sabanitas plants, there are four other water supply sources along the Project. One is the water inlet of Rio Rita, a rural aquaduct supplying water to the little lake-town of Nueva Providencia. Others are the Gatuncillo and Gatun River water inlets. The other major water inlet is in lake Alhajuela,the sourceof water for Panama City, the road,however,passes several kilometers from this inlet.

18.3 Environmental Impact and Evaluation

After studying of the present conditions, the environmental impact of each item is predicted, as follows:

18.3.1 Vegetation

In the short term as a direct impact of the construction phase, destruction of present vegetation and loss of flora associated with this vegetation are predicted. In the long term, altered biological condition may encourage invasion by different species and disturb normal plant succession.

In this sense secondary forests of 12.0 kilometers suffer larger impact than the other vegetation. But impact on the secondary forest is not serious because it has already been altered by man.

18.3.2 Fauna

In the short term,during the construction phase due to the constant noise of heavy equipment and personnel, forest removal and the extraction and deposition of materials from construction sites,there will be a direct impact on fauna. Some species will be forced to migrate to more distant places,the distance of migration depending on the species.

In the longer term, the proposed road leads to further lineal development. This development in turn brings more habitat alterations such as:deforestation,soil removal, increase in water contamination, leading to displacement of the local fauna. Furthermore, due to increased vehicular traffic the road becomes a barrier for certain species. Also it will have an impact on forest-dwelling birds by breaking the continuity of the forest cover.

The most threatened habitat in the Study Area will be the secondary forest, a habitat that regenerates slowly the surface of which is gradually being reduced by man. Most of these secondary forests are between Limon-Sabanitas. However,they are already heavily disturbed.

The proposed road will have no major impact on the fauna of Lake Gatun Recreation Park. The area to be directly affected has already been invaded by squatters who have deforested the park's south eastern boundaries to plant crops. Furthermore,on the north side it is heavily populated and there is intensive pressure on the park's fauna from illegal hunters forcing species to retreat further into the more inaccessible parts of the park. Recently the government constructed an appalling low income housing project on the edge of the park, deforesting several hectares of forest.

In the open habitats the Project will not endanger the fauna. There will be some impact on aquatic habitats particularly in the rainy season when the rains wash the exposed soil, leading to increased sedimentation of lakes and swampy areas. Among the affeeted swamps are a small part at the mouth of the Gatun river and some inlets of Gatun lake.

18.3.3 Erosion

The main erosion problems that can arise from the construction of the road in the four soil categories are as follows:

Construction will entail different activities such as: tree felling, land clearing with heavy equipment, earth moving, cutting, filling, construction of bridges,drainage, culverts, terraces and embankments. These tasks will cause the soil erosion,sedimentation of streams and rivers, and very importantly, silting the Gatun and Alhajuela Lakes,reducing their water storage capacity.

In the long term erosion from slopes of cuts and embankments will not be a problem if proper countermeasures are taken to protect them. Increased soil loss and sedimentation will lead to higher dredging costs for canal operations in Lake Gatun.

Furthermore,increases in sedimentation of rivers and lakes will translate into decreased water quality. It is especially critical at the inlets of major water plants such as Sabanitas in Lake Gatun.

18.3.4 Resettlement,Economic Activities and Public Facilities

The impact of the proposed road will be on existing dwellings and work places in the construction phase. 132 households,2 factories, 1 warehouse, 1 local drug store, 1 furniture shop, 1 church, 1 school, 1 seminary, and 1 kindergarten must be removed or resettled.

Home values along the Project vary substantially. On the basis of their estimated cost they are divided into three categories: low, medium and high cost dwellings. Most houses that will have to be demolished are at the lower end of the price scale, under $ 20,000 including the price of the land. Some houses are in the medium cost ranging from $ 20,000 to $ 50,000. And limited number fall in the upper value category that can be estimated to very between $ 50,000 to $ 300,000.

18.3.5 Safety & Divided of Communities

The impact of the proposed road will be on existing local roads and settlement. Thirty-one local roads are cut by the Project. The proposed road will disturb local communication if no bridge or underpass is provided. On the other hand 16 settlements are divided on both sides of the proposed road. The proposed road also affects the safety and communication of the people in these settlements if any path is not constructed for movement.

18.3.6 Cultural Property

When the prehistoric and historic sites are seen on a map it clearly shows that the proposed road does not affect the sites directly or indirectly.

The sole exception is the old Spanish Royal Road across the isthmus. This route is poorly studied but it can be assumed that it intersects at an unknown place with the Project, so further studies and detailed field inspectiory are required.

18.3.7 Air Pollution,Noise,Vibration

Higher noise levels can be expected from traffic where the proposed road has an embankment type structure.In densely populated area in Alcalde Diaz Section for 2 kilimeters, Many people will be affected by noise.

18.3.8 Water Pollution

The proposed road will have a negative impact on the water quality of Lake Gatun, particularly in the area of the water inlet of the Sabanitas Water Plant.

During the construction phase there will be an increase in water turbidity due to the earth removing by heavy equipment, particularly if it is carried out during the rainy season.

While increased in vehicle traffic will cause higher levels of grease and oil on the road that will eventually flow into streams, rivers and lakes after the road is open.

18.3.9 Total Evaluation

The environmental impact varying. The main impact and its evaluation are summarized up in Table 18.3.1 The Dossibility of water pollution at Sabanitas is very critical. Strict countermeasures are required.

On the other hand, no serious impact is predicted for vegetation, fauna and cultural property. For these items specific countermeasure as not required for mitigate the impact, but general consideration such as minimal deforestation, and a pre-survey of cultural property are required.

Other items suffer some impact but countermeasure is easily taken to mitigated the impact or it may be solved by compensation.

Table 18.3.1 Environmental Impact and Evaluation

Items	Main Impact	Evaluation
Vegetation	feeling secondary forest for 12.0km in Sabanitas Section	III
Fauna	Diviison of habitat and destruction of forest habitat(not for endangeresd sp.)	III
Soil Erosion	category 4 for 24 kilometers	II
Resettlement	132 households	II
Economic Activities	2 factories, 1 warehouse, 1 drug store, 1 furniture shop	II
Public Facilities	1 chuch, 1 schools, 1 seminary 1 kindergarten	II
Safty & Split of Community	31 cross roads 16 settlements along the axis	II
Cultural Property	nil	III
Air pollution, Noise Vibration	densely populated area along the route with enbankment for 2km in Alcalde Diaz Section	I
Water Contamination	Sabanitas Water Inlet	I

I : large impact predicted,strict countermeasure required
II : slighit impact predicted, some countermeasure or compensation is required
III: nil or negligible impact, general consideration can avoid or nitigate the impact

18.4 Countermeasure

Objectives of conservation for each environmental item are established for considering proper countermeasure. Some countermeasures are examined, those are described below, to achieve the each objective. In addition more detailed measure is proposed to maintain or improve the present environment.

As evaluated, water contamination at Sabanitas water inlet is a major and critical environmental problem in this study. Strict countermeasure on it should be taken to maintain good environmental condition. For the others, impacts are not critical but some countermeasure is suggested in addition to general considerations.

18.4.1 Vegetation

For vegetation itself specific countermeasure are not required. But general considerations are necessary during construction and maintenance. The most important consideration is to minimize felling and maintain as much secondary forests as possible along the proposed road to prevent secondary impact such as soil erosion. Inaddition the the following proposals are suggested to a promote the natural and social environments along the proposed road.

1) Panoramic Route in Sabanitas Section

It is suggested that the Sabanitas Section of the road and surrounding countryside be declared a panoramic road, keeping a maximum of the existing natural vegetation.

This sector of the proposed road could then become Panama's first panoramic road. By leaving as much of the existing natural vegetation as possible major ecological, economic and social values will be derived. It should include lands on both sides of the road. The surface of the scenic route area will depend on the topography and the complexity of the landscape. The immediate terrains should be left as forests and as the there should not be any commercial billboards or constructions.

Such a panoramic road will enhance the landscape, and allow access to recreative natural areas for camping, swimming and environmental education. It will also enhance the quality of life.

2) Reforestation

Reforestation should be carried out in all sections of the highway suitable for the purpose, especially in the Alcalde Diaz Section. When planting, preference should be given to native evergreen species that retain their leaves during the dry season. They should also be aesthetic species that provide ample shade. Among recommended native trees are "Espave", "Corotu" and "Panama".

On approach zones, parking areas road crossings, dividing strips, native flowers and palms should be planted to give a pleasing view to travelers.

Reforestation will have many positive environmental benefits. It will help to stabilize slopes, prevent soil erosion and reduce water runoff, which will protect housing and croplands. There is a special need to harmonize highway alignment with the environment and visudal appearance.

Trees should not be planted on the edge of the road, sight and distance should be taken into consideration when trees are planted at road crossing and the inner sides of curved roads. Tree branches should not reach the edge of the highway.

18.4.2 Fauna

Since no major impact is predicted for fauna, some thoughtful countermeasures and general environmental considerations are suggested to avoid an unpredictable impact and promote environmental condition.

a) Underpasses should be constructed to facilitate the movement of fauna between forested areas crossed by the road in the Sabanitas Section. These passage ways or tunnels will allow the genetical interchange and maintain larege population.
b) Maintain maximum forest cover.
c) There should be a strict of land planning along the road to minimize the destruction of natural habitats.
d) Large volumes of trash are alreadyn being dumped into streams and rivers by the population. As population may rise due to the Project the problem of garbage disposal in water ways will affect aquatic habitats. This nega tive impact can be mitigated by environmental education of the population and by an effective road cleaning program.

18.4.3 Soil Erosion

The following countermeasures are suggested here to minimize soil erosion during and after construction of the proposed road.

1) Protection of Embankments:

All road embankments and landfills exposing soil must be protected immediately by planting stoloniferous pastures such as Barchiaria mutica and "humidicola". These are fast growing grasses that secure the soil and are well adapted to local conditions. They grow extensively in the canal watershed and seeds can be easily purchased from local farmers and cattlemen.

2) Terraces:

These works should be constructed in such a manner that soil erosion by heavy and continuous rainfall is minimized.

3) Protection of Shoulders and Embankments:

Road shoulders and embankments should also be protected with locally adapted pastures,such as those already identified above.

4) Fences:

It will be necessary to construct fences on both sides of the highway to prevent the access of wild fauna or cattle from neighboring ranches. During the wet season intrude into the road and soften the exposed soil favoring erosion. Moreover, livestock eat grasses and other vegetation that offering protection to the soil.

5) Soil Protection During Construction phase:

When road working suspended during the construction phase, soils should be covered with polyethylene to prevent soil runoff.

6) Tree Protection:

During the construction phase tree cutting should be kept to a minimum to protect ground surfaces.

7) Institutional Coordination:

During the construction phase it is imperative that a strong and close coordination be maintained between the executing company, INRENARE,IDAAN, MOP, Panama Canal Commision, the municipal local governments and other Institutionals.

18.4.4 Resettlement,Economic Activities, Public Facilities

Compensation is the only fundamental solution for these items. However it should be handled carefully with the following considerations.

1) The affected communities and families have to be approached early to explain the nature of the Project and the need to relocate them. It should be made clear to these families that the Project has a very positive disposition to indemnify them for their losses and relocation.

2) Analyze and establish possible alternative sites for relocation of families whose dwellings will have to be demolished. If possible, the alternative sites should be in neighboring commu-

nities.

3) Close coordination should be established between all parties involved in the Project. This is with the purpose of defusing or keeping to a minimum the pressure of external groups on the Project, groups who might want to make political capital from the situation and would like to get the affected people to boycott the Project. It will be important to channel all the available information on the Project as directly as possible to the affected families and businesses. This direct and frank access will help to minimize intermission of external pressure groups with political interest.

18.4.5 Safety & Division of Communities

To avoid these problems a the following structures are required.

1) Fence:

The Project should have fences along both sides of the highway to keep residential people from the highway to protect them against a traffic accidents. The fence is also useful to keep wildlife out, to protecting wildlife itself and drivers from accidental collision.

2) Overbridges and Underpass:

Overbridges and underpass should be established at necessary points to avoid cutting off local communications.

18.4.6 Cultural Property

The proposed road opens the possibility of increasing our knowledge of the socio-cultural processes of the inter-oceanic region. Although no impact on cultural property is predicted, the following considerations are suggested.

1) Undertake a preliminary reconnaissance along the route of the proposed road based on sampling to detect and eventually carry out an archaeological rescue effort in located sites.

2) Undertake a prospecting by monitoring the construction phase. Monitor attempts to localize sites observed during construction of the proposed road,to evaluate and rescue the located sites and compare the data from the superficial reconnaissance with data from the monitoring.

18.4.7 Air Pollution,Noise and Vibration

Countermeasures should be taken to mitigate pollution for residents along the Project.

1) During the construction phase in the densely populated areas there should be no operation of heavy equipment on Saturday and Sunday.

2) Plant trees along the Project in densely populated area to mitigate air pollution and noise.

3) Establish a monitor system for pollution control.

4) A noise barrier should be built along both sides in the densely populated area of the Alcalde Diaz Section.

Effect of the noise barrier is as follows;

a) Noise level (with protection wall): 62.5 dB (A)
b) Noise level (with protection wall): 53.6 bB (A)

Noise level is calculated by the following formula proposed by Japan Sound Academy.

L50= Lw-8-20log10l+10log10(1/dtanh2 1/d)+αd+αi

Where:

L50: Median of traffic noise level
Lw : Average power level per vehicle
Lw=86+0.2V+10log10(a1+5a2)
a1 : Ration of small vehicle(a1+a2=1.0)
a2 : Ration of large vehicle(a1+a2=1.0)
l : Distance foram sound source
d : Average head way(meter) d=1000V/N
V : Average running speed (Km/hour)
N : Traffic Volume (Vehicle / hour)
αd : Adjustment Factor of diffraction(dB(A))
αi : Adjustment Factor of various causes
l and V (dB(A)) (it is -6.62 in this case)

For N estimated largest colume in the year 2010 is used. For V average running speed is estimated as 80km / hour in the year 2010.

	small vehicle	large vehicle	Total
Panama to Colon	817	178	995
Colon to Panama	544	119	663

Cross section of the west end of Alcalde Diaz section is used for this estimation. The height of embankment is assumed as 5.0 meters and measurement point is set at 1.2 meters high above ground level at the boundary of the right of way.

18.4.8 Water Pollution

Countermeasures are required at the Sabanitas Water Inlet.

1) To avoid water contamination at the plant, three bridges are planned along the Gatun in the Sabanitas Section. Moreover sheet pile will be used to cut off soil particles flowing into the lake during the construction phase.

2) Naked slopes should be recovered by fast growing grass as mentioned above.

3) A high fence is required to discourage garbage disposal.

4) monitor water quality to detect changes in water quality.

19 PROJECT COST ESTIMATE

19.1 Cost Estimation Method

19.1.1 Estimate Preconditions

The construction cost is estimated in accordance with the following criteria.

1) The estimates are made on the assumption that all construction work will be contracted to general contractors by international tender.

2) Cost calculations are based on the material costs, labor costs and machinery cost estimated at July 1993.

3) The costs are estimated for all alternatives and was classified into foreign currency and local currency portions.

Foreign currency and local currency components of each unit price are computed based on the following classification of basic cost elements.

The foreign currency component consists of the costs for:

a) Imported equipment, materials and supplies;
b) Estimated portion of import in domestic materials;
c) Wages of expatriate personnel;
d) Overhead and profit of foreign firms.

The local currency component includes the cost of:

a) Estimated local portion of domestic materials;
b) Wages of local personnel
c) Overhead and profit of local firms; and
d) Taxes.

4) The unit cost of each work item is obtained by totaling the labor costs, equipment costs, material cost, etc. for the item, and the result is checked against recent actual construction cost figures in Panama.

19.1.2 Cost Estimation Method

(1) Method

Using the generally applied estimation concept, the cost estimation proceeded as follows. Each construction cost item (e.g.soil excavation, foundation work, pavement.) for materials, machinery, and labor cost components is calculated as the product of unit price and quantity. Subsequently the direct and indirect costs are calculated plus the compensation costs for house and land acquisition, engineering services costs and contingency amount as shown in Figure 19.1.1.

(2) Labor Cost

Average unit wages are estimated separately for specialized laborers (carpenters, scaffold, masons, steel fitters, etc.) as skilled labor, and for unspecialized laborers as unskilled labor, using available price data bulletins (Lists de Materials de construction: CAPAC 1993.6) as reference. Those who drive normal and dump trucks are classified as drivers, and those who drive special equipment and plants, as operators. To the unit cost of the construction labor 43 percent is added as social charge as shown in Table 19.1.1 and 19.1.2.

Table 19.1.1 Social Charge

Description	Rate per Salary (%)	Remarks
Social Insurance	8.00	
Retirement Fund	5.00	
Bonus	8.33	1 month/year
Vacation	3.48	10 day/year
National Holidays	3.83	11 day/year
License Fee	2.00	
Overtime	4.55	2hr/Week
Interference by Rain	8.36	24 day/year
Total	43.55	

Source: Study Team Estimate

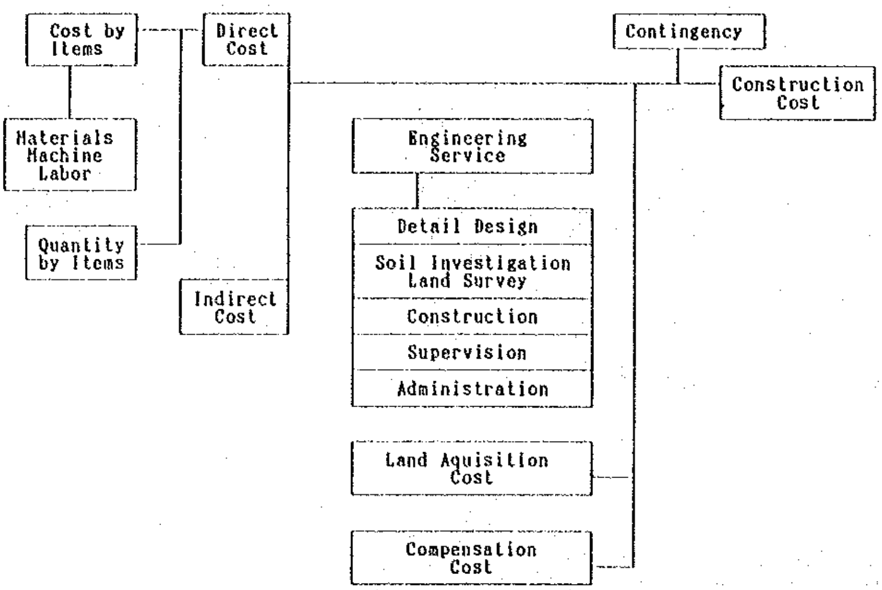


Figure 19.1.1 Cost Estimation Method

Table 19.1.2 List of Labor Cost

(Unit; Balboa / hour)

No.	Classification	Foreign	Local
1	Driver	0.00	2.89
2	Foreman	0.00	3.01
3	Operator	0.00	3.88
4	Skilled Labor	0.00	2.70
5	Unskilled Labor	0.00	1.86

Source: CAPAC and Study Team Estimate

(3) Machinery Cost

The Machinery cost is broken down into rental costs and operation costs. The machine benefit cost is calculated as follows.

$$\text{Rental cost} = B * \left(\frac{D}{Y} + Me + Mg\right) * \frac{1}{H}$$

B: Basic Price
D: Depreciation rate
Me: Annual Maintenance rate
Mg: Annual Management rate
Y: Operational life
H: Annual Operational Hour

This estimation method allows use of some equipment for more than one project, and rental cost is paid only for the hour the equipment is operated. There for equipment may be brought into Panama for construction of the project with out paying import tax. Provided that the equipment is taken out of the country upon completion of the work.(The tax would be paid only if the equipment is sold in Panama) The operation rate, base price annual maintenance rate, and standard annual operational hours are shown in Table 19.1.3.

(4) Material Costs

Materials can be classified into imported articles and domestic articles. The costs of the main construction materials are referenced from the construction Material Price List.(CAPAC July 1993) plus 5 percent sales tax (Impesto de Transferencia de Bienes y Muebles : ITBM).

The costs of imported materials are estimated by adding the custom tariff (Reference: Arancel de Importacion Agoato de 1992) to the CIF value and adding handling charge and ITBM of 5 percent. Although most of the construction materials are available in panama, costs of equipment and plant used for loading transport and / or processing. The percentage of foreign and local portion of materials are shown in Table 19.1.4 and main material costs are shown in Table 19.1.5.

Table 19.1.3 Equipment Data

Equipment Name	Basic Price	Opera- tional Life	Resi -dual Value	Annual Operate Hour	Mainte- nance Rate (%)	Annual Manage Rate (%)	Foreign Financial	Local Financial	Economic
Agg. Spreader 2.3	1500	3	10.00	530	40.00	5.00	1.39	0.20	0.07
Apron Feeder 30t	44600	9	10.00	1000	45.00	5.00	8.58	0.58	0.08
Asphalt Plan 30t	523300	8	10.00	1200	35.00	7.00	175.11	111.67	60.61
Asp. Finaisher 3m	97500	7	10.00	550	35.00	7.00	42.97	2.61	0.46
Batching Plant	473300	7	10.00	950	55.00	7.00	141.59	19.23	7.61
Belt Con. 0.35*10m	2400	2	10.00	600	75.00	5.00	3.49	0.65	0.20
Belt Con. 0.6*15m	19600	4	10.00	600	75.00	5.00	14.2	1.61	0.21
Bulldozer 11t	93300	6	10.00	1200	35.00	7.00	22.51	3.08	1.21
Bulldozer 21t	205800	6	10.00	1200	35.00	7.00	49.02	6.02	2.24
Compressor 4.6m3	19500	6	10.00	1200	35.00	5.00	5.26	1.73	0.85
Compressor 9.6m3	37600	6	10.00	1200	35.00	5.00	9.86	2.97	1.45
Concrete Cutter 0.3m	1900	3	10.00	680	35.00	5.00	1.34	0.19	0.07
Conc. Breaker 30kg	700	2	10.00	960	20.00	5.00	0.42	0.01	0.00
Conc. Bucket	1800	6	10.00	560	55.00	5.00	0.88	0.06	0.00
Conc. Finisher 5.5m	155600	7	10.00	530	35.00	7.00	70.69	3.73	0.44
Conc. Spreader 2.3m	124000	7	10.00	530	35.00	7.00	56.3	2.93	0.33
Crawlor Crane 35t	261700	6	10.00	1200	35.00	7.00	59.52	4.21	0.93
Diesel Hammer 1.26t	44600	6	10.00	800	35.00	7.00	14.87	0.65	0.00
Diesel Hammer 2.5t	69200	6	10.00	800	35.00	7.00	23.07	1.01	0.00
Distributer 4kl	75750	6	10.00	530	40.00	7.00	39.21	2.08	0.10
Dump Truck 11t	75500	4	10.00	1200	50.00	10.00	28.06	3.19	0.90
Dump Truck 2t	16700	4	10.00	1200	55.00	10.00	7.38	2.01	0.91
Dump Truck 6t	49800	4	10.00	1200	50.00	10.00	18.68	2.32	0.71
Earth Auger 0.45	473300	4	10.00	1200	35.00	7.00	144.4	7.44	0.30
Engine Pump 4in	1730	6	10.00	740	110.00	5.00	0.96	0.26	0.10
Grout Mixer	6800	4	10.00	600	90.00	7.00	5.57	0.66	0.12
Grpit Pump	8000	4	10.00	600	90.00	7.00	6.52	0.75	0.12
Hand Hammer 1.1m3	2400	2	10.00	1280	20.00	5.00	1.09	0.04	0.00
Hydro-shovel 0.6m3	214200	6	10.00	1200	45.00	7.00	51.76	4.85	1.21
Lin arker 90kg	4600	4	10.00	1200	30.00	5.00	2.1	1.05	0.55
Mac. Roller 12t	25000	6	10.00	1200	65.00	7.00	7.52	1.83	0.77
Motor Grader 3.7m	118300	6	10.00	1200	35.00	7.00	27.92	3.15	1.11
PC Jack	10500	6	10.00	1200	75.00	10.00	3.06	0.22	0.00
Road Sweeper 1.8	155000	4	10.00	1200	30.00	7.00	47.68	4.17	1.24
Soil Compacter 0.05t	600	4	10.00	1000	45.00	5.00	0.28	0.09	0.04
Soil Compacter 0.2t	2900	4	10.00	1000	45.00	5.00	1.16	0.19	0.07
Soil Mixing Plant 15	157000	6	10.00	1200	50.00	7.00	41.08	5.12	2.35
Spray Gun	25500	5	10.00	1200	85.00	7.00	8.4	0.97	0.14
Sprayer 0.3kl	2200	3	10.00	1200	25.00	5.00	0.84	0.12	0.05
Surf. Vibratr 1.5*0	1800	4	10.00	530	65.00	5.00	1.47	0.22	0.06
Tandem Roller 10t	52500	6	10.00	1200	30.00	7.00	13.18	2.63	1.23
Tire Roller 15t	67500	6	10.00	1200	35.00	7.00	16.17	2.09	0.80
Truck 5t	27500	4	10.00	1200	40.00	10.00	10.22	1.61	0.64
Truck 8t	43750	4	10.00	1200	40.00	10.00	16.02	2.27	0.85
Truck Crane 11t	120800	6	10.00	1200	25.00	7.00	26.13	1.61	0.43
Truck Crane 16t	165800	6	10.00	1200	25.00	7.00	36.05	2.43	0.71
Truck Crane 5t	70300	6	10.00	1200	25.00	7.00	15.32	1.08	0.33
Truck Mixer 3m3	53400	4	10.00	1200	65.00	7.00	20.67	3.60	1.20
Vibratr	860	4	10.00	1000	65.00	5.00	0.37	0.05	0.02
Watering Cart 5.5kl	11000	6	10.00	1000	50.00	7.00	4.2	1.46	0.71
Wheel Loader 1.4m3	228300	6	10.00	1200	30.00	7.00	51.24	4.08	1.21
Truck Crane 40t	568300	6	10.00	1200	25.00	7.00	121.34	5.61	0.93
Truck Crane 70t	841700	6	10.00	1200	25.00	7.00	179.16	7.64	1.00
Concrete Pomp 55	150000	5	10.00	900	55.00	7.00	58.46	6.27	1.45
Truck Crane 90t	1108300	6	10.00	1200	25.00	7.00	233.97	9.11	4.07
Vib-Roller 3.5t	38700	4	10.00	1200	35.00	7.00	12.13	1.00	0.24

Table 19.1.4 Foreign and Local Potion of Material Cost

(Unit; Percent)

Description	Foreign Currency Portion	Local Currency Portion
Sand	60	40
Crusher rum	60	40
Stone	60	40
Wood	60	40
Cement	60	40
Cement Barring	80	20
Conches products	40	60
Asphalt	65	35
Gasoline	44	54
Diesel Oil	60	40
Heavy Oil	56	44
Electricity	60	40

Table 19.1.5 Material Cost

Description	Per-unit		Foreign (US$)	Per Unit Local Cost Financial (BL)	Per Unit Local Cost Economic (BL)
Ancor Bolt D28*600	1.00	PCS	3.11	1.51	0.70
Ancor Cap D80*350	1.00	PCS	1.04	0.50	0.24
Asphalt 80-100	1.00	TON	126.10	77.60	67.90
Asphalt Emulsion-2	1.00	LET	0.14	0.90	0.06
Cement	1.00	TON	57.67	43.20	38.40
Chatter bar	1.00	PCS	44.41	21.58	10.05
Concrete polo 10m	1.00	PCS	151.09	245.52	226.63
Concrete polo 5m	1.00	PCS	68.60	111.48	102.91
Conc.Admixture	1.00	KG	1.98	0.91	0.44
Crusher Run	1.00	CUM	6.67	5.00	4.44
Curing Mat	1.00	SQM	2.38	1.09	0.53
Curing Material	1.00	KG	3.31	1.51	0.73
CV Cable 14A	1.00	LM	0.79	0.46	0.19
Explosive	1.00	KG	6.73	3.86	1.61
Ex-Joint	1.00	LM	491.23	195.47	104.64
Filler	1.00	CUM	6.48	1.62	1.23
Guard Rail	1.00	LM	32.41	15.75	7.34
Hand Rail 2.0*0.8	1.00	LM	33.72	16.38	7.63
Hard Wood	1.00	CUM	360.00	270.00	240.00
Joint Material	1.00	SQM	8.29	3.79	1.84
Joint Sealer	1.00	KG	1.38	0.63	0.31
Lamp HH-400	1.00	PCS	23.27	13.34	5.58
Poizolis	1.00	KG	1.98	0.91	0.44
PC Anchor	1.00	PCS	424.00	206.00	96.00
PC Sheath D65	1.00	LM	2.21	1.07	0.50
PC Steel D12.7	1.00	TON	1795.84	872.51	406.60
PVC 3/4 st	3.00	LM	0.04	0.02	0.01

PVC 3/4 Joint	1.00	LM	0.17	0.08	0.04
PVC Conduit	1.00	LM	0.87	0.39	0.19
Reinforcement	1.00	TON	493.60	123.40	154.25
Rubber Shoe	1.00	SQM	1362.34	622.06	302.39
RC Pipe D1000	1.00	LM	65.40	106.28	98.10
RC Pipe D1200	1.00	LM	99.04	160.94	148.56
RC Pipe D2000	1.00	LM	243.30	395.36	364.95
RC Pipe D600	1.00	LM	27.16	44.13	40.74
Sand	1.00	CUM	5.10	3.83	3.40
Scaffolding	1.00	PCS	6.35	4.76	4.23
Screened Crusher	1.00	CUM	6.30	4.73	4.20
Seed	1.00	KG	5.91	4.59	3.20
Separater	1.00	PCS	25.44	6.36	4.84
Soft Wood	1.00	CUM	270.00	202.50	180.00
Steel Form 0.3*1.5	1.00	PCS	5.62	2.73	1.27
Steel H300	1.00	TON	127.50	61.95	28.87
Steel Write #10	1.00	TON	935.98	454.75	211.92
Stone	1.00	CUM	5.89	4.41	3.92
Taper Pole	1.00	PCS	688.80	215.25	172.20
Tile	1.00	SQM	6.80	3.70	3.20
Traffic G-Brad	1.00	KG	2.31	1.06	0.51
Traffic Paint	1.00	LIT	3.31	0.83	1.03
Traffic Sign 3'	1.00	SET	29.17	14.17	6.60
Traffic Sign 4'*6	1.00	SET	38.90	18.90	8.81
Water Stop	1.00	LM	16.54	7.55	3.67
Wire Mesh	1.00	SQM	4.85	3.93	2.68
Tree	1.00	PCS	5.20	5.30	4.80
Sod	1.00	SQM	0.95	0.97	0.88
Steel pile D800	1.00	LM	241.38	33.34	20.26
Sheet pile	1.00	LM	96.45	13.90	8.45

(5) Indirect Cost

The indirect cost are estimated as 35 percent of other direct construction costs (foreign and local portions accounting for 20 and 15 percent respectively.) and cover the costs of temporary facilities, site offices maintenance and overhead . The total direct and indirect cost the obtained, give the unit construction price for each cost item.

Table 19.1.6 Contents of Indirect Cost

(Unit: Percent)

Description	Foreign Portion	Local Portion	Total
1. Common Temporary Facilities			
1) Transportation	1.06	0.12	1.18
2) Mobilization and Demobilization	0.38	1.07	1.45
3) Temporary Facilities	0.40	0.60	1.00
4) Environment Control	0.20	0.30	0.50
5) Safety Facilities	0.12	1.08	1.20
6) Public Services Charge	-	1.00	1.00
7) Quality Control	0.44	0.44	0.88
8) Field Office Maintenance	0.70	0.89	1.59
Subtotal	3.30	5.50	8.99
2. Field Management	5.60	9.20	12.60
3. General Management	11.40	-	11.40
Total	20.30	14.70	35.00

Source: Team Estimate

(6) Engineering Service Costs

The cost of design and construction supervision are estimated as 10 percent of the total construction cost. The foreign and local portions of this cost are 80 and 20 percent respectively.

(7) Compensation and Land Acquisition costs

Information for estimating unit costs for land acquisition and compensation for house removal were collected from two major sources: The tax assessment data of The ministry of Finance which were revised occasionally, and the actual market price reported in newspapers. Compensation costs for land acquisition are shown in Table 19.1.7.

Table 19.1.7 Compensation Costs

(Unit: Balboa)

Description	Unit	Foreign Portion	Local Portion
Land			
1) Suburban Area	ha	0	500,000
2) Rural Area	ha	0	200,000
3) Mountain Area	ha	0	50,000
House			
1) Suburban Area	PCS	0	30,000
2) Rural Area	PCS	0	15,000
3) Other	PCS	0	5,000
4) Factory	PCS	0	100,000

Source: Study Team

(8) Contingency costs

In general contingency costs include two type of contingencies. The first (physical contingency) covers unexpected cost occurring during actual construction, such as unexpected rock excavation or work delay due to unusual weather. The Second which includes price escalation beyond and above anticipated price inflation. However in the Study solely physical Contingency costs are assumed to be 10 percent of the total project cost.

19.2 Construction Cost Estimation

19.2.1 Quantity of Construction and Cost Items

The quantity of the construction works is estimated from preliminary design drawings such as plans, cross sections and a general view of structures by section.

Cost items and units are counted by work items instead of individual materials; for example pavement works are counted at the unit price per square meter.

For actual cost estimation, each cost item is conceived in three stages: plant products, site products, and work items. The work items conform with cost items for unit price contracting. Plant products and site products are the items of the breakdown of each work item. Specifically, plant products are materials produced and delivered by a field plant, such as asphalt mixture. Asphalt mixture is placed, compacted and finished into a surface course, which is a site product. Work item is, for example, a pavement consisting of site products: an aggregate sub-base course, a stabilized bituminous base course, and an asphalt surface course.

The unit price of each work item, such as per square meter in the case of pavement, is multiplied by the quantity calculated through design, in estimating each cost item. For existing road upgrading projects, which are to be accomplished in urban areas where the use of pavement chiefly accomplish by hand is added as a cost item.

Plant product items, site products items, and work items are listed as shown in Table 19.2.1.

Table 19.2.1 Plant Products, Site Products and Works Items

(1) Plant Products

Description	Unit	Foreign (US $)	Local(Balboa)	
			Financial	Economic
Screened Aggregate	CUM	17.70	9.15	7.61
BT Aggregate	CUM	42.04	24.95	19.76
Asphalt Concrete	CUM	48.05	28.50	22.87
Concrete	CUM	42.34	25.61	21.15

(2) Site products

Description	Unit	Foreign (US $)	Local(Balboa) Financial	Local(Balboa) Economic
Structure Excavation	CUM	6.35	1.56	0.99
Equipment Backfill	CUM	0.76	0.71	0.54
Agg.subbase course	CUM	26.70	11.77	9.47
Concrete Pavement	CUM	69.51	46.69	34.59
Cement - T Base	CUM	28.40	13.20	10.75
BT Base Couse	CUM	51.01	29.70	23.25
Stone Masonry	CUM	33.16	23.44	17.44
Wood Forming	SQM	8.82	14.52	12.72
Steel Forming	SQM	15.44	13.45	8.58
Reinforcing	TON	682.65	369.32	314.18
Staging	CUM	2.51	5.11	4.90
Support	CUM	5.03	7.76	7.34
Lean Concrete	CUM	35.34	53.95	35.94
Foundation Concrete	CUM	40.49	28.35	22.84
Structural Concrete	CUM	51.60	40.92	30.42
PC Concrete	CUM	54.23	43.44	33.42
Erection 70 t	TON	124.66	9.49	3.87
Erection 90 t	TON	130.77	8.45	3.05
Prestressing	TON	6060.71	4443.82	2935.20
Asphalt Surface	CUM	53.40	94.18	57.50
Pilling(D 800)	LM	258.03	38.89	24.61

(3) Works

Description	Unit	Foreign (US $)	Local(Balboa) Financial	Local(Balboa) Economic
Clearing and Grubbing	SQM	1.08	0.24	0.17
Cutting	CUM	4.73	1.21	0.87
Cutting (S.Rock)	CUM	11.57	5.14	3.54
Spoil Soil	CUM	3.80	0.90	0.58
Embankment	CUM	4.31	1.04	0.65
Concrete Pavement 15	SQM	14.69	8.98	6.80
Concrete Pavement 25	SQM	22.21	13.88	10.52
Asphalt Pavement A-1	SQM	25.03	19.72	13.87
Sidewalk Pavement	SQM	10.05	13.64	10.99
Stone Masonry H = 5.0m	LM	167.95	156.33	113.00
RW-7m	LM	1021.07	836.41	648.04
C-Bx 3*3	LM	908.06	658.68	479.78
C-Bx 5*5	LM	2494.46	1934.59	1497.29
C-Bx 7*5	LM	3968.38	2707.47	2277.22
Markings	SQM	3.23	1.80	1.30
Traffic Sign	PLS	62.42	52.28	34.11
Lighting (30m)	DLS	959.65	572.74	386.08
Lighting (35m)	PLS	1198.80	704.54	442.60
Guard Railing	LM	42.31	18.30	8.57
Overlay(15cm)	SQM	8.19	14.22	8.68
P-D1500	LM	277.26	330.06	291.21
P-D1200	LM	167.52	196.09	175.81
P-D 600	LM	55.07	57.94	51.19
U-Ditch	LM	12.53	9.73	6.43
Median(10m)	LM	157.12	77.35	57.58
Seeding	SQM	0.53	0.72	0.44

Source: Study Team

19.2.2 Unit Section

The project under study consists of three construction stages. None needs to be implemented as one project in itself. Therefore, each is divided into a number of unit sections in the manner described below, for cost estimation purpose. They must not be determined with due consideration to project priority, work volume and factors.

1) Each unit section will be connected with other roads in such a way that it can be opened for service and produce benefit before completion of other sections.

2) Each unit section will consist of smaller unit elements to enable formulation of various alternative work programs for project implementation, and the section cost is estimated based on such elements.

19.2.3 Total Project cost

The cost, disregarding price escalation and price contingency of each unit section is estimated based on July 1993 Prices. Project costs are shown in the Table 19.2.2.

Table 19.2.2 Summary of Road Projects Costs

Road	Length (km)	Construction Foreign	Construction Local	Land	Total	Per Km	Foreign (%)	Location (%)
Alcalde Diaz	20.2	75,472	38,632	24,537	138,641	6,858	54.40	45.60
A-1(Panama)	9.2	34,308	18,624	15,956	68,888	7,488	49.80	50.20
A-2(Cement factory)	6.3	24,039	11,772	4,373	40,184	6,379	59.80	40.20
A-3(Chagres)	4.7	17,125	8,236	4,208	29,569	6,271	57.90	42.10
Sabanita	26.2	162,796	85,472	15,852	264,120	10,081	61.60	38.40
S-1(Buena Vista)	16.5	107,457	55,396	9,169	172,022	10,426	62.50	37.50
S-2(Colon)	9.7	55,339	30,076	6,683	92,098	9,495	60.10	39.90
Grand Total	46.4	238,268	124,104	40,389	402,761	8,680	59.16	40.84

Souce:Team Estimate

The total project cost reaches 402.8 million Balboa, of which 138.6 million Balboa is for the Alcalde Diaz section, and 264.1 million Balboa is for the Sabanitas section. The total project cost consists of the compensation costs (Land acquisition costs and house compensation) and construction costs. The total costs for compensation of 40.4 million Balboas account for 10.0 percent of the total project cost.

19.2.4 Contents of Direct Construction Cost

The direct construction cost is the total of each cost of machinery materials and labor. Total direct construction cost is estimated at 221.8 million Balboas. Of which 46.9 percent is construction equipment cost. Labor and materials are accounted as 12.5 and 40.6 percent of total direct construction cost respectively. The Alcalde Diaz and Sabanitas including direct construction cost of bridge are estimated as 15.0 and 35.9 percent of the total direct construction cost, respectively.

19.2.5 Cost per Kilometer

The Sabanitas Colon and Buena Vista, unit section in Sabanitas which including many bridge costs indicate, 10.4 and 9.5 million Balboas respectively per Kilometer of road construction.

The unit section of Panama (A-1), Cement Factory (A-2) and Chagres (A-3) in Alcalde Diaz including four interchanges costs are estimated as 7.5, 6.4 and 6.3 million Balboas per kilometer, respectively.

19.3 Maintenance Costs

19.3.1 Preconditions for Estimation of Maintenance costs

Maintenance operations covers the manafement of maintenance and maintenance work. The management of maintenance includes planning of maintenance, inspections, coordination of maintenance works and management of toll gate systems.

Maintenance work is classified into routine maintenance and periodic maintenance. Routine maintenance work is required irrespective of traffic volume and covers such works as grass cutting, cleaning of pavements and drainages, and daily maintenance work.

The requirement of periodic maintenance work depends on traffic voloumen and the condition of road surfaces. It includies such works and road overlaying, lane marking, sealing, as well as the repair of other facilities.

For the present estimation, the following are not including in the maintenance costs.

a) Prevention and repair of damages caused by natural disasters.
b) Electricity charges for road lighting because they are to be paid by the municipal gocernment or by IRHE.

19.3.2 Estimations of Maintenance Costs

The Prohect under studying will affect the amount of governmnet funds required for road maintenance year by year both during its execution and after its completion. The estimated maintenance costs for the Project exclude the cost of minor improvement work, although this work is presently carried out by governmnet. In the estimation, a level of maintenance higher than the present one has been assumed, e.g. more frequent adfustment of unevenness, renewal of road markings and other safety facilities. The pavemnet shall be overlay when PSI decrease below 2.5. The period until overlaying was calculated with AASHTO method using planned pavement structure and planned traffic volume of this project. The costs were estimated in terms of the direct cost for each work item in accordance with the above. The work items, frequency and estimated cost are shown in Table 19.3.1.

Table 19.3.1 Estimation of Maintenance Costs
(Balboas/Year)

Description				
Management				
Inspection, Admin.	km	4877.4		
Toll gate system	km	7112.9		7 Gates
Routine work				
Grass cutting	km	839.3	1618.1	twice/year
Cleaning of road	km	85.6	25.5	once/month
Cleaning of drain	km	195.7	103.7	twice/year
Repeir (guardrails, traffic sings, patching, etc.)	km	1197.3	1251.9	-
Periodic work				
Overlaying	km	9184.0	15488	once/15years
Lane marking	km	1237.7	791.9	once/ 3years
Repair of facility				
Guardrail	km	1179.6	252.3	once/20years
Traffic sign	km	125.8	91.8	once/20years
Noise Prev.	km	2269.0	1462.4	once/20years
Fence	km	1629.0	2969.8	once/10years
Lamp change	km	134.7	89.84	once/ 2years

20 IMPLEMENTATION SCHEDULE

20.1 Project Outline

20.1.1 Recommended Projects

The master plan for the road network development between the cities of Panama and Colon is formulated in Stage One of the study, and the feasibility study is based on the selected routes. As a result of examining the priority road section, the feasibility study is performed for the Alcalde Diaz and Sabanitas Sections as the recommended project. The recommended projects consists of the following two road projects:

a) Alcalde Diaz Section road construction project
b) Sabanitas Section road construction project

20.1.2 Project Outline

The project consists of the following main construction of facilities and the construction quantities are shown in Table 20.1.1.

a) Construction of 4-lane dual carriageway
b) Construction of five interchanges and two at-grade intersections
c) Construction of one service area
d) Construction of 27 bridges
e) Construction of bus stop

Table 20.1.1 List of Construction Quantities

Road Section / Items	Alcalde Diaz (20.2km)	Sabanita (26.2km)	TOTAL (46.4km)
1.Design Considerations			
Design Traffic Volumes	60,000 V/D	58,000 V/D	----
Design Speed	110km/h	110km/h	----
Levels of Service	C	C	----
Access Control	Full	Full	----
Toll System	Flat Rate	Flat Rate	----
Number of Lanes	4-Lane	4-Lane	----
Width of Lane	3.65m	3.65m	----
Median Width	10.0m	10.0m	----
Shoulder Width (Right)	3.0m	3.0m	----
Shoulder Width (Left)	1.5m	1.5m	----
Right of Way	100m	100m	----
Pavement Type(t=25)	Concrete	Concrete	----
Horizontal Alinement			
Minimum Radius	800m	600m	----
Vertical Alinement			
Maximum	3.0 %	3.0%	----
2.Road Facilities			
Number of Interchange	4 vol	3 vol	7 vol
Average Distance	6.7km/vol	13.0Km/vol	----
Number of Service Area	1 vol	1 vol	2 vol
Number of Bus Stop	4 vol	3 vol	7 vol
3.Quantities			
Road Length	20.2 km	26.2 km	46.4 km
Excavation (1,000)	2,200 m3	4,260 m3	6,460 m3
Embankment (1,000)	1,600 m3	3,270 m3	4,870 m3
Wasted Soil (1,000)	600 m3	990 m3	1,590 m3
Pavement Carriageway(t=25)	309,900m2	382,040m2	691,940 m2
Pavement Shoulder(t=15)	158,900m2	135,700m2	294,900 m2
Bridge			
20m<L<50m	130 m	50 m	180 m
50m<L	245 m	2,145 m	2,390 m
Over Bridge	4 vol	6 vol	10 vol
Land Acquisition			
Residence Area	2.0 km	1.2 km	3.2 km
Compensation			
House Type A	15 vol	0 vol	15 vol
House Type B	24 vol	31 vol	75 vol
House Type C	39 vol	29 vol	68 vol
Factory	2 vol	1 vol	3 vol
4.Project Cost (1,000/B)			
A1(9.2km)	68,888	----	68,888
A2(6.3km)	40,184	----	40,184
A3(4.7km)	29,569	----	29,569
Sub-Total(20.2Km)	138,641	----	138,641
S1(16.5km)	----	172,022	172,022
S2(9.7km)	----	92,089	92,089
Sub-Total(26.2Km)	----	264,120	264,120
Grand Total(46.4Km)	----	----	402,761

20.2 Implementation Schedule and Fund Requirements

20.2.1 Project Priority

(1) Basic Consideration

The total length of the Alcalde Diaz and Sabanitas Sections is 20.2 and 26.2 kilometers, respectively. The Alcalde Diaz Section can be divided into three sub-sections: A-1, A-2 and A-3, and the Sabanitas Section can be divided into two sub-sections: S-1 and S-2, considering the construction costs and traffic characteristics. The implementation schedule is arranged based on the following basic considerations items;

a) To maintain balance with future traffic demands of each section
b) To meet housing and other development schedules.
c) To consider balance with annual requirements of investment costs by each year
d) To formulate road network configuration according to functions and characteristics of proposed road
e) To consider traffic safety and conditions of existing Panama-Colon Highway
f) To consider economic aspects.

(2) Scheduling Conditions

The Project priority is formulated taking into account following conditions:

a) As a result of economic evaluation of the three sections (Alcalde Diaz, Sabanitas S-1 and Sabanitas S-2), the Alcalde Diaz Section has the highest economic indicator. The second highest economic indicator is the Sabanitas S-2 and the last is Sabanitas S-1 sub-section.

Table 20.2.1 Economic Indicators

Section/ Indicators	Alcalde Diaz A-1 to A-3	Sabanitas S-1	 S-2
B/C	6.6	2.3	6.5
IRR	41.0	21.6	37.6
NPV	597.0	133.0	304.0

Based on the economic examination, it is required the Alcalde Diaz Section should be constructed faster than the Sabanitas Section.

b) According to the economic indicators the S-1 sub-section has higher economic indicators than S-2. However, based on the following items, it is recommended that the Sabanitas S-1 sub-section be constructed before the S-2 sub-section.

c) When the future traffic volume exceeds the traffic capacity of the existing road at the same areas of the S-1 and S-2 sub-sections before the proposed roads (S-1 and S-2) are constructed, the S-2 sub-section would be able to add traffic by widening the existing road.
d) However, widening of the existing road from two-lanes to four-lanes in the same area of S-1 is very difficult considering the topographic conditions and construction method which should be built under existing traffic operation.
e) Since the horizontal and vertical alignment of the existing highway in same area of S-1 subsection is very poor and many accidents occurs, necessity of a diversion road is urgent.

20.2.2 Investment Schedule

Taking into account and the project priority the implementation schedule for the projects are shown in Figure 20.2.1. Economic analysis is carried out based on the above-mentioned implementation schedule. As a result of the economic analysis, the implementation schedule is indicated as a high economic return as shown below.

The total investment cost is estimated as 402,7 million Balboas at 1993 prices. The cost of Alcalde Diaz and Sabanitas sections are about 138.6 million and 264.1 million respectively. Based on the implementation schedule, the required investment cost for the projects in each fiscal year is calculated as shown in Figure 20.2.1.

```
                                1900                     2000
Road Section /Year              95   96   97   98   99   00   01   02   03   04
--------------------------------------------------------------------------------
Alcalde Diaz Section (20.2 km)
     A-1 (9.2 km)               ****=========
     A-2 (6.3 km)               ****      ========
     A-3 (4.7 km)               ****           =======

Sabanitas Section (26.2 km)
     S-1 (16.5 km)                        ****===============
     S-2 ( 9.7 km)                                       ****===============
--------------------------------------------------------------------------------
Investment Cost               33,967   48,797  68,749 60,489   19,589
 (1,000/B)                         20,935   56,048   51,091 19,589  23,507
--------------------------------------------------------------------------------
Note: ******  Land & Engineering Period
      ======  Construction Period
```

Figure 20.2.1 Implementation Schedule

21 ECONOMIC EVALUATION

21.1 Objectives and Method of Economic Evaluation

21.1.1 Objectives of Economic Evaluation

The objective of economic evaluation is to answer the question whether the project for the Panama-Colon Highway is economically feasible. The sections for the road that are selected in the technical study, are the subject of this economic evaluation. The economic benefit and cost of the project are evaluated at the border price on a price distortion free basis, and are compared to examine the investment efficiency from the national economic point of view.

21.1.2 Method of Economic Evaluation

The economic benefit and cost are evaluated at border prices that fix the distortion of internal pricing of the Panamanian economy. The major distortion are identified in tradable and untradable goods, land price, labor market and capital market in the Panamanian economy.

The economic feasibility of the project is examined by Benefit Cost Ratio (B/C), Economic International rate of Return (EIRR) and Net Present Value (NPV). A social discount rate of 12 percent which is assumed to reflect the capital cost for investment in Panama is used in the analysis.

21.1.3 Road Section

The road construction section are shown in Table 21.1.1

Table 21.1.1 Road Section for Proposed Road

No.	Road Segment	Length
A-1	San Miguelito - Alcalde Diaz	9.2
A-2	Alcalde Diaz - Calzada Larga	6.3
A-3	Calzada larga - Buenos Aires	4.7
S-1	Buena Vista - Sabanitas	16.5
S-2	Sasbanitas - Colon	9.7

21.2 Economic Benefit

21.2.1 Concept of Economic Benefits

The economic benefits of a road construction project take into account two kinds of savings; vehicle operating cost saving and time cost saving. The first one, vehicle operating cost saving is a cost saving due to the shorter distance and travel time achieved realized by construction of a new road. The following five items are of focus of the Study on the vehicle operating cost saving:

a) Fuel and lubricating oil cost saving
b) Tire wear cost saving
c) Vehicle maintenance cost saving
d) Vehicle wear cost saving
e) Occupant time cost saving

Time cost saving means the opportunity cost of travelers. Travelers can cut their commuting and business time by using the proposed road, and consequently can work more hours to increase income.

The inventory cost of transported commodities by trucks is also saved due to reduced travel time. However, commodity data corresponding to movement of vehicles are not available, so inventory cost is excluded from the calculation of economic evaluation. Six different types of vehicle are assumed for calculation of economic benefit: passenger car, light truck, heavy truck, taxi, public bus, and private bus.

21.2.2 Calculation of Economic Benefits

(1) Vehicle Operating Cost Saving

1) Fuel and Lubricating Oil Cost Saving

Table 21.2.1 shows consumer's prices for fuel and lubricating oil at 1993 price in Panama . Savings of fuel and lubricating oil expenditures due to the improvement of the Panama-Colon Highway will constitute an economic benefit of the project. Consumer prices are obtained from internal information of Ministry of Commercial and Industrial. Oil prices are revalued from the national economic point of view by excluding the import tax. Import tax is a transfer item in the oil price from consumer to the government and has no economic meaning from the national economic point of view. Based on the economic cost of oil, expenditure on oil that would be consumed by each vehicle type if no improvement takes place is calculated. This expenditure constitutes the economic benefit of the project.

Table 21.2.1 Fuel and Lubricating Oil Cost Savings

Cost Components		Gasoline	Diesel	Lubricant
Cnsumer's Price	(B/gal)	1.67	1.09	7
Import Tax	(B/gal)	0.68	0.26	0.67
Economic Cost	(B/gal)	0.99	0.83	6.33
	(B/liter)	0.26	0.22	1.67

Source; Ministry of Commercial and Industrial

Table 21.2.2 Oil Consumption Cost Savings

	passenger Car	Light Truck	Truck	Taxi	public Bus	Bus
Consumption Rate						
Gasoline (km/liter)	8.00	-	-	8.00	-	-
Diesel (km/liter)	-	7.50	3.50	-	3.00	7.50
Lubricant						
(10-3 lit/km)	0.60	1.10	5.00	0.60	6.70	1.10
Fuel and lubricant Costs						
Fuel (c/km)	3.25	2.94	6.29	3.25	7.34	2.94
Lubricant(c/km)	0.10	0.19	0.84	0.10	1.12	0.19
Total(c/km)	3.35	3.13	7.13	3.35	8.46	3.13
(B/1,000km)	33.50	31.30	71.30	33.50	84.60	31.30

Source; Ministry of Commercial and Industrial

2) Tire Wear Cost Savings

Tire wear cost will be saved by the shorter travel an the improved highway, and its cost per mileage is estimated in Table 21.2.3. Import tax (15 percent) and ITBM (5 percent) are deducted from the financial costs of tires to convert to economic cost.

Table 21.2.3 Tire Wear Cost Saving

	Passenger Car	Light Truck	Truck	Taxi	Public Bus	Private Bus
Number of Tires	4	6	6	4	6	6
Financial Cost (B)	34.80	97.50	166.00	35.80	166.00	53.35
ITBM(5%)	1.74	4.88	8.30	1.74	8.30	2.67
Import Tax(15%)	5.22	14.63	24.90	5.22	24.90	8.00
Economic Cost (B)	27.84	77.99	132.80	27.84	132.80	42.68
Tire Life(1,000km)	36.00	50.00	50.00	35.00	16.00	22.00
Tire Wear Cost Saving (B/1,000km-vehicle)	3.13	9.75	16.6	3.13	46.48	11.74

3) Vehicle Maintenance Cost Saving

Vehicle maintenance cost will be saved by the shorter use of vehicle in the new highway. Vehicle maintenance cost is constituted by labor and spare parts costs in maintenance.

Table 21.2.4 Vehicle Maintenance Cost Saving

	passenger Car	Light Truck	Truck	Taxi	public Bus	Bus
Spare Parts Costs						
(a) Spare Parts (% of vehicle cost/1,000km)	0.091	0.088	0.122	0.318	0.318	0.318
(b) Economic Cost of Vehicle (B)	12,593.300	14,972.300	25,596.800	8,762.100	42,658.800	9,678.000
(c) parts Cost (B/1,000)	11.460	13.180	31.230	27.861	135.650	30.780
Labor Cost						
Labor Requirement(hr)	24.000	50.000	250.000	320.000	320.000	250.000
Labor Wage (B/year)	3.125	3.125	3.125	3.125	3.125	3.125
Operating Distance (1,000km/year)	15.000	30.000	30.000	35.000	35.000	15.000
Economic Labor Cost (B/1,000km)	5.000	5.210	26.040	28.570	28.570	52.080
Total (B/1,000km)	16.460	18.380	57.270	56.430	164.230	82.860

Source:MOP internal document.

4) Vehicle Wearing Cost Saving

Vehicle life will be extended due to the shorter distance of travel on a new road in a year, and vehicle wearing cost will be saved in terms of mileage and wearing value of vehicle as shown in Table 21.2.5.

Table 21.2.5 Economic Saving of Vehicle Wearing Cost

	Passenger Car	Light Truck	Truck	Taxi	Public Bus	Private Bus
Economic Vehicle Cost(B)	12,593	14,972	25,596	8,762	42,658	9,678
Residual Value(%)	5	5	10	10	10	10
Total Depreciation(B)	11,964	14,224	23,037	7,886	38,398	8,710
Operating Distance (1,000km)	150	360	350	350	700	180
Depreciation Expense (B/1,000km)	79.76	39.51	22.53	22.53	54.85	48.39

5) Time costs of vehicle occupants

The time costs of vehicle occupants are also counted in operating cost saving because the saved time of drivers and helpers will reduce the costs of vehicle operation.

The average wages of drivers and helpers are applied to the calculation. 874.55 Balboas is applied for the monthly wage of driver, and 485.86 Balboas is applied for that for helper. (See Table 21.2.6). The rate of shadow wage is applied to the calculation of unit labor cost of truck helpers because they are supposed to be unskilled workers, 0.5472.

Table 21.2.6 Time Cost of Vehicle Occupants

	Passenger Car	Light Truck	Truck	Taxi	Public Bus	Private Bus
Number of Drivers	---	---	1	1	1	1
Number of Helper	---	---	1	---	---	---
Annual Working Hours	---	---	1,500	2,400	2,400	1,800
Annual Operating Distance (1,000km)	---	---	30	35	25	15
Working Hours (hr./1,000km)	---	---	100	68.57	68.57	120
Unit Crew Cost (B/hr.)	---	---	1.9	2.92	3.15	2.9

6) Summary of Vehicle Operating Cost

Table 21.2.7 shows the summary of vehicle operating cost savings.

Table 21.2.7 Summary of Vehicle Operating Cost Savings

Cost Saving	Passenger Car	Light Truck	Truck	Taxi	Public Bus	Private Bus
Saving per mileage(B/1,000km)	33.5	31.3	71.3	33.5	84.6	31.3
(1)Fuel & Lubricant	3.13	9.75	16.6	3.13	46.48	11.74
(2)Tire Wear	16.46	18.39	57.27	66.43	164.23	82.86
(3)Maintenance	79.06	39.51	63.99	22.53	54.85	48.39
(4)Vehicle Replacement	132.15	98.95	209.16	125.59	350.16	174.29
(1)+(2)+(3)+(4)						
Saving per hour						
(5)Time Cost of Vehicle Occupants	---	---	1.9	2.92	3.15	2.9

Source:MOP internal document

(2) Time Cost Saving

The time cost saving is defined as the opportunity wages of travelers who drive on a new road. The use of a new road can shorten the duration of travelers' commuting, and thus, a part of the saved time can be allocated for their additional working hours. Therefore, time costs saving should be included in the economic benefits of the road construction project.

The estimation of time cost saving is relatively simple. The method of calculation is multiplying a unit time value by the total time avenge of the project. Basically an unit time value is an opportunity cost of each passenger (user) of various modes of transport, and thus passengers wages and their probabilities to use transportation for the purpose of business and commuting to work are taken into consideration.

Wages of passengers of different vehicles are calculated based upon the average labor wages. In Panama, car-owing households tend to earn higher income than non car owing households who travel by means of public transport. Therefore, different adjusted ratios of the average wages should be applied to the calculation. 80 percent plus to the average wages and 30 percent minus from the average wages are applied to the wage estimation of car users (owners) and bus passengers respectively. The average wages (unadjusted wages) is to be applied to the calculation of wages for co-riders of cars and passengers of taxies as shown in Table 21.2.8.

Table 21.2.8 Labor Wages of Passengers
(Unit; Balboas/ Month)

Class	1983	1986	1991
Average Wage(B/month)	423.96	455.13	485.86
Car Driver	---	---	874.55
Co-driver	---	---	485.86
Passenger of Taxies	---	---	485.86
Passenger of Buses	---	---	340.10

In order to apply the wage data to the analysis of passengers time cost saving, it is essential to specify the passengers probabilities to use vehicles for business and going to/from work. Table 21.2.9 and Table 21.2.10 below how the future trip composition and the number of passengers of each mode of transport respectively, while the unit travel time value for each vehicle type is summarized in Table 21.2.11.

Table 21.2.9 Future Trip Composition in the year 2000

Mode of Transport	Work	Business	Others	Total(%)
1.Walk, Two Wheelers	8.07	0.76	91.17	100.0
2.Private Car	22.35	4.68	72.97	100.0
3.Truck	20.32	39.90	39.78	100.0
4.Taxi	13.53	2.98	83.49	100.0
5.Route Bus	21.28	1.34	77.38	100.0
6.Private Bus	8.03	2.21	89.76	100.0
Average	18.07	4.76	79.72	100.0

Table 21.2.10 Average Number of passengers

	Passenger Car	Truck	Taxi	Public Bus
Driver	1	1	1	1
Passenger	0.99	0.99	0.53	17.13

Table 21.2.11 Unit Travel Time Value

	Passenger Car	Truck	Taxi	Public Bus
Time Value	2.29	1.90	3.19	10.03

(3) Calculation of Economic Benefit

The previous section has given the estimation of vehicle operating cost saving and time saving (due to the construction of a new road) for the year of 2010 as shown in Table 21.2.12.

The economic benefits earned by road construction projects can be calculated with the application of the unit cost savings of vehicle operation and passenger time.

Table 21.2.12 Economic Benefit due to vehicle operating cost and Time Savings

	Total	P.Car	Taxi	Bus	Truck
Year 2000					
(1) Distance Savings: 1,000 PCU-Km/ day.					
A-1,2,3	440	204	28	51	156
S-1	61	30	4	8	19
S-2	72	33	5	15	20
S-1,2	286	137	21	42	86
Total	726	341	50	93	243
(2) Economic Benefit by Distance Savings: 1,000 B/yr.					
A-1,2,3	12,936	8,078	1,071	1,530	2,257
S-1	1,837	1,184	153	224	277
S-2	2,217	1,307	189	436	285
S-1,2	8,717	5,426	799	1,248	1,244
Total	21,653	13,504	1,869	2,778	3,501
(3) Time Savings: 1,000 PCU-hr/day					
A-1,2,3	163	77	12	21	53
S-1	26	13	2	3	8
S-2	12	6	1	2	3
S-1,2	56	27	4	8	17
Total	219	105	16	28	70
(4) Economic Benefit by Time Savings: 1,000 B/yr.					
A-1,2,3	95,160	53,109	11,230	20,716	10,105
S-1	15,056	8,637	1,660	3,194	1,565
S-2	7,531	3,908	935	2,078	610
S-1,2	33,814	18,768	4,170	7,684	3,192
Total	128,974	71,877	15,400	28,400	13,297
Ground Total					
A-1,2,3	108,096	61,187	12,301	22,246	12,362
S-1	16,892	9,821	1,813	3,417	1,841
S-2	9,748	5,215	1,124	2,514	895
S-1,2	42,531	24,194	1,968	8,932	4,437
Total	150,627	85,381	7,269	31,178	16,799

	Total	P.Car	Taxi	Bus	Truck
Year 2010					
(1) Distance Savings: 1,000 PCU-Km/ day.					
A-1,2,3	997	527	37	97	335
S-1	118	63	7	10	38
S-2	359	224	11	44	80
S-1,2	726	418	34	82	192
Total	1,722	945	71	179	527
(2) Economic Benefit by Distance Savings: 1,000 B/yr.					
A-1,2,3	30,015	20,877	1,413	2,882	4,842
S-1	3,595	2,494	252	293	555
S-2	11,765	8,896	412	1,309	1,148
S-1,2	23,063	16,571	1,276	2,451	2,766
Total	53,057	37,448	2,689	5,333	7,608
(3) Time Savings: 1,000 PCU-hr/day					
A-1,2,3	228	123	9	23	72
S-1	125	67	8	12	38
S-2	180	107	11	21	41
S-1,2	372	210	24	40	98
Total	600	333	34	63	170
(4) Economic Benefit by Time Savings: 1,000 B/yr.					
A-1,2,3	130,376	84,479	9,025	23,113	13,758
S-1	72,748	45,882	7,676	11,881	7,310
S-2	112,568	73,359	10,697	20,675	7,838
S-1,2	225,728	144,231	23,068	39,828	18,601
Total	356,104	228,710	32,094	62,941	32,359
Ground Total					
A-1,2,3	160,390	105,356	10,438	25,996	18,600
S-1	76,343	48,376	7,928	12,174	7,865
S-2	124,333	82,254	11,109	21,984	8,985
S-1,2	248,791	160,802	24,344	42,279	21,367
Total	409,181	266,158	34,782	68,274	39,966

21.3 Economic Cost

21.3.1 Concept of Economic Cost

Economic cost reflects the shadow pricing of commodity that assumes no distortion of pricing in a market. Concept of obtaining the economic cost is schematically expressed in Figure 21.3.1. Because the international market is a competitive market to provide a distortion free pricing, traded goods of project is evaluated at a border price such as cargo in freight (c.i.f.) for imported and freight on board (f.o.b.) for exported. On the other hand, there is no such a pricing for non-traded good. Therefore, components of non-traded goods such as machines, materials and labors are treated to be relieved form market distortion and brought to the national border to reflect the border price.

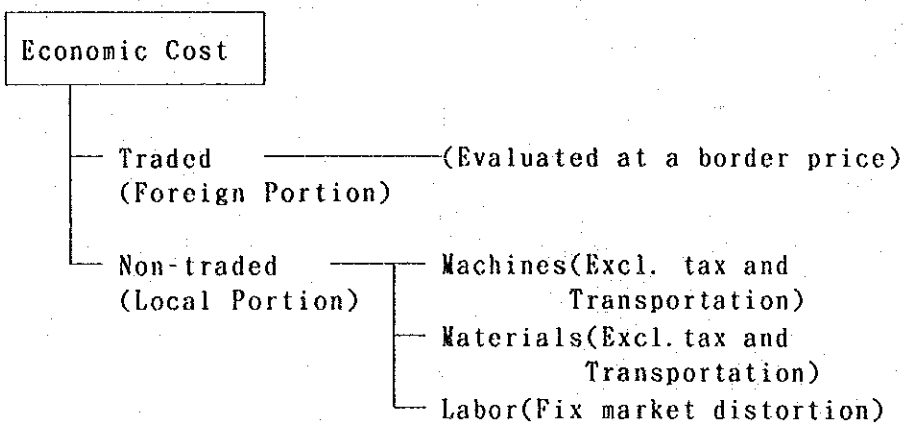


Figure 21.3.1 Concept of Economic Cost

21.3.2 Calculation of Economic Cost

Financial cost and economic cost of project are calculated in Table 21.3.1. Conversion of financial cost into economic cost observes following rule:

1) Equipments: Most equipments are expected to be imported. Import tax is subtracted.

2) Materials: Import tax and sales tax are subtracted from financial costs of material in order to convert to economic costs.

3) Unskilled labor is adjusted by its true productivity. The conversion factor is assumed to be 0.54.

4) Land cost is assumed to reflect its true production by a

market price. Thus is adjustment is not applied for land cost.

Table 21.3.1 Financial and Economic Costs

	Financial Cost of Project			Economic Cost of Project		
	Foreign	Local	Total	Foreign	Local	Total
(1)Direct Cost('000$)						
A-1	21,111	11,293	32,404	21,111	8,128	29,239
A-2	15,036	6,887	21,923	15,036	4,901	19,937
A-3	10,740	4,786	15,526	10,740	3,392	14,132
S-1	66,683	33,013	99,696	66,683	23,062	89,745
S-2	34,046	18,243	52,289	34,046	12,993	47,039
Total	147,616	74,222	221,838	147,616	52,476	200,092
(2)Indirect Cost('000)						
A-1	6,578	4,763	11,341	5,936	4,298	10,234
A-2	4,450	3,223	7,673	4,047	2,931	6,978
A-3	3,152	2,282	5,434	2,869	2,077	4,946
S-1	20,238	14,655	34,894	18,218	13,193	31,411
S-2	10,615	7,686	18,301	9,549	6,915	16,464
Total	45,033	32,610	77,643	40,619	29,414	70,032
(3)Engineering						
A-1	3,500	875	4,375	3,158	789	3,947
A-2	2,368	592	2,960	2,153	538	2,691
A-3	1,677	419	2,096	1,526	382	1,908
S-1	10,767	2,692	13,459	9,692	2,423	12,116
S-2	5,647	1,412	7,059	5,080	1,270	6,350
Total	23,959	5,990	29,948	21,610	5,402	27,012
(4)Land Cost						
A-1	0	15,956	15,956	0	15,850	15,850
A-2	0	4,373	4,373	0	4,364	4,364
A-3	0	4,208	4,208	0	4,182	4,182
S-1	0	9,169	9,169	0	9,159	9,159
S-2	0	6,683	6,683	0	6,142	6,142
Total	0	40,389	40,389	0	39,697	39,697
(5)Contingency						
A-1	3,119	1,693	4,812	3,020	1,322	4,342
A-2	2,185	1,070	3,256	2,124	837	2,961
A-3	1,557	749	2,306	1,514	585	2,099
S-1	9,769	5,036	14,805	9,459	3,868	13,327
S-2	5,031	2,734	7,765	4,868	2,118	6,985
Total	21,661	11,282	32,943	20,984	8,730	29,714
(6)Grand Total						
A-1	34,308	34,580	68,888	33,225	30,387	63,612
A-2	24,039	16,145	40,184	23,360	13,571	36,931
A-3	17,125	12,444	29,570	16,649	10,618	27,267
S-1	107,457	64,565	172,022	104,053	51,704	155,757
S-2	55,339	36,758	92,097	53,543	29,438	82,980
Total	238,268	164,493	402,761	230,829	135,718	366,547
	59%	41%	100%	63%	37%	100%