JAPAN INTERNATIONAL COOPERATION AGENCY

MINISTRY OF WORKS

KINGDOM OF TONGA

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR ROAD IMPROVEMENT WORKS IN TONGATAPU
IN
THE KINGDOM OF TONGA

MARCH 1994

KATAHIRA & ENGINEERS INTERNATIONAL
CHODAI CO., LTD.

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PREFACE

In response to a request from the Government of the Kingdom of Tonga, the Government of Japan decided to conduct a basic design study on the Project for Road Improvement Works in Tongatapu and entrusted the study to the Japan International Cooperation Agency (JICA).

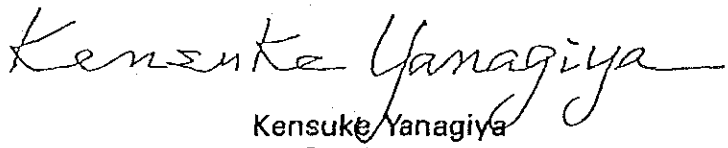
JICA sent to tonga a study team headed by Mr. Hidenao Hayashi, Advisory Officer, Engineering Department, Hanshin Expressway Public Corporation and constituted by members of Katahira & Engineers International and Chodai Co., Ltd., from October 2 to 30, 1993.

The team held discussions with the officials concerned of the Government of Tonga, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Tonga in order to discuss a draft report, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Kingdom of Tonga for their close cooperation extended to the teams.

March 1994



Kensuke Yanagiya
President
Japan International Cooperation Agency

Mr. Kensuke Yanagiya,
President
Japan International Cooperation Agency
Tokyo, Japan

March 1994

Letter of Transmittal

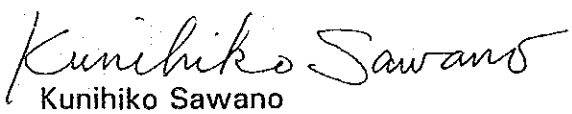
We are pleased to submit to you the Basic Design Study Report on the Project for Road Improvement Works in Tongatapu in the Kingdom of Tonga.

This study was conducted by Katahira & Engineers International and Chodai Co., Ltd., under a contract to JICA, during the period from September 20, 1993 to March 18, 1994. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Tonga and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

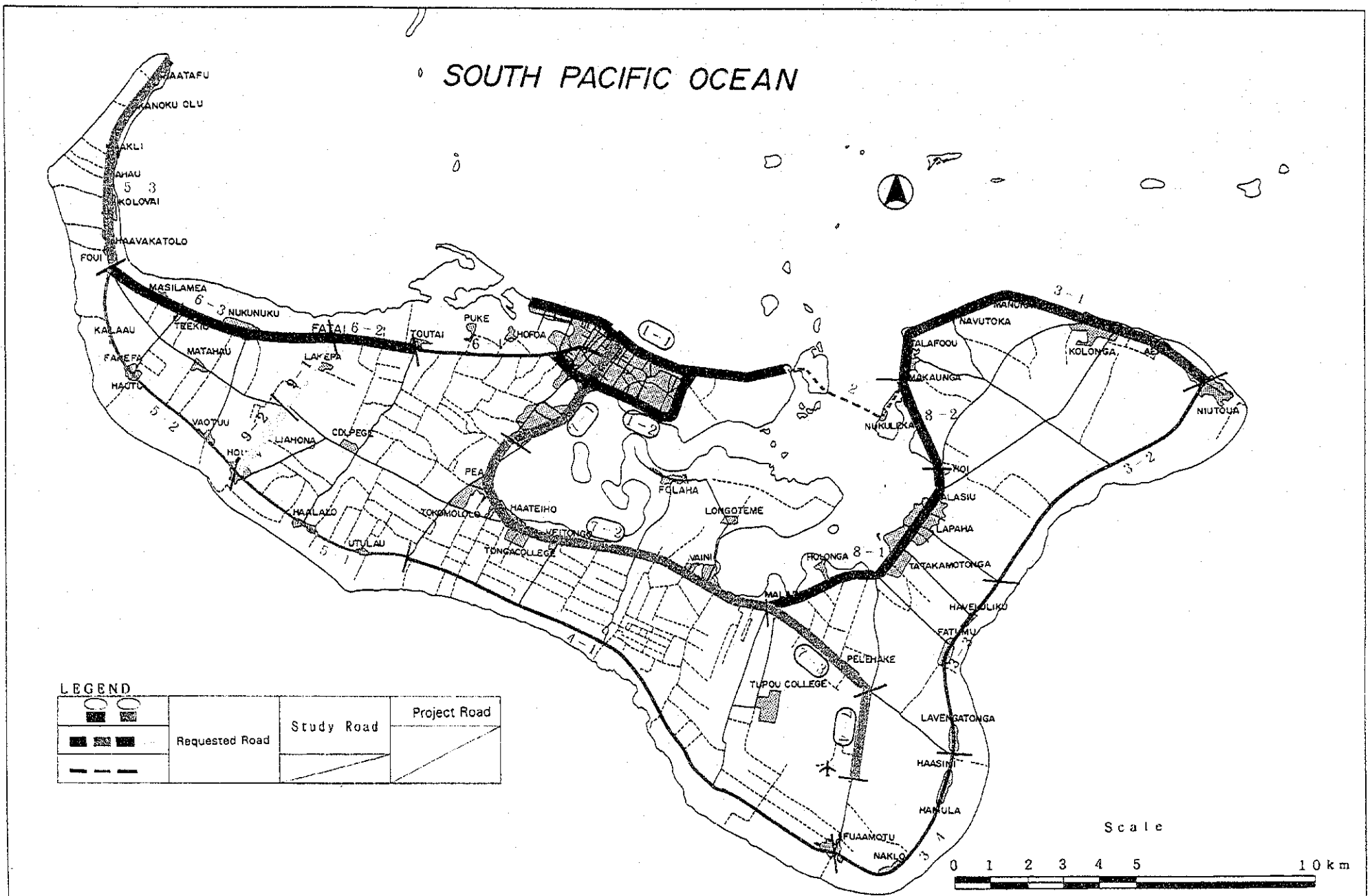
We wish to take this opportunity to express our sincere gratitude to the officials concerned of JICA, the Ministry of Foreign Affairs, and the Ministry of Construction. We would also like to express our gratitude to the officials concerned of the Ministry of Foreign Affairs, the Ministry of Works, the JICA Fiji Office, and the Embassy of Japan in Fiji for their cooperation and assistance throughout our field survey.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,



Kunihiko Sawano
Project manager,
Basic design study team on
the Project for Road Improvement Works in Tongatapu
Katahira & Engineers International
Chodai Co., Ltd.



LOCATION MAP OF STUDY ROADS

SUMMARY

The Government of the Kingdom of Tonga has formulated the economic development strategy aiming at generating economic growth and employment opportunities. Special emphasis is placed on the export and tourism sectors. This requires private sector development serving as the main engine and infrastructure development as the promotive and supportive means.

As of 1989, the road network system in the Kingdom of Tonga extends a total length of 1,790 km, of which only 100 km has a sealed surface and the rest are poorly maintained unsealed roads.

Tongatapu Island, where the capital is located, is the largest and the most populated in the Kingdom. Natural resources for tourism development are abundant therein. However, the road network in the island is unsatisfactory, affecting adversely the transportation of agricultural products to the port, promotion of tourism industry and other socio-economic activities.

To cope with such situation, the Government of the Kingdom of Tonga has been requesting the assistance for road improvement to bilateral aid agencies and other funding organizations. In Tongatapu Island, the road projects are being implemented by ADB assistance and Australian aid. These projects aim at improving mainly secondary class of roads in poor condition. Major arteries are only partially included.

Road construction and maintenance are carried out by the Ministry of Works. The equipment owned by the Ministry is aged and insufficient in number, hampering a smooth execution of road projects and maintenance program.

In such conditions, the Government of the Kingdom of Tonga has requested the Government of Japan for Grant Aid, for improvement of existing roads in Tongatapu and procurement of equipment for road construction and maintenance.

In response to the request, the Government of Japan decided to conduct a basic design study and Japan International Cooperation Agency (JICA) dispatched the Basic Design Study Team to the Kingdom of Tonga, from October 2 to 30, 1993 for the field survey. Based on the results of the field survey and the study in Japan thereafter, a draft report was prepared. JICA dispatched the Draft Report Explanation Team to the Kingdom from February 14 to 23, 1994 for explanation of the draft report and discussion thereon.

As a result of the study on appropriateness, urgency and socio-economic effects of the project, the following components were proposed:

(1) Road Improvement (implemented in two phases)

	Section		Major Works
1st Phase	Section 1	Western part of Sub-section 1-1, 2.8 km	Widening, paving with asphalt concrete
		Central part of Sub-section 1-1, 3.0 km	Overlay with asphalt concrete, construction of surface drainage facilities
		Eastern part of Sub-section 1-1, 1.7 km	Widening, paving with asphalt concrete
		Western part of Sub-section 1-2, 1.3 km	Overlay with asphalt concrete
		Eastern part of Sub-section 1-2, 4.3 km	Paving with asphalt concrete
		Total 13.1 km	
2nd Phase	Section 7	Total 21.0 km	Overlay with asphalt concrete

Section 1 is composed of Vuna Road which is a main road in the capital (Subsection 1-1) and By-pass Road which connects various parts of the island to Queen Salote Wharf bypassing the busy area in Nuku'alofa (Subsection 1-2). Section 7 is a main road connecting the airport to the capital. Thus, both sections are the most important roads playing a role of interconnecting the capital, port and airport and have the largest traffic demand among the major road network in Tongatapu. In view of the above, both sections are planned to be improved with asphalt concrete pavement.

(2) Equipment Procurement (implemented in single phase)

Equipment	Number	Equipment	Number
Motor Grader	2	Vibration Roller (10 t)	1
Backhoe Excavator	1	Vibration Roller (0.7 t)	1
Wheel Loader	1	Plate Compactor	2
Dump Truck (8 t)	3	Chip Spreader	2
Dump Truck (2 t)	1	Asphalt Distributor	1
Cargo Truck	1	Asphalt Sprayer	1
Water Tank Truck	1	Asphalt Burner	1
Pick-up Truck	1	Concrete Cutter	1
Hydraulic Breaker	1	Air Compressor	1
Pneumatic Hand Breaker	2		
Crushing and Screening Plant	1	Spare Parts	20%

In Tongatapu Island, many road projects are planned to be implemented mainly by ADB fund and Australian aid. These projects are to be executed directly by the Ministry of Works. The equipment to be procured will be fully and effectively utilized in these road development projects as well as in road maintenance works.

The implementation period is estimated as follows:

	Detailed Design	Construction/ Procurement
First phase of road improvement	2.5 months	12 months
Second phase of road improvement	2.5 months	10 months
Equipment procurement	2.5 months	8 months

The Ministry of Works is the responsible agency for implementing the Project. The Works Section and the Mechanical Section in the Engineering Division of the Ministry will take charge of the maintenance of the improved roads and the operation and maintenance of the procured equipment, respectively. Both Sections are considered to have enough staff, budget and capability to well operate and manage the Project.

The improvement of the proposed roads will bring various effects such as savings of transport costs, travel time and maintenance costs, prevention of road submergence and freedom from being dusty. The procurement of equipment, improving the equipment fleet of the Ministry of Works, will facilitate the other road projects. Furthermore, the Project will bring indirect effects such as en-

hancement of the quality of life, acceleration of industrial development and activation of socio-economic activities. Since the Project will contribute to the development of the Kingdom, it is concluded to be appropriate to execute the Project in Japan's Grant Aid Program.

The construction of the causeway was cut from the scope of the Project but the initial environmental examination was carried out in this study. As the result, serious adverse impacts on water quality of Fanga'uta Lagoon and animals and plants living there are forecast. It is recommended to conduct the detailed assessment on such factors prior to deciding the project implementation.

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CHAPTER 1

INTRODUCTION

In response to the request from the Government of the Kingdom of Tonga, the Government of Japan decided to conduct a basic design study on the Project for Road Improvement Works in Tongatapu in the Kingdom of Tonga. Japan International Cooperation Agency (JICA) dispatched the Basic Design Study Team headed by Mr. Hidenao Hayashi, Advisory Officer, Engineering Department, Hanshin Expressway Public Corporation, from October 2 to 30, 1993, for the field survey.

The Basic Design Study Team, during its stay in the Kingdom, reviewed the background and contents of the request, carried out the surveys on road condition, traffic, topography, construction materials and equipment, etc. and collected the relevant data for initial environmental examination for the causeway construction.

After returning to Japan, the Team formulated the Project composed of road improvement and equipment procurement, carried out the basic design, and evaluated the Project in respect of appropriateness, urgency and socio-economic effects, based on the results of the field survey. The Team also conducted a initial environmental examination for the causeway construction.

Based on these surveys and studies, a draft report was prepared. JICA dispatched the Draft Report Explanation Team to the Kingdom from February 14 to 23, 1994 for explanation of the draft report and discussion thereon.

As this result, the present report has been finalized. Member list of the study team, survey schedule and member list of the officials concerned of the Kingdom of Tonga are presented in the Appendix of this report.

CHAPTER 2

BACKGROUND
OF
THE PROJECT

CHAPTER 2

BACKGROUND OF THE PROJECT

2.1 Outline of Road Sector

(1) Road Network

In accordance with their function, roads are classified as highways and trunk, feeder and access roads; to each of these categories a special engineering road class (A to D) should correspond. Table 2.1-1 presents the main characteristics of both the functional and engineering classifications, and road length by class.

Table 2.1-1 CHARACTERISTICS OF THE FUNCTIONAL AND ENGINEERING ROAD CLASSES AND ROAD LENGTH BY CLASS

Functional Classification		Road Length in 1988		Engineering Standard
		Whole Country	Tongatapu	
Highways	Major trunk roads with high traffic volumes, linking significant urban centres or to airports.	81.5 km	64.6 km	Class A Sealed Road Reserve width: 14.6m, Formation width: 11.0m, Sealed width: 7.0m or over
Trunk Roads	Roads linking all villages/towns to the highways and/or other villages, or strategically providing a linkage to another trunk road.	363.0 km	188.5 km	Class B Sealed Road Reserve width: 14.6m, Formation width: 9.1m, Sealed width: 7.0m or over
Feeder Roads	Roads linking villages/towns to agricultural areas; roads between trunk roads, or roads to public beaches and major institutions.	666.0 km	248.0 km	Class C Coral Road Reserve width: 11.0m, Formation width: 7.9m
Access Roads	Roads to individual 'apis (small groups of 'apis) or roads between feeder roads.	679.0 km	487.0 km	Class D Coral Road Reserve width: 7.3m, Formation width: 4.9m
	Total	1,789.5 km	988.1 km	

Road network in Tongatapu Island is shown in Figure 2.1-1. Classified as highway are the roads covering the northern coast of the island and the road going to the airport therefrom. Trunk roads are the roads which cover the other coasts than the northern coast; run from east to west in the middle of the western part of the island (Loto Road); and provide linkage between highways/trunk roads at intervals of 2 - 4 km.

(2) Pavement Structure

Pavement types currently used in the Kingdom of Tonga are the following three:

Prime Seal

Heated bitumen is applied on the prepared base course and then sand (usually crusher dust) is spread. Immediately, the road is opened to traffic. Later, the excessive sand which is left not adhering to the bitumen (mostly drifted to the roadsides by the passage of vehicles and by the weather action) is removed. The finished thickness is 3 - 5 mm.

In many cases, chip seal is constructed thereon. But, as the supply of chip materials is behind their demand, the roads are used only with prime seal for long time, usually three months or more. In some cases, chip seal is not planned.

Slurry Seal

Cold premix made of bitumen, aggregates and filler is placed without being compacted. The finished thickness is about 10 mm. This method was often used until the first half of 1980th but was seldom used thereafter.

Chip Seal

Chip seal is constructed on prime seal with one or two layers. Heated bitumen (cut-back of 80 - 100 penetration with light fuel oil and kerosene) is applied, then, aggregates (crushed hard coral or limestone of 15 - 20 mm in size for first layer and 10 - 15 mm for second layer) are spread and compacted. The finished thickness is 16 mm for first layer (recently standard thickness was increased from 12 mm to 16 mm) and 10 mm for second layer. The construction of prime seal and two layers of chip seals is regarded as standard way of pavement. However, the second layer of chip seal has not been constructed yet in the country.

Figure 2.1-2 shows the existing pavement types of the request roads. Generally speaking, chip seal sections are in fair condition but the surface of the other sections is remarkably deteriorated.

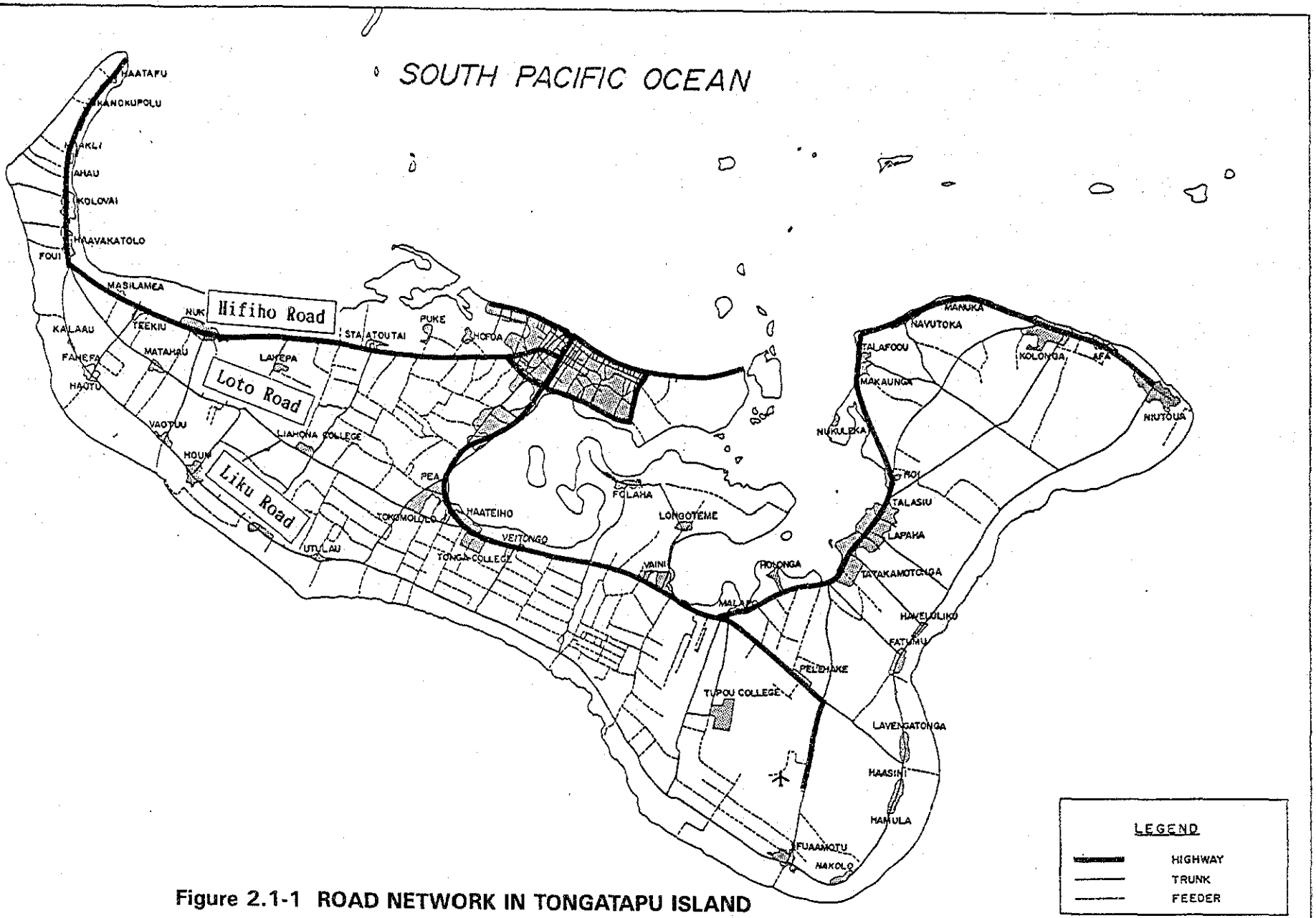


Figure 2.1-1 ROAD NETWORK IN TONGATAPU ISLAND

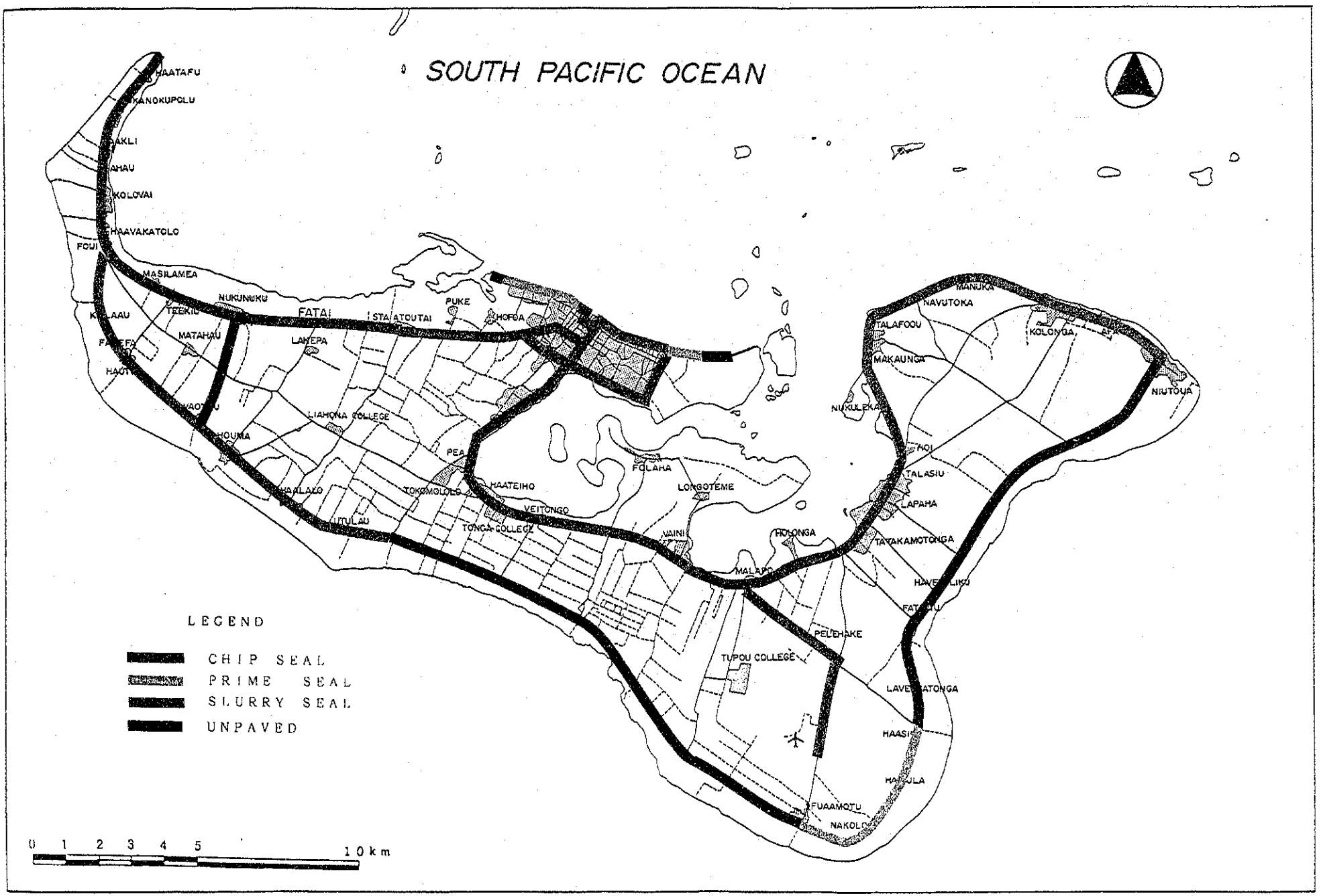


Figure 2.1-2 EXISTING PAVEMENT TYPE OF REQUESTED ROADS

(3) Number of Registered Vehicles

Number of registered vehicles is shown in Table 2.1-2.

Table 2.1-2 NUMBER OF REGISTERED VEHICLES (1985-1990)

Vehicles	1985	1989	1990
Cars & light trucks	1,823	2,307	3,010
Heavy trucks	495	895	966
Taxis	277	691	1,032
Buses	111	95	118
Motor cycles	392	473	501
Total	3,098	4,461	5,627

Table 2.1-2 shows that there has been a significant increase (by 82%) in the number of vehicles over the 1985-1990 period. The proportion of vehicles in Tongatapu is 82.5% in 1985 and 85.8% in 1988.

(4) Traffic Volume

Figures 2.1-3 and 2.1-4 show the traffic volume on major roads in Tongatapu Island, based on the traffic survey conducted in this study and MOW's survey in 1993. According to these figures, the road connecting Nuku'alofa and Fua'amotu International Airport (Section 7) as well as urban roads in Nuku'alofa has a remarkably high volume, followed by the road connecting Nuku'alofa and Fatai (Section 6).

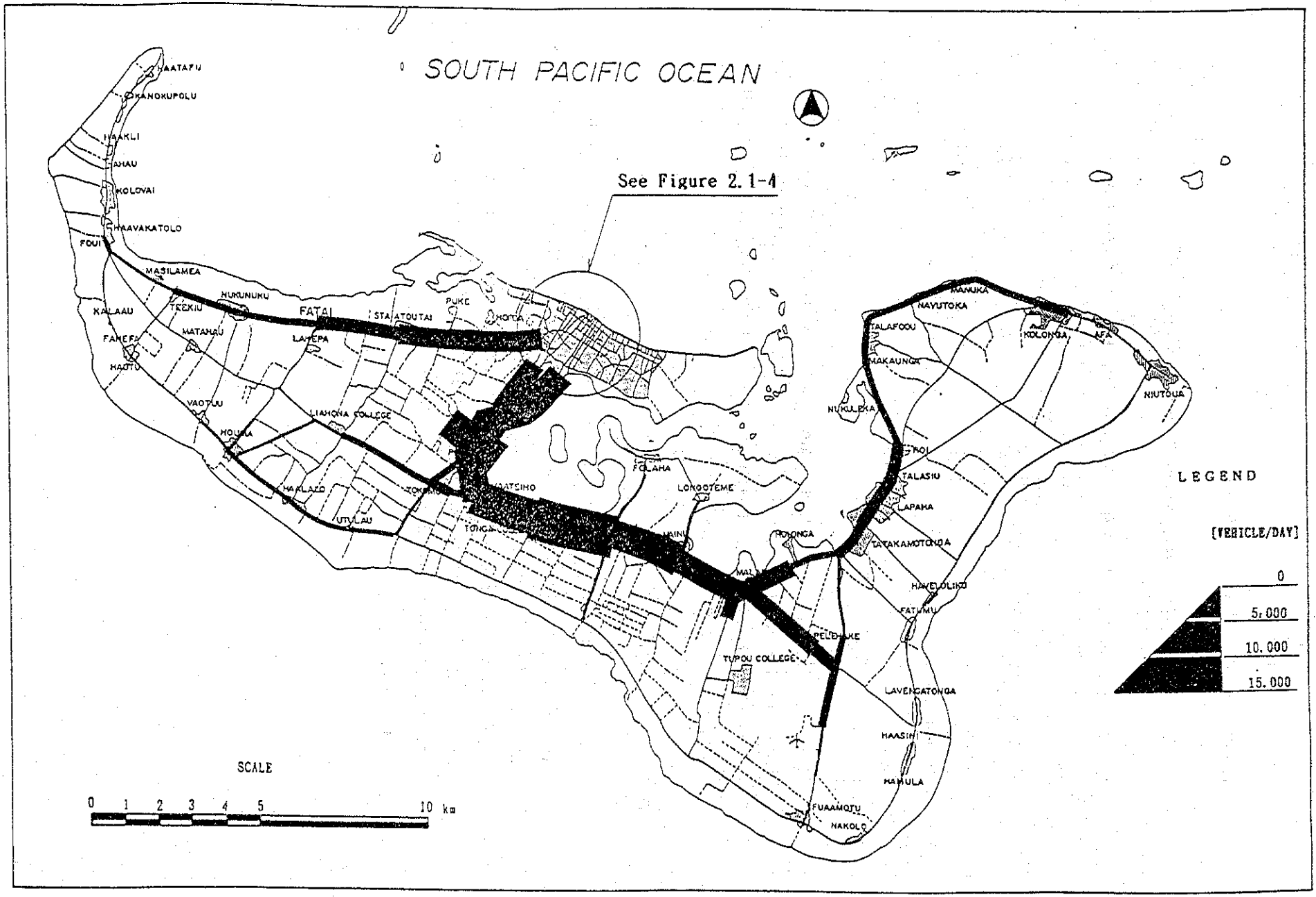


Figure 2.1-3 TRAFFIC VOLUME (OUTER NUKU'ALOFA URBAN AREA)

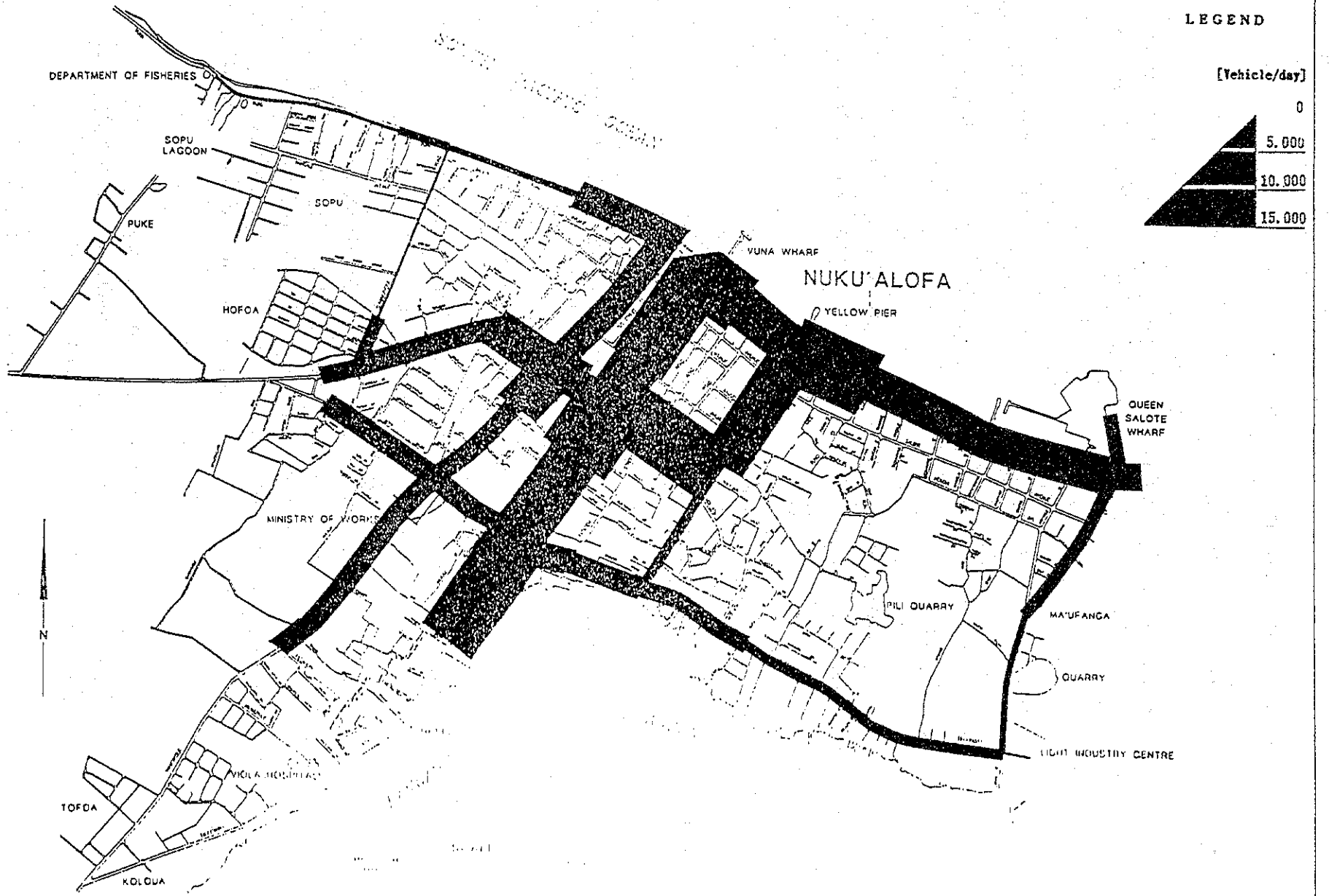


Figure 2.1-4 TRAFFIC VOLUME (NUKU'ALOFA URBAN AREA)

2.2 Outline of Related Development Plans

2.2.1 National Development Plan

The Government of Tonga has been formulating five-year development plans. The current one is the Sixth Development Plan 1991-1995 (DPVI).

The national economic and social objectives for the plan are to:

- achieve sustainable economic growth conductive to a higher per capita income;
- achieve a more equitable distribution of incomes and a more equitable access to goods and services between regional community groups and between income groups;
- generate more employment opportunities;
- restore and control external financial balances;
- enhance the quality of life by raising health standards, maintaining national security and continuing to promote the cultural heritage of the Kingdom;
- develop beneficial relations with other nations; and
- ensure the continued protection and management of natural resources for sustainable development.

The economic development strategy of DPVI aims at generating economic growth and employment opportunities. Special emphasis will be placed on the export and tourism sectors, where certain competitive advantages are perceived. This requires private sector development serving as the main engine and infrastructure development as the promotive and supportive means.

Table 2.2-1 shows the planned allocation of investment during DPVI in comparison with the one for DPV. The investment to agriculture, tourism, roads and education sectors shows a substantial increase.

Table 2.2-1 SECTORAL ALLOCATION ON INVESTMENT

(Unit : T$ million)

	Fifth Five-year Development Plan		Sixth Five-year Development Plan	
	Amount	Share %	Amount	Share %
Agriculture & Forestry	10.7	7.2	22.5	10.1
Fisheries	12.5	8.4	3.2	1.4
Industry & Commerce	20.3	13.6	7.6	3.4
Tourism	6.2	4.1	50.7	22.8
Construction & Housing	6.4	4.3	-	-
Energy	2.1	1.4	6.1	2.7
Water	4.9	3.3	1.3	0.6
Roads	9.8	6.5	20.1	9.0
Marine & Civil Aviation	31.2	20.9	33.7	15.2
Telecommunications & Broadcasting	13.2	8.8	1.9	0.9
Education	18.4	12.3	64.7	29.1
Health	6.9	4.6	3.8	1.7
Environment	-	-	1.7	0.8
Government Services	6.9	4.6	5.1	2.3
Total	149.5	100.0	222.4	100.0

2.2.2 Road Development Plan

Objectives for road transport in the Sixth Five-year Development Plan are:

- to upgrade and maintain the existing network of urban and country roads in order to minimize the costs of road transport;

- to provide road access to all rural areas in the main islands;

- to develop agricultural roads in support of expansion and diversification of primary production;

- to encourage the development of a viable road transport industry;

- to better regulate the public and private transport system in order to allow the existence of safe and competitive passenger services.

The strategy for road development involves a long-term road development programme with construction policies and priorities, and subject to external financial assistance. Following is a profile of the road development programme for the 1991-1995 period:

Programme 1 : Tongatapu Road Works ($7,550,000)
Project 1.1 : Vuna Road Reconstruction
Project 1.2 : Urban Roads, Nuku'alofa
Project 1.3 : Rural Roads, Tongatapu
Project 1.4 : Urban Footpaths Upgrading
Project 1.5 : Urban & Village Minor Roads

Programme 2 : Ha'apai Road Works ($950,000)
Programme 3 : Vava'u Road Works ($2,500,000)
Programme 4 : 'Eua Road Works ($750,000)
Programme 5 : Niuas Road Works ($750,000)
Programme 6 : Other Projects ($3,650,000)
Programme 7 : Management, Design and Technical Assistance ($4,075,000)

2.2.3 Road Projects With External Financial Assistance

Road development in Tongatapu Island is being carried out mainly by ADB fund and Australian aid. Figure 2.2-1 shows the completed and ongoing projects.

ADB assisted and Australian aided projects aim mainly at:

- promoting and supporting the regional development, especially in agricultural and small industrial sectors.

- reducing road maintenance and road user costs by improving the roads in poor condition.

- raising a living standard of communities which have been serviced by sub-standard roads.

Accordingly, the roads with development potential and currently in poor condition are qualified in formulation of the project. As a result, mainly secondary class of roads are selected and major arteries are only partially included.

On the other hand, the requested roads in this Project include all highways and some trunk roads and form a major road network in the island. It is understood that this project aims at upgrading and elevation of durability suitable to the major artery.

Future road projects in Tongatapu Island are presented in Appendix 8.

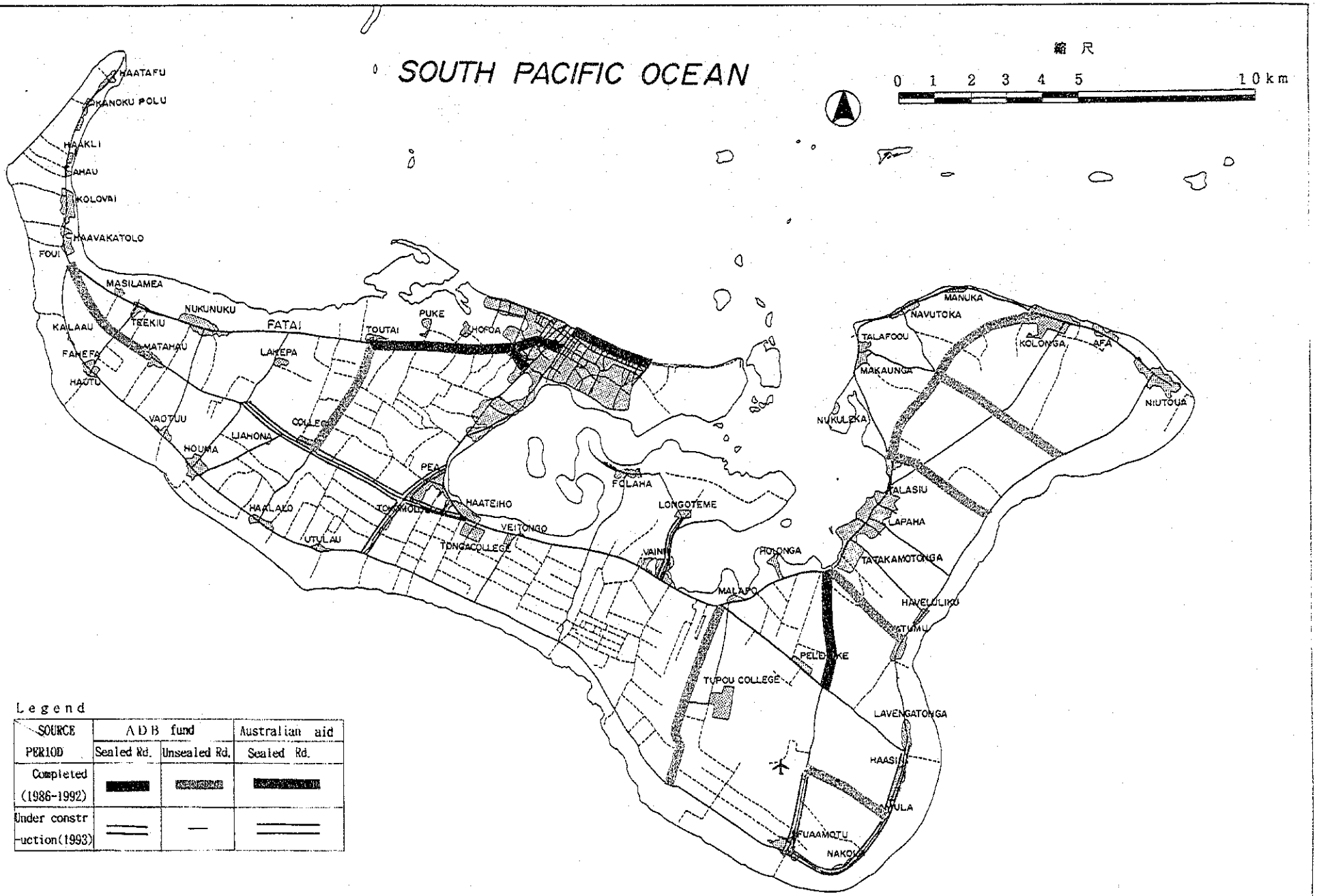


Figure 2.2-1 MAJOR ROAD PROJECTS IN TONGATAPU ISLAND

2.3 Outline of the Request

2.3.1 Background

The Government of the Kingdom of Tonga has formulated the economic development strategy aiming at generating economic growth and employment opportunities. Special emphasis is placed on the export and tourism sectors. This requires private sector development serving as the main engine and infrastructure development as the promotive and supportive means.

As of 1989, the road network system in the Kingdom of Tonga extends a total length of 1790 km, of which only 100 km has a sealed surface and the rest are poorly maintained unsealed roads.

Tongatapu Island, where the capital is located, is the largest and the most populated in the Kingdom. Natural resources for tourism development are abundant therein. However, the road network in the island is unsatisfactory, affecting adversely the transportation of agricultural products to the port, promotion of tourism industry and other socio-economic activities.

To cope with such situation, the Government of Tonga has been requesting the assistance for road improvement to bilateral aid agencies and other funding organizations. In Tongatapu Island, the road projects are being implemented by ADB assistance and Australian aid. These projects aim at improving mainly secondary class of roads in poor condition. Major arteries are only partially included.

Road construction and maintenance are carried out by the Ministry of Works. The equipment owned by the Ministry is aged and insufficient in number, hampering a smooth execution of road projects and maintenance program.

In such conditions, the Government of the Kingdom of Tonga has requested the Government of Japan for Grant Aid, for improvement of existing roads in Tongatapu and procurement of equipment for road construction and maintenance.

2.3.2 Contents of the Request from the Government of Tonga

The contents of the request from the Government of Tonga are understood to be as follows:

(1) Improvement/Construction of Road Sections listed below:

Section	Road Name	Road Improvement (km)	Road Construction (km)	Causeway Construction (km)	Bridge Construction (km)	Total (km)
1.	Vuna Road and By-Pass Road	13.0				13.1
2.	Nuku'alofa - Makaunga	2.0	3.0	2.75	0.25	8.0
3.	Makaunga - Fua'amotu	30.2				30.2
4.	Fua'amotu - Fonongahina	15.3				15.3
5.	Fonongahina - Ha'atafu	18.8				18.8
6.	Fo'ui - Nuku'alofa	14.8				14.8
7.	Nuku'alofa - Fua'amotu Airport	21.1				21.1
8.	Malapo - Makaunga	9.6				9.6
9.	Houma - Fatai	5.1				5.1
	Total	130.0	3.0	2.75	0.25	136.0

Note: The construction of the causeway in Section 2 might be attended with environmental problems which should be solved prior to the implementation. For this reason, Section 2 has been cut from the scope of the study. However, the initial environmental examination for the causeway construction is carried out in this study.

(2) Procurement of Equipment listed bellows:

Equipment		No.
Bulldozer	(16 t, 140 Hp)	1
Wheel Loader	(1.6 m^3)	1
Motor Grader	(125 Hp)	2
Vibration Roller	(8 t)	1
Asphalt Plant	(40 t/hr)	1
Asphalt Finisher	(25 - 4.0 m)	1
Dump Truck	(10 t)	3
Asphalt Distributor	(6 m^3)	1
Water Tank Truck	(15 m^3)	1
Pick-up Truck	(4 x 4)	1

Note: As the result of discussion between the Basic Design Study Team and the officials from the Government of Tonga, contents of requested equipment were changed as described in 3.4.2.

CHAPTER 3

OUTLINE
OF
THE PROJECT

CHAPTER 3

OUTLINE OF THE PROJECT

3.1 Objectives of the Project

Although the road network in Tongatapu Island has been gradually developed in recent years, it is far from being satisfactory to enhance socio-economic development. Pavement types adopted in the country are prime seal, slurry seal and chip seal and high class pavement like asphalt concrete pavement has not been applied yet. Accordingly, they have neither technique nor equipment for construction of asphalt concrete pavement. As the traffic demand increases recently, however, high class pavement with more durability is becoming necessary for important roads.

The Ministry of Works is responsible for the construction and maintenance of roads but the equipment owned by the Ministry is insufficient in number and mostly aged, resulting in difficulty in a smooth implementation of road projects and maintenance program.

The objective of the Project is to cope with the said situation by the following plans:

a) To improve Section 1 and Section 7 with a total length of 34.1 km which are considered as main arteries in the road network in the island interconnecting the capital, port and airport. Pavement type to be adopted is asphalt concrete pavement which is new in the country.

b) To procure necessary equipment to make the equipment fleet of the Ministry of Works more complete aiming at smooth implementation of road construction and maintenance.

3.2 Executing Agency and Operational Structure

(1) Organization of Executing Agency

Figure 3.2-1 shows the government organization.

Responsibilities for the development and administration of road transport are divided among the following ministries.

- the Ministry of Lands, Surveys and Natural Resources has responsibilities relating to the proclamation of public roads and road re serves;

- the Ministry of Works is responsible for the construction and maintenance of roads;

- the Ministry of Police is responsible for the regulation of road transport, while the ministry of Lands, Surveys and Natural Resources authorizes carriage of heavy goods on public roads as set out in the Lands and Roads Act;

- the Ministry of Labour, Commerce and Industries sets the rates of public transportation (bus and taxi fares, truck hire charges) under the Prices of Goods and Services Act.

The organization of the Ministry of Works is shown in Figures 3.2-2 to 3.2-4.

Planning, design, construction and maintenance of roads in Tongatapu Island are conducted by Engineering Division of the Ministry of Works. Under Chief Engineer, Engineering Division is divided into Works Section and Mechanical Section which are responsible for the design, construction and maintenance of roads and operation and maintenance of equipment, respectively.

Annual budget allocated for the Ministry of Works is shown in Table 3.2-1.

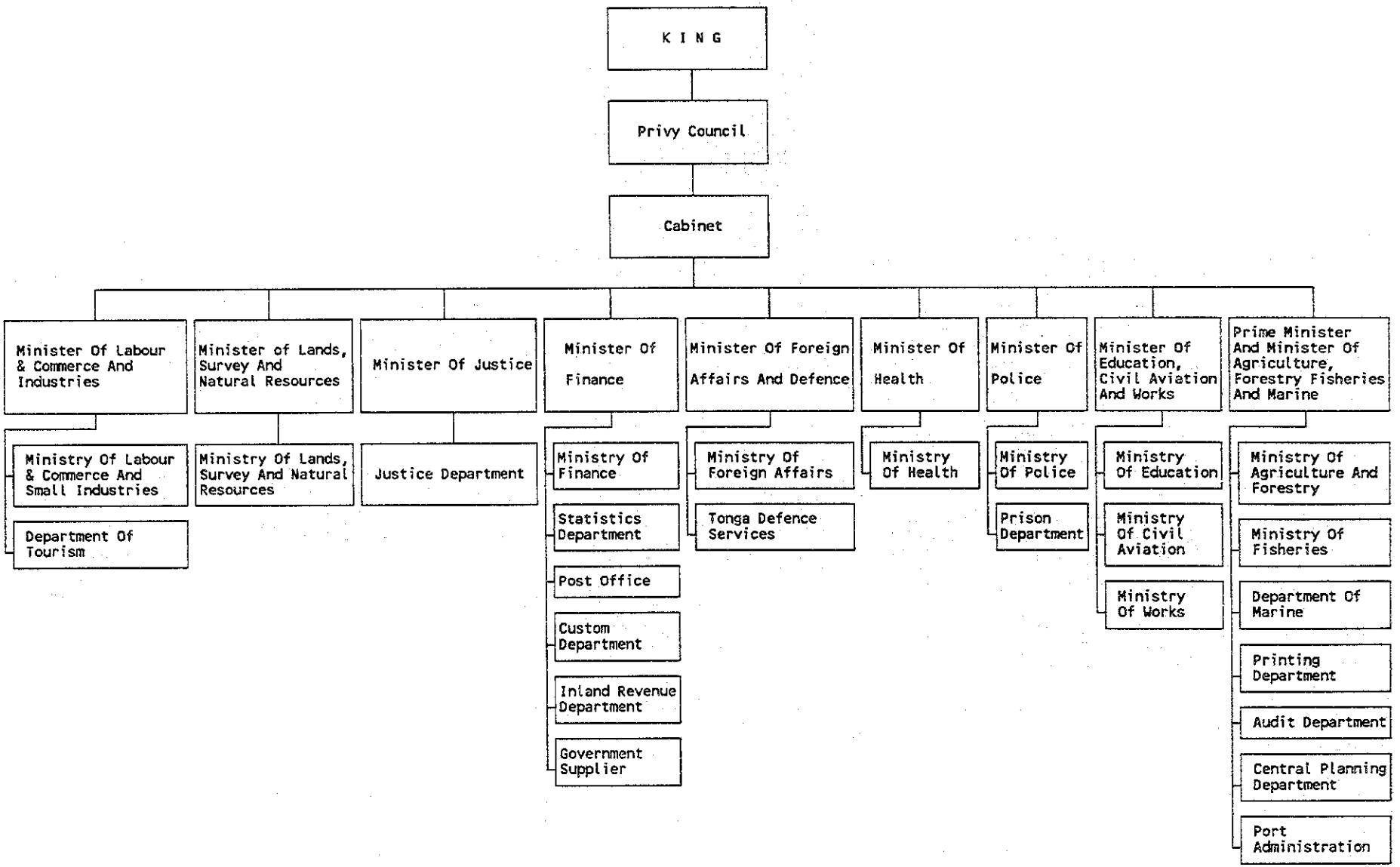


Figure 3.2-1 TONGAN GOVERNMENT ORGANIZATION

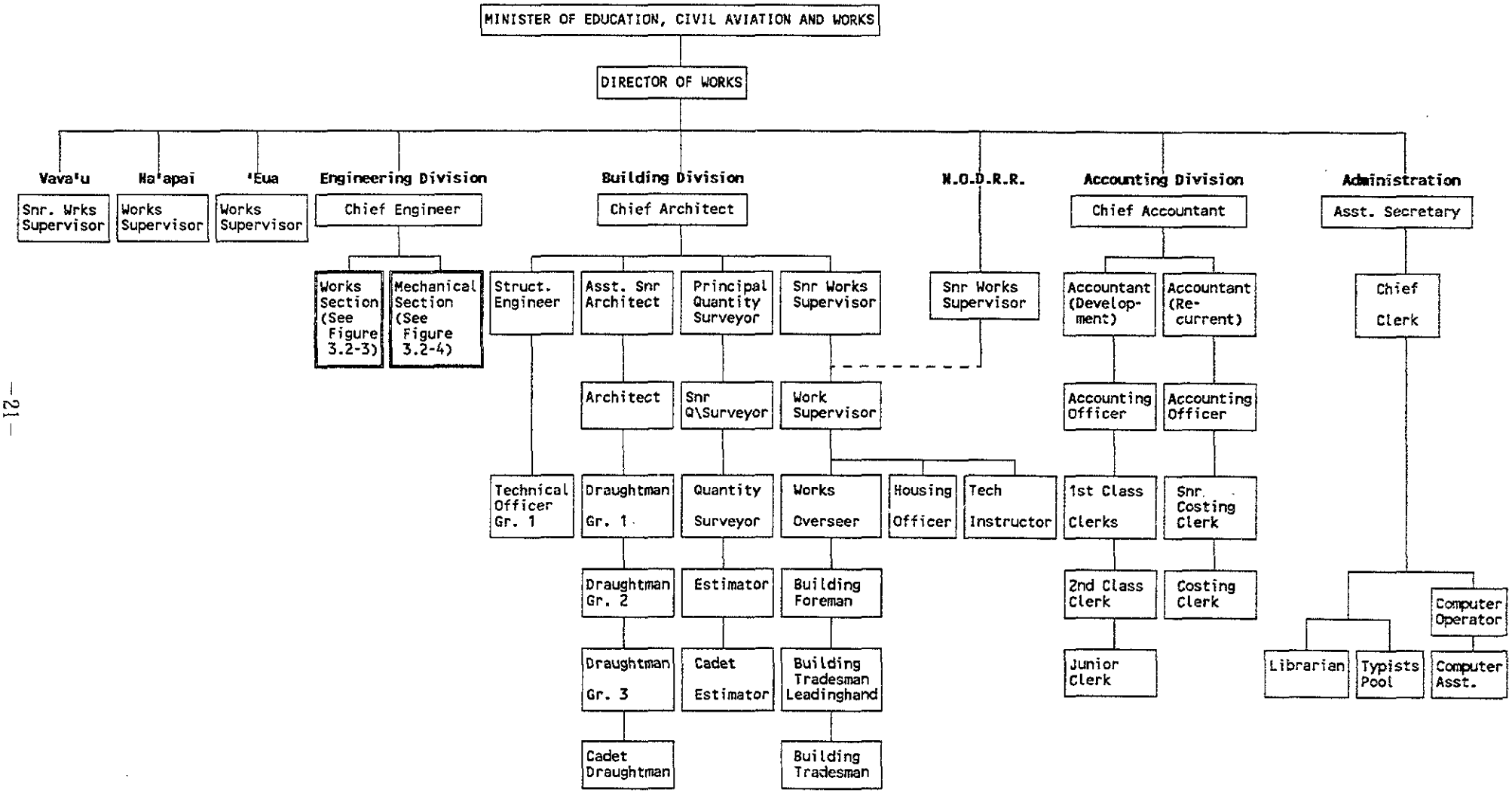


Figure 3.2-2 ORGANIZATION OF MINISTRY OF WORKS

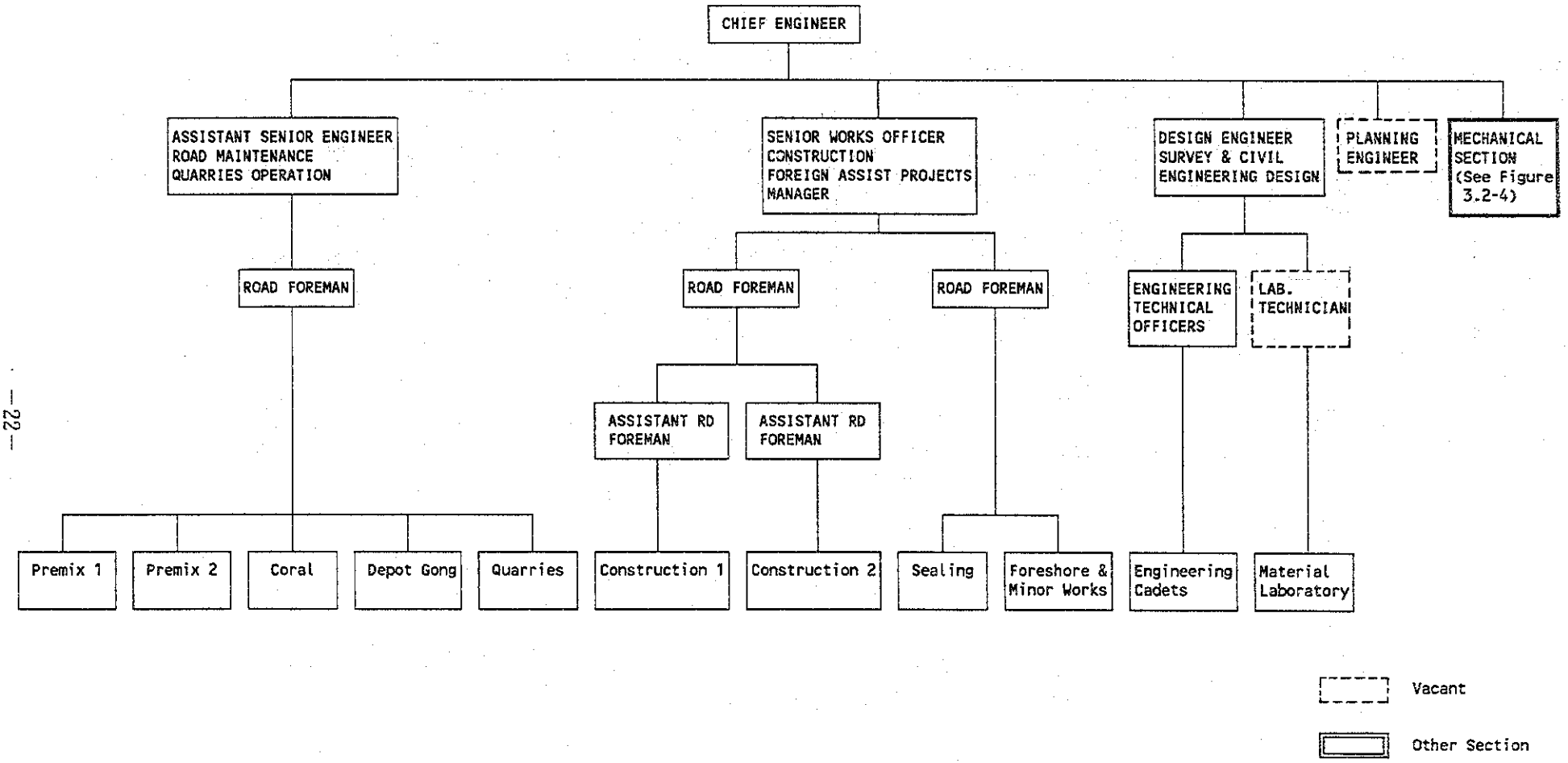


Figure 3.2-3 ORGANIZATION OF WORKS SECTION, ENGINEERING DIVISION, MOW

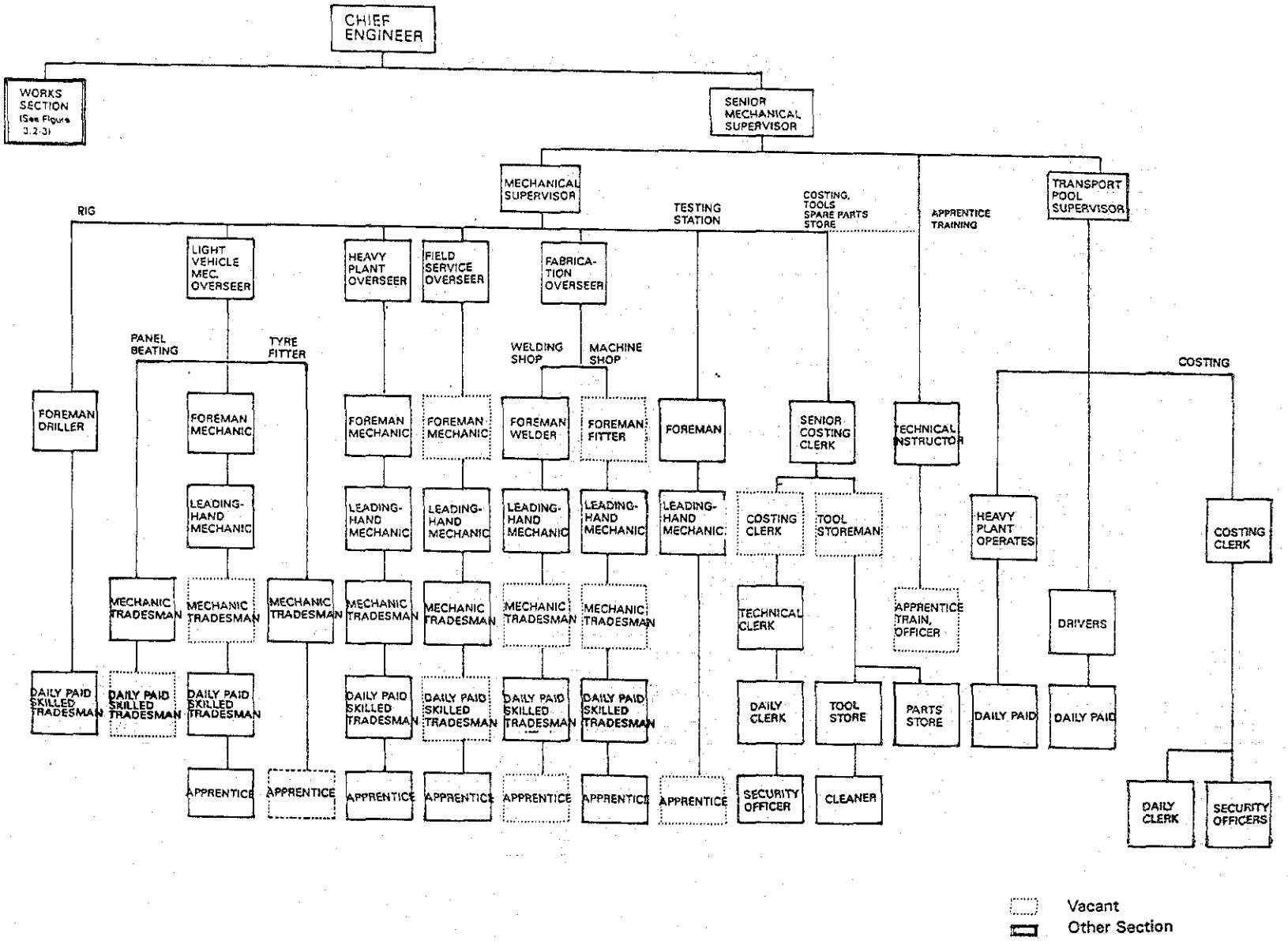


Figure 3.2-4 ORGANIZATION OF MECHANICAL SECTION, ENGINEERING DIVISION, MOW

Table 3.2-1 ANNUAL BUDGETS FOR MINISTRY OF WORKS

(Unit: T$)

I t e m	1991-1992	1992-1993	1993-1994
Recurrent Expenditure for Ministry of Works			
1. Minister's Office	29,455	29,962	30,320
2. Direction	153,029	136,190	145,939
3. Administration	121,837	151,256	170,004
4. General Services	162,463	337,716	359,725
5. Mechanical Service	210,557	224,471	196,240
Maintenance Machine Shops	840,000	648,000	514,080
6. Building Services	331,083	348,524	307,816
Maintenance Carpenters Shops	280,000	227,700	92,000
7. Roads Services	135,144	153,436	124,669
Maintenance Roads	1,493,110	1,431,782	1,167,000
8. Miscellaneous	35,900	59,310	56,720
9. Maintenance Services	243,760	250,084	302,940
Development Expenditure for Roads *			
A. Road Construction	1,902,452	1,541,865	1,250,004
B. Causeways	100,000	50,001	2
C. Roads Planning, Design and Management	30,000	144,451	55,001
Development Expenditure for Ministry of Works *			
A. Administration	894,000	894,002	643,371
B. Vehicles and Equipment	261,000	190,001	1,001,927
C. Miscellaneous	10,000	1,000	1
Total	7,233,790	6,819,751	6,417,759

* including offshore fund

(2) Implementation System of Road Projects

Most road projects are implemented with financial assistance from bilateral aid agencies and other funding organizations. Locally funded projects are limited to small sized and urgent ones.

Design and construction of road projects are carried out directly by the Ministry of Works since there is no private contractor for road construction in the Kingdom.

Conventional types of pavement in the country are prime seal, slurry seal and chip seal. High class pavement such as asphalt concrete pavement and portland cement concrete pavement has not been applied yet.

Procurement way of equipment, materials and labors are as follows:

Equipment

Equipment owned by the Ministry of Works is utilized. When lacking, equipment leased from private leasing companies is used.

Chip Material

The Ministry of Works owns a quarry for chip material in Ahononou and a crushing and screening plant in Taupia. There is no other quarry for producing chip material. The crushing and screening plant in Taupia is supposed to be placed in Vava'u unless the existing plant in Ahononou had been seriously damaged by hurricane in January, 1993.

Base Course Material

There exist several government and private quarries.

Ready Mixed Concrete

Ready mixed concrete is purchased from Royco Industries which installed a batcher plant recently.

Bitumen

Bitumen is imported by the Ministry from New Zealand.

Other Construction Materials

Other construction materials are purchased from private suppliers. Most materials are imports.

Labors

Overseers and skilled labors are the Ministry's staff, while unskilled labors are provisionally employed by the Ministry.

(3) Road Maintenance System

Road maintenance is carried out by the Ministry of Works with local fund. Major items are as follows:

Seal Road
- Pothole patching

Unsealed Road
- Grading
- Pothole repair
- Overlay

Shoulder
- Cutting grass
- Cleaning

Drainage Facilities
- Cleaning

Road maintenance is not sufficient due to lack of fund.

3.3 Study and Examination on the Request (Road Improvement)

3.3.1 Existing Condition of the Requested Roads

Except Section 2 which was cut from the scope of the study, each section is subdivided into subsections for the convenience of evaluation as shown in Figure 3.3-1. Each section is outlined as follows:

(1) Section 1

Subsection 1-1 (Vuna Road) is a 7.5 km long road along the north coast of Nuku'alofa. The subsection is divided into western wing, central part and eastern wing. Central part is paved with chip seal and its condition is relatively good. The rest portions are paved with prime or slurry seal and highly deteriorated.

Subsection 1-2 (By-pass Road) has a role to connect various parts of the island to Queen Salote Wharf bypassing the bussy area in Nuku'alofa. The road is paved with slurry seal and its condition is bad, except western 850 m section which has a chip seal surface in good condition.

(2) Section 2

Section 2 is a section to be newly constructed including causeway, but out of the scope of the study.

(3) Section 3

Subsection 3-1 passes through the northern coast of the eastern part of the island. Villages are scattered along the road. The road is paved with slurry or chip seal and its condition is bad.

Subsections 3-2 and 3-3 cover the eastern coast of the island. Along the road is uninhabited agricultural land except for subsection

3-3 which is sparsely populated. These subsections are unsealed.

Subsection 3-4 passes through southeastern corner of the island. The subsection is being improved in the ADB funded project.

(4) Section 4

Subsection 4-1 passes through the southern coast of the island. Along the road is uninhabited agricultural land. This subsection is unsealed.

(5) Section 5

Subsections 5-1 and 5-2 pass through the southern coast of the western part of the island. Villages are scattered along the road. Houma, the largest village in this area, is located on the boundary of Subsections 5-1 and 5-2. The road is paved with slurry or prime seal and its surface condition is bad.

Subsection 5-3 runs from the junction of Hihifo Road (Section 6), Loto Road and Liku Road (Subsections 5-1 and 5-2) up to the northwestern tip of the island. This road is paved with slurry or prime seal and its surface condition is bad.

(6) Section 6

Subsection 6-1 is a section from Nuku'alofa urban area to its western suburban area. This subsection was improved with chip seal in 1988 in Australian Grant Aid Program, the subsection is in good condition.

Subsections 6-2 and 6-3, together with Subsection 6-1, cover the northern coast of the western part of the island passing through middle-sized villages like Fatai and Nukunuku. These subsections are paved with slurry seal and their surface condition is bad.

(7) Section 7

Section 7, subdivided into Subsections 7-1 to 7-4, is a important road connecting Fua'amotu International Airport to the capital.

Subsection 7-1 is Taufa'ahau Street, the busiest urban street in the capital. This subsection is paved with slurry seal except for 600 m northern section which is paved with chip seal. The surface condition is generally fair except for vicinity of major intersections and curved portions which are deteriorated locally.

Subsection 7-2 runs along the southwestern/western coast of Fanga Uta Lagoon, mostly paved with slurry seal. Surface condition is relatively bad with many potholes.

Subsections 7-3 and 7-4 are inland sections going to the airport. These subsections, paved with slurry seal, are in bad condition.

(8) Section 8

Section 8, subdivided into Subsections 8-1 and 8-2, diverges from Section 7 and runs along the eastern coast of the Lagoon. This road is a main road connecting northeastern part of the island to the airport and capital. Pavement type in this section is mostly slurry seal and its condition is very bad.

(9) Section 9

Section 9, subdivided into Subsections 9-1 and 9-2, is an inland section between Fatai on Section 6 and Houma on Section 5. This section is narrow (4 - 5 m) and unsealed. Subsection 9-1 is planned to be improved in 1994 as an ADB funded project.

Existing condition of the requested roads is presented in Appendix 4.

Length, functional class, role, population served, traffic volume, surface type, condition and width of each subsection are summarized in Table 3.3-1.

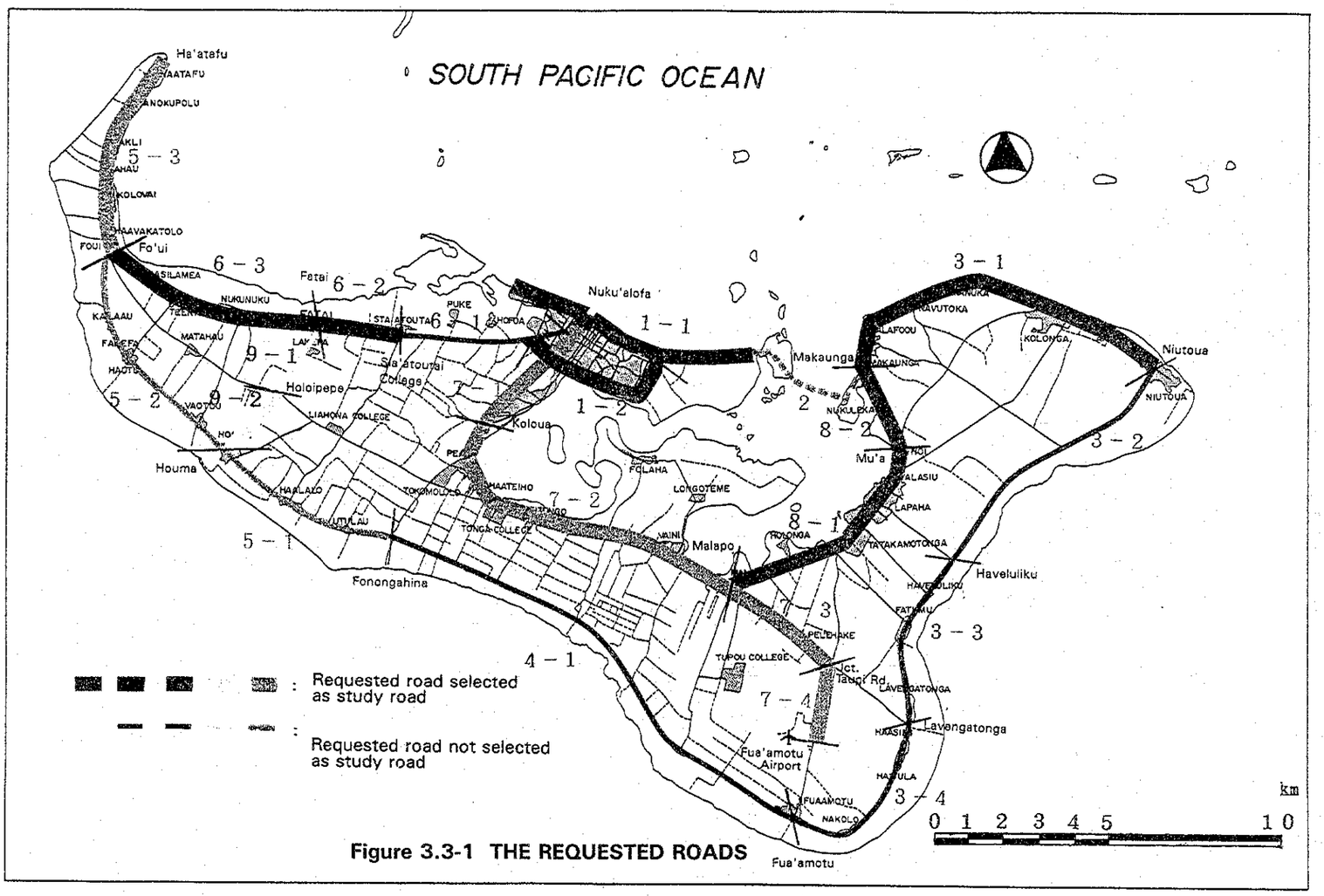


Figure 3.3-1 THE REQUESTED ROADS

Table 3.3-1 CHARACTERISTICS OF THE REQUESTED ROADS

Section		Approximate Length (Km)	Priority by Government of Tonga	Importance of Road: Functional Class	Importance of Road: Remarkable Roles	Importance of Road: Population Served by Road/Km	Importance of Road: Traffic Volume	Importance of Road: 1) Overall Evaluation	Present Condition: 2) Surface Type	Present Condition: 3) Surface Condition	Present Condition: Carriageway Width (m)	Remarks
1-1	Vuna Road	7.5	1	Highway	Main road in the capital.	1,740	7700- 600	A	S	F/VB	10 - 6	
1-2	By-pass Road	5.6			Connect various parts of island to main port.	1,040	3200-1000	A	S	B	6	
2	Nuku'alofa-Makaunga	Out of scope of the study										
3-1	Makaunga-Niutoua	10.6	4	Highway	Serve eastern villages and link them to airport.	340	500	B	S	B/VB	7	
3-2	Niutoua-Havelu'liku	9.7		Trunk Rd.		40	60	C	U	VB	4.5	
3-3	Havelu'liku-Lavengatonga	4.2				140	100	C	U	VB	4.5	
3-4	Lavengatonga-Fua'amotu	5.7				340	300	B	S	F	7	Financed by ADB
4-1	Fua'amotu-Fonongahina	15.3	8	Trunk Rd.	Serve tourist attractions on south coast of island and connect south-western villages to airport.	40	100	C	U	VB	6	
5-1	Fonongahina-Houma	5.7	6	Trunk Rd.	Serve tourist attractions on south-western coast of island and connect south-western villages to airport.	300	700	B	S	B	6	
5-2	Houma-Fo'ui	7.4				220	500- 200	B	S	B	6	
5-3	Fo'ui-Ha'atafu	5.7		Highway		420	700- 500	A	S	B	7	
6-1	Nuku'alofa-Sia'atoutai College	5.4	5	Highway	Serve western villages and link them to urban area.	220	2600-2000	A	S	G	7.5	Financed by AIDAB
6-2	Sia'atoutai College-Fatai	2.7				100	1500	A	S	F	7.5	
6-3	Fatai-Fo'ui	6.7				360	1200- 700	A	S	F/B	7.5	
7-1	Nuku'alofa-Koloua	4.3	2	Highway	Main road connecting airport to the capital.	1,940	7500-3400	A	S	F/B	12 - 8	
7-2	Koloua-Malapo	10.4				750	6700-3200	A	S	F/B	8	
7-3	Malapo-Jct. Taupi Rd.	3.7				230	1200	A	S	B	8	
7-4	Jct. Taupi Rd.-Fua'amotu airport	2.6				220	1200	A	S	B	7	
8-1	Malapo-Mu'a	7.0	3	Highway	Connect north-eastern villages to urban area.	700	2000-1300	A	S	B	7.5	
8-2	Mu'a-Makaunga	2.6				260	900	A	S	B	7.5	
9-1	Fatai-Holoipepe	2.6	7	Trunk Rd.	Connect south-western villages to main highway.	180	200	B	S/U	VB	8 - 5	Financed by ADB
9-2	Holoipepe-Houma	2.5				200	200	B	U	VB	5	
Total		127.9										

Legend 1) Overall Evaluation, A: Very Important, B: Important, C: Less Important
2) Surface Type, S: Sealed, U: Unsealed
3) Surface Condition, G: Good, F: Fair, B: Bad, VB: Very Bad

3.3.2 Selection of Study Roads and Project Roads

(1) Selection Procedure

From the request roads except Section 2, the roads with high necessity and urgency of improvement are selected as study roads. On the study roads, topographic survey is carried out and pavement type to be adopted is investigated. Out of the study roads, those roads in which the proposed type of pavement will not be able to be constructed by Tonga because of no experience and should therefore be constructed by the Government of Japan are selected as project roads. The flow chart of the above procedures is shown in Figure 3.3-2.

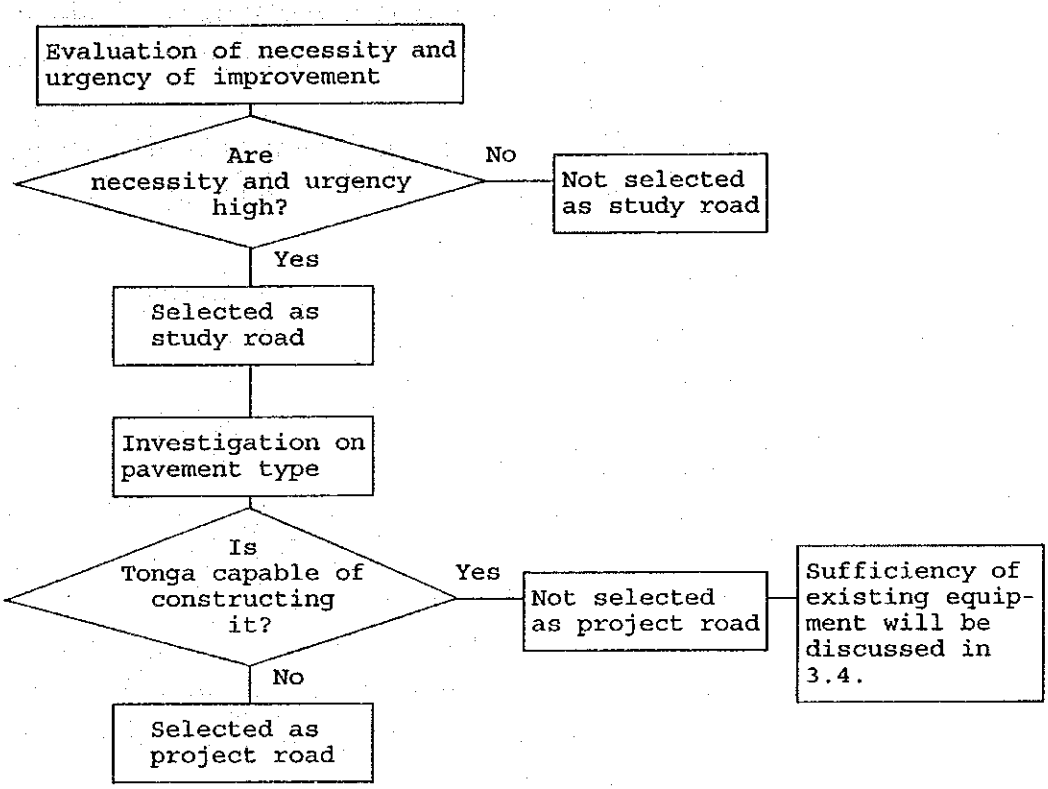


Figure 3.3-2 SELECTION FLOW OF STUDY ROADS AND PROJECT ROADS

(2) Selection of Study Roads

Necessity and urgency of improvement are evaluated by subsection taking into account the following factors:

1. Duplication with other project
2. Priority according to Tongan Government
3. Importance of road

   The following factors are considered in the evaluation of the importance of road:

   - Functional road class (highway/trunk road)
   - Role (role participated in the major road network in Tongatapu Island)
   - Population served by road (population within the area which is directly accessible to the road, expressed by persons per km of road)
   - Traffic volume (daily traffic volume in both directions)

   Based on the above factors, each subsection is ranked any of the following three classes:

   A: Very important
   B: Important
   C: Less important

4. Existing condition of road

   The factors relating to the existing condition of road are as follows:

   - Surface type (sealed or unsealed)
   - Surface condition (rated any of G (good), F (fair), B (bad) or VB (very bad) according to the riding quality varying from being comfortable even in high speed operation to being compelled to operate at low speed)
   - Carriageway width

   Among above, surface type and carriageway width are closely correlated to surface condition (the surface condition of unsealed road and/or narrow road is bad). Therefore, the surface condition can be used as a representative factor of existing condition of road.

The evaluation results are shown in Table 3.3-1.

Based on the above factors, study roads were selected in accordance with the following criteria:

1. Subsections 3-4, 6-1 and 9-1 are omitted because their improvement is completed, on-going or committed in ADB/AIDAB assisted projects.
   Although Subsections 1-1 and 1-2 were partly improved with chip seal in AIDAB projects, these subsections are not considered as omissible sections because it is judged appropriate to strengthen them due to high traffic demand.
2. Subsections ranked as importance A are selected.
3. Subsections ranked as importance B are selected if their existing condition is evaluated as very bad.
4. Subsections ranked as importance C are not selected.

Evaluation results are summarized in Table 3.3-2. The subsections selected as the study roads are as follows:

Subsection 1-1	Vuna Road	7.5 km
Subsection 1-2	By-pass Road	5.6 km
Subsection 3-1	Makaunga-Niutoua	10.6 km
Subsection 5-3	Fo'ui-Ha'atafu	5.7 km
Subsection 6-2	Sia'atoutai College-Fatai	2.7 km
Subsection 6-3	Fatai-Fo'ui	6.7 km
Subsection 7-1	Nuku'alofa-Koloua	4.3 km
Subsection 7-2	Koloua-Malapo	10.4 km
Subsection 7-3	Malapo-Jct. Taupi Road	3.7 km
Subsection 7-4	Jct. Taupi Road-Fua'amotu Airport	2.6 km
Subsection 8-1	Malapo-Mu'a	7.0 km
Subsection 8-2	Mu'a-Makaunga	2.6 km
Subsection 9-2	Holoipepe-Houma	2.5 km
Total		71.9 km

(3) Investigation on Type of Pavement for the Study Roads

Current method of pavement mainly used in the country is chip seal. This method has the advantages that no mixing plant is needed; less amount of bitumen is used; and construction cost is

low. On the other hand, the disadvantages of this method are that the strength is low and the pavement is easily damaged resulting in frequent repair works required; surface smoothness is inferior; and the road is dusty because of excess sand used in the construction of prime seal which is executed prior to the construction of chip seal.

Considering the physical condition of Tongatapu Island, which is advantageous to pavement, such as relatively strong subgrade and base course, good drainage and light axile loads of heavy vehicles, chip seal is considered to be durable, economical and practical method of pavement unless it is adopted to the roads with very heavy traffic volume.

Among the study roads, Section 1 and Section 7 are the most important roads playing a role of interconnecting the capital, port and airport, and traffic demand and population served by these roads are the largest. It is appropriate to adopt asphalt concrete pavement to these two important sections taking advantages of longer usable years, less need of repair works and freedom from being dusty. For the rest sections, chip seal is considered to be applicable.

(4) Selection of the Project Roads

Chip seal is a common method of pavement in the Kingdom of Tonga. However, the Kingdom has no experience of constructing asphalt concrete pavement and therefore, it should be undertaken by the Government of Japan.

Accordingly, the following subsections proposed to be paved with asphalt concrete were selected as the project roads:

Subsection 1-1	Vuna Road	7.5 km
Subsection 1-2	By-pass Road	5.6 km
Subsection 7-1	Nuku'alofa-Koloua	4.3 km
Subsection 7-2	Koloua-Malapo	10.4 km
Subsection 7-3	Malapo-Jct. Taupi Road	3.7 km
Subsection 7-4	Jct. Taupi Road-Fua'amotu Airport	2.6 km
Total		34.1 km

Procedures for selection of the study roads and the project roads are summarized in Table 3.3-2.

Table 3.3-2 SELECTION OF STUDY ROADS AND PROJECT ROADS

Section	Approximate Length (Km)	Necessity/Urgency of Improvement				Selection of Study Roads	* Type of Pavement	Selection of Project Road
		Duplication with Other Project	Priority by Government of Tonga	Importance of Road	Existing Condition of Road			
1-1 Vuna Road	7.5	-	1	A	F/VB	o	AC	o
1-2 By-pass Road	5.6	-		A	B	o	AC	o
3-1 Makaunga-Niutoua	10.6	-	4	B	B/VB	o	CS	x
3-2 Niutoua-Haveluliku	9.7	-		C	VB	x		
3-3 Haveluliku-Lavengatonga	4.2	-		C	VB	x		
3-4 Lavengatonga-Fua'amotu	5.7	ADB		B	F	x		
4-1 Fua'amotu-Fonongahina	15.3	-	8	C	VB	x		
5-1 Fonongahina-Houma	5.7	-	6	B	B	x		
5-2 Houma-Fo'ui	7.4	-		B	B	x		
5-3 Fo'ui-Ha'atafu	5.7	-		A	B	o	CS	x
6-1 Nuku'alofa-Sia'atoutai College	5.4	AIDAB	5	A	G	x		
6-2 Sia'atoutai College-Fatai	2.7	-		A	F	o	CS	x
6-3 Fatai-Fo'ui	6.7	-		A	F/B	o	CS	x
7-1 Nuku'alofa-Koloua	4.3	-	2	A	F/B	o	AC	o
7-2 Koloua-Malapo	10.4	-		A	F/B	o	AC	o
7-3 Malapo-Jct. Taupi Rd.	3.7	-		A	B	o	AC	o
7-4 Jct. Taupi Rd.-Fua'amotu airport	2.6	-		A	B	o	AC	o
8-1 Malapo-Mu'a	7.0	-	3	A	B	o	CS	x
8-2 Mu'a-Makaunga	2.6	-		A	B	o	CS	x
9-1 Fatai-Holoipepe	2.6	ADB	7	B	VB	x		
9-2 Holoipepe-Houma	2.5	-		B	VB	o	CS	x
	127.9					72.0 km		34.2 km

* AC = Asphalt Concrete pavement, CS = Chip seal

3.3.3 Technical Cooperation

Patching of potholes is an important maintenance work of asphalt concrete pavement. However, the Kingdom of Tonga has neither experience of carrying out a patching of asphalt concrete pavement nor equipment therefor such as those for cutting the area of pavement to be repaired, heating the road surface and materials, and compacting thoroughly the patches. Therefore, in addition to procuring the necessary equipment, a manual showing the way of patching should be presented. Furthermore, if a demonstration of patching is carried out and it is recorded in a video tape, it will help the Ministry of Works in full comprehension.

Thus, it is recommended that this Project include, as parts of its scope, procurement of equipment necessary for patching, presentation of manual, demonstration and its recording on video tape.

3.4 Study and Examination on the Request (Equipment Procurement)

3.4.1 Existing Condition of MOW Owned Equipment

The Ministry of Works (MOW) owns a series of equipment for road construction and maintenance. However, most equipment is aged. When becoming unserviceable due to breakdown, equipment leased from private leasing companies is substituted. About 45% of all equipment currently used in MOW is the leased equipment.

Existing condition of equipment is as follows:

(1) Existing Condition of Equipment

- Most equipment is secondhand, imported from Australia or New Zealand.
- Many equipment is damaged. Remarkable damages are oil leaking from engine and transmission of heavy equipment, rust of vehicle body, and damage in panel.
- Working condition is shown in Table 3.4-1.

(2) Repair System

- Field service system has been established in which a field service vehicle goes round working sites of equipment and make necessary services such as oil exchange, greasing and exchange of wasted parts. Field services undertaken are reported monthly.
- Brokendown equipment is carried by semi-trailer to the mechanical workshop for repair.
- Periodical inspection is carried out every after a given number of working hours.
- Equipment status report is prepared monthly, including working hours, fuel and lubricant consumed and labor hours, etc.

(3) Capability of Equipment Maintenance

- Since the working ratio is maintained as 68% in spite of aged equipment, MOW is capable of maintenance of equipment.
- In some cases, old equipment is remodeled for another use. This shows MOW's creativity.
- Apprentice training program is executed.

(4) Parts Management

- MOW has the custody of 1,050 items of parts, amounting to about 120,000 T$.
- Main parts kept are expendable.
- Parts store is about 40 square meters wide. All parts are kept in good order.
- The stock of parts is reported monthly.

(5) Present Problems

- Many equipment is aged.
- Little spare parts for breakdown is stored.
- Because of old model, even equipment manufacturers have no or only a few stock of spare parts in many cases. Therefore, it takes time to obtain necessary parts.
- In some cases, repair manual and parts book are not available since the time of purchase, causing difficulty in identifying the parts and ordering it.
- Budget for procuring parts is insufficient.

Due to the above situation, equipment, when brokendown, keeps on stopping operation for long time, usually for more than six months.

Table 3.4-1 PRESENT STATUS OF EQUIPMENT STATIONED IN TONGATAPU ISLAND

Equipment		Capacity	Number	Working Condition			Rate of Operation	Number of Leased Equipment	Remarks
				Operation	Under Repair	Unrepairable			
Bulldozer		18t	1	1	-	-	100		
		35t	2	1	1	-	50	1	Parts ordered, 210 days unoperated
Motor Grader		3.1m	1	-	-	1	0		
		3.7m	4	3	-	1	75	3	
Backhoe Excavator		0.25m^3 or less	2	1	-	1	50		
		0.7-1.2m^3	1	-	-	1	0	2	
Wheel Loader		2.7-3.3m^3	4	2	1	1	50	5	Parts ordered, 120 days unoperated
Forklift		1t	1	1	-	-	100		
Vehicle	Dump Truck	6t	1	1	-	-	100	21	
	Cargo Truck	6t	2	1	1	-	50		Parts not ordered, 90 days unoperated
	Water Tank Truck	6m^3	2	2	-	-	100	2	
	Fuel Tanker	6m^3	1	1	-	-	100		
	Light Truck	1-2t	3	3	-	-	100		
	Pick-up Truck	1t or less	5	5	-	-	100		
	Sewer Vacuum Truck	6m^3	1	1	-	-	100		
	Distributor	6m^3	1	1	-	-	100		
	Service Truck	2t	1	1	-	-	100		
	Semi-Trailer	35t	1	1	-	-	100		
	Sedan		1	1	-	-	100		
	Land Cruiser		5	5	-	-	100		
	Wagon	10-15 passengers	4	3	1	-	75		Parts not ordered, 30 days unoperated
Agricultural Tractor			5	3	-	2	60		
Crawler Crane		30t-3m	4	1	-	3	25	1	
Pile Hummer			1	1	-	-	100		
Crawler Drill			3	2	-	1	67	1	
Crushing and Screening Plant			2	1	-	1	50		
Screen			1	1	-	-	100		
Roller	Towed Vibration	5t	2	-	-	2	0		
	Tandem	7t	1	-	-	1	0		
	Vibration	3t	2	1	1	-	50		Parts ordered, 90 days unoperated
		8t-10t	2	1	1	-	50	4	Assessment under way, 60 days unoperated
	Tire	10t-30t	1	1	-	-	100		
Asphalt Mixer		200 lit	1	1	-	-	100		
Asphalt Kettle			1	1	-	-	100		
Air Compressor			3	1	-	2	33	1	
Total			73	50	6	17	68	41	

3.4.2 Study and Examination on the Requested Equipment

Construction capability of the Kingdom of Tonga and necessity of procuring equipment were assessed as follows:

1. Asphalt concrete pavement has not been constructed yet and there is no equipment for construction thereof. However, if improvement of Section 1 and Section 7 which are planned to be paved with asphalt concrete will be undertaken by the Government of Japan, no other road is urgently required to be paved with asphalt concrete. Therefore, Equipment for construction thereof is not considered to be necessary.

2. Maintenance and repair of asphalt concrete pavement (especially pothole patching) should be done by the Government of Tonga. However, there is no equipment therefor. Accordingly, it should be procured.

3. Coral road and chip seal are being constructed and maintained with existing equipment. However, the equipment is insufficient in number and some are superannuated, hampering a smooth execution of work.

Based on the above considerations, the purpose of procuring equipment is set up on 1) formation of equipment fleet for maintenance of asphalt concrete pavement, and 2) improvement of equipment fleet for construction and maintenance of coral/sealed roads. Tables 3.4-2 and 3.4-3 show the discussion on necessary equipment and number.

Considering the above discussion and other factors such as degree of aging and availability of leased equipment, equipment procurement plan was discussed between the Basic Design Study Team and the officials from the Government of Tonga.

The latter made a final request as shown in Table 3.4-4.

Table 3.4-2 EQUIPMENT FOR MAINTENANCE OF ASPHALT CONCRETE PAVEMENT

Equipment	Specification	Necessary Number	MOW Owned Equipment		Deficit Number	Final Request	Initial Request	
			Total	Working			Number	Specification
Dump Truck	2t loading capacity	1	0	-	1	1	0	-
Cargo Truck	4t loading capacity with Tail Gate Lifter	1	0	-	1	1	0	-
Pneumatic Hand Breaker	8 kg weight	2	0	-	2	2	0	-
Vibration Roller	0.7t weight	1	0	-	1	1	0	-
Plate Compactor	70 kg weight	2	0	-	2	2	0	-
Asphalt Mixer	200 lit	1	1	1	0	0	0	-
Asphalt Sprayer	200 lit kettle capacity 3 HP engine output	1	0	-	1	1	0	-
Asphalt Burner	Kerosene	1	0	-	1	1	0	-
Tools for Pavement Work	Trowel, Smoother, Rake, Tamper, Scoop, etc.	1	0	-	1	0	0	-
Concrete Cutter	100mm cutting depth 5 HP engine output	1	0	-	1	1	0	-
Air Compressor	2.5 cu.m/min air delivery	1	0	-	1	1	0	-

Table 3.4-3 EQUIPMENT FOR CONSTRUCTION AND MAINTENANCE OF CORAL/SEALED ROADS

Equipment	Specification	Necessary Number	MOW Owned Equipment		Deficit Number	Final Request	Initial Request	
			Total	Working			Number	Specification
Bulldozer	35t Weight 280HP Engine Output	1	2	1	0	1	1	16t, 140HP
Motor Grader	3.7m Blade Width 150HP Engine Output	1	4	3	0	2	2	125HP
Backhoe Excavator	0.45 cu.m bucket capacity	1	1	0	1	1	0	-
Wheel Loader	2.7 cu.m bucket capacity	2	4	2	0	1	1	1.6 cu.m
Dump Truck	8t loading capacity	4	1	1	3	3	3	10t
Water Tank Truck	8t loading capacity	2	2	2	0	1	1	15 cu.m
Crawler Drill	5t air pressure	1	3	2	0	0	0	-
Hydraulic Breaker	800 kg Weight	1	0	-	1	1	0	-
Crushing and Screening Plant	50-60 t/h Production capacity	1	2	1	0	1	0	-
Vibration Roller	10t Weight	1	2	1	0	1	1	8t
Tire Roller	8 - 20t Weight	1	1	1	0	0	0	-
Chip Spreader	Attached to 8t dump truck	2	0	-	2	2	0	-
Asphalt Distributor	3 - 4 cu.m loading capacity	1	1	1	0	1	1	6 cu.m
Air Compressor	18 cu.m/min. air delivery	1	3	1	0	0	0	-

Table 3.4-4 DISCUSSION ON EQUIPMENT PROCUREMENT PLAN (1/2)

Initial Request		Study Team's Preliminary Recommendation		Final Request	Discussion
Equipment/ Specification	Number	Equipment/ Specification	Number		
Bulldozer 16 t, 140 HP	1	Bulldozer 35 t, 280 HP	0	(35t) 1	· Capacity is raised because of intended use for rock excavation. · MOW owns two. One is under repair, for which a leased one is substituted. · Priority is low.
Motor Grader 125 HP	2	Motor Grader 150 HP, 3.7m	1	(150 HP) 2	· MOW's one, out of four, is broken and going to be scrapped. Three are leased additionally. · Team suggests one for substitution for the broken one. · MOW requests two because of their frequent use.
Wheel Loader 1.6 m^3	1	Wheel Loader 2.7 m^3	1	(2.7 m^3) 1	· Capacity is raised because of intended use for aggregate loading in crushing and screening plant. · Out of MOW's four, one is under repair and one is scrapped. · Five are leased.
Dump Truck 10 t	3	Dump Truck 8 t	3	(8t) 3	· Capacity is dropped considering aggregate producing capacity and hauling distance. · One is intended to be used for hauling from quarry to plant, and two from plant to construction site. · Presently working are only leased ones.
Water Tank Truck 15 m^3	1	Water Tank Truck 8 t	1	(8t) 1	· Capacity is dropped considering water supplying capacity and hauling distance. · MOW's one, out of two, is superannuated. · Two are leased.
Pick-up Truck 4 x 4	1	Pick-up Truck 4 x 2	0	(4 x 2) 1	· Specification is dropped considering road condition. · Team considers unnecessary because MOW's ones are all in operational condition and no one is leased. · MOW requests one because existing ones are aged and engineers often share a ride to go to site.
Vibration Roller 8 t	1	Vibration Roller 10 t	1	(10t) 1	· Capacity is raised considering the use for compaction of chip seal. · MOW's one, out of two, is not working. Repairability is being assessed. · Four are leased.
Asphalt Plant 40 t/h	1	-	0	0	· No plan of asphalt concrete pavement construction.
Asphalt Finisher 2.5 - 4 m	1	-	0	0	· No plan of asphalt concrete pavement construction.
Asphalt Distributor 6 m^3	1	Asphalt Distributor 3 - 4 m^3	1	(3-4 m^3) 1	· Capacity is dropped considering capacity of existing kettle and work volume. · Existing one is aged. This equipment is not available in private leasing companies.

Table 3.4-4 DISCUSSION ON EQUIPMENT PROCUREMENT PLAN (2/2)

Initial Request		Study Team's Preliminary Recommendation		Final Request	Discussion
Equipment/ Specification	Number	Equipment/ Specification	Number		
–		Backhoe Excavator 0.45 m^3	1	1	· Presently, no equipment is available for cutting large-sized rocks, causing reduction of efficiency in aggregate production. · This is used for cutting rocks with hydraulic breaker attached thereto and for excavation in quarry.
–		Drum Truck 2 t	1	1	· Small class is recommended because of intended use for carrying material for maintenance work.
–		Cargo Truck 4t, with Tail Gate Lifter	1	1	· This is used for carrying small machinery and tools for maintenance work, attached with tail gate lifter in stead of crane.
–		Hydraulic Breaker 800 kg	1	1	· This is used for cutting rocks attached to backhoe excavator.
–		Pneumatic Hand Breaker 8 kg	2	2	· This is used for breaking into small pieces the deteriorated portion of pavement cut rectangularly by concrete cutter.
–		Crushing and Screening Plant 50 - 60 t/h	1	1	· The former plant was seriously broken by hurricane in January 1993. · Existing plant which was purchased for the purpose of use in Vava'u was placed in Tongatapu as substitution for the former one. MOW intends to transfer the existing one to Vava'u if new one is procured.
–		Vibration Roller 0.7 t	1	1	· These are used for compaction of asphalt mixture. · Selection of equipment depends on the area to be repaired.
–		Plate Compactor 70 kg	2	2	
–		Chip Spreader Attached to 8t dump truck	2	2	· This is necessary for avoiding loss in spreading chips. · This is attached to dump truck.
–		Asphalt Sprayer 200 lit, 3HP	1	1	· This is necessary for spreading bitumen uniformly. · Kettle capacity is set at 200 lit considering work volume.
–		Asphalt Burner Kerosene	1	1	· This is used for heating road surface and materials to be put.
–		Tools for Pavement Work Trowel, etc.	1	0	· This is needed for manual works in pavement repair but can be procured locally.
–		Concrete Cutter Cutting Depth 100 m	1	1	· This is used for cutting the area of pavement to be repaired.
–		Air Compressor 2.5 cu.m/min	1	1	· This is used for operation of pneumatic hand breaker. · Portable type is selected for the convenience of transportation.

3.4.3 Proposed Site for Crushing and Screening Plant

The crushing and screening plant at Ahononou Quarry was seriously damaged by hurricane in January 1993 to the extent of being unrepairable. The Government of Tonga made an additional request for procurement of a plant for substitution. Condition of the damage and proposed site for a new plant are as follows:

(1) Condition of Damage

- Main parts of the plant were destroyed by strong wind. Its resuscitation is impossible.

- The plant is placed 50 m away from the coastline and always exposed to scattering of sea water. Therefore, rust has eaten deeply into the bolts. An attack of hurricane under such situation made the damage more serious.

(2) Proposed Site for New Plant

- The proposed site is about 500 m inland from Ahononou Quarry.

- Since it is away from the coastline to some extent and surrounded by coconut trees, the influence by sea water is considered to be small.

- It is located along the access road to the quarry. No additional access road is required.

- Since it is in the coconut forest, cutting of coconuts, clearing, placement of foundation concrete and construction of slope for putting materials are required for installing a new plant.

- There is no supply of electricity in the vicinity. A generator is needed.

3.4.4 Technical Cooperation

To help the Ministry of Works in operation and maintenance of the equipment, it is necessary to present an operation and maintenance manual and to make a demonstration of operation. No other technical cooperation is deemed necessary.

3.5 Operation and Maintenance Plan

Maintenance of the improved roads will be carried out by the Ministry of Works. Although the Ministry has neither experience nor equipment for the maintenance of asphalt concrete pavement, it will be well coped with by providing necessary equipment and a maintenance manual in this project. Comparing with the pavement types currently used in the country, asphalt concrete pavement is more durable and accordingly, it is expected to reduce much the time and expense for maintenance.

Procured equipment will be operated and maintained also by the Ministry of Works. Since present system of the Ministry for management of equipment, inspection and repair thereof, parts management and apprentice training is well working, operation and maintenance of the procured equipment will be also well carried out in the present system as is, except that the spare parts to be increased by this plan may outgrow the existing parts house. It will be solved by the plan of the Government in which the building of 700 square meters in area currently used for a storehouse of dead articles by the Ministry of Finance is vacated and converted to parts house of the Ministry of Works. The layout of the mechanical workshop is shown in Figure 3.5-1.

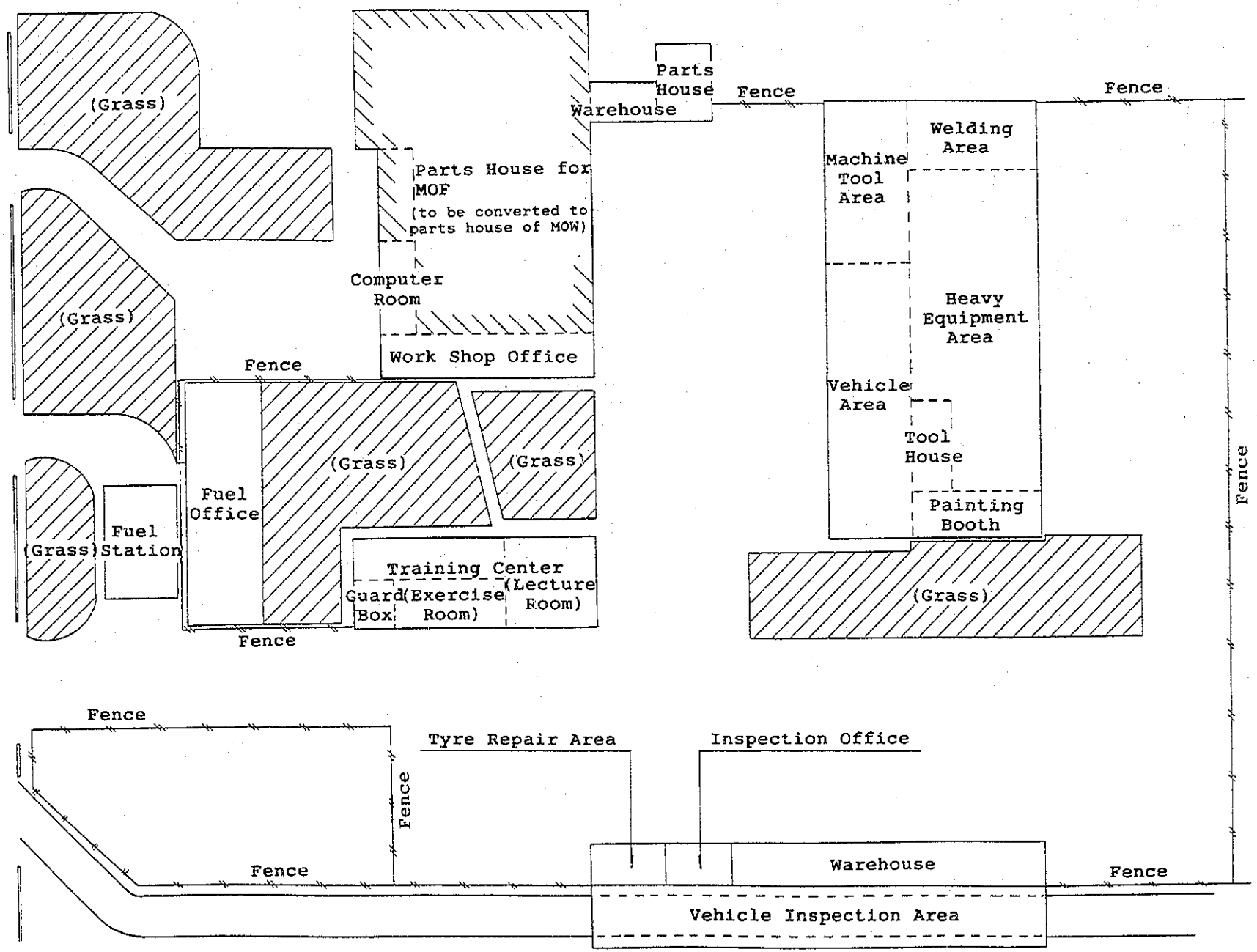


Figure 3.5-1 LAYOUT OF MECHANICAL WORKSHOP

CHAPTER 4

BASIC DESIGN

CHAPTER 4

BASIC DESIGN

4.1 Design Policy

4.1.1 Road Improvement

The basic policy in the design of improvement of the proposed roads was established as follows, taking into consideration the main purpose of the project which is to improve the riding quality of the existing roads.

(1) Road Width

Existing widths of carriageway, shoulder and sidewalk are basically maintained, except for the portion where the existing width is below the standard. In such case, it is widened.

(2) Alignment

Since the existing alignment of the proposed roads, both horizontally and vertically, meets the geometric standard, no change is made.

(3) Pavement

Asphalt concrete pavement is adopted for the reason described in 3.3.2. The design performance period is 15 years, which is deemed to be longer than usual. The reasons of selecting a long performance period are as follows:

- Budget for rehabilitation of roads is not sufficient to warrant the timely execution of rehabilitation.

- Pavement thickness is not excessive even though a long performance period is selected, because subgrade and base course are firm and axle loads of heavy vehicles are not so heavy.

(4) Surface Drainage

In general, present surface drainage relies on infiltration into ground around the road, except in some area in Nuku'alofa. Where it goes well, the present way is followed. Where the drainage problem is identified, a drainage system is designed.

(5) Miscellaneous Facilities

Roads have various miscellaneous facilities such as lighting, guard rail, traffic signal, bus stop, traffic sign, road marking, etc. Among them, lighting and traffic signs exist already along the proposed roads. There is no place where guard rail is necessary because of the flat terrain. Presently, no traffic signal is installed at any intersection in the country and the traffic at busy intersections is controlled manually by policemen during peak hours. Since this way goes well, the installation of traffic signals is not urgently needed. Bus stops are indicated by traffic sign and busses stop at the side of carriageway. At the important stops with many passengers getting on and off, it is advisable to construct bus stops outside the carriageway to avoid interrupting the passage of through traffic. New pavement marking is needed because existing one will disappear by the road improvement. Based on the above considerations, bus stop and pavement marking are included in this project as miscellaneous facilities.

(6) Procurement of Equipment, Materials and Labors

Equipment, materials and labors are locally procured as much as possible. However, their local availability is limited.

(7) Construction Phasing

Considering the work volume and construction cost, the project is implemented in the following two phases.

- First phase : Improvement of Section 1 (13.1 km)
- Second phase: Improvement of Section 7 (21.0 km)

4.1.2 Equipment Procurement

The basic policy in the selection of equipment type and number is as follows:

(1) Use of Equipment

If the improvement of Section 1 and Section 7 which are planned to be paved with asphalt concrete is undertaken by the Government of Japan, it is deemed that there is no other urgent demand of construction of asphalt concrete pavement. Therefore, the equipment for asphalt concrete paving is omitted. The intended uses of equipment are as follows:

- Maintenance of asphalt concrete pavement (mainly patching)
- Construction and maintenance of coral/sealed roads

(2) Types and Numbers of Equipment

Considering the composition of equipment fleet necessary for the above uses, the following components are selected:

- Missing equipment.

- The equipment needing costly maintenance due to age, or the one expected to become unserviceable in near future.

- The equipment frequently used so that the capacity of the fleet can be increased as a whole if it is additionally procured.

4.2 Study and Examination on Design Criteria

4.2.1 Road Improvement

(1) Design Speed

Design speeds are chosen depending on roadside conditions as follows:

Section	Design Speed (km/h)	
	Standard	Exceptional
1-1, 1-2, 7-1 (Urban area)	60	50
7-2, 7-3, 7-4 (Rural area)	80	60

(2) Geometric Design Standard

Design Speed (km/h)	Minimum Radius of Curve (m)		Sight Distance (m)	Maximum Grade (%)
	Standard	Exceptional		
80	280	230	110	4
60	150	120	75	5
50	100	80	55	6

(3) Width

Minimum Causeway Width (m)	Minimum Shoulder Width (m)		Sidewalk Width
	Standard	Exceptional	
7.0	1.0	0.5	follow existing width

Note: The exceptional values may be used when necessary to avoid existing properties.

(4) Pavement

The minimum performance period (the period of time that an initial pavement structure will last before it needs rehabilitation) shall be 15 years.

(5) Surface Drainage

Surface drainage system is designed to cope with rainfall intensity for recurrence interval of two years.

According to the New Zealand Meteorological Service, the rainfall intensity for 10-minute duration and 2-year frequency is 114 mm/h.

Based on the observation records in the foreshore protection project, tide levels are assumed as follows:

High water level :	+ 0.77 m
Mean sea level :	0
Low water level :	- 0.77 m

4.2.2 Equipment Procurement

Type and specification of equipment are determined so as to conform to the intended use in this Project. The following are the common equipment which is assigned to the specific use:

- Backhoe excavator : This is used to cut large-sized rocks into pieces acceptable to the crushing and screening plant. For this purpose, the hydraulic breaker is attached thereto.

- Wheel loader : This is used in the crushing and screening plant to load materials and to move products to the stock yard.

- Air compressor : This is used to operate the pneumatic hand breaker.

- Dump truck (2t) & Cargo truck : These are used for the maintenance of asphalt concrete pavement. Dump truck carries materials and cargo truck small machinery and tools.

4.3 Basic Plan (Road Improvement)

4.3.1 Cross-sectional Elements

Cross-sectional elements are carriageway, shoulder, sidewalk and green belt.

The width of each element follows the existing, except for the widening sections mentioned below:

Widening section : Starting portion of Subsection 1-1 (western part) 2.767 km

Ending portion of Subsection 1-1 (eastern part) 1.703 km

Refer to 4.3.7 for the cross-sectional elements of each section.

4.3.2 Alignment

As present horizontal and vertical alignments meet the geometric design standard, alignment is not changed.

4.3.3 Pavement

Present conditions of road surface vary much but base courses are generally sound with little damage. Taking this into consideration, pavement design is carried out in accordance with the following principles:

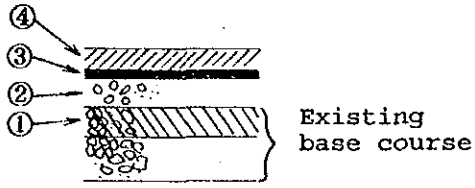
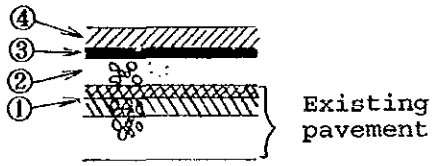
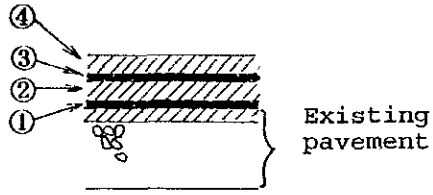
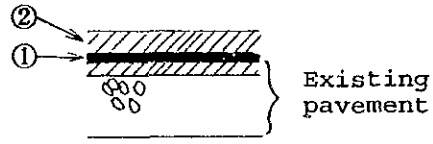
- Existing base course is used as is in principle.
- For unsealed roads, upper part of existing base course is scarified, additional base course material is placed and compacted, and asphalt concrete is constructed thereon.

- For sealed roads in bad condition, existing surface and upper part of base course are scarified, additional base course material is placed and compacted, and asphalt concrete is constructed thereon.

- For sealed roads where the surface condition is not very bad, overlay with asphalt concrete is applied. Overlay is done by one layer or two layers depending on the extent of damage. In case of two layers, the first layer is placed for the purpose of filling up damaged portions and leveling.

Pavement types are classified into four as shown in Table 4.3-1.

Table 4.3-1 PAVEMENT TYPES

Pavement Type	Present Condition	Main Work Items
AC - 1	· Unsealed	① Scarification of the upper part of base course ② Placing and compaction of additional base course material ③ Prime coast ④ Asphalt concrete surfacing 
AC - 2	· Sealed · Surface condition is bad.	① Scarification of the existing surface and the upper part of base course ② Placing and compaction of additional base course material ③ Prime coast ④ Asphalt concrete surfacing 
AC - 3	· Sealed · Surface condition is a little bad.	① Tack coat ② Asphalt concrete leveling ③ Tack coat ④ Asphalt concrete surfacing 
AC - 4	· Sealed · Surface condition is fair.	① Tack coat ② Asphalt concrete surfacing 

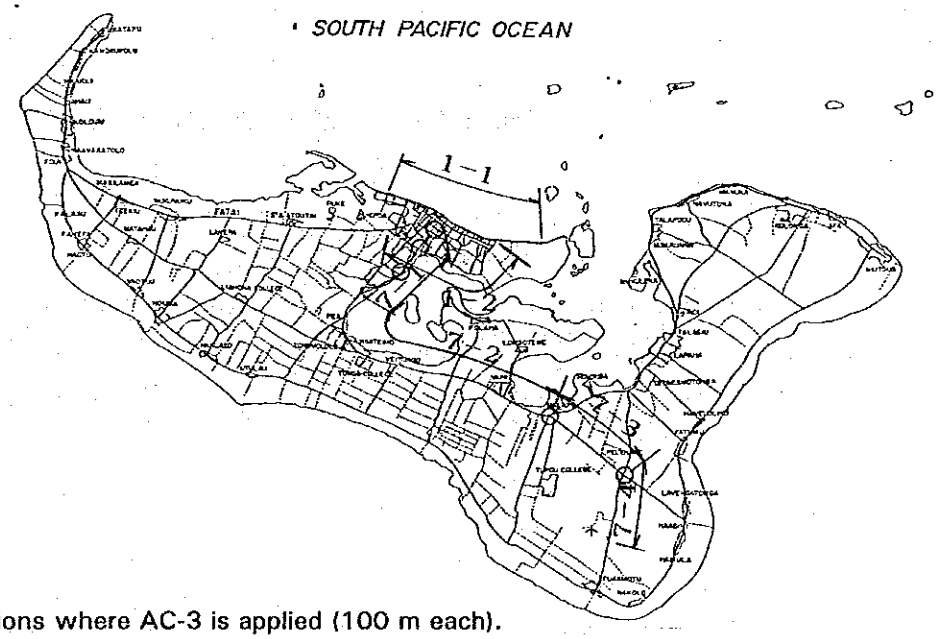
The pavement design was carried out in accordance with AASHTO GUIDE FOR DESIGN OF PAVEMENT STRUCTURES 1986.

Pavement type and thickness of each section are shown in Table 4.3-2.

Table 4.3-2 PAVEMENT TYPE AND PAVEMENT THICKNESS

Sub-Section	Section Length (km) (Successively from starting point)	Pavement Type	Pavement Thickness (mm) Scarification	Additional Base Course Material	Asphalt Concrete Leveling	Asphalt Concrete Surfacing
1 - 1	0.123 km	AC - 1	50	100	-	50
	2.644 km	AC - 2	50	100	-	50
	3.059 km	AC - 4	-	-	-	50
	1.578 km	AC - 2	50	100	-	50
	0.125 km	AC - 1	50	100	-	50
1 - 2	1.299 km	AC - 4	-	-	-	50
	4.257 km	AC - 2	50	100	-	50
7 - 1 ↓ 7 - 4	· Sections marked ○ in the figure below.	AC - 3	-	-	30	40
	· Other sections than the above	AC - 4	-	-	-	50

Note: The starting points of Subsections 1-1 and 1-2 are the western ends.



○ : Sections where AC-3 is applied (100 m each).

4.3.4 Surface Drainage

For the Areas A to D shown in Figure 4.3-1, the surface drainage systems are designed as follows:

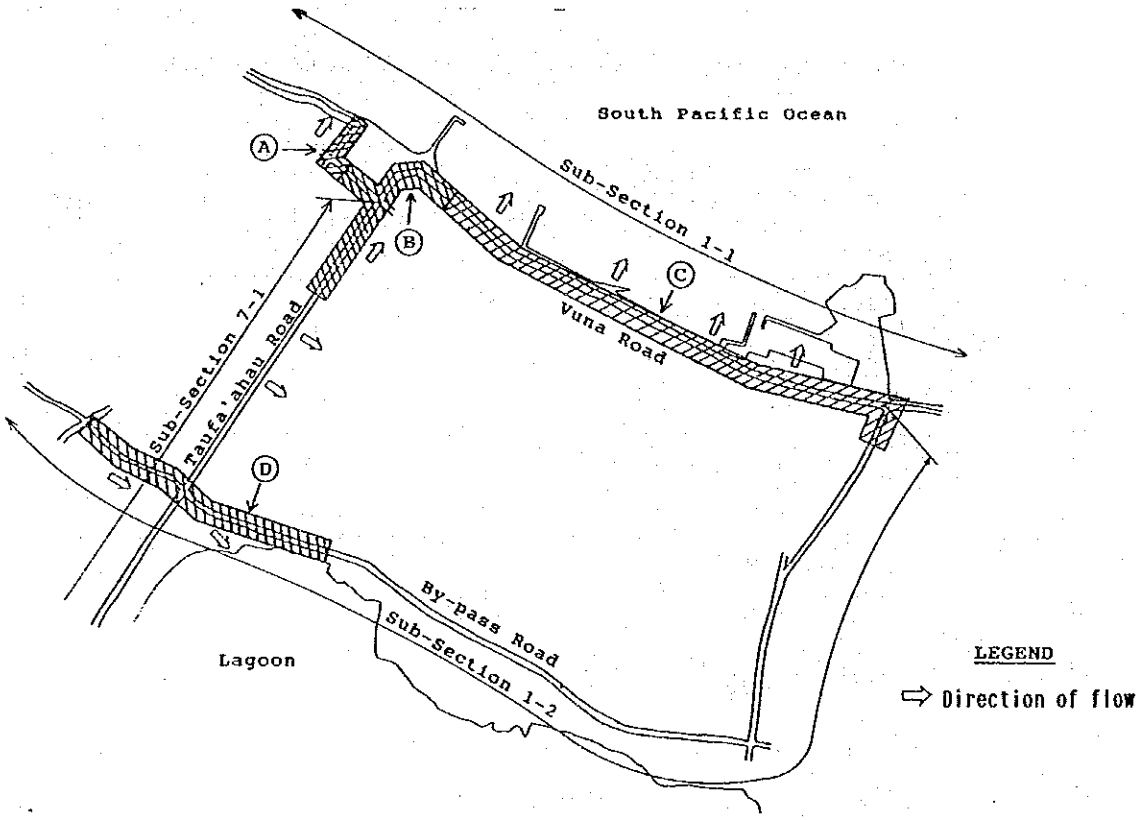


Figure 4.3-1 AREAS FOR THE DESIGN OF DRAINAGE SYSTEM

- Area A

  Rainwater flows into the side ditches on both sides of the road and then drains through the drainage canal into the sea. Catch basin is installed at the end of the drainage canal to prevent the pollution of sea water.

- Area B

  There exists a drainage system in this area. Since the efficiency of

the existing system might be reduced due to sedimentation of soil, the pipe culverts and catch basins are planned to be cleaned up in this Project.

- Area C

  Same as the area A

- Area D

  At present, this area is drained through earth side ditches and open channels leading to the Lagoon. The existing system is partly incomplete (in some portions, the side ditch is interrupted by paths) and partly working badly due to sedimentation of soil. Restoration of earth side ditches, cleaning of existing culverts and additional construction of pipe culverts are included in this Project.

For the other area than the above, the present way by infiltration into ground is followed.

The computation for the design of drainage system in each area is as follows:

(1) Area A

Figure 4.3-2 shows the drainage system in the area A.

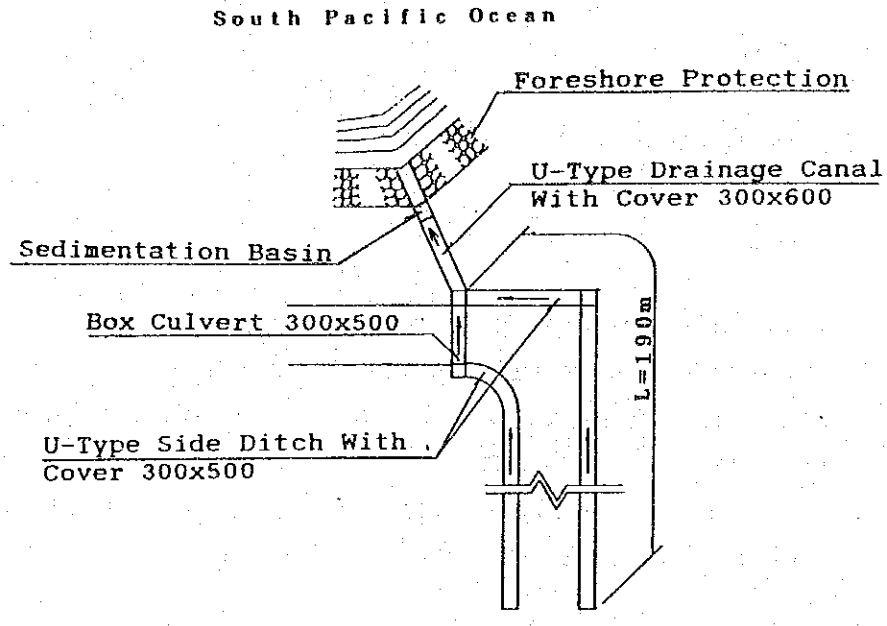


Figure 4.3-2 DRAINAGE SYSTEM IN THE AREA A

Rainfall discharge and drainage capacity are given by the following formulas:

$$Q = \frac{1}{3.6 \times 10^6} C \cdot I \cdot a$$

$$Q_c = A \cdot v$$

$$v = \frac{1}{n} \cdot R^{2/3} \cdot i^{1/2}$$

Where, Q : Rainfall discharge (m^3/sec)
C : Coefficient of run-off
I : Design intensity of rainfall (mm/h)
a : Catchment area (m^2)
Q_c : Drainage capacity (m^3/sec)
A : Cross-sectional area of running water (m^2)
v : Mean velocity of stream (m/sec)
n : Coefficient of roughness (sec/$m^{1/3}$)
R : Hydraulic radius (m), R = A/P (P : Length of wetted perimeter)
i : Hydraulic gradient

Design variables are assumed as follows.

C = 0.95 (Paved surface)
I = 114mm/h (2-year frequency and 10-minute duration)
a = W · L (W = width of catchment area, L = length of catchment area)
A = 0.8 · B · H (B = width of ditch, H = height of ditch, where effective height is assumed to be 80% of actual height considering the allowance for soil sedimentation.)
n = 0.015 (Cast-in-place concrete)
R = 0.8 BH / (B + 2x0.8H)
i = 0.001 - 0.0016 (U-type side ditch with cover), or
0.002 (Box culvert and U-type drainage canal with cover)

Table 4.3-3 shows the calculation of rainfall discharge, Q and drainage capacity, Q_c. The adequacy of drainage capacity is confirmed if $Q < Q_c$.

Table 4.3-3 COMPUTATION OF DRAINAGE SYSTEM IN THE AREA A

Drainage Facility	Cross Sectional Area B(m)xH(m)	Catchment Area W(m)xL(m)=a(m2)	Rainfall Discharge Q(m3/sec)	Area of running water A(m2)	Hydraulic Radius R(m)	Hydraulic Gradient i	Mean Velocity v(m/sec)	Drainage Capacity Qc(m3/sec)
U-type side ditch	0.3x0.4	5.6x190=1064	0.032	0.096	0.102	0.001	0.460	0.044
Box culvert	0.3x0.5	5.6x190=1064	0.032	0.120	0.109	0.002	0.680	0.082
U-type drainage canal	0.3x0.5	11.2x190=2128	0.064	0.120	0.109	0.002	0.680	0.082

(2) Area B

The computation is omitted because the existing system is utilized.

(3) Area C

Figure 4.3-3 shows the drainage system in the area C. Computation formulas and design variables are the same as those for the area A.

The computation results are shown in Table 4.3-4.

Table 4.3-4 COMPUTATION OF DRAINAGE SYSTEM IN THE AREA C

Drainage Facility	Cross-Section B x H	Location	Catchment Area a (m²)	Rainfall Discharge Q(m3/sec)	Area of Running Water A (m²)	Hydraulic Radius R (m)	Hydraulic Gradient i	Mean Velocity v(m/sec)	Drainage Capacity Qc(m3/sec)
U-type side ditch 300 x 400	0.3x0.3	Sta. 4+400 →Sta. 4+250	5.6x150 = 840	0.025	0.072	0.092	0.001	0.430	0.031
U-type side ditch 300 x 500	0.3x0.4	Sta. 4+000 →Sta. 4+250	5.6x250 = 1,400	0.042	0.096	0.102	0.001	0.460	0.044
U-type side ditch 300 x 600	0.3x0.5	Sta. 4+400 →Sta. 4+700	5.6x300 = 1,680	0.051	0.120	0.109	0.001	0.481	0.058
U-type side ditch 300 x 600	0.3x0.5	Sta. 5+400 →Sta. 5+000	5.6x400 = 2,240	0.067	0.120	0.109	0.0015	0.589	0.071
U-type side ditch 300 x 600	0.3x0.5	Sta. 5+400 →Sta. 5+829	5.6x429 = 2,402	0.072	0.120	0.109	0.0016	0.608	0.073
Box culvert 300 x 500	0.3x0.5	Sta. 4+250	5.6x(250+150) = 2,240	0.067	0.120	0.109	0.002	0.680	0.082
Box culvert 400 x 600	0.4x0.6	Sta. 5+829	5.6x(429+152 x2)=4,105	0.123	0.192	0.141	0.002	0.808	0.155
U-type drain canal 400 x 700	0.4x0.6	Sta. 5+000	5.6x(200x2+ 72+400)=4,883	0.147	0.192	0.141	0.002	0.808	0.155

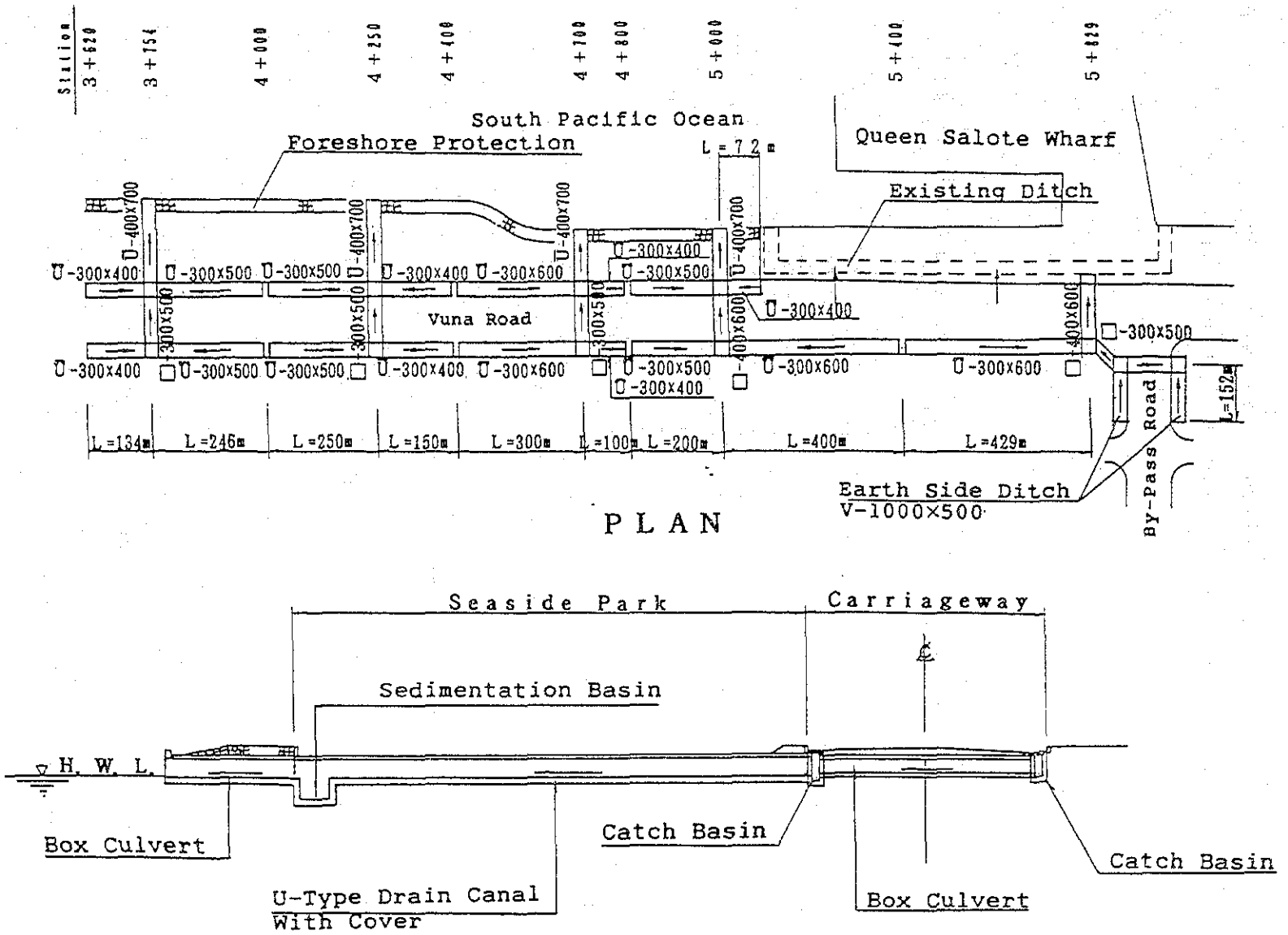


Figure 4.3-3 DRAINAGE SYSTEM IN THE AREA C

(4) Area D

The drainage system in the area D is shown in Figure 4.3-4. The computation is omitted because of the existing system.

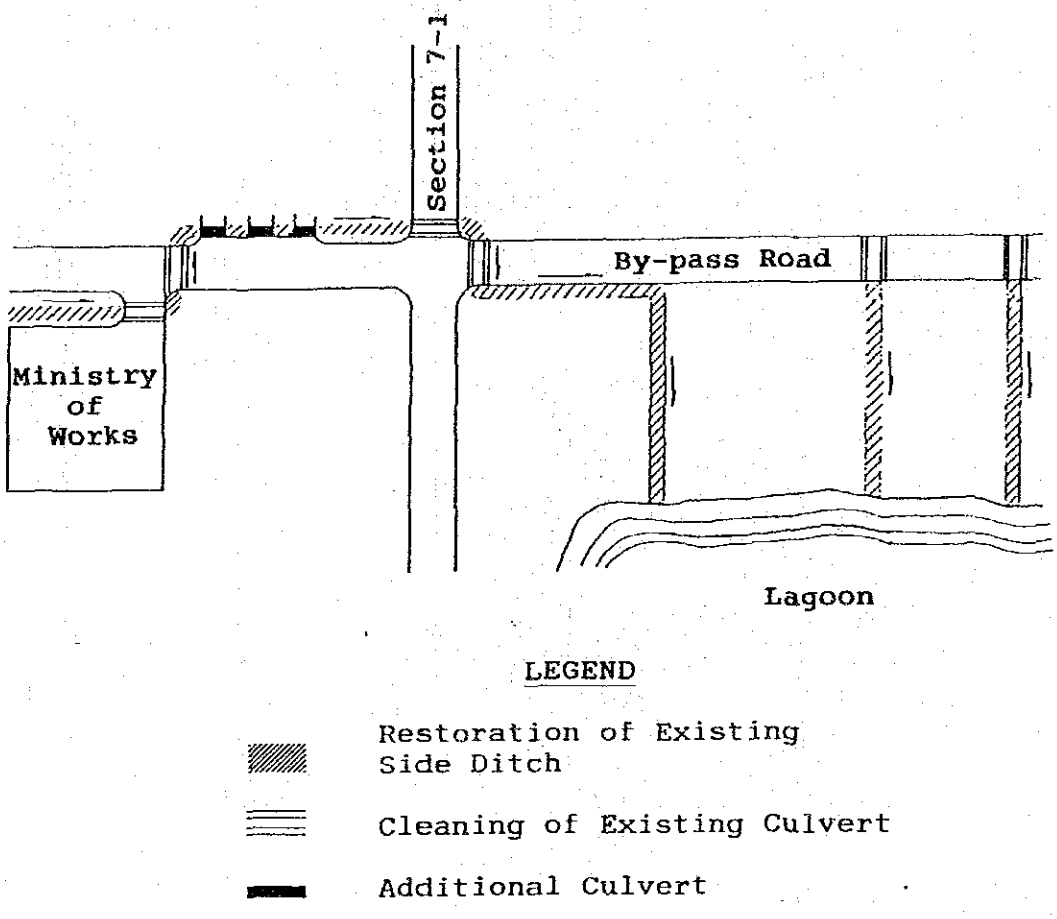


Figure 4.3-4 DRAINAGE SYSTEM IN THE AREA D

4.3.5 Bus Stop

Bus stops are planned to be constructed outside the carriageway at the designated points along Section 7 and a part of Subsection 1-2 which are the important bus routes. Location and shape of bus stops are shown in Figure 4.3-5.

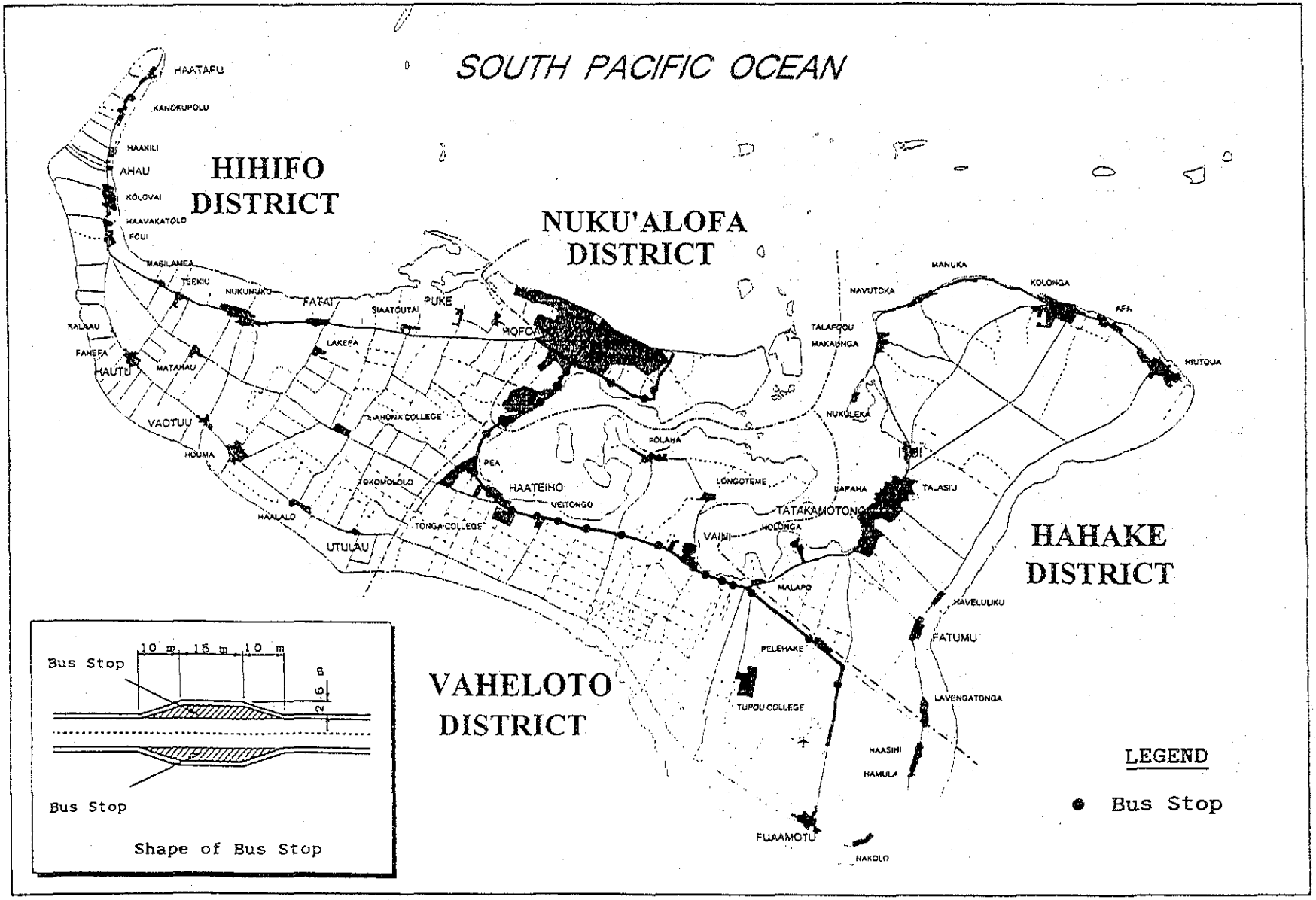


Figure 4.3-5 LOCATION AND SHAPE OF BUS STOPS

4.3.6 Road Marking

Center lines, carriageway outside lines, stop-lines and pedestrian crossings are drawn as road markings. Carriageway outside lines are limited to the sections with curbs on both sides. Pedestrian crossings are put in principle on the locations where existing. The shape and size are basically the same as the existing, and finally decided through the discussion with the Ministry of Police.

4.3.7 Typical Cross-Sections

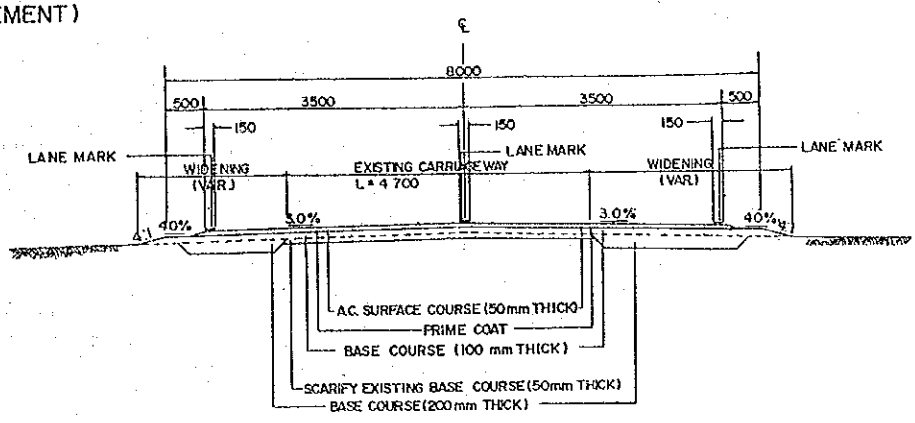
Typical cross sections are shown in Figure 4.3-6. There are 16 types of typical cross-sections. Their application is shown in Table 4.3-5.

Table 4.3-5 APPLICATION OF TYPICAL CROSS-SECTIONS

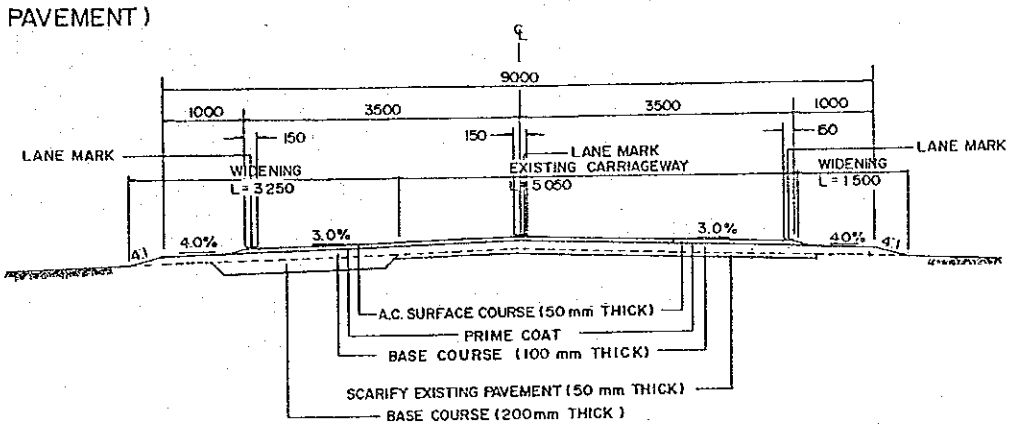
Sub-Section	Section Length (km) (successively from starting point)	Typical Cross-Section Number	Pavement Type
1 - 1	0.123	1	AC - 1
	2.644	2	AC - 2
	0.117	3	AC - 4
	0.195	4	AC - 4
	0.548	3	AC - 4
	0.363	4	AC - 4
	0.020	3	AC - 4
	0.380	4	AC - 4
	0.017	3	AC - 4
	0.380	4	AC - 4
	0.020	3	AC - 4
	0.262	4	AC - 4
	0.318	5	AC - 4
	0.020	3	AC - 4
	0.419	5	AC - 4
	1.578	6	AC - 2
	0.125	7	AC - 1
Total	7.529		
1 - 2	1.299	9	AC - 4
	4.257	8	AC - 2
Total	5.556		

Sub-Section	Section Length (km) (successively from starting point)	Typical Cross-Section Number	Pavement Type
7 - 1	0.372	13	AC - 4
	0.169	14	AC - 4
	0.100	11	AC - 3
	0.728	12	AC - 4
	0.070	11	AC - 3
	1.007	12	AC - 4
	0.102	11	AC - 3
	1.806	12	AC - 4
Total	4.354		
7 - 2	2.704	16	AC - 4
	7.620	16	AC - 4
	0.049	15	AC - 3
Total	10.373		
7 - 3	0.050	15	AC - 3
	3.591	16	AC - 4
	0.050	15	AC - 3
Total	3.691		
7 - 4	0.050	15	AC - 3
	2.570	16	AC - 4
Total	2.620		

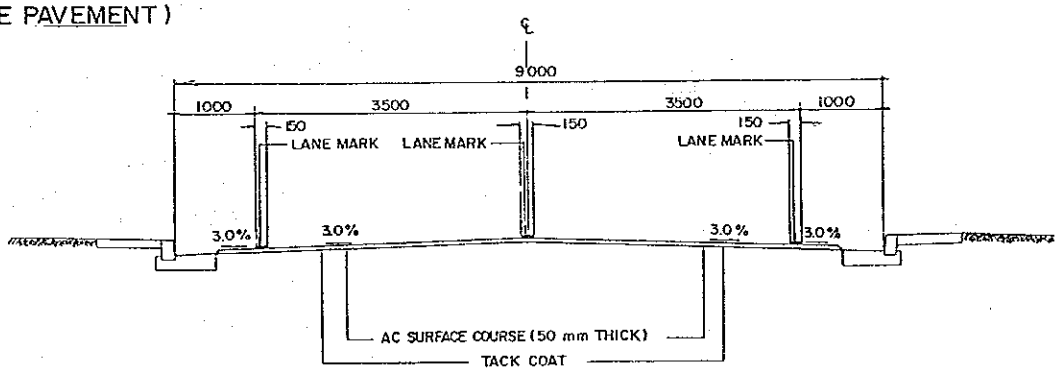
NO. 1 (AC-1 TYPE PAVEMENT)



NO. 2 (AC-2 TYPE PAVEMENT)



NO. 3 (AC-4 TYPE PAVEMENT)



NO. 4 (AC-4 TYPE PAVEMENT)

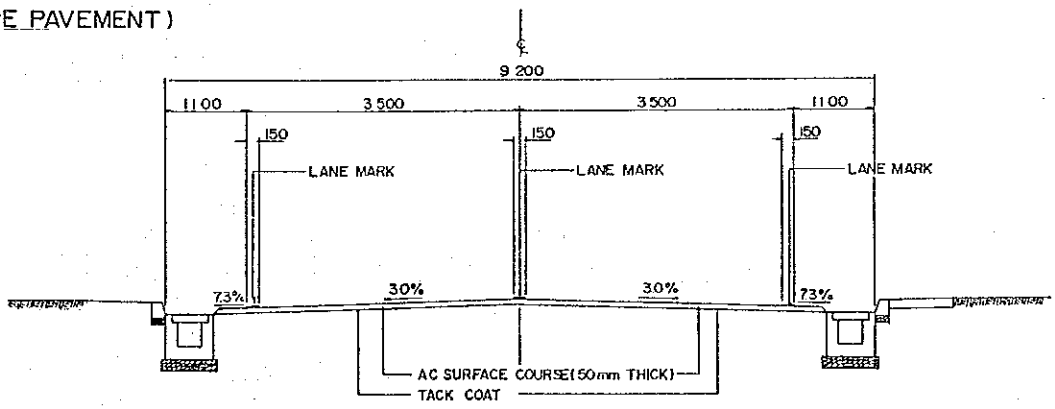
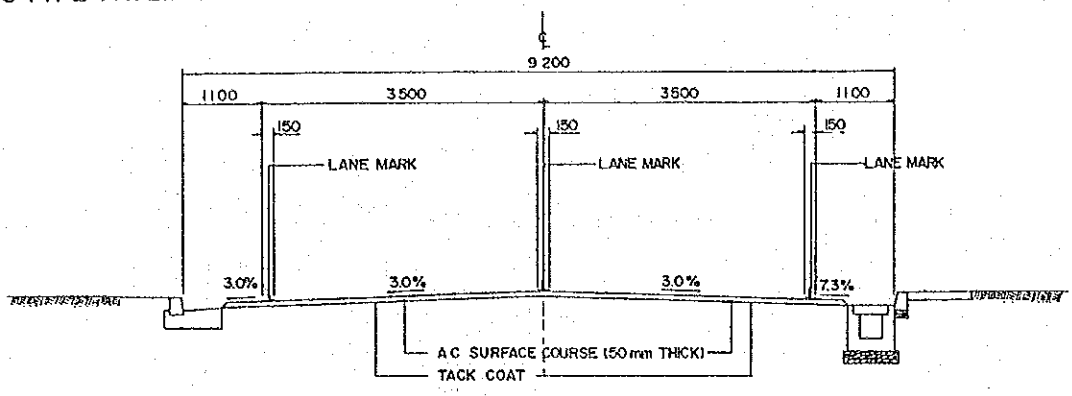
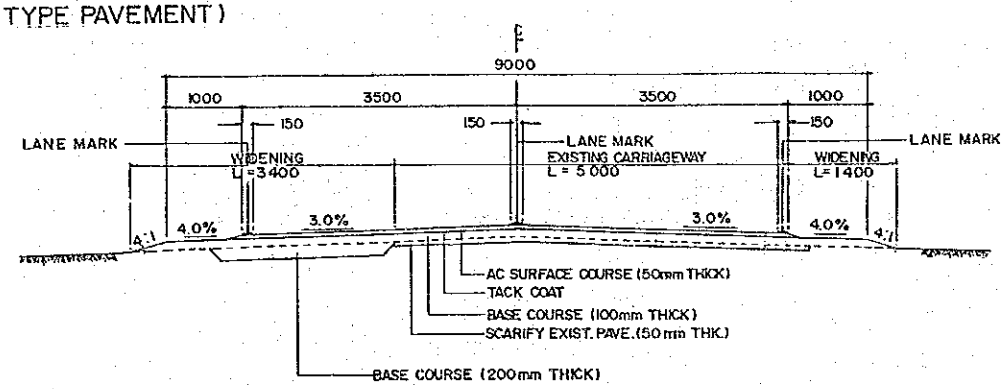


Figure 4.3-6 TYPICAL CROSS-SECTIONS (1/4)

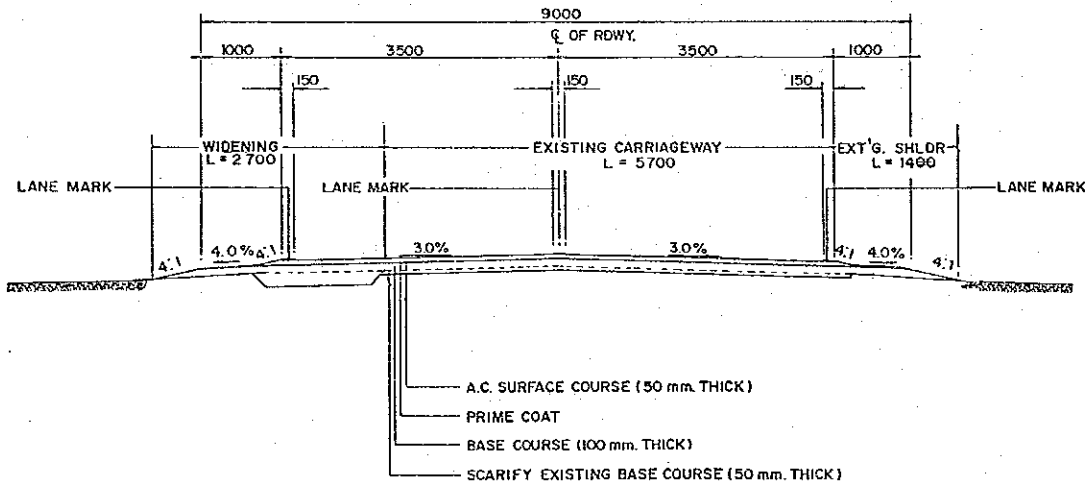
NO. 5 (AC-3 TYPE PAVEMENT)



NO. 6 AC-2 TYPE PAVEMENT)



NO. 7 (AC- I TYPE PAVEMENT)



NO.8 (AC-2 TYPE PAVEMENT)

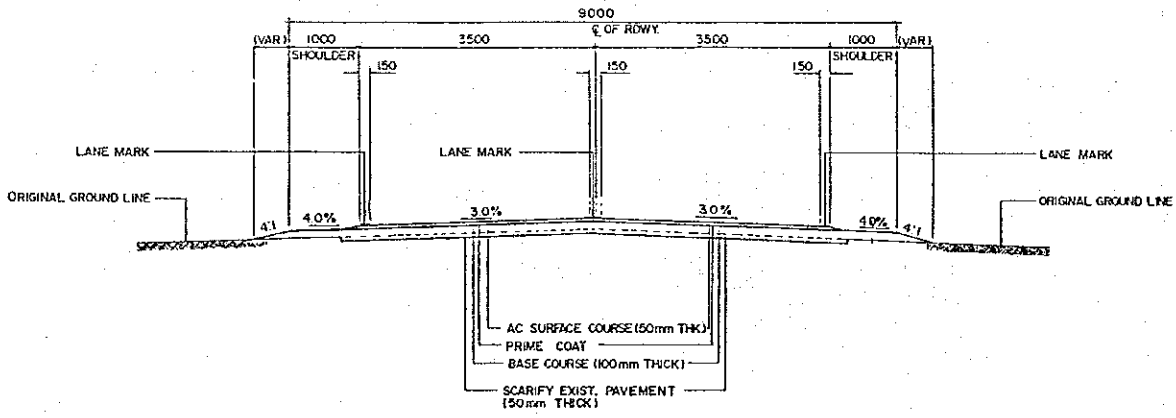
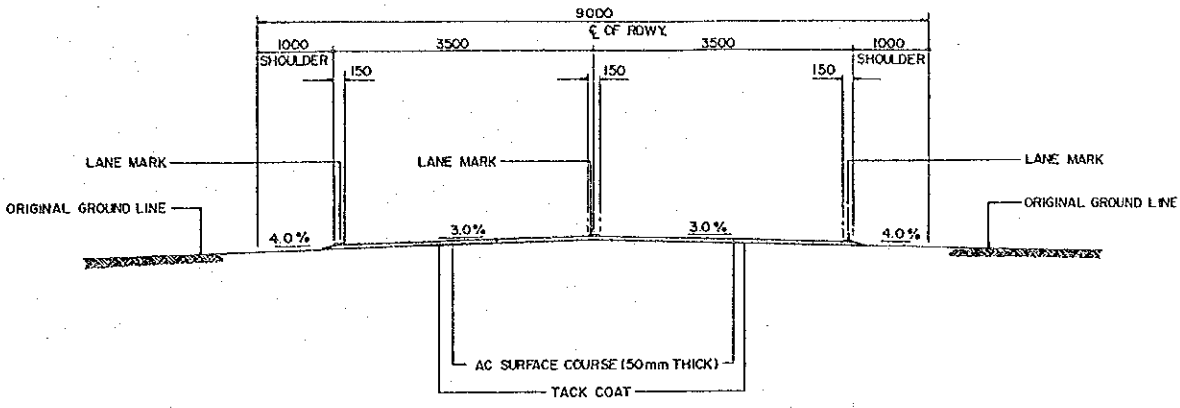
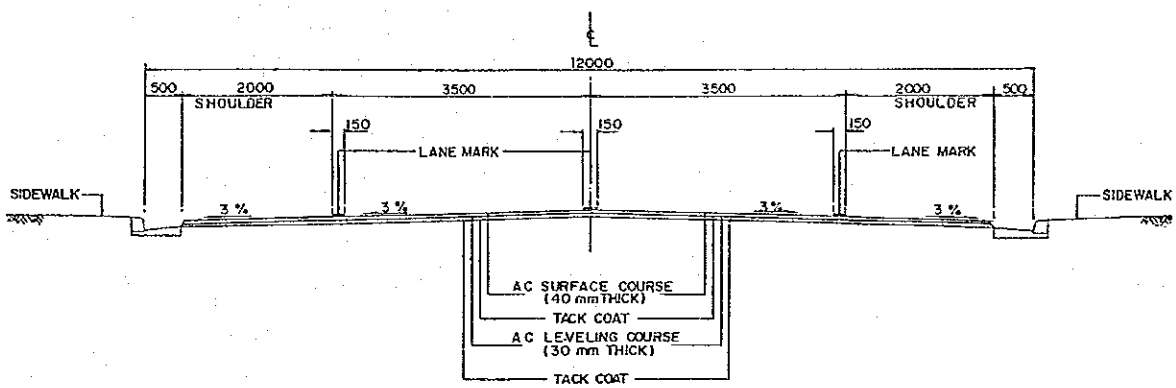


Figure 4.3-6 TYPICAL CROSS-SECTIONS (2/4)

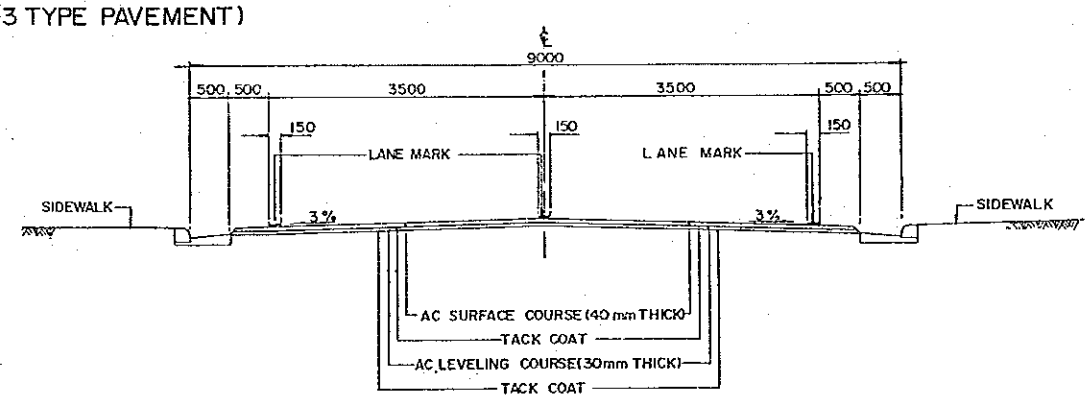
NO.9 (AC-4 TYPE PAVEMENT)





NO.10 (AC-3 TYPE PAVEMENT)

NO.11 (AC-3 TYPE PAVEMENT)



NO.12 (AC-4 TYPE PAVEMENT)

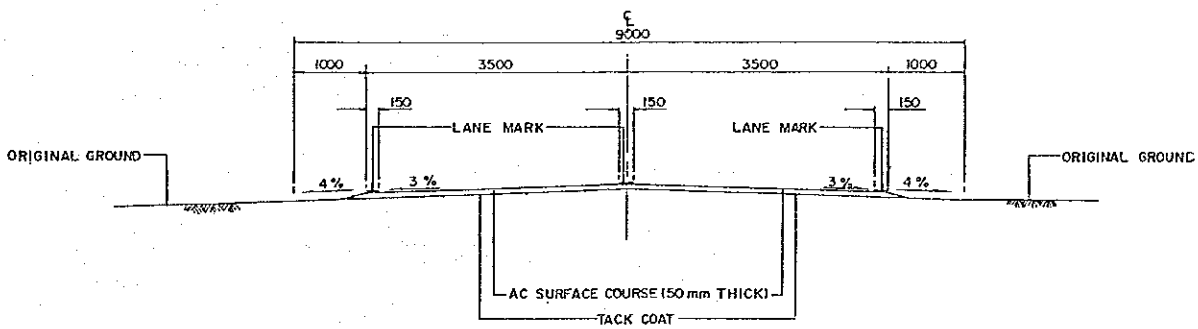
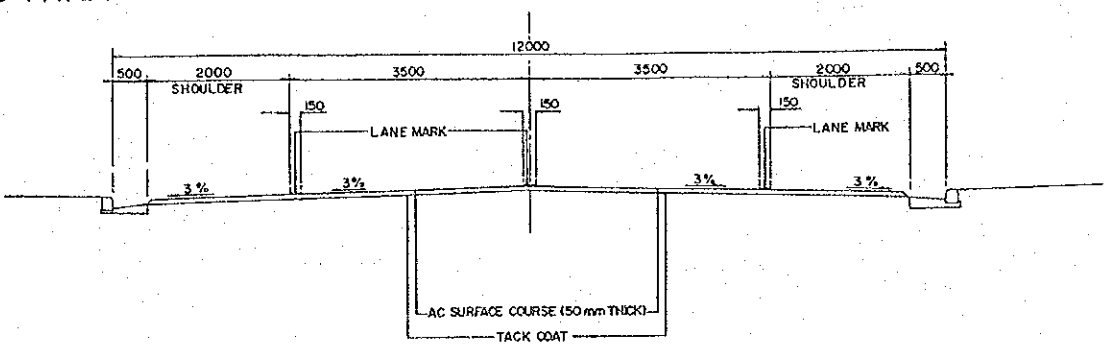
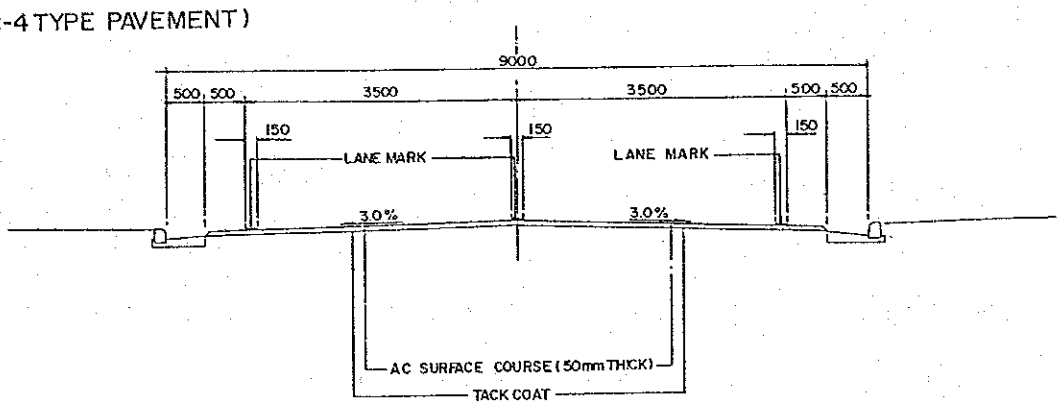


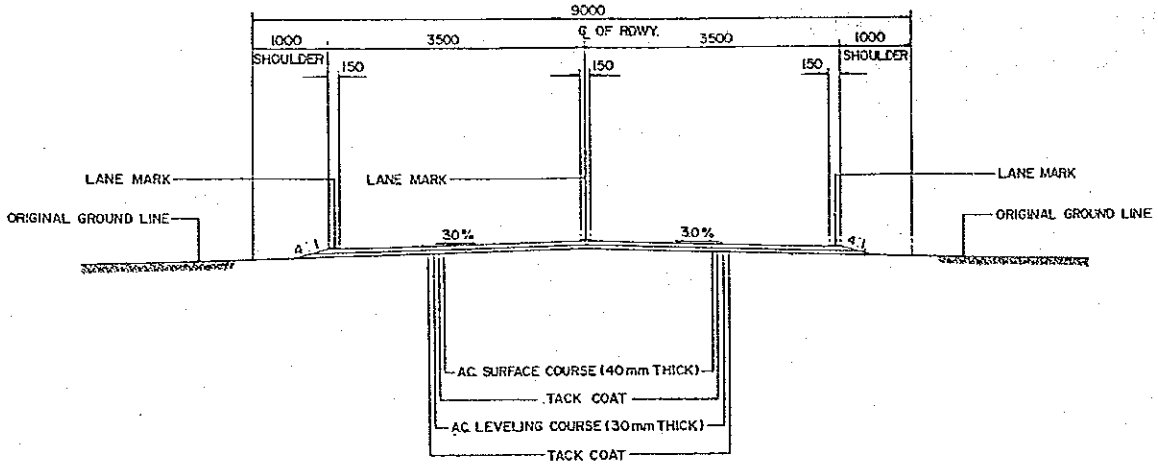
Figure 4.3-6 TYPICAL CROSS-SECTIONS (3/4)

NO. 13 (AC-4 TYPE PAVEMENT)



NO. 14 (AC-4 TYPE PAVEMENT)





NO.16 (A.C-4 TYPE PAVEMENT)

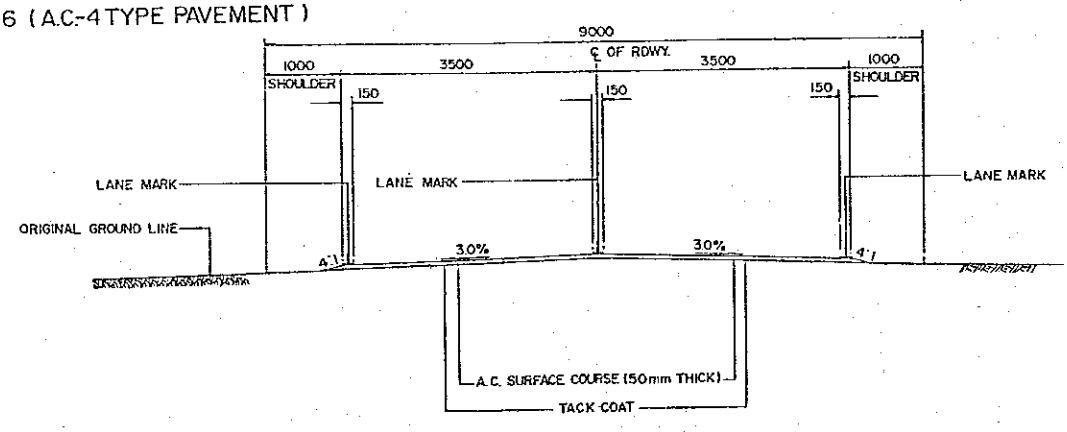


Figure 4.3-6 TYPICAL CROSS-SECTIONS (4/4)

4.4 Basic Design (Equipment Procurement)

4.4.1 Equipment Types and Numbers

Equipment types and numbers should be decided taking into consideration the appropriate composition of equipment fleet meeting its purpose of use, condition of the existing equipment, availability of equipment owned by private leasing companies, etc. The study thereon was made through the discussion between the Basic Design Study Team and the officials from the Government of Tonga. The results of the study and the final request of the Government of Tonga are summarized in Table 3.4-4. Among the finally requested equipment, a bulldozer was omitted for the following reasons:

- The Ministry of Works owns two 35-t bulldozers out of which one is working and the other is under repair (parts have been ordered). The Ministry leases a bulldozer for substitution. Two bulldozers, including leased one in the mean time until the one under repair becomes serviceable, are considered to be good enough in view of the combination with other equipment.

- Bulldozer is given low priority.

Finally proposed equipment and its main use intended are summarized in Table 4.4-1.

Table 4.4-1 PROPOSED EQUIPMENT AND MAIN USE

Equipment	Number	Main Use Intended										
		Construction of Coral/Sealed Roads						Maintenance of Coral Roads			Maintenance of Sealed Roads	Maintenance of Asphalt Concrete Pavement
		Production of Chips	Production of Base Course Material	Earth Work	Subgrade	Base Course	Surface Course	Grading	Pothole Repair	Overlay with Base Course Material	Patching	Patching
Motor Grader	2			o	o	o		o				
Backhoe Excavator	1	o	o									
Wheel Loader	1	o	o									
Dump Truck (8 t)	3			o	o	o	o			o		
Dump Truck (2 t)	1								o		o	o
Cargo Truck	1								o		o	o
Water Tank Truck	1			o	o	o		o		o		
Pick-up Truck	1			o	o	o	o			o		
Hydraulic Breaker	1	o	o									
Pneumatic Hand Breaker	2											o
Crushing and Screening Plant	1	o	o									
Vibration Roller (10 t)	1			o	o	o	o	o		o		
Vibration Roller (0.7 t)	1								o		o	o
Plate Compactor	2								o		o	o
Chip Spreader	2						o			o		
Asphalt Distributor	1						o					
Asphalt Sprayer	1										o	o
Asphalt Burner	1				-							o
Concrete Cutter	1											o
Air Compressor	1											o

4.4.2 Specifications of Proposed Equipment

Type and specifications for the proposed equipment were determined according to its intended use, as presented in Table 4.4-2. The specifications are indicated in accordance with JAPAN'S CONSTRUCTION EQUIPMENT SPECIFICATION MANUAL 1992, Japan Mechanized Construction Association.

Spare parts equivalent to 20% of FOB prices are proposed to be included. The spare parts should be selected carefully to avoid waste. The following are recommended as major components of spare parts:

- Parts specified in the Maintenance Manual to be replaced in periodic inspection
- Consumable parts such as cutting edge, teeth, tire, spring, etc.
- Electric parts
- Necessary parts in disassembling/reassembling such as overhaul kit

Table 4.4-2 SPECIFICATIONS FOR EQUIPMENT

EARTH WORKING EQUIPMENT		
MOTOR GRADER		
ENGINE OUTPUT	HP	more than 155
OPERATING WEIGHT	kg	more than 12500
DIMENSIONS		
· Overall Length	mm	less than 8500
· Overall Width (Without Blade)	mm	less than 2500
· Overall Height	mm	less than 3500
· Blade Length x Height	mm	more than 3700 x 600
· Ground Clearance	mm	more than 350
· Wheel Base	mm	more than 6000
PERFORMANCE		
· Max. Travel Speed Forward-Reverse	kg/h	more than 45 - 45
· Min. Turning Radius	mm	less than 6900
· Front Axle Oscillation	deg	more than 15
· Blade Max. Lift	mm	more than 450
· Articulation	deg	more than 25
ENGINE		
· Type		Water Cooled Diesel
· Displacement	cc	more than 6400
POWER TRAIN		
· Clutch		Multiple Disc Type
· Transmission		Planetary Power Shift
· Brake		Air or Hydraulic Actuate
TIRE		
· Size	piece	13 - 24 - 10PR
· No. of Tire		6
ATTACHMENT		
· Scarifier		
No. of Teeth	piece	more than 11
Width	mm	more than 1200
· Canopy		Steel

EXCAVATING EQUIPMENT		
BACKHOE EXCAVATOR		
ENGINE OUTPUT	HP	more than 84
OPERATING WEIGHT	kg	more than 11800
DIMENSIONS		
· Overall Length	mm	less than 7600
· Overall Width	mm	less than 2500
· Overall Height	mm	less than 2800
· Bucket Cap.	m^3	more than 0.45
· Ground Clearance	mm	more than 400
· Track Gauge	mm	more than 1950
· Track Length	mm	more than 2750
PERFORMANCE		
· Max. Travel Speed	km/h	more than 3.5
· Swing Radius	mm	less than 2500
· Swing Speed	rpm	more than 11
· Arm Crowd Force	kg	more than 5900
· Bucket Digging Force	kg	more than 7800
WORKING RANGE		
· Max. Digging Height	mm	more than 8450
· Max. Dumping Height	mm	more than 6000
· Max. Vertical Wall Digging Depth	mm	more than 4900
· Max. Digging Reach at Ground	mm	more than 8100
ENGINE		
· Type		Water Cooled Diesel
· Displacement	cc	more than 3250
HYDRAULIC SYSTEM		
· Pump Type		Variable Piston Type
· Flow	l/min	more than 195
UNDERCARRIAGE		
· Shoe Type		Triple Grouser
· Shoe Width	mm	more than 500
· Ground Pressure	kg/cm^2	less than 0.40
BUCKET		
· No. of Teeth	piece	more than 4 (with Side Cutter)
ATTACHMENT		
· Service Port		HYDRAULIC BREAKER

LOADING EQUIPMENT		
WHEEL LOADER		
ENGINE OUTPUT	HP	more than 170
OPERATING WEIGHT	kg	more than 16000
DIMENSIONS		
· Overall Length	mm	less than 7900
· Overall Width (Without Blade)	mm	less than 2850
· Overall Height	mm	less than 3550
· Bucket Cap.	m^3	more than 2.6
· Ground Clearance	mm	more than 450
· Wheel Base	mm	more than 3150
PERFORMANCE		
· Max. Travel Speed Forward-Reverse	kg/h	more than 34 - 38
· Tuning Radius (over tire)	mm	less than 6450
· Breakout Force	kg	more than 10500
WORKING RANGE		
· Dumping Clearance	mm	more than 2600
· Dumping Reach	mm	more than 1200
· Digging Depth	mm	more than 20
ENGINE		
· Type		Water Cooled Diesel
· Displacement	cc	more than 6600
POWER TRAIN		
· Torque Converter		Single Stage
· Transmission		Planetary Power Shift
· Brake		Air-Hydraulic Actuate
TIRE		23.5 - 25 - 12PR
BUCKET		
· Type		Rock Bucket (Teeth & Segment)

HAULING EQUIPMENT		
DUMP TRUCK (8 t)		
ENGINE OUTPUT	HP	more than 180
WEIGHT		
· Max. Loading Cap.	kg	more than 8000
· Vehicle Weight	kg	more than 6300
· Gross Vehicle Weight	kg	more than 14450
DIMENSIONS		
· Overall Length	mm	less than 7000
· Overall Width	mm	less than 2500
· Overall Height	mm	less than 3300
· Wheel Base	mm	more than 3700
· Body		
Length	mm	more than 3800
Width	mm	more than 2200
Height	mm	more than 600
PERFORMANCE		
· Max. Travel Speed	km/h	more than 85
· Min. Turning Radius	mm	less than 7800
ENGINE		
· Type		Water Cooled Diesel
· Displacement	cc	more than 7000
POWER LINE		
· Transmission Type		Constant Mesh or Synchromesh
· No. of Speed		more than 5F - 1R
TIRE		
· Size		more than 10 - 20 14PR
· No. of Tire (without spare)	piece	6
GATE		
· Type		Tail Gate

Table 4.4-2 SPECIFICATIONS FOR EQUIPMENT

HAULING EQUIPMENT

DUMP TRUCK (2 t)			CARGO TRUCK			WATER TANK TRUCK			PICK-UP TRUCK		
ENGINE OUTPUT	HP	more than 85	ENGINE OUTPUT	HP	more than 155	ENGINE OUTPUT	HP	more than 180	ENGINE OUTPUT	HP	more than 75
WEIGHT			WEIGHT			WEIGHT			WEIGHT		
· Max. Loading Cap.	kg	more than 2000	· Max. Loading Cap.	kg	more than 4000	· Max. Loading Cap.	kg	more than 8000	· Max. Loading Cap.	kg	more than 1000
· Vehicle Weight	kg	more than 2000	· Vehicle Weight	kg	more than 3600	· Vehicle Weight	kg	more than 6000	· Gross Vehicle Weight	kg	more than 2450
· Gross Vehicle Weight	kg	more than 4700	· Gross Vehicle Weight	kg	more than 8500	· Gross Vehicle Weight	kg	more than 14200			
DIMENSIONS			DIMENSIONS			DIMENSIONS			DIMENSIONS		
· Overall Length	mm	less than 4800	· Overall Length	mm	less than 8650	· Overall Length	mm	less than 8250	· Overall Length	mm	less than 4950
· Overall Width	mm	less than 1700	· Overall Width	mm	less than 2500	· Overall Width	mm	less than 2500	· Overall Width	mm	less than 1700
· Overall Height	mm	less than 2200	· Overall Height	mm	less than 2600	· Overall Height	mm	less than 3300	· Overall Height	mm	less than 1650
· Wheel Base	mm	more than 2450	· Wheel Base	mm	more than 4700	· Wheel Base	mm	more than 4100	· Wheel Base	mm	more than 2850
· Body			· Body			· Tank			· Body		
Length	mm	more than 2800	Length	mm	more than 6200	Loading Cap.	lit	more than 8000	Length	mm	more than 1350
Width	mm	more than 1600	Width	mm	more than 2050	Length	mm	more than 4900	Width	mm	more than 1450
Height	mm	more than 320	Height	mm	more than 400	Width	mm	more than 2050	Height	mm	more than 400
						Height	mm	more than 1100			
PERFORMANCE			PERFORMANCE			PERFORMANCE			PERFORMANCE		
· Max. Torque	kg·m	more than 20	· Max. Travel Speed	km/h	more than 95	· Max. Travel Speed	km/h	more than 95	· Max. Torque	kg·m	more than 14.5
· Min. Turning Radius	mm	less than 5100	· Min. Turning Radius	mm	less than 8800	· Min. Turning Radius	mm	less than 8700	· Min. Turning Radius	mm	less than 5900
ENGINE			ENGINE			ENGINE			ENGINE		
· Type		Water Cooled Diesel	· Type		Water Cooled Diesel	· Type		Water Cooled Diesel	· Type		Water Cooled Diesel
· Displacement	cc	more than 2950	· Displacement	cc	more than 6000	· Displacement	cc	more than 7000	· Displacement	cc	more than 2400
POWER LINE			POWER LINE			POWER LINE			POWER LINE		
· Transmission Type			· Transmission Type			· Transmission Type			· Drive		4 x 2
· No. of Speed		5F - 1R	· No. of Speed		Constant Mesh or Synchromesh 5F - 1R	· No. of Speed		Constant Mesh or Synchromesh 5F - 1R	· No. of Speed		5F - 1R
TIRE			TIRE			TIRE			TIRE		
· Size		more than 6.5 - 16 - 8PR	· Size		8.25 - 16 - 14PR	· Size		more than 10 - 20 - 14PR	· Front Size		more than 6 - 14 - 6PR
· No. of Tire (without spare)	piece	6	· No. of Tire (without spare)	piece	6	· No. of Tire (without spare)	piece	6	· Rear Size		more than 6.5 - 14 - 8PR
									· No. of Tire (without spare)	piece	4
GATE			GATE			SPRINKLER			CABIN		
· Type		Tail Gate	· Type		with Tail Gate Lifter	· Pump Type		PTO Drive	· Type		Double Cabin
			· Loading Cap.	kg	more than 1000	· Pump Cap.	l/min	more than 500			
						· Width	mm	more than 2200			
						· 2-Way Cock	piece	more than 2			
						· 4-Way Cock	piece	more than 1			

Table 4.4-2 SPECIFICATIONS FOR EQUIPMENT

BREAKER					
HYDRAULIC BREAKER			PNEUMATIC HAND BREAKER		
WEIGHT (with Chisel)	kg	more than 700	WEIGHT	kg	more than 7
DIMENSIONS			DIMENSIONS		
· Overall Length (with chisel)	mm	more than 2000	· Body Length	mm	more than 465
· Chisel Diameter x Length	mm	more than 100 x 950	· Cylinder Diameter	mm	more than 35
· Hose Size	mm	more than 19	· Shank Diameter x Length	mm	more than 26 x 80
			· Hose Diameter x Length	mm x m	more than 19 x 20
PERFORMANCE			PERFORMANCE		
· Max. Blow	bpm	more than 800	· No. of Blow	bpm	more than 1250
· Max. Hydraulic Flow	l/min	more than 110	· Air Consumption	m^3/min	less than 1.2
· Max. Operation Pressure	kg/cm²	more than 180	· Piston Stroke	mm	more than 120
ATTACHMENT			ATTACHMENT		(per one breaker)
· Chisel			· Hose	length x pce	20m x 2
Point Type	piece	5	· Hose Band	piece	4
Flat-end Type	piece	5	· Shank Moil Point	length x pce	450mm x 5

AGGREGATE PRODUCTION EQUIPMENT			
CRUSHING AND SCREENING PLANT			
		Portable-Type	Fixed-Type
CRUSHING CAP.	t/h	more than 50	more than 50
TOTAL WEIGHT OF PLANT	kg	less than 38000	less than 48000
DIMENSIONS			
· Primary Unit			
Overall Length (with draw bar)	mm	less than 5550 (6650)	less than 6800
Overall Width	mm	less than 2400	less than 2600
Overall Height	mm	less than 3600	less than 5050
· Secondary Unit			
Overall Length (with draw bar)	mm	less than 7000 (8200)	less than 7200
Overall Width	mm	less than 2850	less than 2800
Overall Height	mm	less than 2950	less than 3900
· Belt Conveyor Width x Length	mm x m	less than 500 x 12	less than 500 x 12
PERFORMANCE			
· Max. Feed Size Thick x Width x Length	mm	more than 265 x 340 x 610	more than 220 x 300 x 400
· Revolution			
Primary Crusher	rpm	more than 300	more than 265
Secondary Crusher	rpm	more than 370	more than 360
· Main Conveyor Speed	m/min	more than 70	more than 70
· Stockpiling Conveyor Speed	m/min	more than 35	more than 35
· Min. Produce Size	mm	25 - 13 - 5	25 - 13 - 5
POWER LINE			
· Drive		Electric Motor	Electric Motor
· Total Rated Output	KW	less than 95	less than 95
TIRE			
· Primary Crusher			
Size		9 - 20 - 14PR	-
No. of Tire	piece	6 (2 x 4)	
· Secondary Crusher			
Size		9 - 20 - 14PR	-
No. of Tire	piece	6 (2 x 4)	
· Conveyor			
No. of Tire	piece		
ATTACHMENT			
· Generator	KVA	more than 100	more than 100

COMPACTING EQUIPMENT		
VIBRATION ROLLER (10 t)		
ENGINE OUTPUT	HP	more than 95
OPERATING WEIGHT	kg	more than 9950
DIMENSIONS		
· Overall Length	mm	less than 5700
· Overall Width	mm	less than 2350
· Overall Height	mm	less than 2900
· Wheel Base	mm	more than 2950
PERFORMANCE		
· Max. Travel Speed	km/h	more than 12
· Frequency	vpm	more than 1800
· Centrifugal Force	kg	more than 21000
· Min. Turning Radius	mm	less than 5700
ENGINE		
· Type		Water Cooled Diesel
· Displacement	cc	more than 3900
POWER LINE		
· Transmission		Planetary or Hydraulic
· Brake		Hydraulic
WHEEL		
· Roller		
Type (pce)		Smooth Drum (1)
Diameter x Width	mm	more than 1500 x 2130
· Tire		
Size		23.1 - 26 - 8PR
Type (pce)		Block Pattern (2)

Table 4.4-2 SPECIFICATIONS FOR EQUIPMENT

COMPACTING EQUIPMENT									PAVING EQUIPMENT							
VIBRATION ROLLER (0.7 t)				PLATE COMPACTOR					CHIP SPREADER				ASPHALT DISTRIBUTOR			
ENGINE OUTPUT	HP	more than	5.9	ENGINE OUTPUT	HP	more than	2.6		ENGINE OUTPUT	HP	more than	5	ENGINE OUTPUT	HP	more than	160
OPERATING WEIGHT	kg	more than	640	WEIGHT	kg	more than	70		WEIGHT	kg	less than	500	WEIGHT			
DIMENSIONS				DIMENSIONS					DIMENSIONS				· Max. Loading Cap.	kg	more than	3500
· Overall Length	mm	less than	2900	· Overall Length	mm	less than	1100		· Overall Length	mm	less than	2500	· Vehicle Weight	kg	more than	6700
· Overall Width	mm	less than	810	· Overall Width	mm	less than	430		· Overall Width	mm	less than	1050	· Gross Vehicle Weight	kg	more than	10500
· Over Height	mm	less than	1240	· Overall Height	mm	less than	850		· Overall Height	mm	less than	1250				
· Wheel Base	mm	more than	550										DIMENSIONS			
				PERFORMANCE					PERFORMANCE				· Overall Length	mm	less than	7950
PERFORMANCE				· Max. Travel Speed	km/h	more than	1.5		· Max. Spreading Width	mm	more than	2300	· Overall Width (without Spray Bar)	mm	less than	2500
· Max. Travel Speed	km/h	more than	3	· Frequency	vpm	more than	5500		· Spreadable Max. Size	mm	more than	30	· Overall Height	mm	less than	2850
· Frequency	vpm	more than	3000	· Centrifugal Force	kg	more than	1350						· Wheel Base	mm	more than	3700
· Centrifugal Force	kg	more than	1000						ENGINE				· Bitumen Tank Cap.	m^3	more than	4
				ENGINE					· Type		Air Cooled Gasoline					
ENGINE				· Type		Air Cooled Gasoline			· Displacement	cc	more than	180	PERFORMANCE			
· Type		Air Cooled Diesel											· Max. Travel Speed	km/h	more than	90
				POWER LINE					ATTACHMENT				· Min. Turning Radius	mm	less than	7500
ROLLER				· Type		V-Belt			· Tripod (with Jack)	set	1					
· Diameter x Width	mm	more than	400 x 650						· Tool for setting	set	1		ENGINE			
				VIBRATING PLATE									· Type		Water Cooled Diesel	
				· Length x Width	mm	more than	550 x 380						· Displacement	cc	more than	6550
													POWER LINE			
													· Transmission Type			
													· No. of Speed			
													TIRE			
													· Size		8.25 - 20 - 14PR	
													· No. of Tire (Without Spare)	piece	6	
													SPRAY SYSTEM			
													· Engine Output	HP	more than	19
													· Spray Type		Always One-side Open Type	
													· Max. Spraying Width	mm	more than	3600
													· Spraying Cap.	l/min	more than	350
													· Nozzle Interval	mm	more than	120

Table 4.4-2 SPECIFICATIONS FOR EQUIPMENT

(5/5)

PAVING EQUIPMENT

ASPHALT SPRAYER

ENGINE OUTPUT	HP	more than 5
DIMENSIONS		
· Overall Length	mm	more than 2000
· Overall Width	mm	more than 1000
· Overall Height	mm	more than 1000
PERFORMANCE		
· Pump Cap.	l/min	more than 30
· Bitumen Tank Cap.	lit	more than 200
· Fuel for Burner		Kerosene
ENGINE		
· Type		Air Cooled Gasoline
TIRE		
· Size (piece)		3.25 - 8 - 4PR (2)
ATTACHMENT		
· Hose	Length x pce	5 m x 2
· Spray Bar	piece	5
· Spray Nozzle	piece	10

ASPHALT BURNER

FUEL		Kerosene
DIMENSIONS		
· Flame Length	mm	more than 1200
· Torch Diameter	mm	more than 120
PERFORMANCE		
· Fuel Consumption	l/h	less than 6
· Tank Cap.	lit	more than 35
ATTACHMENT		
· Hose	Length x pce	3 m x 5

ROAD MAINTENANCE EQUIPMENT

CONCRETE CUTTER

ENGINE OUTPUT	HP	more than 5
WEIGHT	kg	less than 135
DIMENSIONS		
· Overall Length	mm	less than 1600
· Overall Width	mm	less than 570
· Overall Height	mm	less than 1000
PERFORMANCE		
· Blade Size	mm	more than 300
· Max. Cutting Depth	mm	more than 100
ENGINE		
· Type		Air Cooled Gasoline
ATTACHMENT		
· Cutting Blade Size x Piece	mm	Diamond 305 x 5

AIR COMPRESSOR

AIR COMPRESSOR

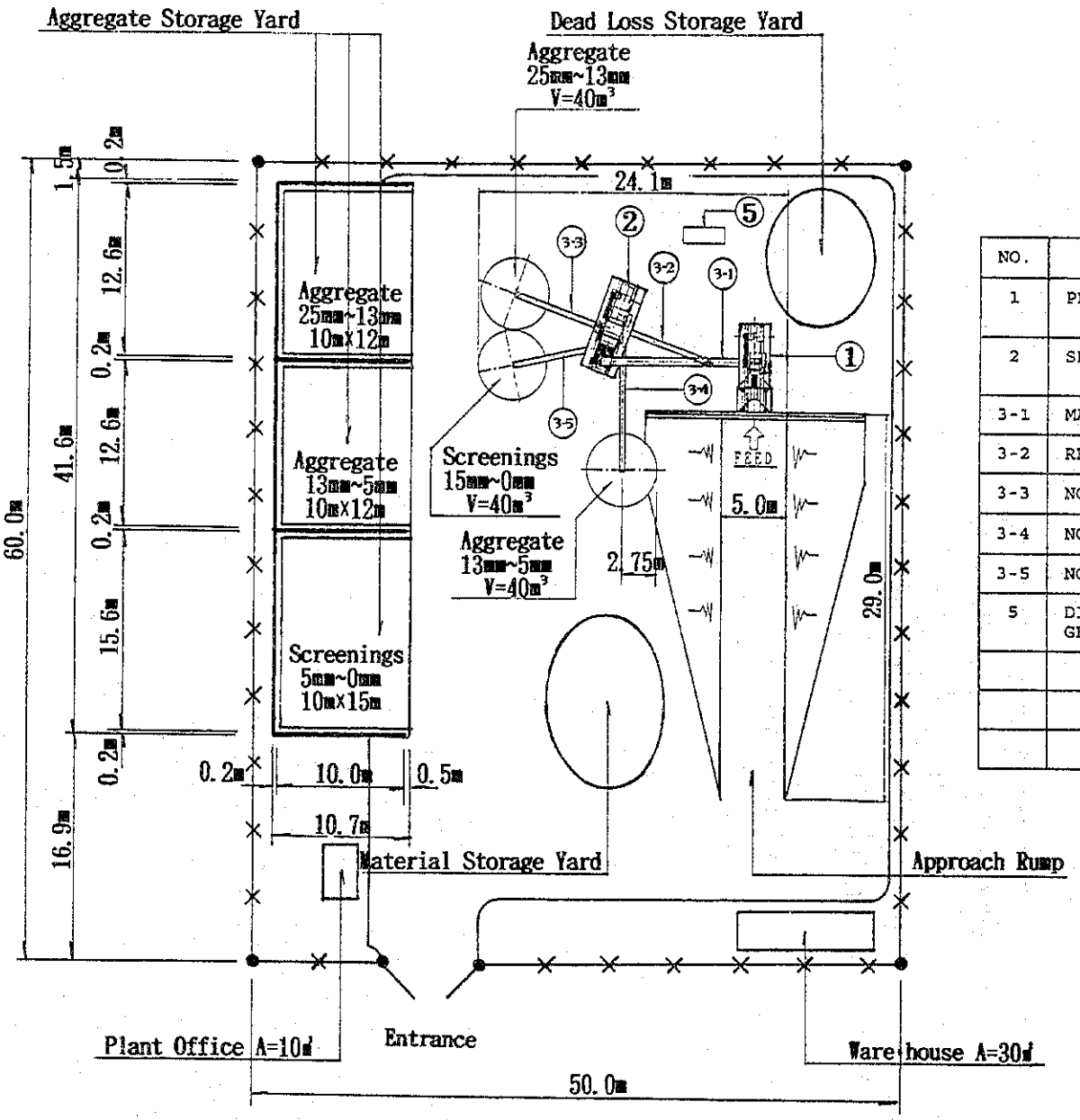
ENGINE OUTPUT	HP	more than 24
WEIGHT	kg	less than 800
DIMENSIONS		
· Overall Length	mm	less than 2750
· Overall Width	mm	less than 1390
· Overall Height	mm	less than 1850
PERFORMANCE		
· Free Air Delivery	m^3/min	more than 2.4
· Discharge Pressure	kg/cm²	more than 7
· Receiver Tank Cap.	lit	more than
ENGINE		
· Type		Diesel
· Displacement	cc	more than 1100
TIRE		
· Size		
· No. of Tire	piece	2
AIR COCK		
· Size	mm	more than 19
· No. of Cock	piece	more than 2

4.4.3 Design of Crushing and Screening Plant

Crushing and screening plant was designed in consideration of the following:

- Specifications for the plant machinery are as shown in Table 4.4-2.
- The site is about 500 m inland from Ahononou Quarry and along the access road thereto. Since the proposed site is presently coconut forest, coconuts should be cut and the land should be cleared.
- Because of no supply of electricity in the vicinity, a generator is used for power source. It is not mounted on the crushing unit but installed in a simple building.
- A slope for putting materials is constructed by embankment, with reinforced concrete retaining wall in front.
- Stock yards are of size accommodating about 300 cu.m for each size of aggregate.

The layout of the crushing and screening plant is shown in Figure 4.4-1.



List of Electricity Power

NO.	NAME OF PARTS	SIZE	REMARKS	SET(S)	MOTORS
1	PRIMARY UNIT	LGF-600x2100 S-3		1	39.2kw
2	SECONDARY UNIT	LS-1200x2400 F4S		1	48.0kw
3-1	MAIN BC	500mmx12m		1	2.2kw
3-2	RETURN BC	450mmx12m		1	1.5kw
3-3	NO.1 STOCKPILING BC	350mmx10m		1	1.5kw
3-4	NO.2 STOCKPILING BC	350mmx10m		1	1.0kw
3-5	NO.3 STOCKPILING BC	350mmx10m		1	1.0kw
5	DIESEL ELECTRIC GENERATOR	DCA-180SPK	200V150KVA	1	
	TOTAL POWER				94.4kw

Figure 4.4-1 LAYOUT OF CRUSHING AND SCREENING PLANT

4.5 Implementation Plan

4.5.1 Basic Condition

This project, if approved, shall be implemented in accordance with the provisions of Japan's Grant Aid Program after the signing of the Exchange of Notes between the Governments of Japan and Tonga.

The project is composed of road improvement and equipment procurement. The road improvement is planned to be implemented in two phases taking into consideration the work volume and construction cost. Section 1, composed of the major roads in Nuku'alofa urban area and given higher priority, is planned to be implemented in the first phase and Section 7 in the second phase. Although the project implementation is phased, the equipment and labor should be used as continuously as possible over two phases to minimize the loss due to idling equipment.

The equipment procurement is planned to be implemented in single phase.

The project components are summarized as follows:

- Road Improvement:
  - First phase : Section 1 (13.1 km)
  - Second phase : Section 7 (21.0 km)

- Equipment Procurement:
  - Implementation in single phase

It is noted that the road improvement and the equipment procurement are individually independent projects. The equipment procured in this project will not be used for the road improvement in this project.

The Ministry of Works is the responsible agency for implementing the project. The Works Section and the Mechanical Section in the Engineering Division of the Ministry will take charge of the maintenance

of the improved roads and the operation and maintenance of the procured equipment, respectively. The organization of the executing agency is described in 3.2.

4.5.2 Implementation Supervisory Plan

(1) Road Improvement

A Japanese consultant will supervise the implementation of the project on behalf of the Government of Tonga. The consultant will carry out the detailed design, assistance in tendering and construction supervision in accordance with the consultant contract concluded between the Government of Tonga and the consultant.

Detailed Design

Major works in the detailed design to be carried out by the consultant are as follows:

- Soil Investigation
- Detailed Design
- Preparation of Drawings and Specifications
- Construction Schedule and Cost Estimates
- Preparation of Tender Documents
- Preparation of Maintenance Manual for Asphalt Concrete Pavement

The following are the points to be noted:

- Soil Investigation

  The investigation on the existing pavement structures and their strengths is necessary to provide basic data for the pavement design.

At 9 locations (4 in Section 1 and 5 in Section 7), the following investigations are to be carried out:

- Anger boring and sampling (base course and subgrade)
- Laboratory tests (natural water content, sieve analysis, consistency, CBR)

- Preparation of Maintenance Manual for Asphalt Concrete Pavement.

  A manual presenting the method of patching to be carried out when potholes are found in future will be prepared.

The necessary time for the detailed design is 2.5 months each for the first and second phases.

Assistance in Tendering

The consultant will render the following services during the period from tender notice to construction contract.

- Tender notice
- Pre-qualification
- Pre-bid conference and tendering
- Tender evaluation
- Contract facilitation

The necessary time for tendering is three months for the first phase and two and half months for the second phase.

Construction Supervision

The consultant will carry out the construction supervision of the work which will be executed by the contractor. The main work items are as follows:

- Inspection and approval of site survey
- Inspection and approval of construction schedule
- Quality control
- Progress control
- Measurement of work
- Inspection of safety aspect
- Final inspection and turnover

Construction period is twelve months for the first phase and ten months for the second phase. To successfully carry out the supervision involving various works as mentioned above, the consultant personnel is required to station during whole period of construction.

(2) Equipment Procurement

Detailed Design

Main work items to be carried out by the consultant are as follows:

- Detailed design of the equipment and preparation of specifications.
- Detailed design, and preparation of drawings, construction schedule and specifications for the construction of the crushing and screening plant
- Estimation of the project cost
- Preparation of tender documents

The necessary time for the detailed design is 2.5 months.

Assistance in Tendering

Major services to be provided by the consultant are as follows:

- Tender notice
- Evaluation of letter of interest
- Tendering
- Tender evaluation
- Contract facilitation

Construction Supervision

Main work items to be executed by the consultant are as follows.

- Review and approval of fabrication plan and specifications prepared by the contractor
- Inspection of the quantities and specifications prior to shipment.
- Review of operation manuals and maintenance manuals.
- Inspection of equipment assembly.
- Construction supervision for the crushing and screening plant
- Management in the guidance of operation and maintenance to be conducted by the contractor
- Turnover

The estimated durations for fabrication and for assembly, installation, test run and turnover are 6 months and one month, respectively. Spot supervision is required for the former and stationary supervision for the latter.

4.5.3 Procurement Plan

(1) Road Improvement

In principle, materials, equipment and labors necessary for the project are planned to be procured locally as far as available. However, locally available items are only a few.

Materials

Main materials which are produced in the Kingdom of Tonga are aggregates, base course materials and ready mixed concrete. Other materials can be purchased from local suppliers, but in many cases, the stocks are not enough.

Table 4.5-1 shows the procurement plan of major materials.