社会開発協力部報告書

No. 8

FIJI

RURAL WATER SUPPLY DEVELOPMENT PROJECT

BASIC DESIGN STUDY REPORT

MARCH 1981

JAPAN INTERNATIONAL COOPERATION AGENCY

FIJI

RURAL WATER SUPPLY DEVELOPMENT PROJECT

BASIC DESIGN STUDY REPORT

MARCH 1981

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

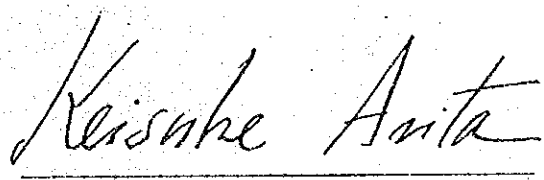
In response to the request of the Government of Fiji, the Japanese Government decided to conduct a survey on "Rural Water Development Project" and entrusted the survey to the Japan International Cooperation Agency. The J.I.C.A. sent to Fiji a survey team headed by Mr. Susumu Sakaguchi from 4th October to 6th November, 1980.

The team exchanged views with the officials concerned of the Government of Fiji, and conducted a field survey in the project area on Vanua Levu Island. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of Fiji for their close cooperation extended to the team.

March, 1981



Keisuke Arita

President
Japan International Cooperation Agency

MODEL AREA

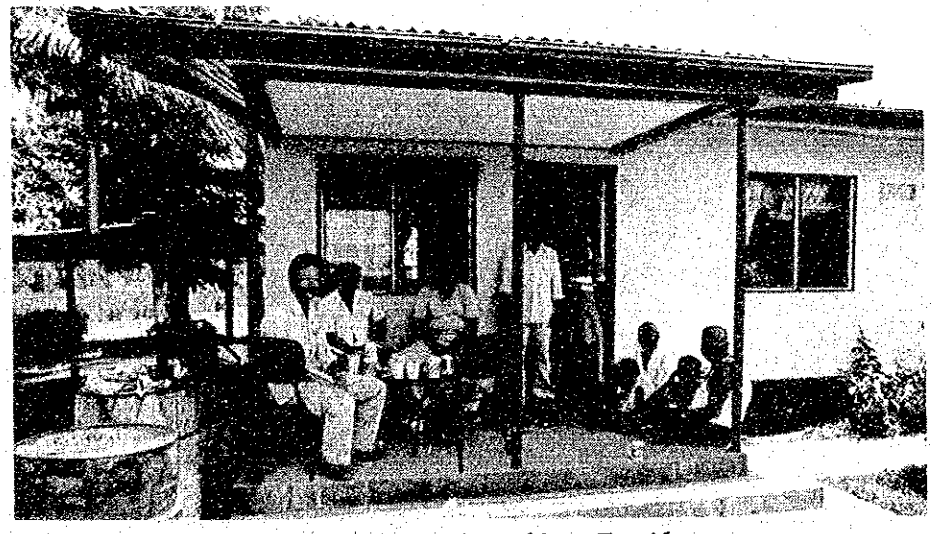
SETTLEMENT

A Distant View of Vunicuicui

MODEL AREA
SETTLEMENT

Proposed Piping Route of Conveyance Pipe

Proposed Construction Site of Distribution Tank



House of Typical Indian Family

MODEL AREA

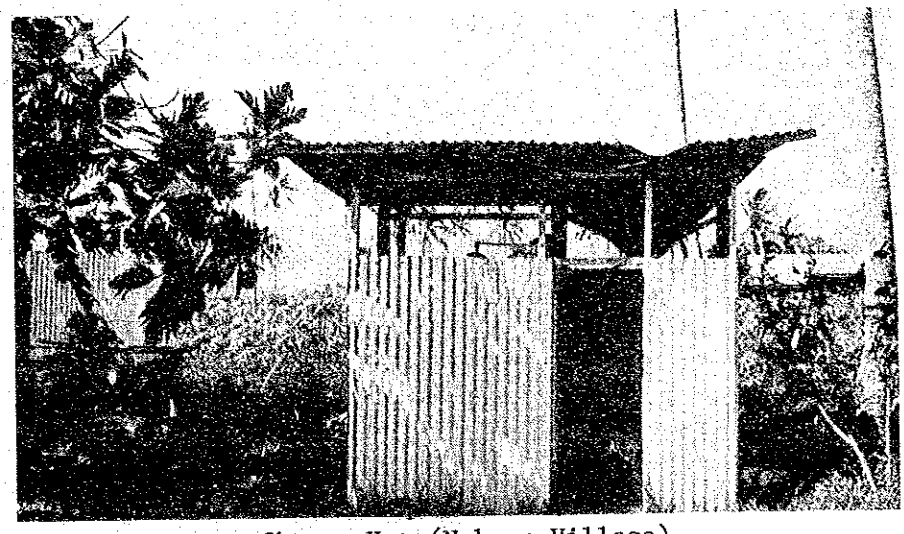
VILLAGE

A Distant View of Vunimoli Village

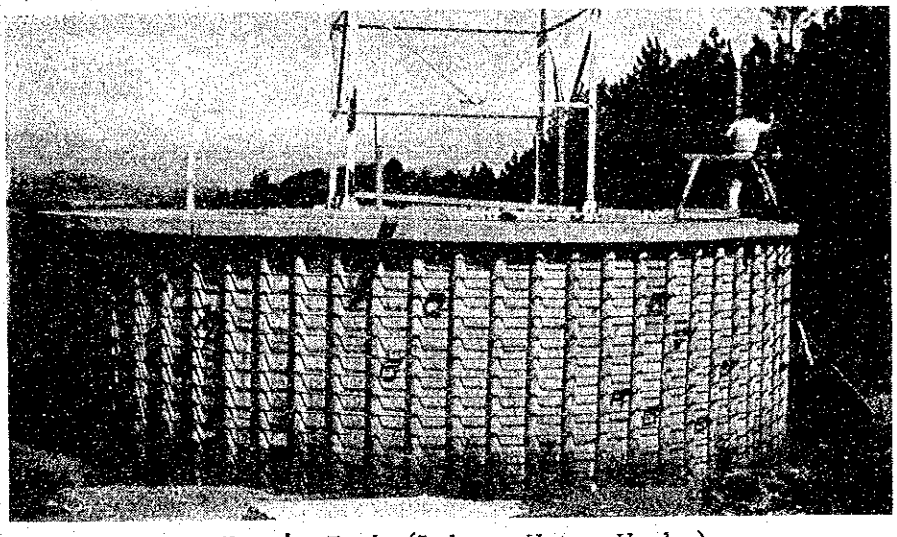
House of Typical Fiji FAmily

EXISTING FACILITIES

Water Tap (Nakama Village)



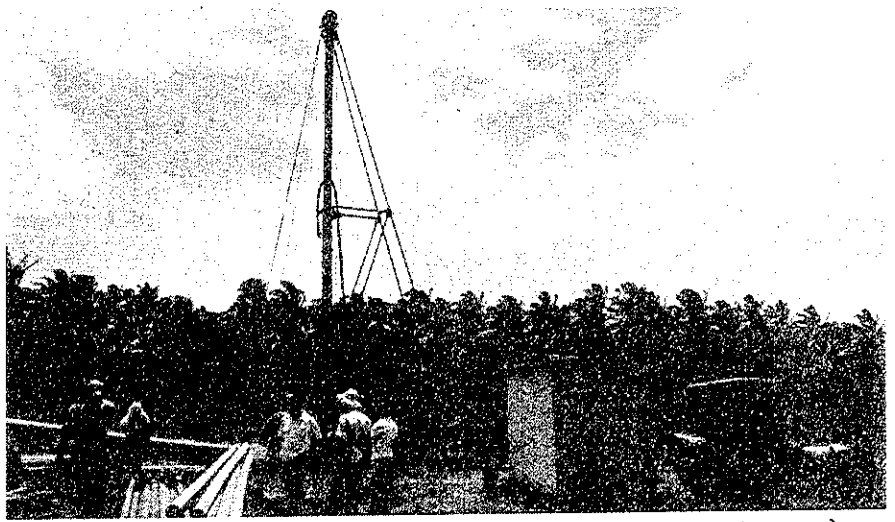
Shower Hut (Nakama Village)



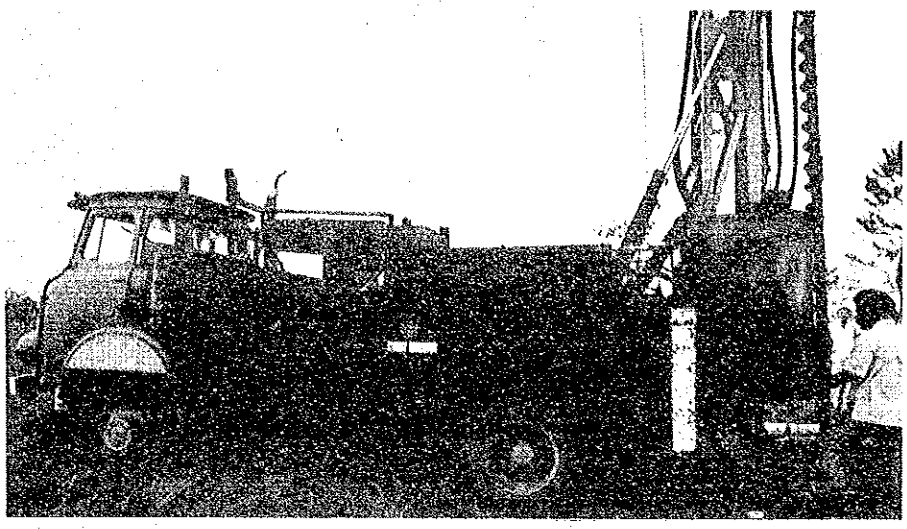
Hume's Tank (Labasa Water Works)

Existing Shallow Well
(Nabekavu Settlement)

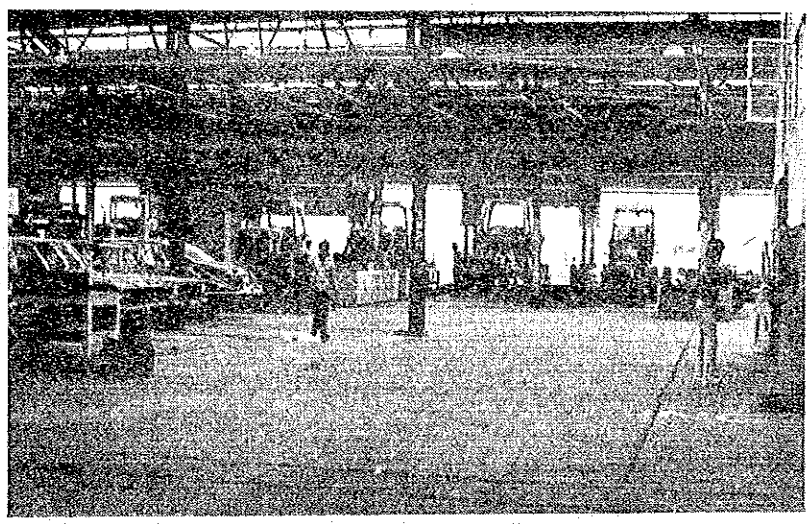
Existing Deep Well (Vunivau Bua Settlemtnt)



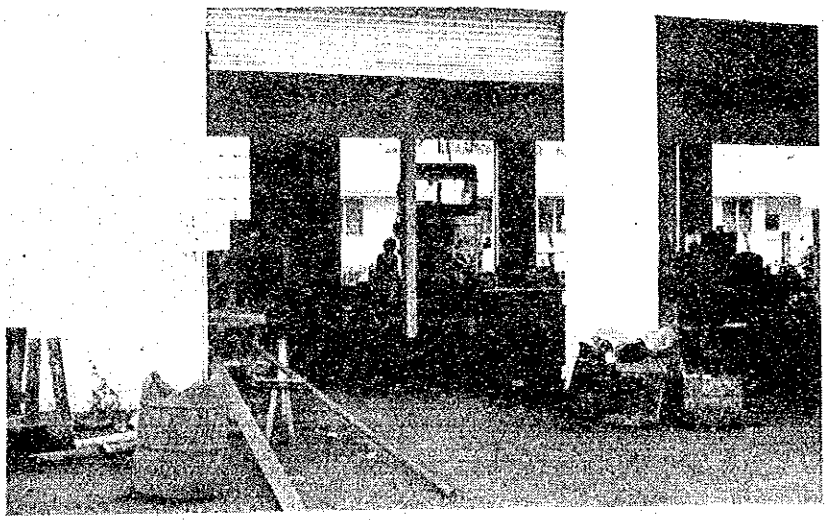
Boring Rig possesed by MRD (Vunivau Bua Settlement)



Boring Rig possesed by MRD (Seaqaqa) Settlement)



PWD's Stock Yard & Factory (Suva)



PWD's Stock Yard & Factory (Labasa)

TABLE OF CONTENTS

Appendices

S U M M A R Y

SUMMARY

1. This study was made in response to a request by the Government of Fiji to study for efficient assistance from the Government of Japan to a groundwater development project aiming at supplying domestic water for the inhabitants of Vanua Levu Island.

2. As shown in Figure 1-1, the areas covered by this study consist of six settlements, five villages, and four schools in Vanua Levu Island.

3. Affected by southeast trade wind, the northern and western parts of Vanua Levu Island have relatively little rainfall. In the dry season from June to August, the volume of surface water reduces, and shallow hand-dug wells often run dry. All of the study area are located in the north and west where the inhabitants utilize surface water and shallow wells as the main sources of their domestic water. Consequently, the problem of water shortage is critically serious. Besides, along with the progress of forest development and establishment of new sugar-cane plantations, there appear signs of surface water pollution in the areas. For the above circumstances, groundwater is increasingly important as a source of domestic water, and the groundwater development is gainning higher priority than any other water source development plan of the areas.

4. The groundwater development of the island has been initiated by a series of study and field survey, including investigation of boring and groundwater survey, by the Mineral Resources Department as commissioned by the Public Works Department. However, due to lack of well-drilling machines, this development plan was obliged to be overdue. For this reason, there is strong request from the Government of Fiji for assistance to this point.

5. Followings show the scale and construction costs of the domestic water supply systems estimated from basic design of the settlements, villages, and schools covered by this study. The total construction cost

of all areas under study was estimated at about 315 million yen, without labor costs for Fiji officials, equipment unloading costs, inland transportation costs and storage costs.

Estimated Scale and Construction Costs of Facilities for Individual Areas

	Population (Number of Pupils) (persons)	Quantity of Water Demand (m^3/day)	Construction Costs (¥1,000)		
			Foreign Currency	Local Currency	Total
1.Settlement Areas	5,810	546	148,590	130,010	278,600
Vunicuicui	880	132	17,610	15,490	33,100
Vunika	1,670	251	41,275	27,725	69,000
Vunimoli & Waidamudamu	740	37	28,648	30,452	59,100
Nabekavu	1,980	99	38,878	33,122	72,000
Vunivau Bua	540	27	22,179	23,221	45,400
2.Village Areas	2,120	108	18,220	10,780	29,000
Vunimoli	150	8	1,822	1,078	2,900
Namoli	90	5	1,822	1,078	2,900
Korowiri	200	10	1,822	1,078	2,900
Vuo	570	29	3,644	2,156	5,800
Matai Labasa	1,110	56	9,110	5,390	14,500
3.Schools	991	31	6,225	1,375	7,600
Coqueloa Sangam School	142	4	1,400	70	1,470
Valevasoga Primary School	311	10	1,400	70	1,470
Lekutu Junior Secondary School	420	13	2,025	1,165	3,190
Lekutu Bhartiya School	118	4	1,400	70	1,470
Total	-	-	173,035	142,165	315,200

Note : 1990 was set as the target year for the design.

6. As to possible cooperation from Japan concerning the present domestic water supply plan based on groundwater development in Vanua Levu Island, we suggest the following ; (1) well-drilling machines and ancillary equipments;(2) well construction materials; (3) pumping equipments; (4) piping materials; and (5) spare parts. These materials and machines are considered indispensable to the development plan. Financial assistance for the said materials and machines seems to be most efficient.

7. Regarding the present project, among the equipments and materials suggested for financial assistance, the quantity of well construction materials, pumping equipments and water distribution materials for individual area is as follows. The total cost of these materials and equipments including well drilling machines and ancillary equipments, spare parts, and ocean freight was estimated at 200 million yen.

Well Construction Materials:

Construction materials for all wells under consideration at all areas and schools (20).

Pumping Equipment:

- Vertical turbine pump with diesel engine (4 sets): for Vunicuicui(1), Vinika (1), and Nabekavu (2).
- Vertical shaft mono type pump with diesel engine (8 sets) : for Vunimoli and Waidamudamu (2), Vunivau Bua (2), and four schools (4).
- Foot operated pumps (10 sets): for Vunimoli Village (1), Namoli Village (1), Korowiri (1), Vuo Village (2), and Matai Labasa (5).

Water Distribution Materials :

Regarding the settlement areas, only to Vunicuicui which was choosen as a model area, the total foreign currency component is considered for financial aids. As for the village areas where Vunimoli was set as a model area, required water distribution materials (including piping materials, small prefabricated tanks

and corrugated zinc sheet for shower room) are considered for ten sites where foot operated pumps will be set.

8. The Public Works Department of Fiji is responsible for the overall implementation of the project. However, the Mineral Resources Department (MRD) is commissioned the construction of wells which will be put directly under the management of the Public Works Department after constructed.

9. The period of construction consists of three months of preparation and order for the first step and six months of assembly and transportation for the second step. Construction shall get started three months after the arrival of materials and equipments. But during these three months for planning stage, pumps can be fixed at areas where wells already exist (3 schools). The construction of water supply system in the settlement areas will be carried by four working teams in apperiod of 24 months. The construction in the villages and schools will be undertaken by one team and require a period of 12 months. The well drilling requires a period of 30 months using one drilling machine.

CHAPTER 1 OUTLINE OF THE STUDY

CHAPTER 1 OUTLINE OF THE STUDY

1-1 Objectives of the Study and its Background

This study was carried out following the preliminary study conducted in July, 1980 concerning the domestic water supply plan of Fiji and in response to the request for aid submitted in August 1980 to Japan by the government of Fiji for development of groundwater resources in the Vanua Levu Island.

As stated in the report on the preliminary study, Fiji is in the process of implementing a series of five-year development plans; the eighth five-year development plan is expected to be initiated in January, 1981. The seventh and the eighth plans place special emphasis on regional development, aiming in particular at improving domestic water supply facilities for the purpose of obtaining stable supply of good quality water for Fijian villages and Indian settlements that are found scattered away from urban areas. For this purpose, Public Works Department, in charge of water works, has been investigating the possibility of groundwater resources development in cooperation with Mineral Resources Department in 60 to 80 regions in the nation. However, due to lack of boring equipments and technical experts necessary for the project, the groundwater development has not been well under way.

Also the prospected budget at F$4.44 million (or approximately 1,240 million yen) allocated to rural water supply development plan in the eighth five-year plan is considered insufficient for the successful implementation of the plan.

These conditions described above constitute the background of the request for aid submitted to Japan by the Government of Fiji.

The objectives of the phase II study is to investigate the most effective way for the Japanese Government to assist Fiji Government implementing the projects for developing domestic water supply systems. More specifically the following tasks have to be performed. First of all, the project areas for domestic water supply in

the Vanua Levu Island, priority ranking for six settlements and five villages were chosen for the study areas in basis of the recommendations of the preliminary study and also on the request of the Fiji Government. Then, for each of these areas, basic design and cost estimation are drafted for set to the construction of water supply systems, in addition to the investigation of groundwater development.

1-2 Project Areas

The project areas for this study were determined as given below, based on the results of the preliminary study and the requests of the Fiji government as they were clarified during discussions with the survey team. The locations of these areas are shown in Figure 1-1.

Settlements

(1) Vunicuicui
(2) Vunika
(3) Vunimoli
(4) Waidamudamu
(5) Nabekavu
(6) Vunivau Bua
(7) Seaqaqa

* Note: Seaqaqa was one of the objects for the field survey as requested by the Fiji Government, but is not treated as the project area in this study since its area under the development plan is too large and it is left for future development by national policies.

Villages

(1) Vunimoli
(2) Namoli
(3) Korowiri
(4) Vuo
(5) Matai Labasa

Others

During the field survey period, an additional request was made by the Fiji Government for the investigations of existing wells in primary and secondary schools. The followings, are the schools that this survey dealt with.

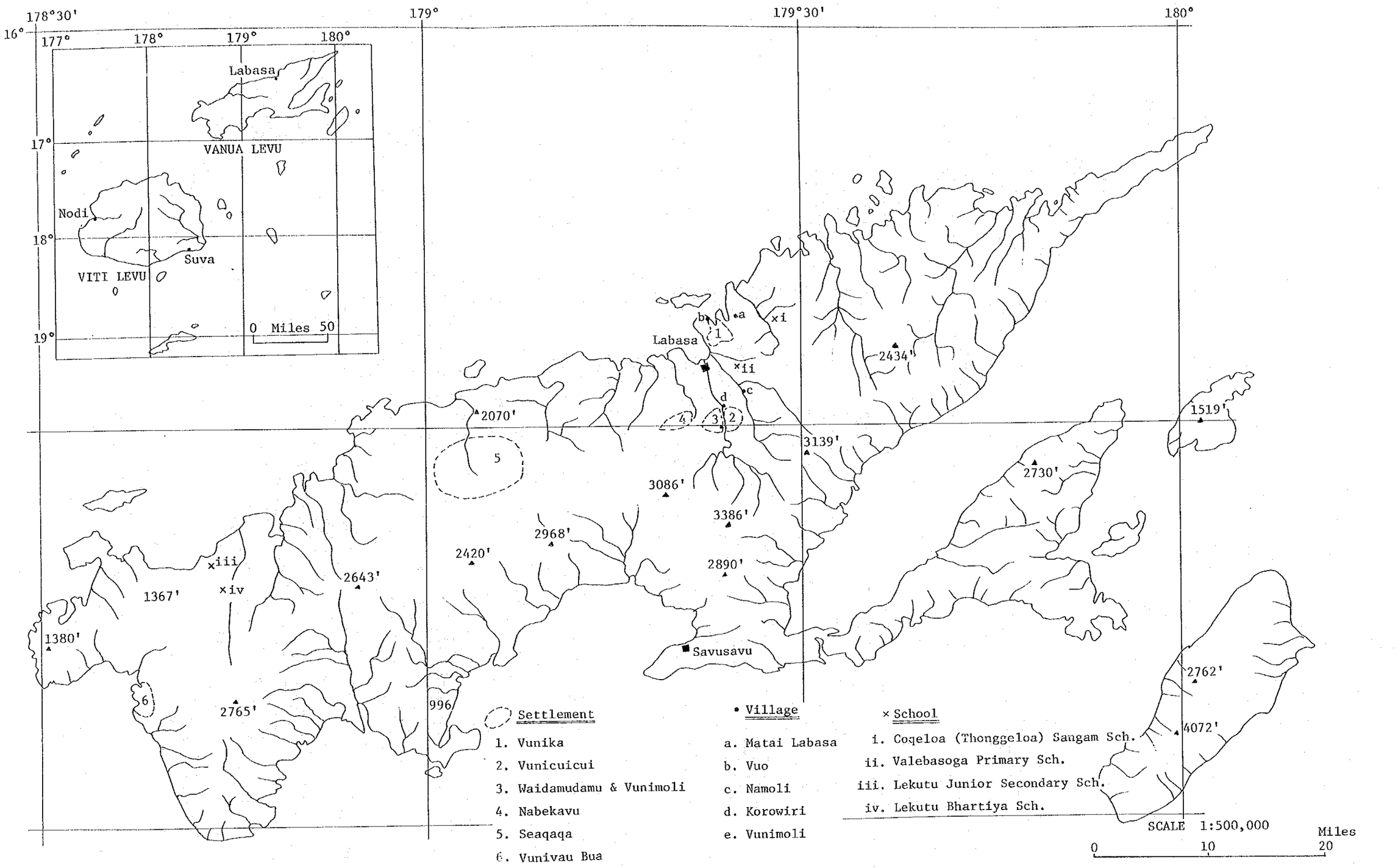
(1) Coqeloa (Thonggeloa) Sangam School
(2) Velebasoga Primary School
(3) Lekutu Junior Secondary School
(4) Lekutu Bhartiya School

This study thus dealt with facilities for seven settlements (of which six essential), five villages and four schools.

What is meant by a "settlement" is a community with gathering of two or three houses as one unit scattered mainly in sugar cane fields and most of these houses are inhabited by Indians.
A domestic water supply system for these scattered communities is called a Settlement Water Supply System, which is characterized by relatively large project area and the total population served of 400 to 2,000 persons.
On the other hand, a domestic water supply system for Fijian people who form a larger village (20 to 30 houses) of 150 to 200 population is called a Village Water Supply System. These are two representative rural water supply system is Fiji.

These are two representative rural water supply systems in Fiji.

Fig. 1-1 Locations of Objective Areas for the Study



Settlement

1. Vunika
2. Vunicuicui
3. Waidamudamu & Vunimoli
4. Nabekavu
5. Seaqaqa
6. Vunivau Bua

• Village

a. Matai Labasa
b. Vuo
c. Namoli
d. Korowiri
e. Vunimoli

× School

i. Coqeloa (Thonggeloa) Sangam Sch.
ii. Valebasoga Primary Sch.
iii. Lekutu Junior Secondary Sch.
iv. Lekutu Bhartiya Sch.

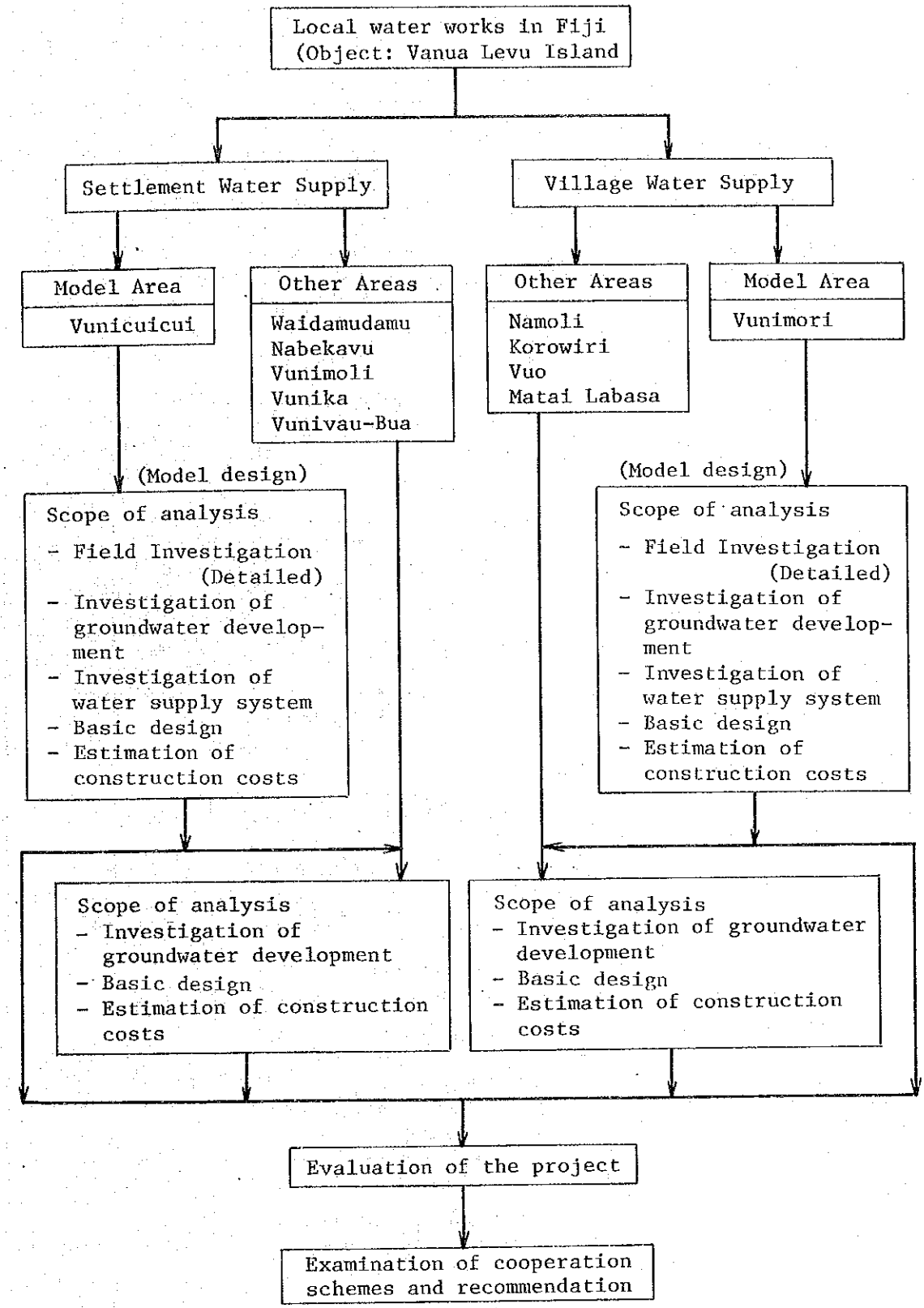
1-3 Methods and the Scope of the Study

The basic design (the second phase) study was accomplished in 85 days including 36 days spent for the field investigation. It was found difficult to investigate all the project areas in the same degree of detail and to draft basic design based on the investigation results. In view of this difficulty, the survey team adopted a method of the study shown in Figure 1-2.

Following the scheme in Figure 1-2, first the settlement of Vunicuicui was selected as a model area for formulating Settlement Water Supply System, since the area had a high priority and water supply sources had been decided upon. Detailed field investigation was conducted and a basic design was drafted for the Vunicuicui settlement, and for other settlements, domestic water supply systems were planned based on a brief field survey, air photos, topographic and geologic maps and other data as well as the basic design for the model area.
The same method was applied also to formulating Village Water Supply System, and the village of Vunimoli was selected as a model area.

The study involved collecting data necessary for drafting basic design, a survey of all the project areas and detailed field investigations of the model areas, including reconnaissance of local topography, inspection of locations of wells and distribution tanks.
Water quality of existing wells in the areas was also tested. Based on the results of these investigations, drafting of basic design for the project areas, estimation of construction costs, evaluation of the project and examination of cooperation schemes were conducted in a stepwise manner.

Fig. 1-2 Flow Chart showing the steps of the study



1-4. Members of the Survey Team

	Speciality	Name	Affiliation
Leader	General	Susumu Sakaguchi	Kyowa Consultant Co., Ltd.
Member	Machinery and Equipments	Mikio Kurosaki	Kajitani Engineering Co., Ltd.
"	Facility Planning	Masaharu Takasugi	Kyowa Consultant Co., Ltd.
"	Geology, Hydrology	Mitsuyoshi Nishikawa	Kyowa Consultant Co., Ltd

1-5. Schedule of the Survey Team

Date	Day of Week	Survey Activities
Oct. 3	Fri.	Leave Tokyo (All members)
4	Sat.	Arrive Fiji (Nadi) Arrive Suva
5	Sun.	Meeting among the survey team
6	Mon.	Visit the Embassy. First discussion session with Mr. Reid, Mr. Taylor of PWD and Mr. Rahiman of MRD concerning objectives, methods, scope and schedule of the survey. (From 2 p.m. at the Embassy)
7	Tues.	Visit the Mineral Resources Department, study and observation of the Pipe factory (Stinson AHI Limited) and others.
8	Wed.	Arrive Labasa Meet Mr. Booth in charge of water works in the Vanua Levu Island and receive basic information. Survey : Seaqaqa area accompanied by Mr. Rahiman.
9	Thur.	Survey : Vunika, Vunicuicui and Waidamudamu areas. Investigate the intake point of municipal water supply for Labasa.
10	Fri.	Survey the villages of Nakama and Vunimoli. Mr. Rahiman returned to Suva in the afternoon.

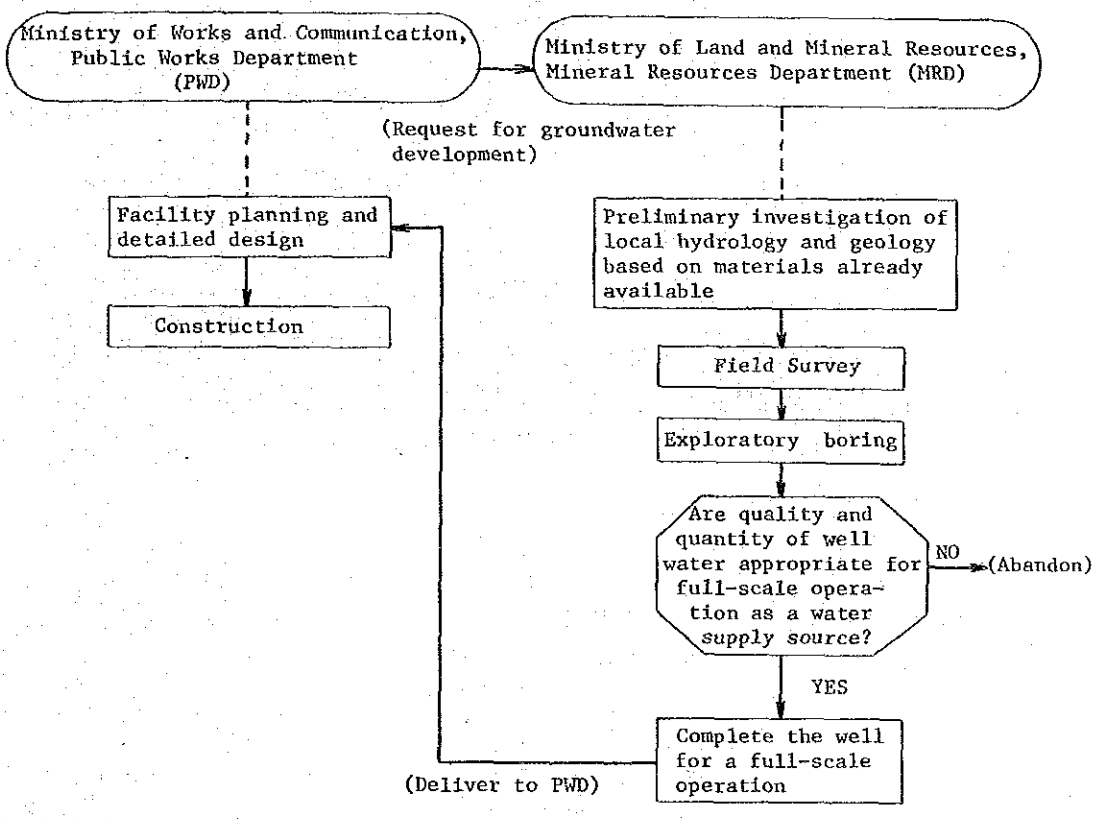
Date	Day of week	Survey Activities
Oct. 11	Sat.	Study materials obtained. (in the morning) Survey the villages of Vuo and Matai Labasa. (in the afternoon) Sakaguchi, the leader, returned home (arrived in Tokyo on Oct. 12)
12	Sun.	Inspect the port of Savusavu, used for unloading machinery and materials.
13	Mon.	Mr. Ratuyawa arrived at Labasa. Office work
14	Tues.	Make necessary arrangements with Mr. Booth. Inspect the municipal water supply reservoir for Labasa. Office work (afternoon)
15	Wed.	Investigation of Vunicuicui, the model district. Examine geological conditions of Vunika area. Survey the villages of Namoli and Korowiri.
16	Thur.	Survey Vunivau Bua and take samples for water quality tests.
17	Fri.	Investigation of Vunimoli village. Take samples of currently used water supply source for water quality tests. Also take samples of groundwater from existing wells at Indian school in Vunicuicui area.
18	Sat.	Second survey of Seaqaqa, take samples of hot-spring near Nakama village.
19	Sun.	Office work
20	Mon.	Meeting with Mr. Booth to adjust opinions on master plans etc. Three members leave Labasa and arrive Suva (afternoon)
21	Tues.	Office work (at the Embassy),Data collection
22	Wed.	Office work (at the Embassy)
23	Thur.	Ditto

Date	Day of week	Survey Activities
Oct. 24	Fri.	Meeting for an interim report with Mr. Reid, Mr. Taylor of PWD and Mr. Rahiman of MRD
25	Sat.	Kurosaki, the member, returned home (arrived in Tokyo on Oct. 26)
26	Sun.	Holiday
27	Mon.	Office work (at the Embassy)
28	Tues.	Sakaguchi, the leader arrived in Suva (Left Tokyo on Oct. 27)
29	Wed.	Office work (at the Embassy)
30	Thur.	Inspect water treatment plant in Suva, collect hydrological data.
31	Fri.	Office work (at the Embassy)
Nov. 1	Sat.	Holiday
2	Sun.	Holiday
3	Mon.	Draw up a progress report.
4	Tues.	Ditto
5	Wed.	Ditto
6	Thur.	Final meeting with Mr. Reid and Mr. Taylor and Mr. Rahiman. Submit the progress report. Exchange of Minutes. (at the Embassy)
7	Fri.	Sakaguchi, Takasugi and Nishikawa leave Fiji (arrive in Tokyo)

1-6 List of Organization with Persons in Charge and Interviewees

As described before, the rural water supply development projects in Fiji have been undertaken by Waterworks Division of Public Warks Department, the authorities concerned, in cooperation with Mineral Resources Department conducts in developing groundwater sources. These projects have been implemented based on the procedure outlined in Figure 1-3.

Fig. 1-3 Procedure of rural water supply development projects



Organizations of Public Works Department and Mineral Resources Department are given respectively in Figure 1-4 and Figure 1-5.

As seen in the survey schedule, the survey team met with many high-ranked officers in these two departments and the counterparts. They provided with many useful opinions and advices as well as essential data.

Fig. 1-4 ORGANIZATION CHART
OF
PUBLIC WORKS DEPARTMENT
(MINISTRY OF WORKS AND COMMUNICATION)

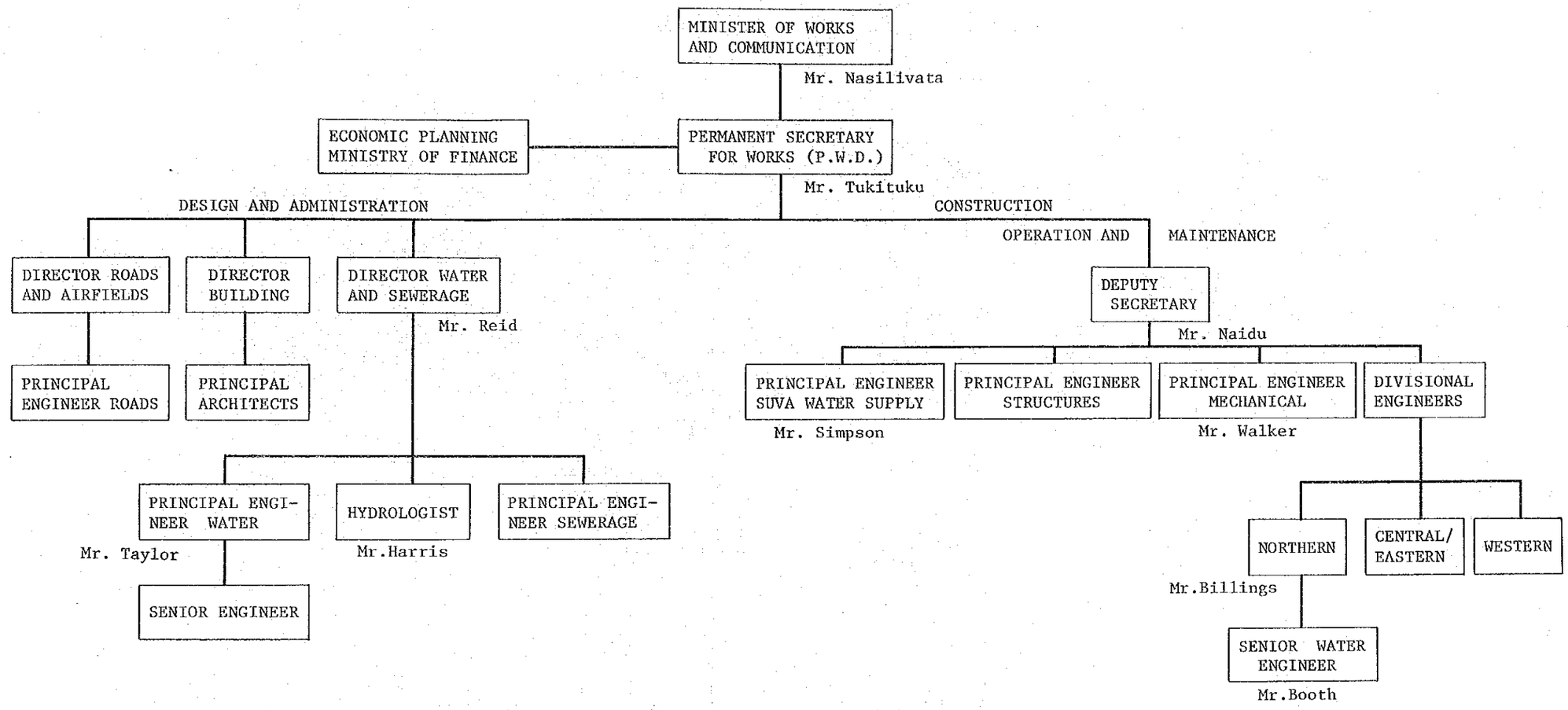


Fig. 1-5

ORGANIZATION CHART
OF
MINERAL RESOURCES DEPARTMENT
(MINISTRY OF LANDS & MINERAL RESOURCES)

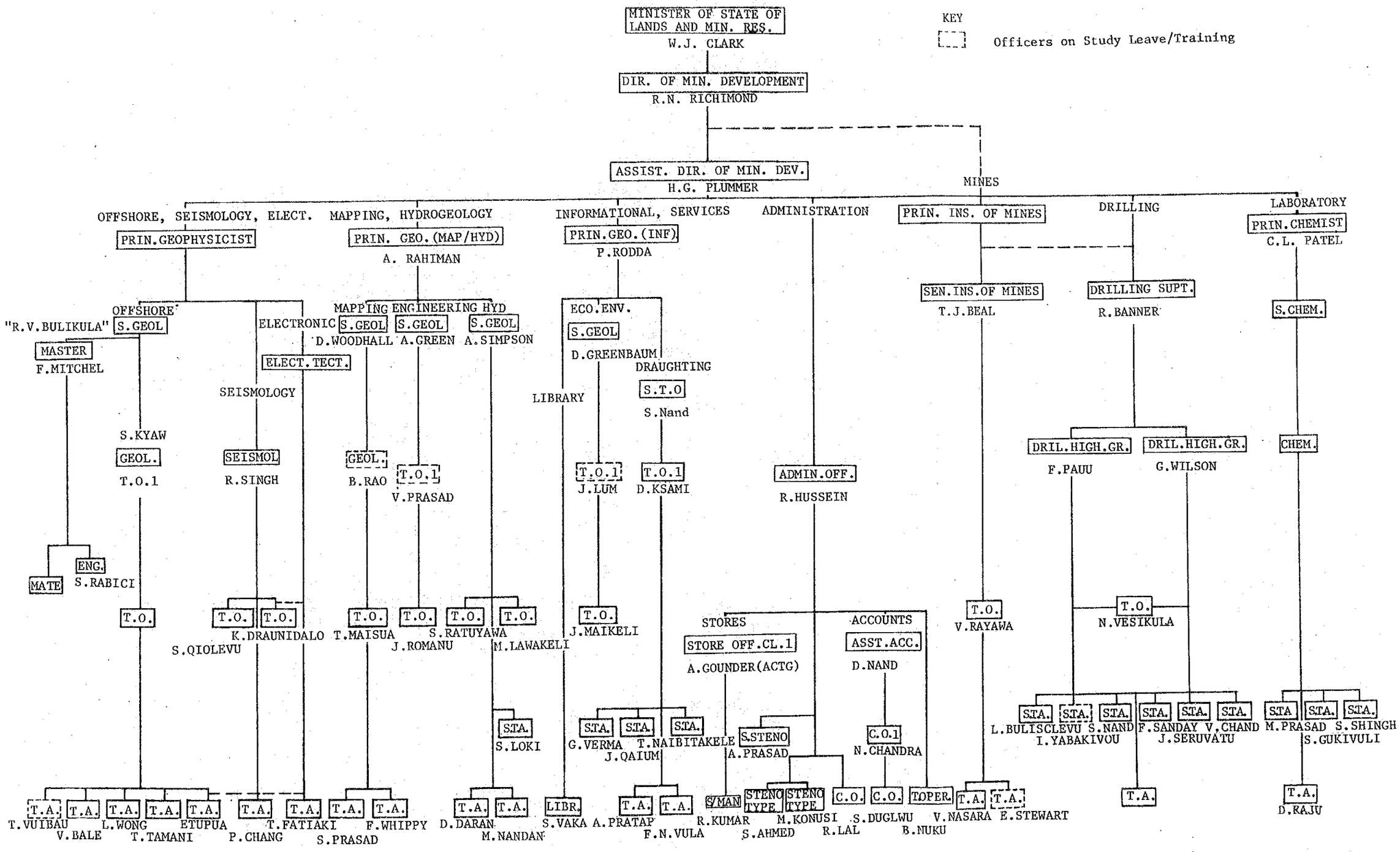


Table 1-1 gives a list of the persons that the team talked with and also the counterparts.

Table 1-1 List of Interviewees

Affiliation	Name	Position
Public Works Department	Mr. Alexander Reid	Director, Water & Sewerage
	Mr. Peter Taylor	Principal Water Engineer
	Mr. Billings	District Engineer Northern
	Mr. Jeff Booth	Senior Water Engineer, Northern
	Mr. Lloyd Harris	Hydrologist
Mineral Resources Department	Mr. Abdul Rahiman	Principal Geologist
	Mr. Robert Banner	Drilling Superintendent
	Mr. Samisoni N Ratuyawa	Technical Officer Hydrogeology Section (Counterpart)
	Mr. Vesikula Narman	Technical Officer Drilling Section
	Mr. Chhagaulal Patel	Principal Chemist
Japanese Embassy	Mr. Hiroshi Ohtaka	Ambassador Plenipotentiary
	Mr. Tsutomu Sugimoto	Councillor
	Mr. Katsuji Takayama	Second Secretary

1-7 Minutes of Discussion

MINUTES

In response to the request made by the Government of Fiji for the Groundwater Project (Hereinafter referred to as "the Project") in Vanua Levu Island, Fiji, the Government of Japan has sent, through Japan International Cooperation Agency (JICA), a team headed by Mr. Susumu Sakaguchi to conduct a basic design study for 34 days from 4th October till 6th November, 1980.

The team stayed in Vanua Levu Island for 13 days and visited the Project sites as well as Savusavu port, and had meetings with the officials and engineers of the Mineral Resources Department (Hereinafter referred to as "MRD") and the Public Works Department (Hereinafter referred to as "PWD") Northern Division.

The team also had a series of discussion and exchanged views with the officials of the MRD as well as PWD at the Japanese Embassy in Suva.

Both parties have agreed to recommend to their respective Governments to examine the results of the study attached herewith toward the realization of the Project.

6th November, 1980

.....	.....
Susumu Sakaguchi	Alexander Reid
TEAM LEADER	DIRECTOR OF WATER AND SEWERAGE
THE JAPANESE SURVEY TEAM	PUBLIC WORKS DEPARTMENT
	GOVERNMENT OF FIJI

1. The proposed sites of the Project will be at various settlements and villages in Vanua Levu Island in Fiji, e.g. Vunika, Vunicuicui, Waidamudamu, Nabekavu, Vunimoli, Vunivau (Bua) etc.

2. The objectives of the Japanese Assistance is to provide necessary well drilling rig with ancillary equipment and incidental facilities and limited extent of the materials for the pumping and water distribution systems in order that the PWD Northern Division with the Cooperation from the MRD can develop ground-water resources and construct water supply points in the Project sites.

3. The Japanese Survey Team will convey the desire of the Government of Fiji to the Government of Japan that the latter will take necessary measures to cooperate in implementing the Project and will provide the well drilling rig and other items as listed in Annex I within the scope of Japanese economic cooperation in Grant form.

4. The Government of Fiji will take necessary measures on condition that the grant assistance by the Government of Japan is extended to the Project:

   a) to secure and ensure necessary local budget and staffs to carry out the Project.

   b) to ensure to provide items necessary for the Project other than listed in Annex I.

c) to ensure prompt unloading and customs clearance in Fiji of imported machines and equipment for the Project. And, also to facilitate the internal transportation as well as appropriate storage and preventive maintenance for them.

d) to exempt Japanese national concerned, if any, from customs duties, internal taxes and other fiscal levies which may be imposed in Fiji on the occasion of the supply of goods and commissioning service of the supplied machineries for the Project.

ANNEX I

Items requested by the Government of Fiji whose cost will be born by the Government of Japan:

1) Well Drilling Machine and Ancillary Equipment

Truck mounted well drilling rig, with drilling tools for direct mud circulation as well as air percussion drilling methods including drill bits, fishing tools, casing tools, test and development equipment, tender truck with crane and pickup trucks.

2) Well Construction Materials

Surface steel casings, well screens and incidental supplies

3) Pumping Units

Manual (foot) operated pumping units and submersible or vertical shaft deep well pumps with power units.

4) Water Distribution Materials

Piping materials, water tanks etc.

5) Spare Parts and Supplies

Spare parts for two years operation for the drill rig, compressor, engines, pumps and vehicles including drill bits and other wearing tools for the well drilling.

CHAPTER 2 OUTLINE OF THE PROJECT AREAS

CHAPTER 2 OUTLINE OF THE PROJECT AREAS

2-1 Natural Environment

1) Location

Fiji is located in Southern Melanesia in the Southern Pacific Ocean, 1,848 km north of New Zealand and 3,154 km toward north-east from Australia. Its territory has the area 18,273 km^2.

Among 320 large and small islands that constitute the country of Fiji, the island at Vanua Levu, the object at the survey, is the second largest, next to the island of Viti Levu where the city of Suva, the capital, is situated.
The island of Vanua Levu is of a long and narrow shape, about 170 km long in the direction of east-by-northeast to west-by-southwest and about 35 km wide, with the area 2,317 square miles (or 6,000 km^2). It extends over Long. 178°30' E-180°E and Lat. 16°10'S-17°S.

Located toward slightly east from the center of the nothern shoreline is the town of Labasa, Division Headquarters. Labase is approximately 130 miles (or 200km) from the capital city of Suba in the north-by-northeast direction (See Figure 2-1).

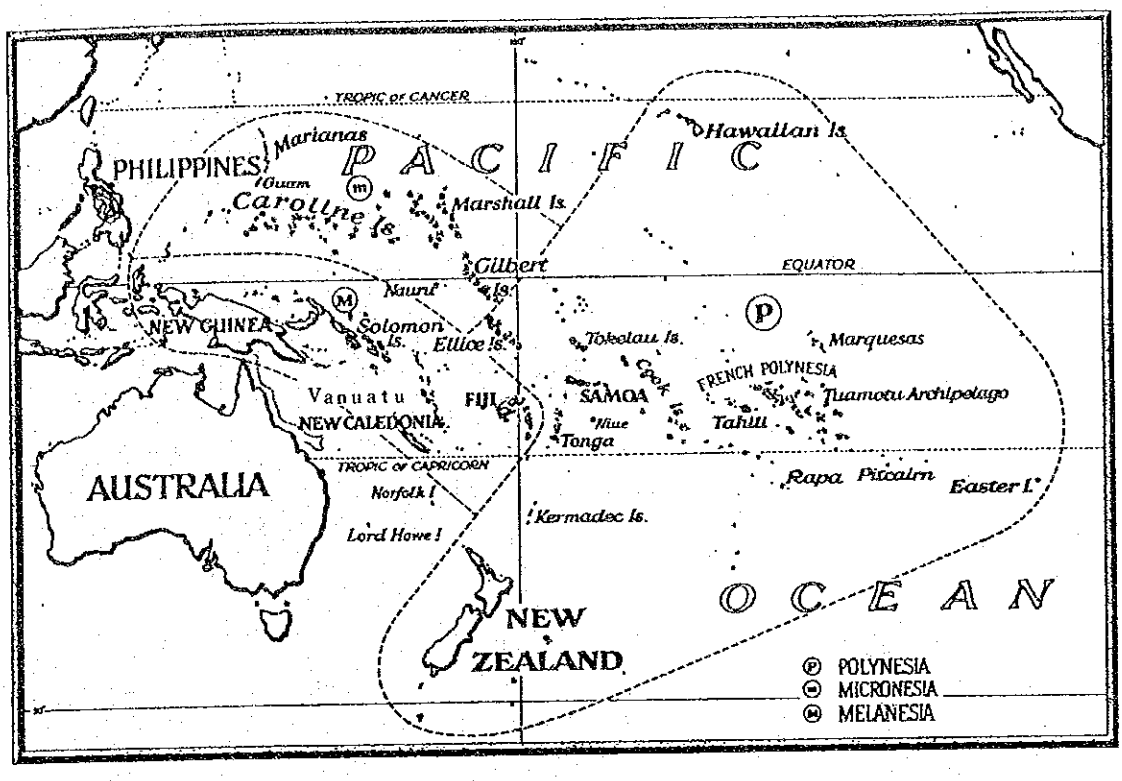
2) Topography

On the Vanua Levu island, about 10 volcanic centers formed by Volcanic eruption along the major axis of the island, which constitute the mountainous region. The major axis of the mountain lies nearer to the south-east coast, and thus the south-east slopes are steeper.

The maintain region ranges in altitude from about 1,000 to 2,000 feet (or 300 to 600m) with about 10 peak of 2,000 to 3,000 feet (or 600 to 900m) height. The heighest peak is Mt. Nasorolevu having 3,386 feet (or 1,032m) located south of Labasa.

Between the foot of the mountain region and the shoreline a

Fig. 2-1 Location of Fiji



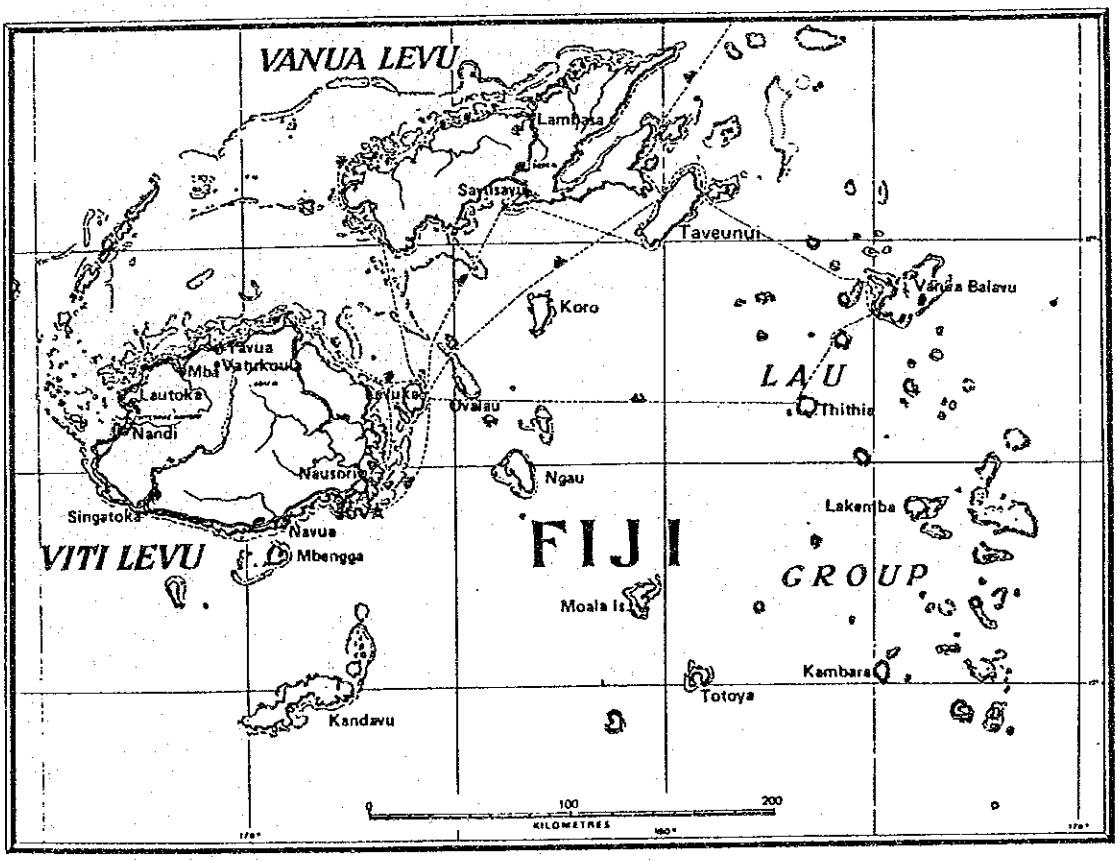


Fig. 2-2 Topographic Condition of Vanua Levu Island

chain of rugged hills extends. These hills develop in the north-by-northwest to south-by-southeast direction in the form of branches.

Rivers run through lowlands between the hills, spreading alluvial plains toward the shoreline. The alluvial plains at the mouth of Labasa, Ndreketi and Wanikoro rivers are relatively large but others and all small.

Figure 2-2 gives a topography map at the Vanua Levu island.

3) Geology and Hydrogeology

(1) Outline at local geology

The local gelogy of the Vanua Levu island consists of volcanic-and sedimentary-type rock of Upper Miocene to Recent age.

There are four distinct Volcanic Groups and an alluvium group. These groups arranged on a stratigraphic classification basis as Table 2-1.

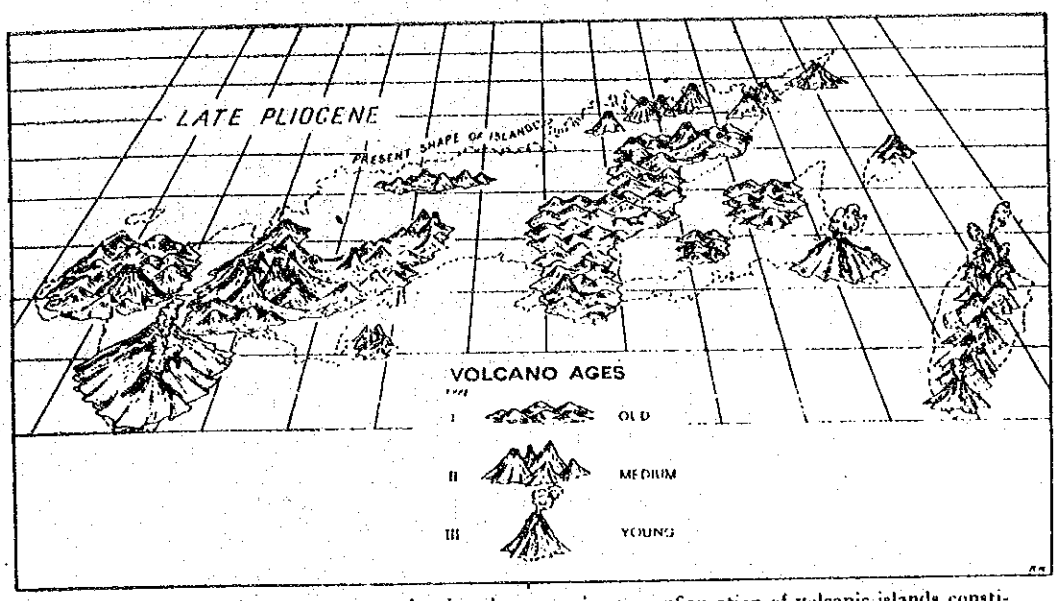
Table 2-1 Stratigraphic classification of the Vanua Levu island

<table>
<tr><th></th><th></th><th></th><th colspan="2">(the western and central part) (the eastern part)</th></tr>
<tr><td rowspan="5">Cenozoic Era.</td><td>Quarternary period</td><td>Present</td><td colspan="2">Alluvium</td></tr>
<tr><td rowspan="4">Tertiary period</td><td rowspan="2">Pliocene</td><td>Mbua Group</td><td>Undu Gp.</td></tr>
<tr><td>Narard Gp.</td><td rowspan="2">Natewa Gp.</td></tr>
<tr><td rowspan="2">Miocene</td><td rowspan="2">Natewa Gp.</td></tr>
<tr><td></td></tr>
</table>

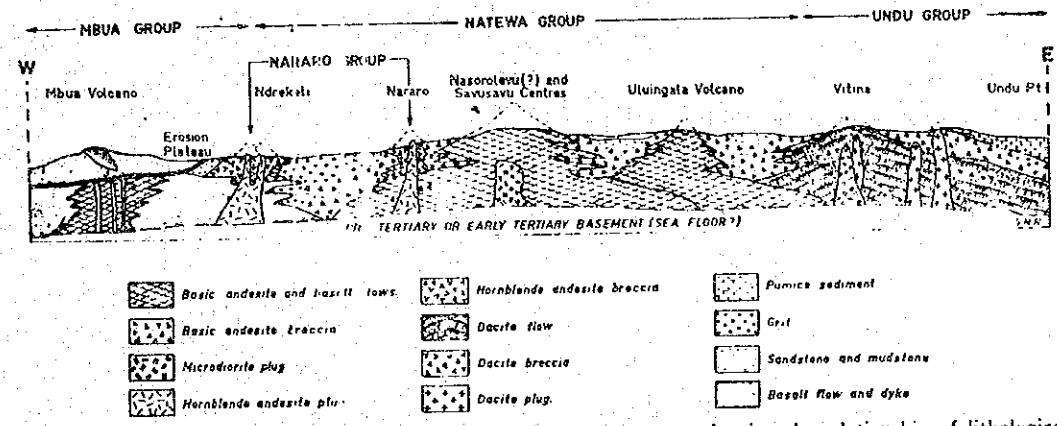
The geological structure and its distribution may be clarified by Figure 2-3 and Figure 2-4.

Characteristics of each geological group are described below.

Fig. 2-3 General Geological Structure of Vanua Levu



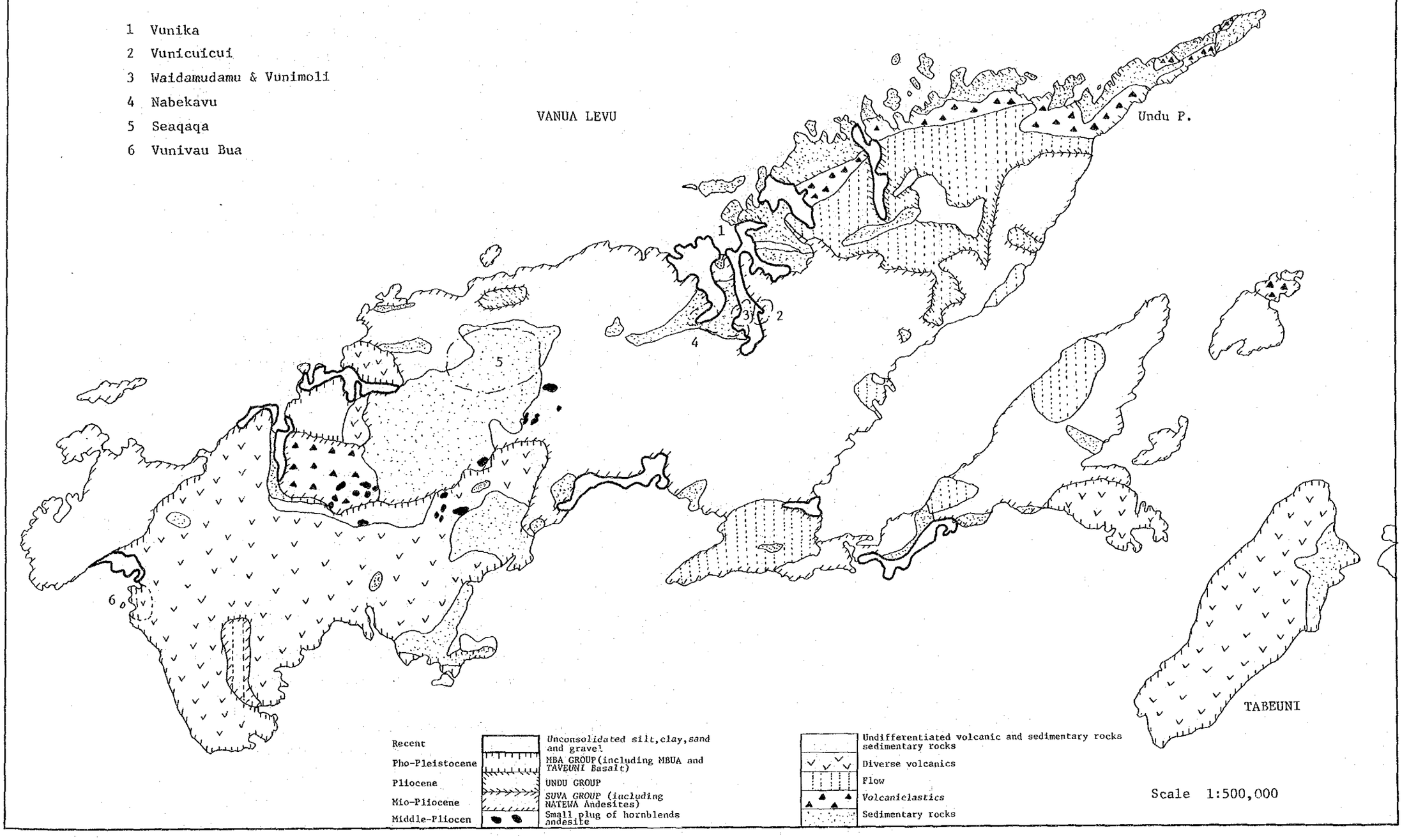
1. Palaeogeographic reconstruction showing the approximate configuration of volcanic islands constituting Vanua Levu in late Pliocene times



2. Diagrammatic composite section across Vanua Levu from west to east showing the relationship of lithological units (the proportion of flows to breccias is greatly exaggerated)

Fig. 2-4 Geological Map

1 Vunika
2 Vunicuicui
3 Waidamudamu & Vunimoli
4 Nabekavu
5 Seaqaqa
6 Vunivau Bua



(1) Natewa Group

This group consists primarily of basic andesites and volcaniclastics rocks. It is found distributed widely in the central part of Vanua Levu and the area extending from the Yangganga island on the west to the Rambi island as the east.

(2) Undu Group

Distribution of this group consisting of dacites and rhyolites is confined to the north-western part at the island. Unconformity is observed of some joints with the Natewa Group described above.

(3) Nararo Group

This group is primarily of acid andecites and its distribution is confine to the western part of the island as volcanic plugs and bedded breccias at points where the Natewa Group and the Mbua Group come in contact with each other.

(4) Mbua Goup

This Group is mainly massive, subaerial flow basalts which originated from a shield volcano in the southwestern part of the island. Its distribution is confined to the south-western part of the island

(2) Outline of local hydrogeology

Groundwater development initiated in 1970 in the Vanua Levu island is still at a preliminary stage, and extensively exploratory borling is underway.
The number of exploratory and production wells drilled by 1980 to 14, but the distribution of aquifers has not been fully grasped yet.
Promising geological strata in the Natewa and Undu Groups include zones of clastic rocks that have not undergone

cementing, weathered zone of lava streams, zones with extensive joints, fractured zones such as faults by geological movements. Zones with columnar joints developed in the basalt lava flows in the Mbua Group are also considered promising for good acquifers.

According to earlier reports, a typical exploration well has a diameter 150 to 200mm and depth 40 to 120m but in most cases 40 to 60m. Pumping tests have been carried out, but some wells lacks the data. Values of hydrogeological parameters are highly variable with the pumping rate ranging from 65 to 600 m^3/day, the specific capacity from 6 to 75 m^3/day/m, and the transmissivity from 5 to 250 m^2/day. These data are classified according to geological divisions as given in Table 2.2.

Table 2-2 Hydrogeological parameters for each geological division

Geological division	Pumping rate m^3/day	Specific capacity m^3/day/m	Transmissivity m^2/day
Undu Group	109 ∿ 222	8 ∿ 26	10 ∿ 11
Natewa Group	65 ∿ 363	2 ∿ 74	4 ∿ 94
Mbua Group	181 ∿ 608	6 ∿ 70	7 ∿ 250

The location and the dimensions at existing wells are given respectively in Figure 2-5 and Table 2-3.

Nothing much can be said about Undu Group at wells, since the number of wells is small. Of four wells in the Natewa Group for which pumping data were available, three have records on pumping rate of 80,180 and 363 m^3/day, respectively. In contrast, five wells in the Mbua Group have recorded the pumping rate of 181,269, 375, 428 and 608 m^3/day, respectively and thus this group is considered superior in the quality of aquifer than Natewa Group.

Fig. 2-5 Location of Existing Deep Wells

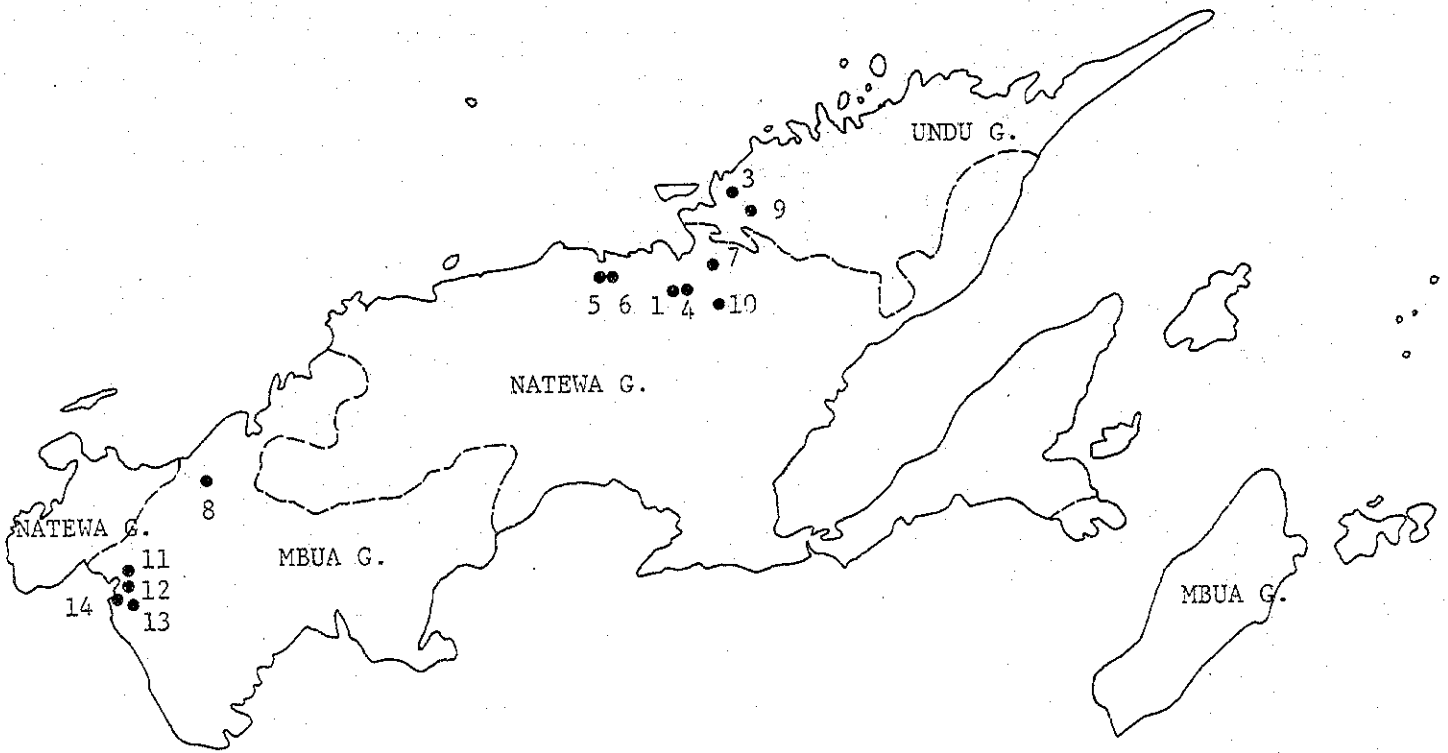


Table 2-3 List of Existing Deep Well

	Drilling date commenced ∿ completed	Well No.	Location	Rock group	Depth (m)	Drilling diameter (m ∿ φmm)	Depth water first struck (m)	Pump Test: Casing specification for pump test (Depth-Diameter-kinds)	Pump Test: Depth of slots, and length (m)	Pump Test: s.w.ℓ. (m) b.g.ℓ.	Pump Test: p.w.ℓ. (m) b.g.ℓ.	Pump Test: Pumping rate (m^3/day)	Pump Test: Drawdown (m)	Pump Test: Specific capacity (m^3/day/m)	Pump Test: Transmissivity (m^2/day)	Pump Test: Remarks	Final casing (type*)	Present condition
1	5.3.70 ∿20.5.70	VAN 6/2	Waigele	Natewa	64.63	φ152											Type 1	Not use because well collapsed
2	11.6.70 ∿5.10.70	-	Nanduna Savenakai	Natewa	120.43	φ152											Type 1	"
3	3.10.70 ∿25.11.70	VAN 6/3	Nangingi	Undu	85.34	0∿3.05 φ203 ∿85.34 φ152	4.57		36.58	2.14	10.67	222.2	8.53	26.09	11.52		Type 1	"
4	14.1.71 ∿12.3.71	VAN 6/1	Nakama	Natewa	64.62		11.89			5.18		180.1				Could not measure because dipper wedged between casing and borehole.	Type 1	"
5	29.3.71 ∿14.5.71	VAN 6/6	Langgele	Natewa	95.12	φ152											Type 1	Not use because pump failed (Settlement)
6	1.6.71 ∿28.6.71	VAN 6/4	Vunivathea	Natewa	33.53				10.67	2.23	33.53	65.5	31.31	2.09		Hole pumped empty in 6 Hr. 6 Hr.	Type 3	Not use
7	2.7.71 ∿6.8.71	VAN 6/5	Valebosoga	Natewa	56.1	φ152				0.4	Dry	80.81				Hole pumped empty	Type 1	Not use because pump failed (School)
8	23.8.71 ∿1.9.71	VAN 3/1	Korokandi	Mbua	45.72				39.32	0.56	16.77	269.8	16.21	16.72	11.33		Type 1	Not use because pump failed (School)
9	9.2.72 ∿22.2.72	VAN 6/8	Coqeloa	Undu	45.73	φ152				6.86	20.33	109.2	13.47	8.11	9.72		Type 1	Not use because pump failed (Settlement)
10	9.3.72 ∿27.3.72	VAN 6/7	Vunicuicui	Natewa	57.91	0∿38.4 φ203 ∿57.91 φ152		0∿38.4 φ152 steel	19.20	3.00	7.88	363.6	4.88	74.47	94.2		Type 1	Use for Indian School since 1978 (School)
11	25.4.80 ∿20.5.80	CDH/W/80/22	Vunivau Bua	Mbua	46.34	0∿3.05 φ254 ∿41.16 φ2286 ∿46.34 φ177.8	19.82	0∿3.05 φ254 steel 0∿41.16 φ200 steel 41.16∿46.34 φ177.8 open	19.82 ∿ 22.87 38.11 ∿ 41.16 41.16 ∿ 46.34 (open) } 11.28	0.083	8.79	608.8	8.707	69.92	250		Type 2 φ150 PVC Depth of slots 37.2∿46.34 ℓ= 11.24	Possible to use
12	9.6.80 ∿4.7.80	CDH/W/80/23	Vunivau Bua	Mbua	45.73	0∿6.1 φ254 ∿45.73 φ228.6	10.67	0∿6.1 φ254 steel 0∿15.24 φ203 steel 0∿45.73 φ152 PVC	3.05 ∿ 15.24 15.24 ∿ 45.73 } 42.68	0.5	17.99	375.92	17.49	21.50	100		Type 2 φ150 PVC Depth of slots 12.2∿45.73 ℓ= 33.53	Use for Indian School (School)
13	16.7.80 ∿31.7.80	CDH/W/80/24	Vunivau Bua	Mbua	60.98	0∿9.15 φ254 ∿60.98 φ203	5.18	0∿9.15 φ254 steel 0∿3.05 φ203 steel 0∿60.98 φ152 PVC	9.15 ∿ 15.24 27.44 ∿ 60.98 } 39.63	3.36	33.49	181.44	30.13	6.02	7.29		Type 2 φ150 PVC Depth of slots 9.15∿15.24 27.44∿60.98 } ℓ=39.63	Not use because well collapsed and not drinkable
14	11.9.80 ∿25.9.80	CDH/W/80/42	Vunivau Bua	Mbua	51.8	0∿9.15 φ254 ∿51.8 φ203	5.18			8.64	22.56	428.86	13.92	30.81	36.97		Type 2	

* Final casing type Type 1: Steel casing / Without casing Type 2 : all casing Type 3 : back fill

4) Meteorology and vegetation

The meteorology of the Vanua Levu island is clearly affected by its local topography, and the climatic winds from the southeast give higher precipitation to the eastern and southern parts at the island, which are covered by dense a thick growth of tropical rain-forest. On the other hand, the nothern and western parts behind the mountainous region has relatively low precipitation and are covered mainly long grasses and scrab. On low marsh lands along the shoreline, mangroves flourish.

On the islands of Vanua Levu and Taveuni, 74 meteorological observation stations existed as of 1978. One station has observation records for over 70 years and a few stations have only 3 to 4 year records.

Table 2-4 Number of meteorological observation station on Vanua Levu and Taveuni isands

Length of records (years)	Number of
70	1
50 ∿ 69	6
30 ∿ 49	7
20 ∿ 29	18
15 ∿ 19	12
10 ∿ 14	8
5 ∿ 9	18
3 ∿ 4	4
Total	74

Based on the meteorological data of these observation stations, annual average precipitation are drawn as given in Figure 2-6.

The mountainous region of the Vanua Levu island is high-precipitation area with the annual precipitation raging from 3,200 to 6,400 mm, while the annual precipitation in the hilly districts

and plains in the nothern part of the island is between 2,000 and 2,800 mm. According to the observation data at the Labasa Mill and the Labasa Airfield located in the town, the annual average temperature is 25.4°C, and the maximum difference in the manthly average between 23.5°C in July and 26.8°C in February is only 3.3°C; that is the region is under very warm climate throughout the year.

Despite this mild climate, the region has both dry and wet seasons. During the dry season (May through October) both temperature and precipitation are low, and the reverse is true for the wet season (November through April). Meteorological data for the Labasa area given as a reference in Table 2-5.

Table 2-5 Meteorological data for the Labasa area

Mean Temperature (°C)

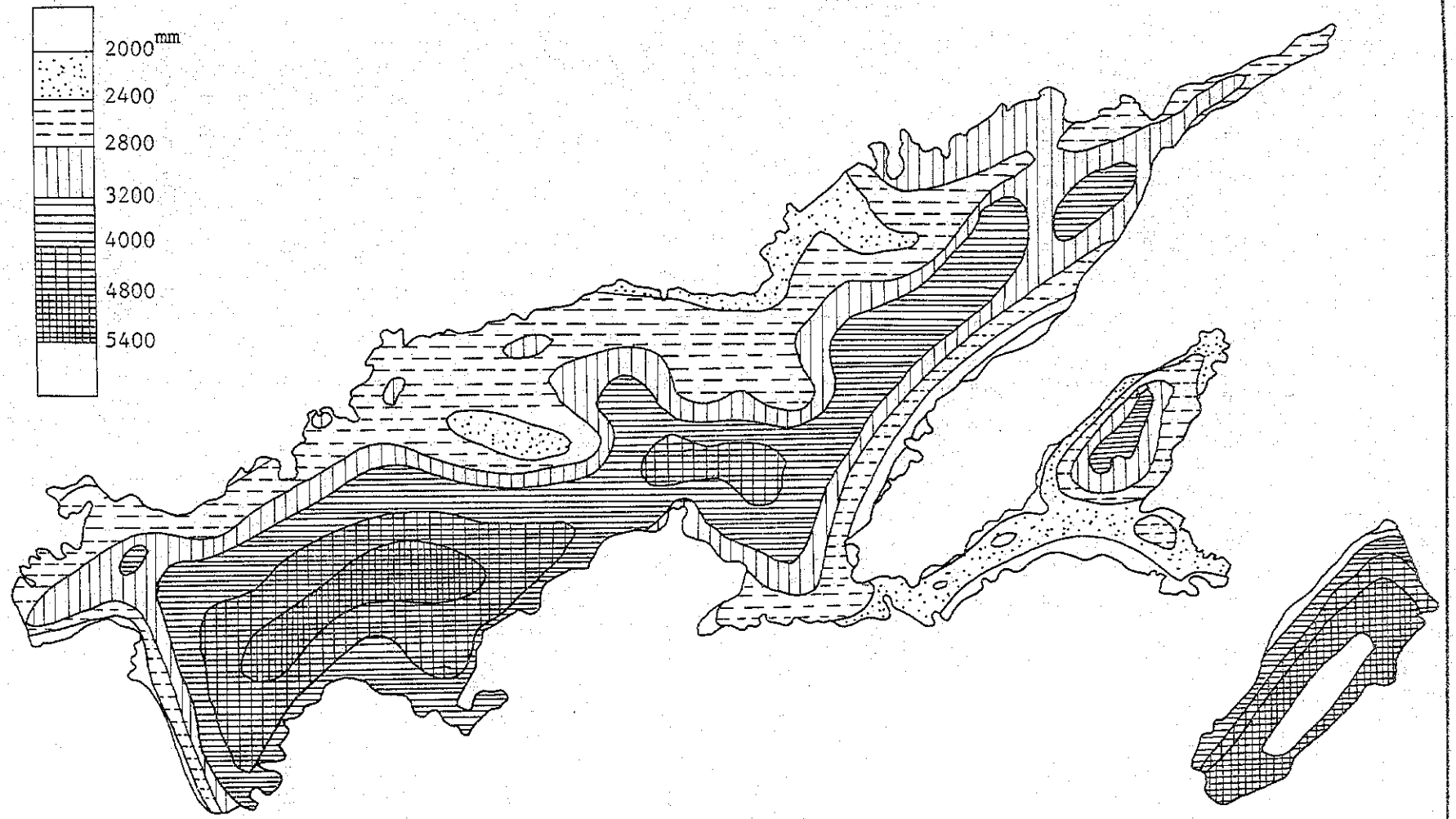
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Labasa Mill	26.6	26.7	26.5	26.1	25.1	24.3	23.7	24.0	24.7	25.3	25.8	26.3	25.4
Labasa Airfields	26.6	26.8	26.2	26.2	24.9	24.4	23.5	23.8	24.7	25.4	25.7	26.2	25.4

* Labasa Mill (Lat.16°3/4' S, Long 179°23 1/2' E) Number of Years 39/40 HT + 3.35m
Labasa Airfield (Lat. 16°28' S, Long 179°20 1/2' E) Number of Year 14/15 HT + 14.94m

Monthly Mean Temperature (mm)

Labasa Airfields	356	456	406	239	81	35	46	33	81	85	169	259	2,295

Fig. 2-6 Annual Precipitation



2-2 Social Environment

1) Population

According to 1976 population statistics, the total population of Fiji is 588,000 of which Fijian and Indian constitute about 94% and the rest consists of European, Chinese and other immigrants from Ocean Islands. The Indian population is slightly more than the Fijian.

Population changes from 1936 to 1976 are as given in Table 2-6.

Table 2-6 Population changes
(total of the Fiji islands)

Year	1936	1946	1956	1966	1976
Population	198,000	260,000	346,000	477,000	588,000
Ratio to the previous decade	-	1.31	1.33	1.38	1.23

The rate of increase in population is relatively high it was 38% in the 1956 - 1960 period. The subsequent decade, however, observed a lower increase rate of 23%, and the increase in the latest few years is expected to be around 2% annually.

The population of the Vanua Levu islands was 103,000 in 1976, corresponding to about 18% of the total population of Fiji. The population of the project areas is summarized in Table 2-7. Figures given in the table are not exact, but the total population was about 9,300 in 1976, and it is expected to increase to about 12,300 in 1990, the target year for the present (the second phase) study for basic design.

Table 2-7 Population of the Project Areas (According to Census 1976)

DISTRICT	FIJIANS		INDIANS		OTHERS		TOTAL		PREDICTED 1990	
	No.of Households	Population	No. of Households	Population	No. of Households	Population	No. of Households	Population	No. of Households	Population
VUNICUICUI	1	6	107	661	-	1	108	668	142	881
VUNIKA	3	18	219	1,249	-	2	222	1,269	292	1,674
VUNIMOLI	10	57	36	225	1	8	47	290	61	382
WAIDAMDAM	-	3	38	269	-	1	38	273	50	360
NABEKAVU							(245)	1,500	324	1,979
VUNIVAU BUA	-	-	62	413	-	-	62	413	81	544
SEAQAQA	-	-	62	413	-	-	800	4,880	1,055	6,439
TOTAL	-	-	-	-	-	-	1,522	9,293	2,005	12,259

[Example of estimation for population and the number of households in the future]

VUNICUICUI Population (1976) : 668 men

" (1990) : $668\ (1 + 0.02)^{14} = 881$ men

VUNICUICUI Number of households : $\frac{108 \text{ houses}}{668 \text{ houses}} \times 881 \text{ men} = 142 \text{ houses}$

The annual increase of 2% was assumed for future population changes.

Table 2-8 Gross Domestic Product (GDP)

Year	Nominal value		Real value (1968)	
	GDP	Increase(%)	GDP	Increase(%)
1970	168.9	20.2	148.7	-
1975	515.4	25.5	196.8	0.1
1976	570.6	10.7	202.1	2.7
1977	649.5	13.8	211.1	4.4
1978	729.9	12.4	216.4	2.5

(1 million Fiji dollar)
Current Economic Statistics
Bureau of Statistics

(2) Economic development plans

The seventh development plan for the period 1976 - 1980 aims at 7.3% annual average increase of the Gross Domestic Product. This development plan places emphasis on reduction of discrepancy in income and employment levels between urban and local areas by distributing economic activities. This goal, however, is not easy to attain, and it will be succeeded by the eighth development plan for the 1981 - 85 period.
The rural water supply development plans form links in the series of projects under the eighth development plan. The plan has not been made public as official documents, but the total budget at 4.44 million Fiji dollars is expected to be allocated to the rural water supply development plans, of which 2.74 million Fiji dollars will be spent on the settlements and 1.07 million Fiji dollars for the villages.

(3) Industries

Agricultural production including fishery and forestry sections is about one-fifth of the Gross Domestic Product. The major agricultural product is sugar that accounts for more than half of the total exports for Fiji every year. The next important

products are coconuts. The forestry is expected to grow and improve the composition of exports. The forestry with pine and other kinds of trees has been under way, and some trees of over 10 years aged have already been exported.

The tourism is also contributing to the economic development of Fiji. The total number of tourists was 184,000 in 1978 of which 40.7% is from Australia, 22.2% from New Zealand, 16.0% from U.S.A, 5.3% from Canada, 2.3% from Britain and the rest from other places. A regular passenger service from Japan started in July, 1980, which will increase tourists from Japan. Revenue from the tourism and sugar exports are compared in Table 2-9.

Table 2-9 Major industries in Fiji for obtaining foreign money

Year	Sugar	Tourism	Others	Total
1966	21.7	7.8	24.5	54.0
1969	28.1	18.5	33.6	80.2
1977	93.6	68.5	65.4	227.5
1978	83.3	73.0	77.7	234.0
Ratio (1978)	35.6%	31.2%	33.2%	100 %

3) Lifestyle

(1) Clothing

Usually Fijian clothing is characterized by a half-sleeve shirt and a skirt-like cloth called Sulu Vaka Taga for a man, and for woman by a combination of Sulu and satin damask which is called Jabb. In urban areas, however, trousers, jeans and one-piece dresses are more common. Many Indian women in a sari are also seen.

(2) Food

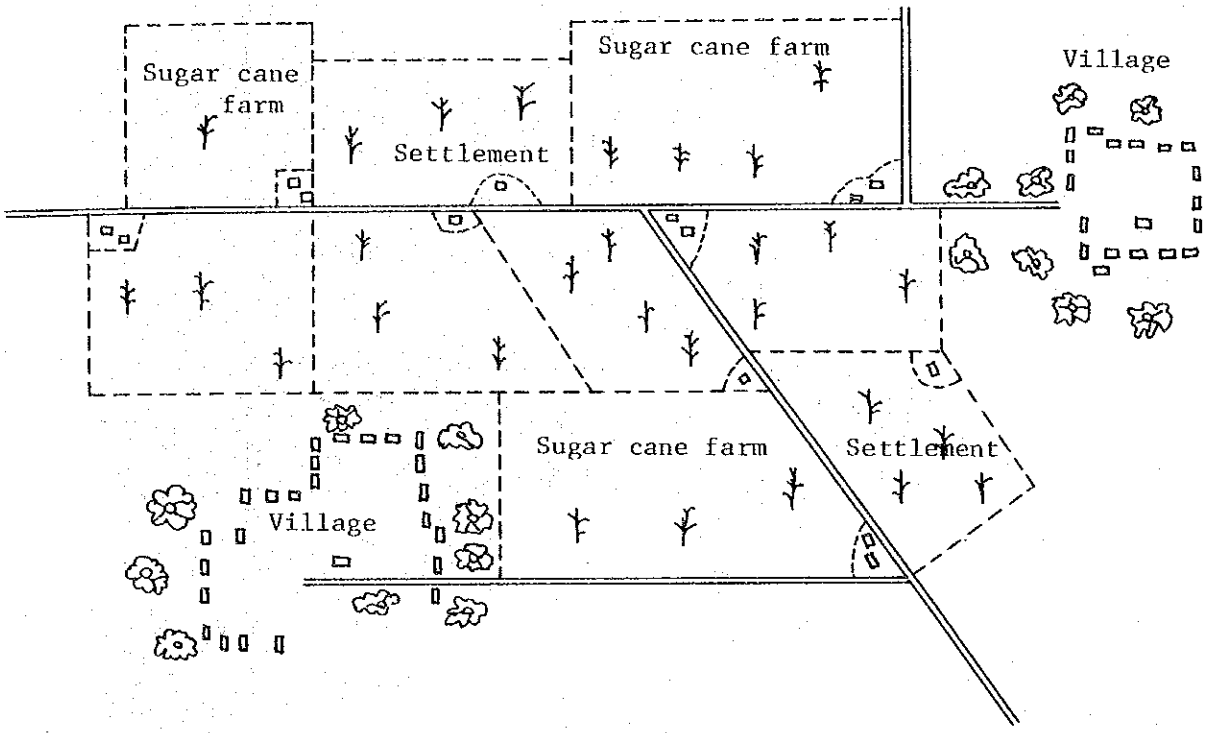
The principal foods for Fijian are casabas, taro and rice, but in urban areas imported foods are abundant and canned meat and fish meat as well as domestically produced meat are popular as side dishes. The principal food for many Indians is curry.

(3) Housing

Widely distributed in urban areas are zinc-roofed houses, which have made ways into other areas, too. Polynesian houses made of logs, palm leaves and bamboos predominate country sides.
The housing situations in Vanua Levu island are as described in the follwing paragraph.

Habitation patterns are different for a settlement and a village. A settlement is inhabited by Indians who settled primarily for sugar cane production and built a house on the farm; as a result houses are scattered. A village, on the other hand, consists of Fijian households that have houses concentrated on the land inherited from their ancestors. Typical conditions of location for these two types of housing are illustrated by Figure 2-7, where a few villages are seen distributed in a district of settlement.
Figures 2-8 through 2-10 show typical plans of houses in a settlement or a village.

Fig. 2-7 Conditions of Location for Houses in Settlement and Villeges



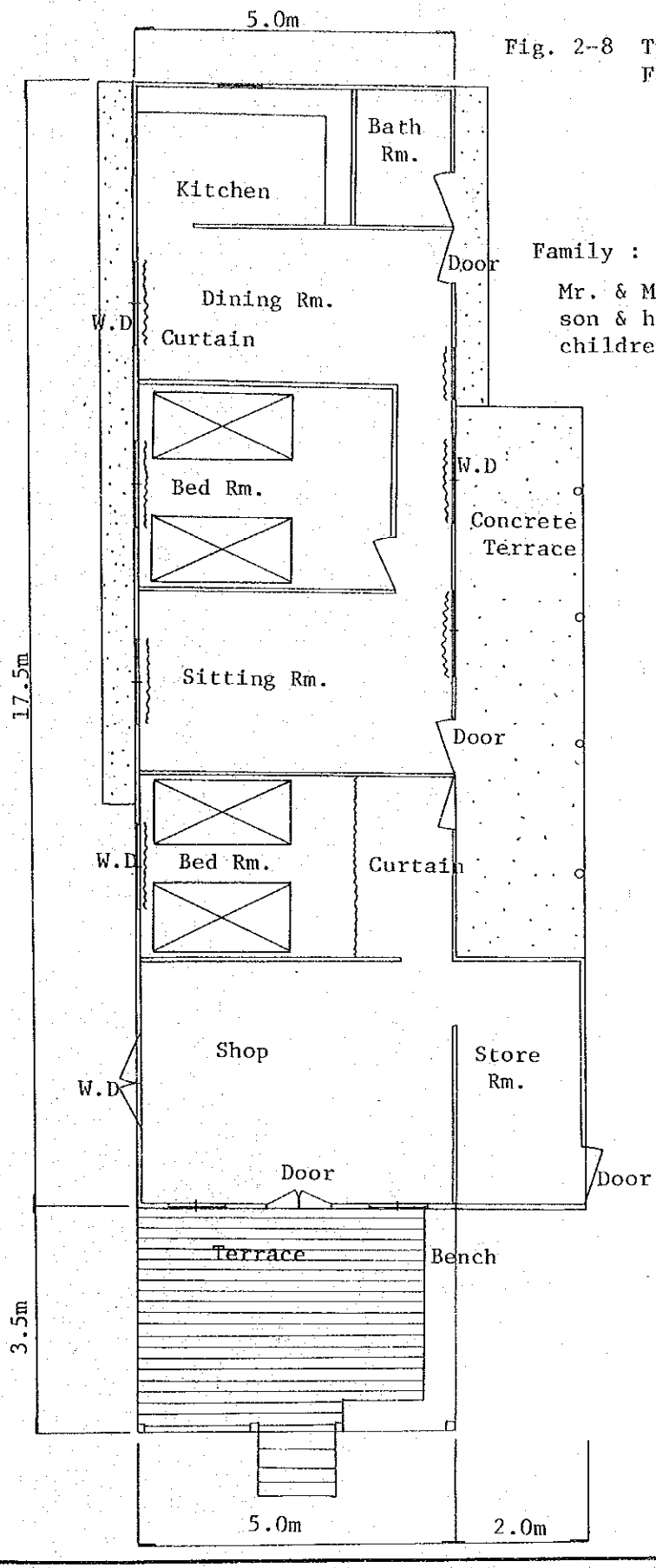


Fig. 2-8 Typical House of Indian Family in Vunicuicui

Scale: 1/100

Fig. 2-9 Vunimoli Village S=1/1,000

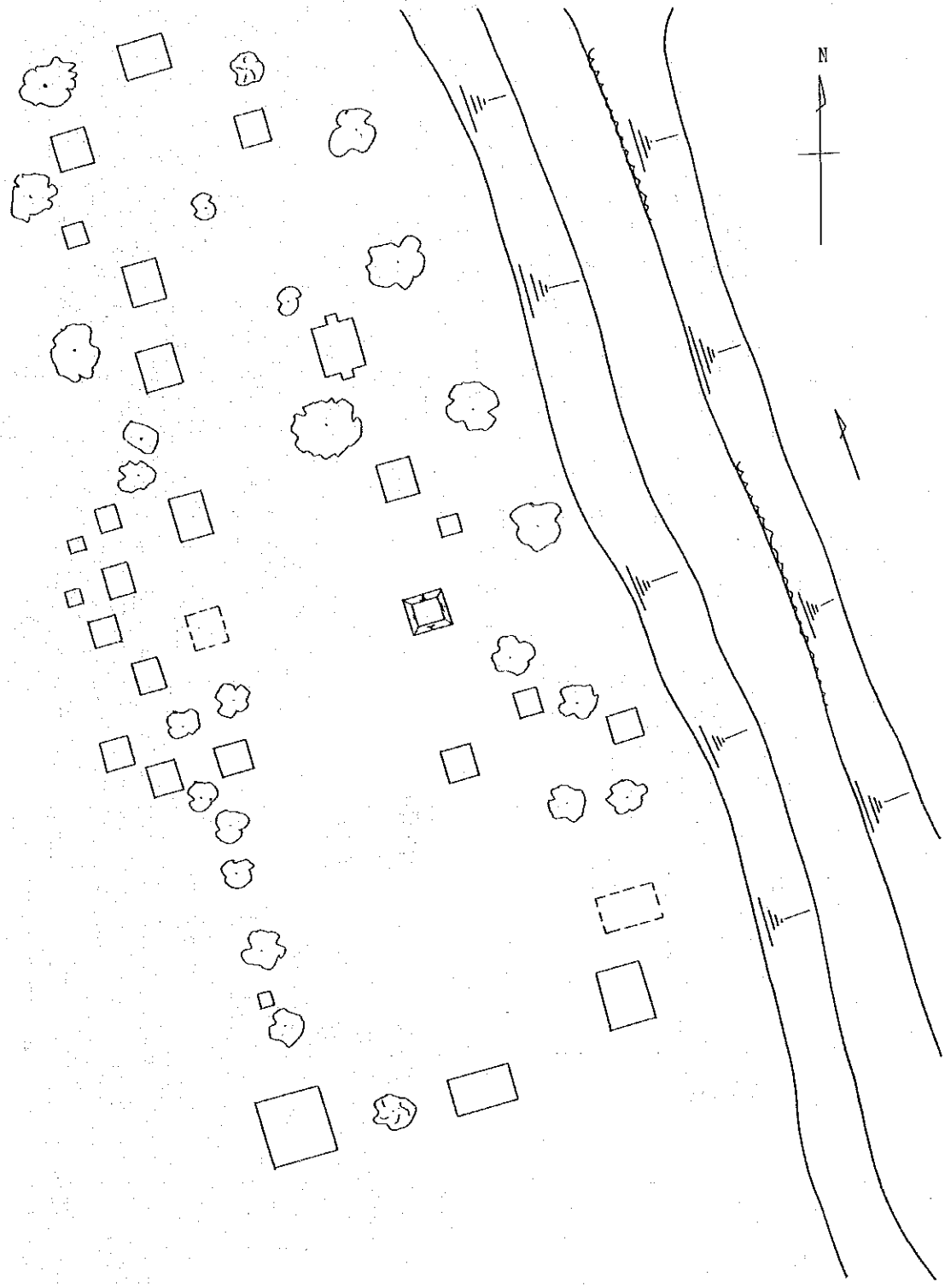
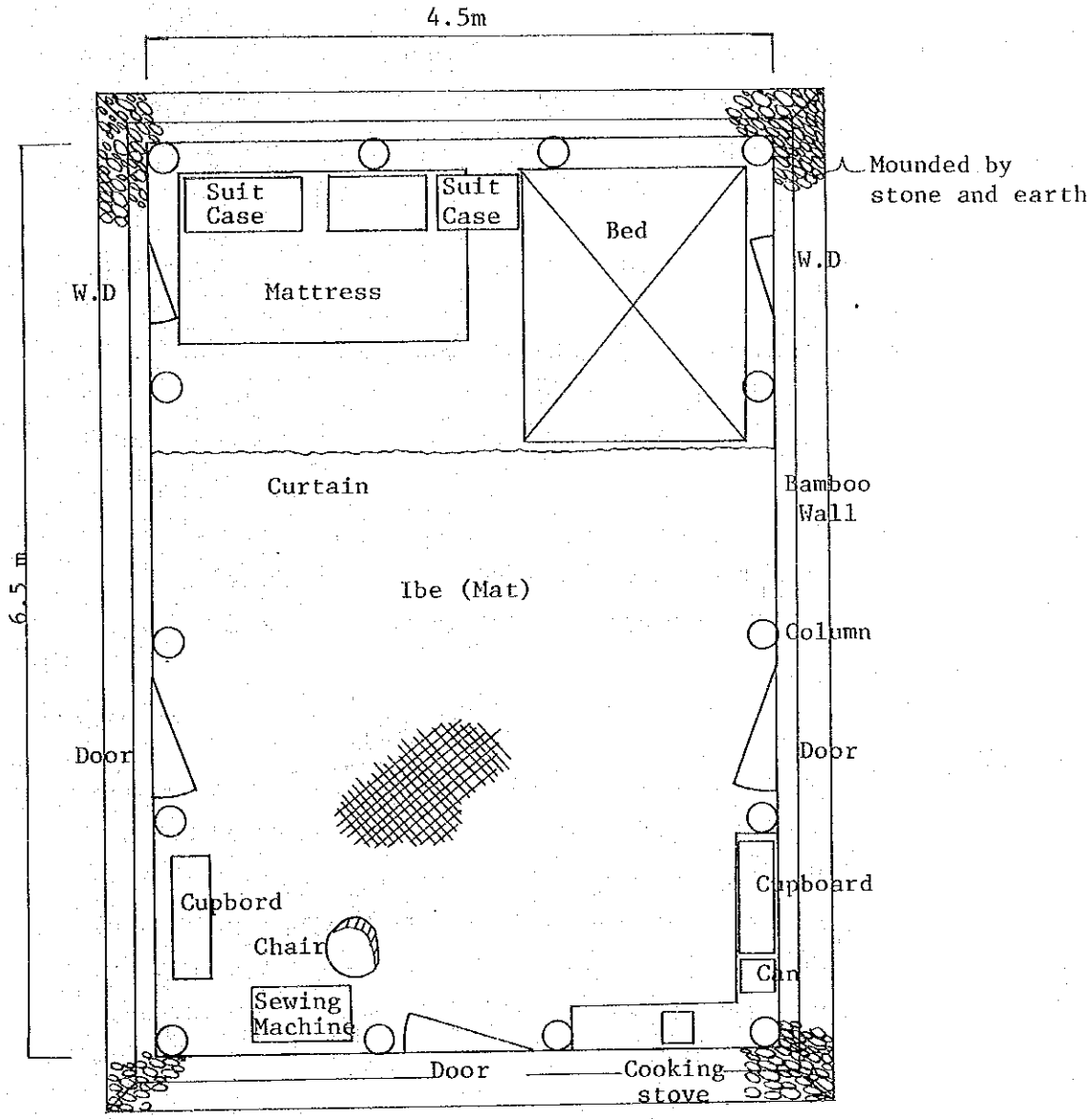


Fig. 2-10 Typical House of Fijian Family in Vunimoli Village

Scale : 1/50



Family : Mr.& Mrs. Alekisa Darodaro and a child

4) Transportation

Road networks in Fiji are mostly in good conditions with the length of public roads reaching 3,300 km, of which 1,200 km is paved. In Vanua Levu island, city streets in Labasa area are paved with asphalt, but others are macadam roads.

Fiji locates at an important position in air-transport networks in the Southern Pacific, and many international lines from Australia, New Zealand, USA, France and Japan make stop there. Also domestic lines connect the islands.

Fiji has three major parts in Suva, Lautoka and Levuka, and two marine transportation companies are operating regular lines from Japan. On Vanua Levu island, there are piers at Malau near Labasa used by sugar factories. On the opposite side of the island there is a port of Savu Savu that can be used by large freighters.
Marine Transportation Department of the Fiji government provides service for inter-island cargo transportation, and Public Works Department has its own barges to transport cargos.

5) Schools

Of 760 schools confirmed by 1975 statistics, 35 schools are managed by the Government, 100 by churches and the rest by local municipalities. Total number of students as about 108,000.
As of 1980, there exist in Vanua Levu island 145 primary schools and 24 secondary schools with about 26,000 students. Of these four schools with about 1,000 students in total are in the project areas.

6) Current water uses

The Labasa area that is most populated on the Vanua Levu island is taking its water from a water fall at the most upstream portion of Nanenivunda River, a tributeary of Dreketi River. The water is transported after chlorination to three reservoirs around the town and then distributed within the town.

The reasons why the water from such a remote water source are considered to be as follows. First, possibility of pollution is minimal even in the future when the town expands; secondaly the quality of water is so good that it can be supplied only with chlorination, and also operation and maintenance are easy.

Other districts in the project areas rely for their domestic water supply on deep wells developed around schools by MRD. Each well serves a school and only four to five houses around it. Many other residents make use of shallow hand-dug wells or near-by creeks. In the districts where the main water transmission line passes some people around it receive services from the line to be used for domestic purposes.

An Indian family in Vunicuicui uses four drumful of water per day for 20 family members. It is estimated from this, the daily water use per capita is about 40 liters.
Most people in the project areas procure the minimum amount of water necessary for life from shallow wells, surface water, rain water and other scurces. It requires considerable labor and the water quality is also questionable since they do not have means for chlorination
Existing water supply facilities for each settlement in the project areas near Labasa are briefly described as follows.

(1) Vunicuicui

i) Farms near Labasa River take water from the river.

ii) Most other farms obtain water from hand-dug wells; some of them use creeks as supplementary sources for washing water.

iii) At Indian schools they provide water from wells developed in 1972 by MPD for the schools and teachers quarters.

(2) Vunika

i) They face with problems of salt water intrusion, and wells located on foundation rocks of hilly districts dry up even during short dry seasons.

ii) Wells in alluvial plains suffer from salt water intrusion.

iii) Two households connect to the Labasa water transmission line at their own costs but its supply is irregular due to low water pressure.

(3) Vunimoli and Waidamudamu

i) These are the only districts equipped with water supply facilities under their own management. At present they have a small facilities and plan for another. This existing facilities belongs to Islamia School and utilizes creek water by using a dike. It provides water not only to the school but also to residents along the transmission line.

ii) There exists a plan for a large-scale water supply facilities to take water from Koroutari in the southern part of the districts. The facilities is expected to serve farmers along the road leading to Labasa and also along Waidamudamu road. Until the plan is implemented, they will continue to use water from hand-dug wells and Labasa River. The river water is exposed to possible pollution, and a quarry on the upstream may makes it unsuitable for domestic supply in the future.
Quality of groundwater from shallow wells is largely acceptable.

(4) Nabekavu

i) Hand-dug wells and Wailavu River are being used.

ii) Hand-dug wells have 1.2 to 1.4 m deepth, and one of them are installed with engine pumps to supply about 600 galons water per day for 20 people without any threst of drying-up or high variations of water table. Some other wells experience frequent exhaustion.

iii) Most wells are collecting water from weathered zones.

(5) Seaqaqa

i) There exists a system to supply water from a creek to a part of inhabited districts along a public road. Treatment capacity of this plant is 33,000 galons per day and the plant supplies water to about 30 households and two schools with 300 to 400 students.

ii) Of 800 households inhabited in the area the majority are utilizing their own supply facilities based on wells water or creek water, and 60 to 70% of them are obtaining relatively sufficient quantity of water.

iii) Water distribution by a pipeline system will be uneconomical since houses are scattered. Therefore it is expected that each house keeps using their own well for water source.

CHAPTER 3 BASIC DESIGN

CHAPTER 3 BASIC DESIGN

3-1 Scope of the project areas

Based on the first phase official mission conducted in July, 1980, the subsequent request for cooperation from the Fiji government and discussions between the survey team and the concerned organizations in Fiji, the project areas were selected in the Vanua Levu island as the following distribution in the location of each district shown in Figure 3-1.

Settlements :
- Vunicuicui
- Vunika
- Vunimoli
- Waidamudamu
- Nabekavu
- Vunivau Bua
- Seaqaqa

Villages :
- Yunimoli
- Namoli
- Korowiri
- Vuo
- Matai Labasa

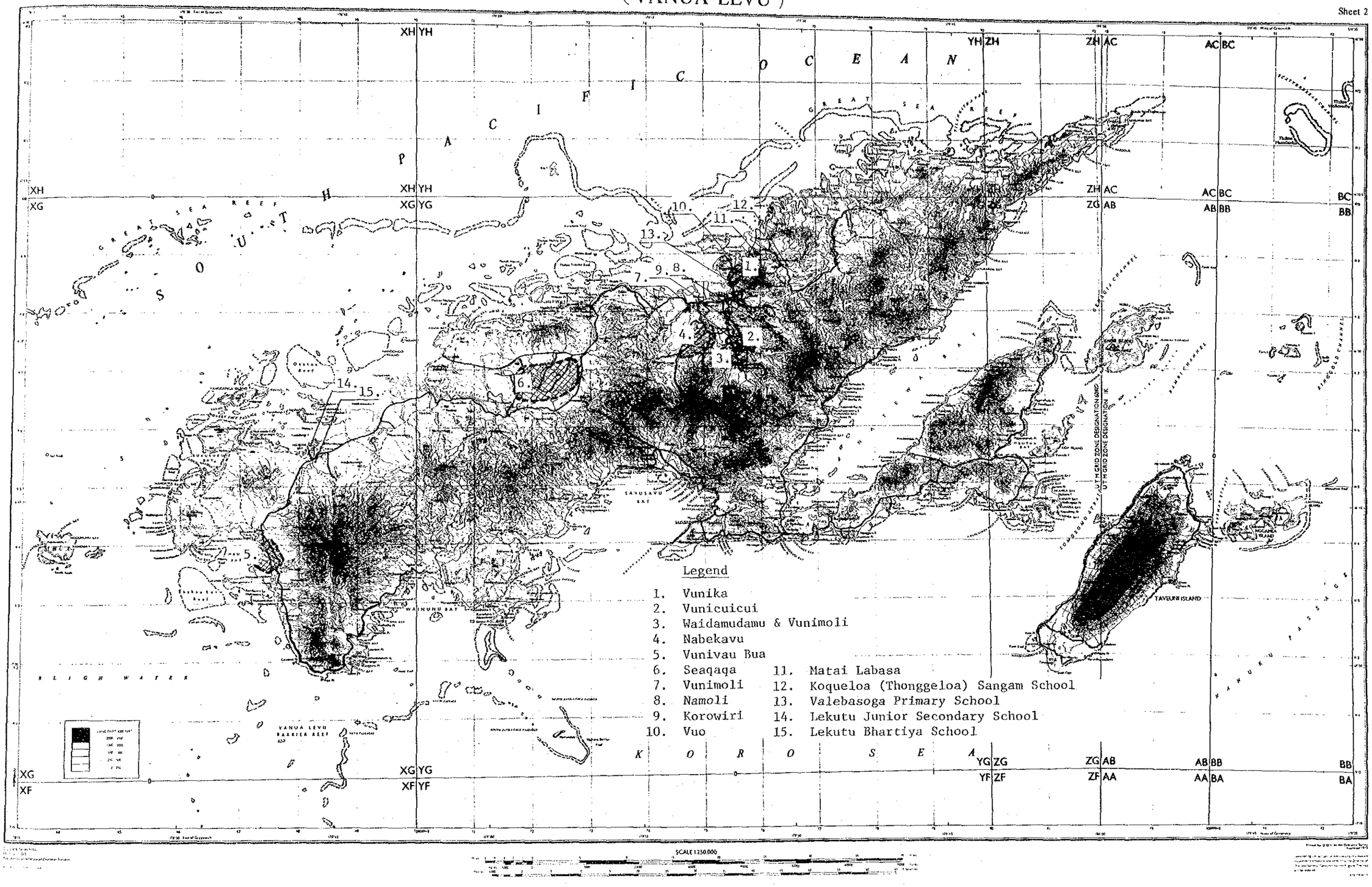
Note: It was found out during the survey that the following schools require pumping equipments to supplement existing water works. Therefore, these schools were included as objects for the present survey to examine proprieties.

- Coqueloa (Thonggeloa) Sangam School
- Valebasoga Primary School
- Lekutu Junior Secondary School
- Lekutu Bhartiya School

FIJI 1:250,000

Fig. 3-1 PROPOSED PROJECT SITES (VANUA LEVU)

Sheet 2



Legend

1. Vunika
2. Vunicuicui
3. Waidamudamu & Vunimoli
4. Nabekavu
5. Vunivau Bua
6. Seaqaqa
7. Vunimoli
8. Namoli
9. Korowiri
10. Vuo
11. Matai Labasa
12. Koqueloa (Thonggeloa) Sangam School
13. Valebasoga Primary School
14. Lekutu Junior Secondary School
15. Lekutu Bhartiya School

3-2 Basic Policies for Plan Formulation

To formulate plans for domestic water supply, the present status of water use patterns in the project areas, prospects for future development, on-going plans, basic policies and design standards of PWD, the concerned authorities, were taken to account.
In addition, the results of and the data collected during the field survey including meetings and interviews were utilized to determine the basic policies for plan formulation. These are as follows.

1) The target year for the plans is 1990

2) Specifics of the plans follow the design standards of PWD, and basic conditions for planning are to procure the minimum quantity of water necessary for domestic uses.

3) Planned facilities shuld be economical, easy to operate and maintain, reasonably durable at the same time.

4) Detailed designs are drawn for the model districts representing settlements and villages, and based on the model design, only rough designs will be given for other area.

5) Service area for each system, in principle, is taken to be the area that can be covered by the amount of water pumped up from the corresponding well. (The final plan to determine servise area will be based on the results of pumping tests for production well)

6) The water transmission and distribution schems should be adaptable to future increase in water demand resulted from individual house connection and suitch over to water charge system.

7) The plans should be flexible in the scope that is capable to modify the scale of plans in response to the grant aid scheme.