(4) Water Treatment System

(a) Disinfection Facility

Disinfection facility with chlorination injection equipment shall be installed in the following borefield. The capacity of the disinfection plant shall have 120% of the production volume of each source.

Table B2.3-37 Disinfection Facility

Water Source	Capacity of Disinfection Plant (m^3/day)
Titinge new borefield	3,850
Skyline new borefield	3,850
Borderline new borefield	3,850
Mataniko existing borefield	3,100
Kombito existing EU borefield	2,400
Panatina existing borefield	4,400

Source : JICA Study Team

(b) Intermediate Water Treatment Facility

There are many complaints from the customers that turbidity of the tap water from the spring sources becomes high just after the heavy rain. In order to prevent spring water from such contamination, intermediate water treatment facility shall be installed inside the town boundary and near the intake point of each spring source. As the intermediate water treatment facility, inline filter shall be adopted as mentioned in B2.3.1-(4). The capacity of the facility is shown bellow.

Table B2.3-38 Capacity of Intermediate Water Treatment Facility

Water Source	Treatment Capacity (m^3/day)
Konglai spring gravity system	4,300
Konglai spring pumping system	1,100
Rove spring	2,000
Kombito spring	2,000

Source : JICA Study Team

For the outline of intermediate water treatment facility to reduce turbidity, refer to Option J-1.

B2.4 Plan for Sewerage Facility Improvement

For future plan for sewerage facility improvement in Study area, not only facility plan but also other factors related to enhancement of sanitary conditions need to be considered. Improvement of sewerage system with consideration of sanitary and environmental conditions has been proposed as mentioned below.

B2.4.1 Basic Policy for Sewerage Facility Improvement Plan

In the facility improvement plan for the year 2010, following points which are the major problems faced with SIWA shall be considered.

Table B2.4-1 Basic Policy for Sewerage Facility Improvement Plan

Issue to be solved	Current Situation	Countermeasures for Improvement
Sewage outfall facility	Existing sewage outfall facilities were constructed almost 40 years ago. These facilities have not been rehabilitated, indeed over time they have deteriorated as a result of damage and lack of maintenance. The result has been an increase in environmental degradation of coastal region.	Wastewater flows in Honiara will be concentrated at three major outfalls; Rove, Point Cruz, and Lio Creek. And cyclone proof ocean pipelines and outfalls (400m x 3 numbers) and new pumping stations (2 locations) will be constructed
Household septic tank	General users of septic tanks commission cleaning staff to take out accumulated sludge (desludge). Desludging work is done by Honiara City Council or private maintenance company. However, because of lack of manpower and financial capability, it is difficult for Honiara City Council to provide satisfactory maintenance service.	SIWA is going to take over operation and maintenance work from City Council. After the transfer of maintenance work, service will be provided regularly and effectively. Another advantage is that SIWA can obtain additional revenues from carrying out maintenance service.
Sludge treatment	Sludge generated from communal and household septic tanks is dumped into the final disposal site without any treatment. This is not environmentally safe and may encourage further pollution and insanitation.	A new sludge treatment facility using natural drying with a drying bed system will be constructed at the site near Alligator Creek. This system does not require complicated or high maintenance cost. Chemicals, fossil fuel, or electricity is not required and the dried sludge can be utilized in agricultural fields.
Operation equipment	Appropriate equipment is required for the purposes as follows: 1) For removal and transportation of sludge from septic tanks 2) For Cleaning of inner sewer mains which are blocked and may cause frequent floods in the service area of SIWA sewer connection. 3) For loading dried sludge onto the dump truck at the sludge treatment facility	Procurement of Following equipment is proposed: 1) Vacuum truck (x4) 2) Sewer cleaning truck (x1) 3) Wheel loader (x1)

Source : JICA Study Team

B2.4.2 Conditions for Sewerage Facility Improvement Plan

Basic conditions for sewerage facility improvement plan for Honiara city in 2010 are as follows:

Table B2.4-2 Basic Conditions for Sewerage Facility Improvement Plan for Honiara

Item	Overall	Sewer Network	Non-sewered	
			Household Septic Tank	Non-served
Design Population	78,865	7,450	58,715	12,700
Design Households*[1]	11,110	1,050	8,270	1,790
Design Sewage Volume*[2] (m^3/day)	18,350	1,730	13,660	2,960
Design Sludge Volume*[3] (m^3/day)	11	–	–	–

Note: 1. Including commercial connections
2. 60% of water supply amount in 2010
3. 0.06% of sewage volume

Source : JICA Study Team

B2.4.3 Sewerage Facility Improvement Plan in the Year 2010

Facility improvement plans in the Study area have been prepared by the assistance of AusAID and EU

in the year 2000. Therefore, in this Study, these plans are reviewed and the facility improvement plan for the target year 2010 will be formulated based on these plans and the field surveys.

In scope of work for this Study, facility improvement plan of sewerage system is second priority. Conservation of water source and improvement of water distribution system are put first in the scope of this Study.

Because of shortage of financial capability of SIWA, sufficient expense for facility improvement of sewerage system cannot be budgeted. Even if complete sewer net work and fully equipped advanced wastewater treatment plant are constructed, SIWA cannot afford to maintain or operate these new advanced facilities. Therefore, construction of large-scale conventional wastewater treatment plant is not a recommended option for improvement of sewerage facility in Honiara.

However, as a result of water quality analysis of this Study, it was found that water sources for SIWA water supply services are not contaminated by wastewater generated from households. This is because population in Honiara City is relatively small (about 60,000 persons and 33persons/hectar) and residential houses are not concentrated in only one area but dispersed at different places. Wastewater from residences is finally disposed into the sea. Safe ocean disposal of raw or partially treated sewage is possible in Honiara because depth of the sea along Honiara costal region is relatively deep and favorable for dispersion. For depths exceeding 50 meters, effluent dilution alone will achieve satisfactory water quality outcomes. In practice, further dispersion will occur as a result of long-shore currents. It is predicted that if a cyclone-proof ocean pipeline and outfall can be constructed at a depth of 50m or more, impacts on environment will be of low significance as estimated in the AusAID report. To minimize the construction cost for improvement of sewerage system in Honiara, ocean disposal of sewage is favorable option.

On the other hand, it is expected that expansion of sewer network without enhancement of wastewater treatment in Honiara will not contribute to environmental protection. Construction of new sewer network which covers entire Honiara City costs high and reduction of pollutant is difficult to be achieved.

Instead of expansion of sewer network, spread of household septic tanks and proper maintenance of communal septic tanks will be more effective for environmental protection and less costly.

Considering these factors, following components of facility improvement plan for sewerage system are proposed.

(1) Rehabilitation of existing sewerage system: sewage outfall facility

(2) Spread of installation of household septic tank and transfer of operation and maintenance work to SIWA

(3) Construction of new sewerage treatment facility: sludge treatment facility

(4) Procurement of operation equipment: vacuum truck, sewer cleaning truck and wheel loader

(1) Rehabilitation of Existing Sewerage System: Sewage Outfall Facility

As mentioned in the previous chapter, existing sewerage system was constructed almost 40 years ago (after 1968). These facilities, especially sewage outfalls have not been expanded or rehabilitated to meet the growth in population or change of environment– indeed over time they have deteriorated as a result of damage and lack of maintenance. The result has been an increase in environmental degradation of coastal region.

For feasible improvement plan of sewerage system in Honiara, it is proposed that wastewater flows in Honiara would be concentrated at three major outfalls; Rove, Point Cruz, and Lio Creek. The former two outfalls are existing; on the other hand, the later is proposed one near the mouth of Lio Creek, which runs through Panatina ward.

Components of this option are cyclone proof ocean pipelines and outfalls (400m x 3 numbers) and new pumping stations (2 locations).

Because of limited financial power of SIWA, it is difficult to construct fully developed sewerage system including sewer mains, wastewater treatment plants and pumping stations. In addition to that, as far as health and environmental impact is concerned, disposal of sewage into ocean will not be directly harmful for drinking water sources and marine environment because sewage can be diffused safely if a cyclone proof ocean pipeline and outfall is constructed at a depth of 50m or more.

Figure 2.4-1 shows proposed sewerage system in Honiara.

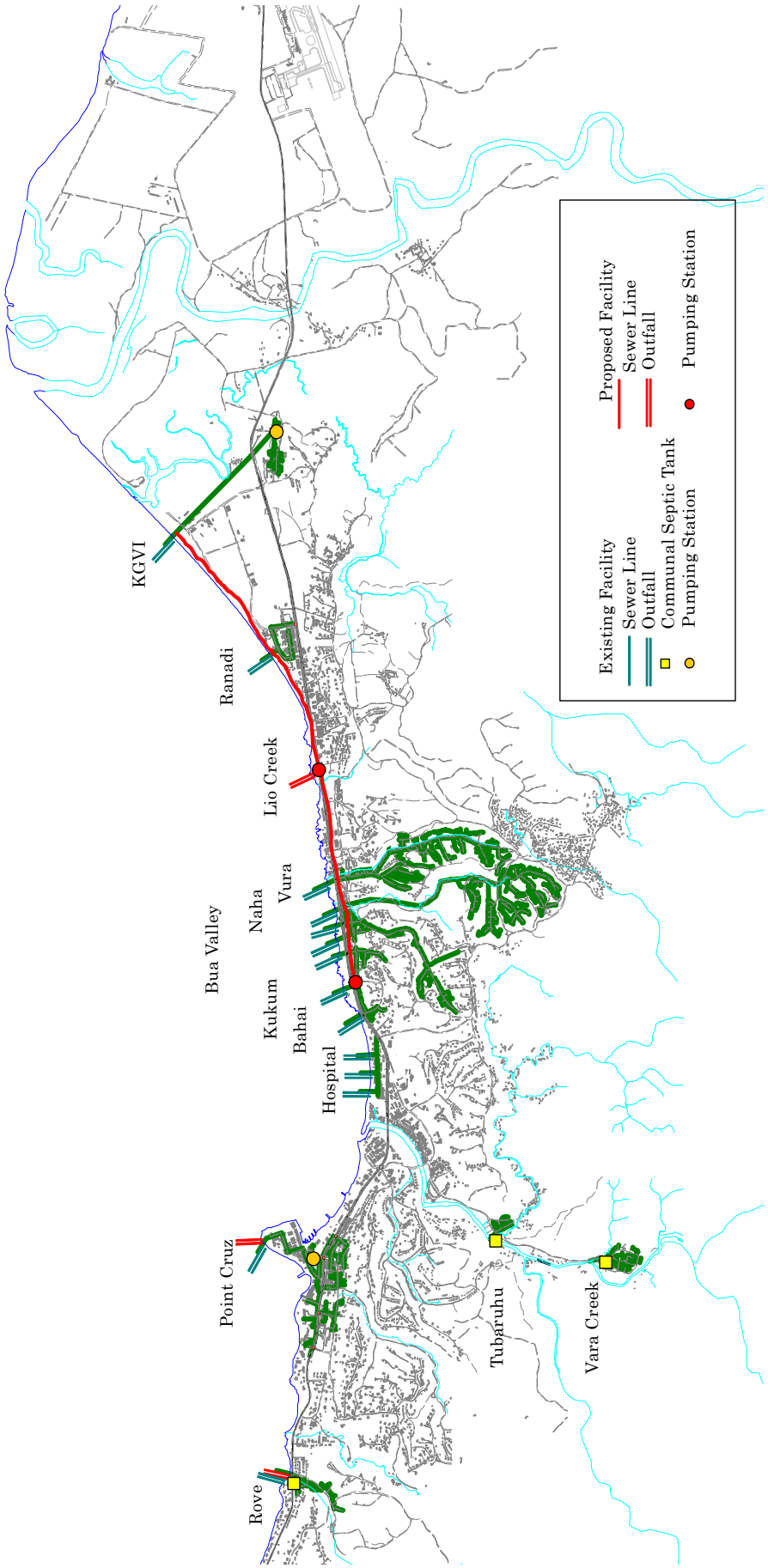


Figure B2.4-1 Proposed Improvement Plan for Sewerage System in Honiara

Source : JICA Study Team

(2) Spread of Installation of Septic Tank and Transfer of Operation and Maintenance Work to SIWA

In the Study areas, most of the households, private offices, and institutions are not connected sewer lines. Even in Honiara, where sewer lines for domestic service are still functioning, only 10 percent of houses are sewered. For the rest of these, septic tanks are installed. As mentioned in previous section, due to shortage of budget for improvement of sewerage system, it is difficult for SIWA to expand sewerage system into non-sewered area and construct conventional large-scale sewage treatment plants in the study area. Moreover, it is expected that expansion of sewer network without enhancement of wastewater treatment in Honiara will not contribute to environmental protection but increase amount of pollutant from untreated sewage. Therefore, individual treatment facility such as septic tank is still effective method.

Although individual users of the septic tanks are responsible for operation and maintenance works, desludging work is usually done by city council or private maintenance companies. In general, individual users of septic tanks commission cleaning staff of city council or private company to take out accumulated sludge (desludge). Because of lack of manpower and financial capability, it is difficult for city council to provide satisfactory maintenance service.

SIWA is planning to take over operation and maintenance work from city council. After it is taken over by SIWA from city council, maintenance service will be provided regularly and effectively. Another advantage is that SIWA can obtain additional revenues from carrying out maintenance service. As an additional advantage, transfer of operation and maintenance work of septic tank from city council will lead to additional revenues for SIWA.

In present, when cleaning communal septic tank, SIWA commissions city council or private company to carry out actual work. In order to take over the operation and maintenance of septic tank, SIWA must set up a new section for septic tank. At the start of operation and maintenance service for septic tanks by SIWA, SIWA will need to procure necessary equipment for actual cleaning work for septic tanks such as vacuum truck, which will be described in detail in the subsequent section.

(3) Construction of New Sewerage Treatment Facility: Sludge Treatment Facility

A serious issue in Honiara would is the disposal of sewage solids.

Currently, sludge generated from communal and household septic tanks in Honiara is taken out by cleaning staff of Honiara City Council or private sector and transported to final disposal site (landfill site). The final disposal site is not a sanitary landfill so that all wastes are just dumped openly. Sludge from septic tanks is also dumped without any treatment. The final disposal site is located along the Lungga River and leachate generated from disposed wastes and sludge is believed to seep into the water body. Although Lungga River is not used as water sources for drinking water, it is not recommended that sewage sludge is disposed at the open dump site which is not environmentally safe and may cause further pollution and insanitation.

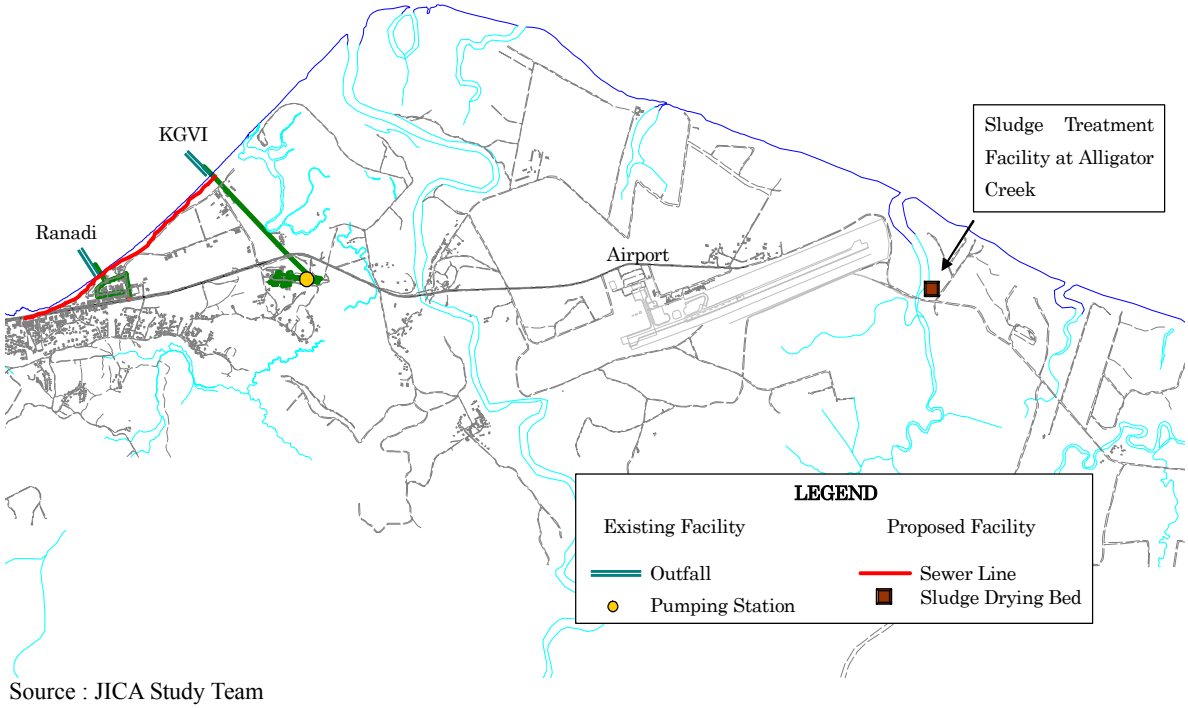
As mentioned in previous sections, the most appropriate wastewater disposal mechanism for Honiara is minimal treatment and a deep outfall. Wastewater discharged into sewer line finally pours into the ocean and diffuses. In this case, sludge from raw sewage is largely not separated from the wastewater – which is really a form of sewage solids - can continue to be disposed of through the reticulated sewerage system.

However, the future plan of sewerage system improvement shows that 80% of domestic wastewater is still treated in septic tank. As far as septic tank is concerned, sludge accumulated at the bottom of septic tank must be taken out and disposed to the landfill site.

In the future plan, it is proposed that a new sludge treatment facility using the natural drying with a drying bed system will be constructed at the site near Alligator Creek. This system does not require complicated or high maintenance cost. Chemicals, fossil fuel, or electricity is not required and the dried sludge can be utilized in agricultural fields. Although agricultural use is not high at present, this system still has the advantage of low cost for construction and maintenance.

Proposed sludge treatment system consists of 1) sludge drying bed, 2) concrete floor for crushing of dried sludge and 3) sewage settling tank.

Proposed sludge treatment facility at Alligator Creek is shown in Figure 2.4-2.



Source : JICA Study Team

Figure B2.4-2 Proposed Sludge Treatment Facility at Alligator Creek

(4) Procurement of Operation Equipment: Vacuum Truck, Sewer Cleaning Truck and Wheel Loader

Plan for procurement of operation equipment for improvement of sewerage system is as follows.

(a) Vacuum Truck

Even in the near future, most of the households will continue to utilize septic tanks as main facility for wastewater treatment from toilet and domestic water use. In the future, SIWA will take over the duties for operation and maintenance of septic tanks from Honiara City Council.

For removal and transportation of sludge from septic tanks, vacuum trucks are required. In the year of 2010, it will be estimated that there are 9,050 non-sewered households in Honiara, and about 80% of non-sewered households are equipped with septic tanks. It is assumed that 7240 households use septic tanks and it is obligatory for one household to carry out desludging once a year.

One vacuum truck operates for seven hours a day and six days a week. For one day, it is estimated that one truck can cover about six households because one cleaning service plus one trip take about 45 minutes to one hour, and the truck must go to the sludge treatment site for dumping collected sludge at least once a day. In consideration of aforementioned conditions, the required number of vacuum truck in Honiara is roughly calculated as follows:

8270 [households] ÷ 315 [days] ＝ 26 [households/day] (for entire city)

26 [households/day] ÷ 6 [households/car/day] = 4.3 ≒ 4 [car/day]

Hence, the required number of vacuum truck is four (4).

(b) Sewer Cleaning Truck for Sewer Pipes

There often happens blockage of sewer mains, which may cause frequent floods in the service area of SIWA sewer connection. SIWA has requested a vehicle for cleaning up the insides of sewer pipes. One jet cleaning truck is applied for washing inside sewer pipes by a jet of water. This vehicle is equipped with high pressure water pump, hose reel, high pressure hose, and washing nozzle.

(c) Wheel Loader

One wheel loader is necessary at the sludge drying bed facility to load dried sludge onto the dump truck.

B2.4.4 Establishment of Environmental Standards and Effluent Standards

As far as environmental and effluent standards are concerned, there are no guidelines for water quality of inland and marine water body at present, although Environmental Act has been enacted in Solomon Islands. Only for drinking water, WHO Guideline and Australian Drinking Water Guideline are applied. At present, consisting of members from Ministry of Health and Medical Services, Ministry of Environment and Conservation, Ministry of Natural Resources and SIWA, Solomon Islands Drinking Water Guideline Committee (SIDWGC) is formulated for establishment of new original drinking water quality guideline in Solomon Islands. The committee has been preparing for enactment of new original guideline in the year 2006. SIWA plays a main part of making out a draft guideline. However, establishment of environmental standards for public water body and effluent standards for wastewater discharge generated from source of pollution have not been thoroughly discussed among the government agencies.

Present condition of sewerage treatment in the study areas are not monitored regularly because of luck of policy for environmental conservation and enhancement of hygiene conditions. Not only domestic wastewater, but also discharge generated from industries, commercial sewerage facilities and public institutions must be regulated according to effluent standards.

It is proposed that the committee for establishment of new guidelines for environmental standards and effluent standards should be organized. As well as the SIDWGC, the committee should consist of Ministry of Health and Medical Services, Ministry of Environment and Conservation, Ministry of Natural Resources and SIWA.

The committee should aim at enactment of these guidelines by the target year 2010.

B2.5 Cost Estimation

B2.5.1 Water Supply Facility Improvement Plan

As mentioned in B2.3 "Plan for Water Supply System", 6 options (Option A, B1, B2, C, D1, and D2) are proposed in the AusAID report and 3 options (Option J-1, 2 and 3) in this Study. The capital cost and operation cost of the above options except Option C of the AusAID report have been compared as follows.

(1) Capital Cost and Operation Cost for Proposed Options in this Study

In this Study, three (3) options have been examined in the aforementioned sections. The results of the examinations for the capital cost and operation cost are summarized as shown in Table B2.5-1 and Table B2.5-2.

Table B2.5-1 Capital Cost of Proposed Options in this Study

(Unit : x1,000US$)

Item	Option J-1	Option J-2	Option J-3
Source development	2,262	895	1,698
Water treatment	1,286	1,711	1,416
Pumping station	436	191	367
Distribution storage	700	700	779
Distribution mains	883	1,194	751
Engineering & contingency	1,670	1,407	1,503
Total	7,236	6,098	6,514

Source : JICA Study Team

Table B2.5-2 Operation Cost (Annual) of Proposed Options in this Study

(Unit : x1,000US$)

Item	Option J-1	Option J-2	Option J-3
Pumping costs	998	847	1,009
Treatment costs	143	227	196
Maintenance costs for the proposed facilities	71	59	64
Maintenance costs for the existing assets, wages, vehicles, etc.	353	353	353
Cost for environmental mitigation measures - Monitoring for groundwater level of boreholes	5	5	5
Total	1,570	1,491	1,628

Source : JICA Study Team

(2) Comparison of Capital Cost and Operation Cost for Options

Capital cost and operation cost have been calculated based on the data applied in the AusAID report. The cost applied in the AusAID report is adjusted with the inflation rate of 4% which is adopted in ADB project now under construction in Solomon.

The details for the calculation of capital cost and operation cost are compiled in Annex-7. The capital cost and operation cost for each option are summarized in Table B2.5-3.

Table B2.5-3 Capital Cost and Operation Cost for Each Option

(Unit : x1,000US$)

Option	Capital Cost (US$)	Operation Cost (US$/year)
Option J-1	7,236	1,570
Option J-2	6,098	1,491
Option J-3	6,514	1,628

Source : JICA Study Team

As shown in the above table, Option J-2 is the lowest in the capital cost and operation cost and therefore considered as the most appropriate project. However, as mentioned in most appropriate project shall be evaluated through both financial analysis and risk analysis.

B2.5.2 Sewerage Facility Improvement Plan

As mentioned in section 2.4 in this chapter, sewerage system improvement plan includes following components.

1. Improvement of sewage outfall system
2. Construction of sludge treatment facility
3. Procurement of operation equipment

Capital cost for the sewerage system improvement work is estimated as follows.

Table B2.5-4 Capital Cost for Sewerage System Improvement in Honiara

(Unit : x1,000US$)

No.	Component	Quantity	Capital Cost
1	Improvement of sewage outfall system		
	- Cyclone proof ocean pipeline & outfalls	3 sets	1,640
	- Pumping station	2 nos.	134
	Sub-total		1,774
2	Construction of sludge treatment facility		
	- Sludge drying bed	3 nos.	96
	- Septic tank	1 no.	38
	Sub-total		134
3	Procurement of operation equipment		
	- Vaccum truck	4 nos.	653
	- Jet cleaning truck for sewer pipe	1 no.	180
	- Wheel loader for sludge disposal	1 no.	67
	Sub-total		900
	Grand Total		2,808

Source : JICA Study Team

B2.6 Technical Evaluation and Risk Analysis for the Project

Three (3) options were proposed for mid-term facility improvement plan for Honiara water supply system in this report as shown in Table B2.3-1. Technical evaluation was done and social risk was examined for each option as follows;

B2.6.1 Technical Evaluation

(1) Water Intake Volume from Konglai Spring

Technical evaluation related to the water intake volume from Konglai Spring is done because it is unstable as a major water source as mentioned below.

Konglai Spring is located in the customary land, on which 40% of the total water production of Honiara is depended upon in this option, has experienced frequent blockages of the inflow points in the catchment area (that is called "sinkhole"). There are 4 large sinkholes in the catchment area of Konglai Spring. Main sinkholes are located about 2km from the spring and in a large catchment area of the customary land. It is very difficult for SIWA to do maintenance of the sinkholes because SIWA staff cannot reach to the sinkholes without permission of the landowners. It is a big obstacle for SIWA's management and therefore SIWA is desirous of shifting water sources from the spring in the customary land to new boreholes inside the town boundary.

Blockage has been occurred six (6) times for the past ten (10) years from 1995 to 2005 by heavy rain or vandalism. The latest blockage happened after the heavy rain at the beginning of October 2005 and the water intake volume from the spring decreases to about 40% of the normal condition. Water shortages have occurred in many places of the city. At the moment (the end of April 2006), it is uncertain when the blockage will be removed and Konglai Spring will be restored. Rationing of water supply is now executed in the western half of the city and therefore the residents suffer from insufficient water supply.

In consideration of the above-mentioned circumstances, technical evaluation related to the water intake volume from Konglai Spring was done for each option. The evaluation results are shown in Table B2.6-1 below.

Table B2.6-1 Technical Evaluation

Option	Ratio to Total Water Distribution in Honiara (2010)	Ratio to Total Intake Volume from Konglai Spring (2010)	Comment	Technical Evaluation
J-1	14%	35%	Even if blockage occurs in Konglai Spring and the recover is not possible, required water volume can be taken from the spring because the base flow from the spring is about 40% of the normal situation. Therefore, there is no technical problem in terms of securing required water intake volume in this option.	A
J-2	40%	100%	40% of water demand in Honiara depends on Konglai Spring. When Konglai Spring is blocked, the influence on the water supply system is large. Therefore, this option has much disadvantage.	C
J-3	17%	43%	The risk is similar to Option J-1. Even if blockage occurs in Konglai Spring and the recover is not possible, required water volume can be taken from the spring. Therefore, there is no technical problem in terms of securing required water intake volume in this option.	A

Category of Risk A : Low B : Medium C : High
Source : JICA Study Team

(2) Groundwater Development

In formulation of groundwater development plan for the above three options, not only groundwater development potential but also technical issues below shall be evaluated.

- Impact to groundwater use other than SIWA
- Land subsidence by over pumping
- Sea water intrusion

After the evaluation of the above issues, there are no technical disadvantages related to the groundwater development in all options as mentioned below;

(a) Impact to groundwater use other than SIWA

It is only SIWA that uses groundwater in large scale in Honiara City. Other than SIWA, there are few private owners of boreholes. Hand-dug well is not used in Honiara city. Therefore, impact by new groundwater development may be negligible on the groundwater use other than SIWA. Pumping-up of groundwater will cause lowering groundwater level that will bring about decrease and drying-up of spring water. Therefore, long-term monitoring of spring water is necessary especially in Kombito area. Following results of the monitoring, pumping rate form boreholes should be carefully controlled.

(b) Land Subsidence

Land subsidence occurs by consolidation of alluvial soft clay due to over-pumping. Pumping-up of groundwater from alluvial sand-layer will cause consolidation of the overlying clayey-layer. In Honiara city, alluvial sand-layer is distributed only in the narrow area along the coast. Currently the

groundwater is not pumped up from sand-layer, and it will not even in the future. Considering geological situation above, land subsidence is not likely to take place in the future. However, long-term monitoring on land-subsidence is necessary along the coast.

(c) Sea Water Intrusion

Pumping-up from boreholes in the coastal area is likely to cause sea water intrusion into aquifer. Possibility of sea water intrusion depends on i) distance between the sea and boreholes, ii) yield from boreholes and iii) amount of groundwater that is naturally flowing in aquifer. Therefore, it is necessary to design proper yield and well location to prevent sea water intrusion. For this design, relationship shown in Table B1.3-11 is applicable. It is concluded that the sea water intrusion will not occur if yield from a borehole is kept less than 800m^3/day, and this borehole is located at farther than 1km from the shoreline.

Implementation of long-term and periodic monitoring is important to detect the impact and to formulate countermeasure to mitigate impact. Items to be monitored are listed in Table B2.6-2.

Table B2.6-2 Items to be Monitored in Groundwater Development

Technical Issue	Evaluation	Item for monitoring
a) Impact to groundwater use other than SIWA	Negligible	Groundwater level
b) Land Subsidence	Negligible	Land elevation
c) Sea Water Intrusion	Negligible	Water quality (salinity)

Source : JICA Study Team

B2.6.2 Social Risks

(1) Relationship with Customary Landowners

One of the social risks is the relation with the customary landowners. It has been examined in each option as follows.

Table B2.6-3 Risk for Relation with Customary Landowners

Option	Risk	Evaluation
J-1	1. By shifting substantial amount of water from Konglai Spring to the new groundwater within the town boundary, SIWA will face some problems with the landowners of the Konglai Spring area. Raising unit price of current water right fee is considered as one of the risks. 2. For the new boreholes development, there will be risks as follows; ➢ Land lease will not be permitted by the land owners ➢ It will be permitted but at an exorbitant lease price.	C
J-2	1. No change of relation with the land owners of Konglai Spring area. So there is no risk for Konglai Spring. Risk for development of new boreholes is almost the same as other options.	B
J-3	Similar to Option J-1.	C

Category of Risk A : Low B : Medium C : High
Source : JICA Study Team

<u>Negotiation with landowners</u>

Currently the Government does payment for water-right to landowners. Even though duty of payment is transferred from the Government to SIWA in the future, SIWA will manage to pay it. Payment for water right may be small compared with O/M cost for water supply such as electricity cost. Burden of payment for water right is not the main motive for SIWA to convert water sources from Konglai Spring to the groundwater. Instability of Konglai Spring is main motive for conversion. However, less expensive payment for water-right will contribute to improvement of financial state of SIWA. In

negotiation with the landowners, SIWA should act as listed below.

- The contract will continue until 2005, SIWA must continue payment for land lease regardless of use of Konglai Spring to avoid trouble with the landowners.
- There is high possibility that the landowners will increase charge for land-lease and water-right to compensate reduction in income due to reduction in intake of water from Konglai Spring.
  - SIWA should negotiate with landowners claiming that payment is only for land-lease and not for water-right
  - SIWA should insist that charge for land-lease should be based on official land evaluation,
  - SIWA should try to make payment less expensive and constant for long-term.
  - SIWA should explain to landowners the future plan that intake of water from Konglai Spring will be gradually reduced. It will contribute for SIWA to get concession form the landowners.

Without above claim, it is likely that charge for water-right will be easily increased in the future, and other landowner will follow the example of Konglai Spring.

- The landowner expects regular income from Konglai Spring. Sudden decrease in income will make landowner to complain and feel uneasy, which will lead to instability of water supply by SIWA. Therefore, sudden decrease in payment to the landowner should be avoided. According to Mid-term Improvement Plan by this Study, water intake from Kongali Spring must be continued even though intake rate will be reduced. Then, SIWA has to avoid trouble with the landowners, with flexible correspondence to request from the landowners on increase in payment.

(2) Security of Infrastructure

In the light of the social unrest on Guadalcanal occurred from 2000 to 2003, further acts of sabotage and interference with sources and storage tanks that are located in customary lands cannot be ruled out. Continued reliance on Konglai Spring as the main source of water is assessed as a major and unacceptable risk. The security of the project is assessed as follows;

Table B2.6-4 Risk for Security of Infrastructure

Option	Risk	Evaluation
J-1	Major sources are located within the town boundary so that the security risk is assessed as low.	A
J-2	In this option, Konglai Spring is still the major source. Therefore, the security risk is assessed as high.	C
J-3	Major sources are located within the town boundary so that the security risk is assessed as low.	A

Category of Risk A : Low B : Medium C : High
Source : JICA Study Team

B2.7 Project Evaluation

The project evaluation is aiming at selection of the water supply system in Honiara to be the most practical one for SIWA from viewpoints of viability.

The project evaluation is also made by risk analysis in addition to financial analysis. Financial analysis is made for these 3 alternatives (Option J-1, J-2 and J-3) of water supply system in Honiara.

Evaluation indicators are normally demonstrated by the Internal Rate of Return (IRR), Net Present Value (NPV), and Benefit-Cost Ratio (B/C) to which the Notes mentioned below shall be referred.

(Notes)

1. The Internal Rate of Return (IRR): The internal rate of return of a project is defined as that discount rate which equates the present values of the project's benefits and costs, so that the net present value is zero. The decision rule for the IRR criterion is: accept the project if IRR is

greater than or equal to relevant discount rate; reject if otherwise. In the case of competing projects, select the project with the highest IRR.

2. Net Present Value (NPV): Net present value is defined as the difference between the present values of project benefits and project costs. The decision rule for the NPV criterion is: accept projects with greater than or equal to 0, and reject if otherwise. In the case of competing projects, select the project with the highest NPV.
3. Benefit-Cost Ratio (B/C): The benefit-cost ratio is the ratio of the present value of gross benefits to the present value of gross costs. The decision rule is: accept projects with B/C greater or equal to 1; reject it otherwise. In the case of competing projects, select the project with the highest B/C.

B2.7.1 Preconditions

Financial analysis is made on the basis of the following preconditions.

(1) Scope of Analysis

A Comparison between newly incremental benefit and cost generated from the project to be implemented is made at the year 2005 price. Financial analysis is carried out for 3 alternatives (Option J-1, J-2 and J-3).

The scope of analysis is financial comparison between newly incremental revenue and expenditure with project A benefit and cost generated from existing facilities are excluded for the comparison of project profitability as deemed as a sunk cost, because of this project is not new one, rehabilitation project.

(2) Benefit

It is assumed that the project benefit is to be i) newly generated water sales by increasing number of users and water consumption unit, ii) saving of water production cost for water leakage, and iii) reduction of land lease fee for customary land.

(a) Incremental water sales

Incremental water sales after implementation of the Project (With Project).is assumed by water demand (revenue water) and average water unit price (assumed price).

1) Revenue water

Revenue water is estimated by incremental water demand and revenue water ratio by year as shown in Table B2.7-1.

Table B2.7-1 Revenue Water in Honiara

Indicators	FY 2005	FY 2010	FY2016
A) Daily Maximum Water Demand (m^3/day) [1)]	25,719	30,587	31,948
B) Revenue Water Ratio (%) [2)]	57%	57%	70%

Notes: 1. Refer to Table G4-1.
2. Refer to Table G1-3.

Source : JICA Study Team

a) Average water unit price

Average water unit price is assumed by water demand proportion for domestic and commercial customers and government facilities in accordance with the preset tariff rate.

Table B2.7-2 Average Water Unit Price for Financial Analysis

Category	Average water unit price in FY2005 1)	Water demand proportion in FY2016 2)	Assumed unit price
Domestic	SI$1.58/m^3	62%	SI$0.98/m^3
Commercial/Government	SI$7.14/m^3	38%	SI$2.71/m^3
Weighed average unit price	SI$4.31/m^3	100%	SI$3.69/m^3

Notes: 1) Average water unit price at the 2005 is that water billed .amount is divided by water sales unit per category.
2) Water demand proportion at the 2016 is based on water demand per category.
Source : JICA Study Team

2) Saving of water production cost by leakage reduction

It is expected that water leakage will be reduced after implementation of the project (from the 2011 onward). Saving of water production cost is assumed as project benefit of which reduction of operation cost i.e., electricity, chemical materials for chlorination

Reduction of leakage : 11,569 m^3/day (in FY2011) – 12,131m^3/day (in FY2010) = －562m^3/day

3) Reduction of land lease fee

It should be considered that reduction or increment of land lease fee dealing with a benefit or cost, if this fee is to be changed by option.

At the Skyline tank, the water from Mataniko source and that from Konglai source is merged and mixed. Total water from Mataniko and Konglai source is 125,600m^3 per month. The total amount of water from Konglai has been calculated by SIWA based on the water consumption amounting to 60,800m^3 per month equivalent to SI$114,000. 25% of consumption due to tribe amounts to SI$28,500 per month are being paid by the Department of Land and Survey on behalf of SIWA.

Intake ratio from Konglai source and contribution ratio for the Project is shown in Table B2.7-4.

Table B2.7-3 Intake ratio from Konglai source by option

Option	Ratio to Intake water volume from Konglai Spring in 2010	Contribution ratio for the Project (Benefit ratio)
J-1	35%	65%
J-2	100%	0%
J-3	43%	63%

Source : JICA Study Team

(3) Project Costs

Project costs is consisting of initial cost as capital cost in order to upgrade existing water supply system in Honiara and operation and maintenance (O & M) cost for upgraded facilities, not including sewerage and water supply system in provincial centers.

(a) Capital cost

Capital cost of 3 Option is estimated as shown in Table B2.7-4. Option J-1 is the most expensive one and Option J-2 is the lowest one. The cost difference is approximately 18% between Option J-1 and J-2.

According to the project implementation program, investment schedule is from FY2007 to FY2010 as shown in Table B2.7-9 Discounted Cash Flow Worksheet. It should be considered replacement cost of submergible bore pumps at water source and pumping stations after 15 years. Initial and replacement costs by option are shown as follows.

Table B2.7-4 Capital Cost by Option

Project		Capital Cost (US$)	Capital Cost (SI$)
Option J-1	Initial Cost	7,236,306	50,654,142
	Replacement Cost	786,324	5,504,268
Option J-2	Initial Cost	6,097,485	42,682,395
	Replacement Cost	331,112	2,317,784
Option J-3	Initial Cost	6,514,158	45,599,106
	Replacement Cost	630,243	4,411,701

Note: 1US dollar is equivalent to SI$7.0
Source : JICA Study Team

(b) Operation and Maintenance (O & M) cost

O & M cost of each option is comparing with newly incremental cost with Project and Without Project. O & M cost is consisting of electricity cost at each pumping station, operation and maintenance cost of existing assets and is estimated in section B2.5.1 as shown in Table B2.7-5.

Table B2.7-5 Annual O & M Cost by Option

Project	a) Electricity Cost (US$)	b) System Maintenance Cost (US$)	c) Total Cost (a+b) (US$)	d) Newly Incremental Cost (Total Cost -Without Project)	
				(US$)	(SI$)
Without Project	611,495	406,700	1,018,195	0	0
Option J-1	998,012	572,278	1,570,290	552,095	3,864,665
Option J-2	846,733	643,991	1,490,724	472,529	3,307,703
Option J-3	1,009,082	618,963	1,628,045	609,850	4,254,950

Note: 1US dollar is equivalent to SI$7.0
Source : JICA Study Team

(4) Discount Rate

According to "CBSI Annual Report", the weighted average indicative interest rates for deposits of commercial banks widened from 13.48% in 2003 to 13.74% in 2004. Commercial bank's lending rate is some 16% p.a.
In this Study, it is adopted the following discount rates for the case study of financial analysis.

Table B2.7-6 Case Study of Discounted Rate

Discount Rate	Remarks
10.0%	The discount rate is normally adopted 10%-12% p.a. for the Project evaluation, in this case, it is adopted discount rate 10% p.a. for the case study.
3.5%	The weighted average rate is assumed to be 3.5% p.a. discount rate based on assumption of foreign soft loan with 1.6% p.a. for 80% of total project cost from international organization, etc. and domestic commercial loan with 16% p.a. for 20% of total project cost
1.0%	The weighted average rate is assumed to be 1.0% p.a. discount rate based on assumption of foreign grant aids for 95% of total project cost from international organization, etc.and domestic commercial loan with 16% p.a. for 5% of total project cost

Source : JICA Study Team

B2.7.2 Project Evaluation Results

(1) Evaluation by Financial Analysis

Financial indicators such as Net Present Value (NPV), Benefit-Cost Ratio (B/C) and Internal Rate of Return (IRR) of the Option J-1, 2 and 3 are examined by cash flow analysis as shown in Table B2.7-7 (for the discounted cash flow worksheet, refer to Table B2.7-9, B2.7 -10 and B2.7-11).

In case the discount rate 10%, NPV and B/C ratio of 3 options show all negative. In case the discount

rate 3.5%, all the options show positive indicators. Thus, it can be concluded that Option J-2 is profitable project in terms of financial analysis when they are implemented through either foreign soft loan or foreign grant aid.

Table B2.7-7 Evaluation by Financial Analysis

Option	Discount Rates	NPV (SI$'000)	B/C	IRR	Evaluation
J-1	10.0%	-9,322	0.72	7.2%	B
	3.5%	24,167	1.59		
	1.0%	54,165	2.23		
J-2	10.0%	-958	0.97	9.7%	A
	3.5%	37,369	2.09		
	1.0%	70,778	2.90		
J-3	10.0%	-7.894	0.74	7.5%	B
	3.5%	23,974	1.65		
	1.0%	52,451	2.32		

A : Much profitable B : Less profitable than A C : Not profitable
Source : JICA Study Team

(2) Evaluation by Risk Analysis

As mentioned above, Option J-2 has been selected as the most profitable project by the financial analysis. However, evaluation by risk analysis should also be considered as explained in B2.6:

(3) Overall Evaluation

The overall evaluation through financial analysis and risk analysis is as shown in Table B2.7-8. Although Option J-1 and J-3 have the same mark, Option J-1 is considered more favorable because it is less ratio to the total intake volume from Konglai Spring and less O & M cost than J-3. Therefore, it was concluded that Option J-1 is the most viable project among 3 options.

Table B2.7-8 Result of Overall Evaluation

Option	Financial Evaluation	Technical Evaluation	Evaluation by Social Risk		Overall Evaluation (Rank)
			Relation with Landowner	Security of Infrastructure	
Weight	1.0	1.0	0.5	0.5	
J-1	B (2)	A (3)	C (0.5)	A (1.5)	1 (7.0)
J-2	A (3)	C (1)	B (1.0)	C (0.5)	3 (5.5)
J-3	B (2)	A (3)	C (0.5)	A (1.5)	2 (7.0)

Note : Figure in ( ) shows a mark for each rank, 3 for A, 2 for B and 1 for C.
Source : JICA Study Team

Table B2.7-9 Discounted Cash Flow Worksheet (Option J-1)

		A.Water Sales Unit (m3)			B. Benefit Stream (SI$ 1,000)				C: Cost Stream (SI$ 1,000)			Balance (B-C)	D. Net Present Value (SI$ 1,000)				
No	Year	a) Without Project	b) With Project	c) Newly Incremental Water Unit (b-a)	Incremental Water Sales	Saving of Costs	Land Lease Fee	Total	Capital Cost	O & M Cost	Total		Discount Rate= 10%	Discount Rate= 3.5%	Discount Rate= 1.0%		
0	2005	5,351		0				0			0	0	0	0	0		
1	2006	5,351		0				0			0	0	0	0	0		
2	2007	5,351		0				0	5,065		5065	-5,065	-4,186	-4,729	-4,966		
3	2008	5,351		0				0	20,262		20262	-20,262	-15,223	-18,275	-19,666		
4	2009	5,351		0				0	20,262		20262	-20,262	-13,839	-17,657	-19,471		
5	2010	5,351		0				0	5,065	3,865	8930	-8,930	-5,545	-7,519	-8,497		
6	2011	5,351	6,608	1,257	4,638	757	222	5,617		3,865	3865	1,752	989	1,425	1,650		
7	2012	5,351	6,867	1,516	5,595	757	222	6,574		3,865	3865	2,709	1,390	2,129	2,527		
8	2013	5,351	7,140	1,789	6,600	757	222	7,580		3,865	3865	3,715	1,733	2,821	3,430		
9	2014	5,351	7,426	2,075	7,658	757	222	8,637		3,865	3865	4,772	2,024	3,502	4,364		
10	2015	5,351	7,729	2,378	8,774	757	222	9,753		3,865	3865	5,888	2,270	4,174	5,330		
11	2016	5,351	8,163	2,812	10,375	757	222	11,354		3,865	3865	7,489	2,625	5,130	6,713		
12	2017	5,351	8,163	2,812	10,376	757	222	11,356		3,865	3865	7,491	2,387	4,957	6,647		
13	2018	5,351	8,163	2,812	10,376	757	222	11,356		3,865	3865	7,491	2,170	4,789	6,582		
14	2019	5,351	8,163	2,812	10,376	757	222	11,356		3,865	3865	7,491	1,972	4,628	6,516		
15	2020	5,351	8,163	2,812	10,376	757	222	11,356		3,865	3865	7,491	1,793	4,471	6,452		
16	2021	5,351	8,163	2,812	10,376	757	222	11,356		3,865	3865	7,491	1,630	4,320	6,388		
17	2022	5,351	8,163	2,812	10,376	757	222	11,356		3,865	3865	7,491	1,482	4,174	6,325		
18	2023	5,351	8,163	2,812	10,376	757	222	11,356		3,865	3865	7,491	1,347	4,033	6,262		
19	2024	5,351	8,163	2,812	10,376	757	222	11,356	5,504	3,865	9369	1,987	325	1,033	1,644		
20	2025	5,351	8,163	2,812	10,376	757	222	11,356		3,865	3865	7,491	1,113	3,764	6,139		
21	2026	5,351	8,163	2,812	10,376	757	222	11,356		3,865	3865	7,491	1,012	3,637	6,078		
22	2027	5,351	8,163	2,812	10,376	757	222	11,356		3,865	3865	7,491	920	3,514	6,018		
23	2028	5,351	8,163	2,812	10,376	757	222	11,356		3,865	3865	7,491	837	3,395	5,958		
24	2029	5,351	8,163	2,812	10,376	757	222	11,356		3,865	3865	7,491	760	3,281	5,899		
25	2030	5,351	8,163	2,812	10,376	757	222	11,356		3,865	3865	7,491	691	3,170	5,841		
Total					188,908	15,139	4,446	208,493	56,158	81,165	137,323	71,170	-9,322	24,167	54,165	IRR	7.2%
												B/C	0.72	1.59	2.23		

Source : JICA Study Team

Table B2.7-10 Discounted Cash Flow Worksheet (Option J-2)

		A.Water Sales Unit (m3)			B. Benefit Stream (SI$ 1,000)				C: Cost Stream (SI$ 1,000)			Balance (B-C)	D. Net Present Value (SI$ 1,000)				
No	Year	a) Without Project	b) With Project	c) Newly Incremental Water Unit (b-a)	Incremental Water Sales	Saving of Costs	Land Lease Fee	Total	Capital Cost	O & M Cost	Total		Discount Rate= 10%	Discount Rate= 3.5%	Discount Rate= 1.0%		
0	2005	5,351		0				0			0	0	0	0	0		
1	2006	5,351		0				0			0	0	0	0	0		
2	2007	5,351		0				0	4,268		4,268	-4,268	-3,527	-3,984	-4,184		
3	2008	5,351		0				0	17,073		17,073	-17,073	-12,827	-15,399	-16,571		
4	2009	5,351		0				0	17,073		17,073	-17,073	-11,661	-14,878	-16,407		
5	2010	5,351		0				0	4,268	3,308	7,576	-7,576	-4,704	-6,379	-7,208		
6	2011	5,351	6,608	1,257	4,638	757	0	5,395		3,308	3,308	2,087	1,178	1,697	1,966		
7	2012	5,351	6,867	1,516	5,595	757	0	6,352		3,308	3,308	3,044	1,562	2,392	2,839		
8	2013	5,351	7,140	1,789	6,600	757	0	7,357		3,308	3,308	4,049	1,889	3,075	3,739		
9	2014	5,351	7,426	2,075	7,658	757	0	8,415		3,308	3,308	5,107	2,166	3,747	4,670		
10	2015	5,351	7,729	2,378	8,774	757	0	9,531		3,308	3,308	6,223	2,399	4,412	5,633		
11	2016	5,351	8,163	2,812	10,375	757	0	11,132		3,308	3,308	7,824	2,742	5,359	7,013		
12	2017	5,351	8,163	2,812	10,376	757	0	11,133		3,308	3,308	7,825	2,493	5,179	6,944		
13	2018	5,351	8,163	2,812	10,376	757	0	11,133		3,308	3,308	7,825	2,267	5,003	6,876		
14	2019	5,351	8,163	2,812	10,376	757	0	11,133		3,308	3,308	7,825	2,061	4,834	6,808		
15	2020	5,351	8,163	2,812	10,376	757	0	11,133		3,308	3,308	7,825	1,873	4,671	6,740		
16	2021	5,351	8,163	2,812	10,376	757	0	11,133		3,308	3,308	7,825	1,703	4,513	6,674		
17	2022	5,351	8,163	2,812	10,376	757	0	11,133		3,308	3,308	7,825	1,548	4,360	6,607		
18	2023	5,351	8,163	2,812	10,376	757	0	11,133		3,308	3,308	7,825	1,407	4,213	6,542		
19	2024	5,351	8,163	2,812	10,376	757	0	11,133	2,318	3,308	5,626	5,507	900	2,865	4,559		
20	2025	5,351	8,163	2,812	10,376	757	0	11,133		3,308	3,308	7,825	1,163	3,933	6,413		
21	2026	5,351	8,163	2,812	10,376	757	0	11,133		3,308	3,308	7,825	1,057	3,800	6,350		
22	2027	5,351	8,163	2,812	10,376	757	0	11,133		3,308	3,308	7,825	961	3,671	6,287		
23	2028	5,351	8,163	2,812	10,376	757	0	11,133		3,308	3,308	7,825	874	3,547	6,224		
24	2029	5,351	8,163	2,812	10,376	757	0	11,133		3,308	3,308	7,825	794	3,427	6,163		
25	2030	5,351	8,163	2,812	10,376	757	0	11,133		3,308	3,308	7,825	722	3,311	6,102		
Total					188,908	15,139	0	204,047	45,000	69,468	114,468	89,579	-958	37,369	70,778	IRR	9.7%
												B/C	0.97	2.09	2.90		

Source : JICA Study Team

Table B2.7-11 Discounted Cash Flow Worksheet (Option J-3)

		A.Water Sales Unit (m3)			B. Benefit Stream (SI$ '000)				C: Cost Stream (SI$ '000)			Balance (B-C)	D. Net Present Value (SI$ '000)				
No	Year	a) Without Project	b) With Project	c) Newly Incremental Water Unit (b-a)	Incremental Water Sales	Saving of Costs	Land Lease Fee	Total	Capital Cost	O & M Cost	Total		Discount Rate= 10%	Discount Rate= 3.5%	Discount Rate= 1.0%		
0	2005	5,351		0				0			0	0	0	0	0		
1	2006	5,351		0				0			0	0	0	0	0		
2	2007	5,351		0				0	4,560		4560	-4,560	-3,769	-4,257	-4,470		
3	2008	5,351		0				0	18,240		18240	-18,240	-13,704	-16,451	-17,703		
4	2009	5,351		0				0	18,240		18240	-18,240	-12,458	-15,895	-17,528		
5	2010	5,351		0				0	4,560	4,255	8815	-8,815	-5,473	-7,422	-8,387		
6	2011	5,351	6,608	1,257	4,638	757	195	5,589		4,255	4255	1,334	753	1,086	1,257		
7	2012	5,351	6,867	1,516	5,595	757	195	6,547		4,255	4255	2,292	1,176	1,801	2,137		
8	2013	5,351	7,140	1,789	6,600	757	195	7,552		4,255	4255	3,297	1,538	2,504	3,045		
9	2014	5,351	7,426	2,075	7,658	757	195	8,610		4,255	4255	4,355	1,847	3,195	3,982		
10	2015	5,351	7,729	2,378	8,774	757	195	9,726		4,255	4255	5,471	2,109	3,878	4,953		
11	2016	5,351	8,163	2,812	10,375	757	195	11,327		4,255	4255	7,072	2,479	4,844	6,339		
12	2017	5,351	8,163	2,812	10,376	757	195	11,328		4,255	4255	7,073	2,254	4,681	6,277		
13	2018	5,351	8,163	2,812	10,376	757	195	11,328		4,255	4255	7,073	2,049	4,523	6,215		
14	2019	5,351	8,163	2,812	10,376	757	195	11,328		4,255	4255	7,073	1,863	4,370	6,153		
15	2020	5,351	8,163	2,812	10,376	757	195	11,328		4,255	4255	7,073	1,693	4,222	6,092		
16	2021	5,351	8,163	2,812	10,376	757	195	11,328		4,255	4255	7,073	1,539	4,079	6,032		
17	2022	5,351	8,163	2,812	10,376	757	195	11,328		4,255	4255	7,073	1,399	3,941	5,972		
18	2023	5,351	8,163	2,812	10,376	757	195	11,328		4,255	4255	7,073	1,272	3,808	5,913		
19	2024	5,351	8,163	2,812	10,376	757	195	11,328		4,255	4255	7,073	1,157	3,679	5,855		
20	2025	5,351	8,163	2,812	10,376	757	195	11,328	4,411	4,255	8666	2,662	396	1,338	2,182		
21	2026	5,351	8,163	2,812	10,376	757	195	11,328		4,255	4255	7,073	956	3,435	5,739		
22	2027	5,351	8,163	2,812	10,376	757	195	11,328		4,255	4255	7,073	869	3,318	5,683		
23	2028	5,351	8,163	2,812	10,376	757	195	11,328		4,255	4255	7,073	790	3,206	5,626		
24	2029	5,351	8,163	2,812	10,376	757	195	11,328		4,255	4255	7,073	718	3,098	5,571		
25	2030	5,351	8,163	2,812	10,376	757	195	11,328		4,255	4255	7,073	653	2,993	5,515		
Total					188,908	15,139	3,899	207,945	50,010	89,355	139,365	68,580	-7,894	23,974	52,451	IRR	7.5%
												B/C	0.74	1.65	2.32		

Source : JICA Study Team

B2.8 Project Implementation Program

Mid term facility improvement plan shall include following projects with priority.

Priority-1 : Improvement of water supply system in Honiara

Priority-2 : Improvement of water supply system in Auki
(The improvement plan for Auki is described in PART C.)

Priority-3 : Improvement of sewerage system in Honiara

Based on the priority, project implementation program is formulated as shown in Table B2.8-1.

Table B2.8-1 Project Implementation Program

(unit : x 1000US$)

No.	Project	Investment Amount	2006	2007	2008	2009	2010	2011
1	Improvement of water supply system in Honiara (Option J-1)	7,240		1,020	2,600	2,600	1,020	
2	Improvement of water supply system in Auki	330				330		
3	Improvement of sewerage system in Honiara	2,810				670	2,140	
	Investment Amount - Total Accumulated	10,380		1,020	2,600	3,600	3,160	

Source : JICA Study Team

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PART C

PROVINCIAL CENTERS WATER SUPPLY AND SEWERAGE

PART C PROVINCIAL CENTERS WATER SUPPLY AND SEWERAGE

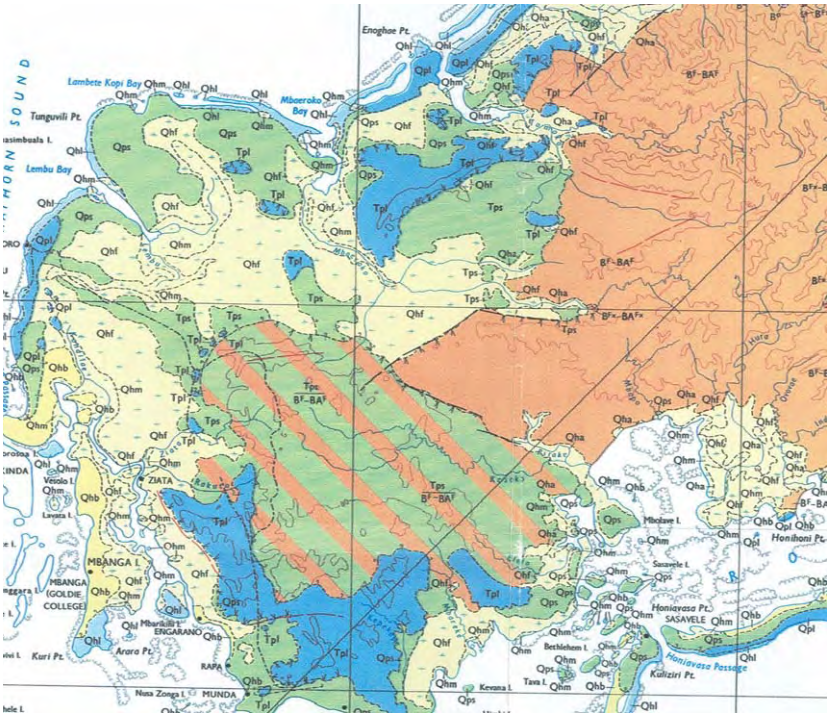
C1 NORO

C1.1 Existing Conditions

(1) Natural Conditions

(a) Topography and geology

Noro is located in marine terrace. Limestone of coral reef in the Tertiary forms the narrow terrace extending along the coast. There is swampy low land behind the terrace, where natural water drainage system is undeveloped. Sediments of this low land comprise reef lagoon deposit overlaid with swamp deposit such as clay and silt. Residential area of Noro is distributed in the top and the slope of the terrace. Inland area of Noro shows hilly terrain with gentle slope comprising limestone and the other sedimentary rocks of the Tertiary, where little outcrops are seen due to thick forest.



Legend

Formation		Mark	Age
Alluvium, swamp, mangrove, beach deposit		Qh,Qhf,Qhm	Holocene
Limestone		Qhl	
Roviana Formation	Limestone	Qpl	Pleistocene
	Sand, clay	Qps	
	Limestone	Tpl	Pliocene
	Sand, clay	Tps	
Basalt-basaltic andesite lava		BF～BAF	Pliocene ～ Pleistocene

Source : JICA Study Team

Figure C1.1-1 Geological Map of Noro

(b) Climate

There is no long-term meteorological data in Noro. Instead, precipitation and temperature of Munda

(1996-2004) are shown in Annex-1. According to data, monthly temperature is the highest of 30.7 ℃, showing almost the same temperature throughout year with seasonal difference within 3℃. Annual precipitation is 3,607mm. Precipitation is the highest in March with 459mm, and it is the lowest in October with 218mm, showing enough precipitation throughout a year.

(2) Socio-economic Conditions

Noro is located in the western part of New Georgia Island, Western Province. Population in Noro is around 3,500. Major industry in Noro is fishing and private canned food company, Solomon Taiyo (Soltai). After the ethnic tension, public order is improved and private companies resume the business in Noro.

(3) Field Surveys

(a) Surface Water Survey

In Noro, Measurement was carried out only at intake point. No.1 is upstream area of intake, and No.2 is downstream area of it. Surface water discharge measurement points are shown in Figure C1.1-3 and Figure C1.1-2. The results of the Surface water discharge measurement are shown in Table C1.1-1. Discharge measurement was conducted in June to June 2005 in the dry season and November 2005 in the rainy season.

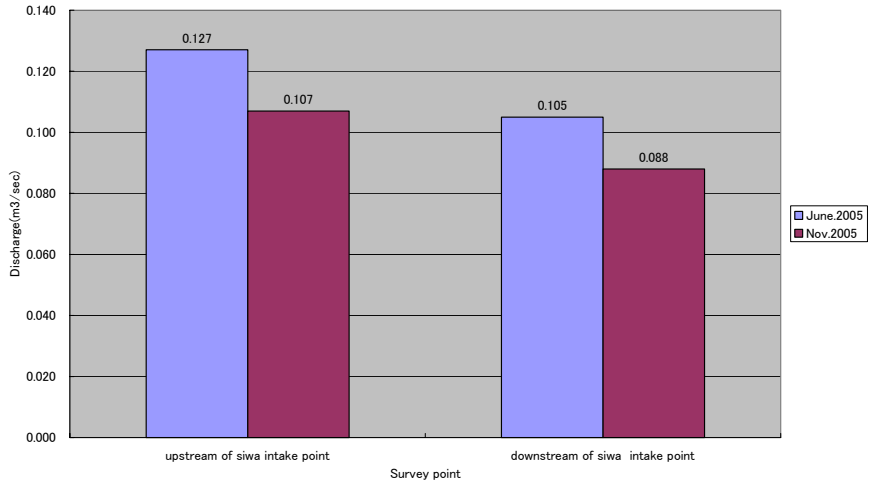
Water flow is 0.127m^3/s in June and 0.107m^3/s in November at No.1, and 0.105m^3/sin June and 0.088m^3/s in November at No.2. Difference of discharge is the water volume withdrawn into the pump station for the tap water of Noro area. River width is 3.4m and maximum depth is 0.23m at upstream part of intake, while width of the river is 3.5m and maximum depth is 0.16m at downstream part.

Discharge of the rainy season was slightly less than dry season.

Table C1.1-1 Results of Surface Water Discharge Measurement in Noro

Area	No	Name	Water flow (m^3/s)	Survey Date
Noro	No.1	Upstream area of SIWA intake point	0.127	9 Jun. '05
			0.107	30 Nov '05
	No.2	Downstream area of SIWA intake point	0.105	9 Jun. '05
			0.088	30 Nov '05

Source : JICA Study Team



Source : JICA Study Team

Figure C1.1-2 Results of Surface Water Discharge Measurement

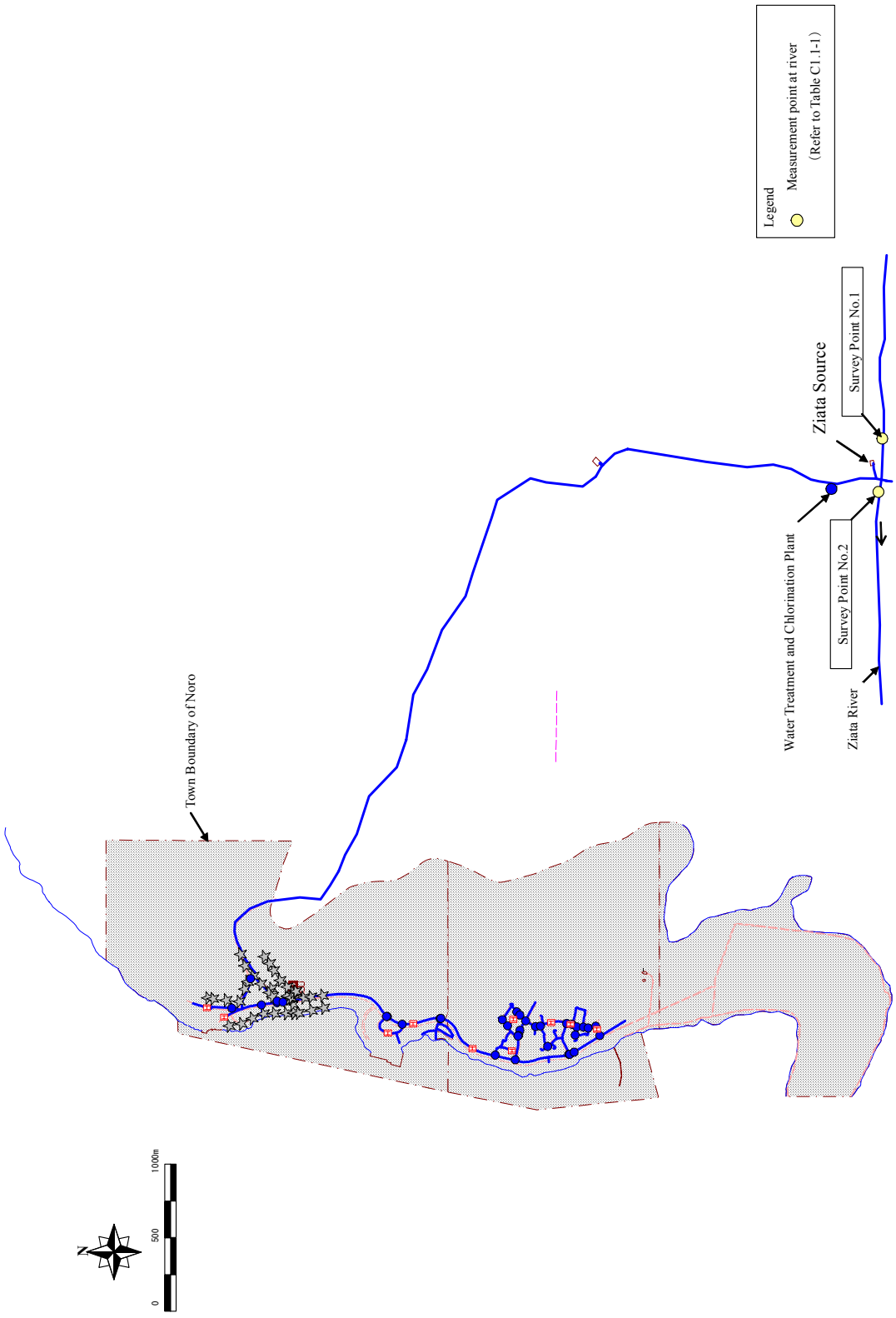


Figure C1.1-3 Surface Water Discharge Measurement Points in Noro

Source : JICA Study Team

(b) Groundwater Survey

1) Hydrogeology

Noro is located in coral reef limestone that extends along the narrow shoreline. This limestone is porous and highly permeable. It is possible to get groundwater from boreholes in the limestone area. However, limestone is distributed only in the narrow coastal area. Therefore, groundwater development in large scale is impossible. There is swamp area in the inland of Noro, where limestone disappears and only mudstone with low permeability is distributed.

2) Groundwater Development

If groundwater development is carried out within Noro town area, payment for water right will not be necessary, and problem for site acquisition will not happen. Limestone of the shoreline is attractive target for groundwater development. In the past, MME drilled 10 test boreholes around Noro, and they did study on hydrogeology (F.K.Buckley, 1979 - 1981). Hydrogelogical condition and possibility of new groundwater development were analyzed in this study. However, finally groundwater development in the area was abandoned due to the reason below.

- Limestone is distributed only along the shoreline in the narrow area with width of 300m. Limestone is replaced with mudstone in inland area next to Noro town area.
- Sea water seems intruding into the deep part of limestone. Thin lens of fresh water is floating over sea water within limestone body.
- Increase in pumping rate will easily cause increase in concentration of salinity of groundwater, which will immediately go out of drinkable level.

Groundwater development is impossible in limestone area where Noro is located, except for small scale development. In the current water supply system, water taken from Ziate River is distributed to Noro though purification plant and reservoir tank. Mudstone is distributed in site of the purification plant and reservoir tank. However, there is high possibility that mudstone is underlain with limestone and basaltic lava. This limestone and basaltic lava seems to have high permeability, and sufficient groundwater will be obtained from borehole if it is drilled in the site.

(c) Water Quality Survey

Water quality survey in Noro consists of field water quality survey at site and water quality analysis in the laboratory. Field water quality survey was conducted by the Study Team with cooperation of SIWA. Water quality analysis was conducted by SIWA in the laboratory.

Field water quality survey and water quality analysis were conducted from June to July 2005 for an investigation of surface water and ground water quality in the dry season, and November 2005 for an investigation in the rainy season.

1) Result of water quality survey

Field water survey points were selected from the upstream area and downstream area of the Ziata intake point.

The field water quality survey points and the water sampling points for water quality analysis are shown in Figure C1.1-6.

The results of the field water quality survey are shown in Table C1.1-2. The results of the DO measurement are shown in Figure C1.1-4 and the results of COD measurement are shown in Figure C1.1-5.

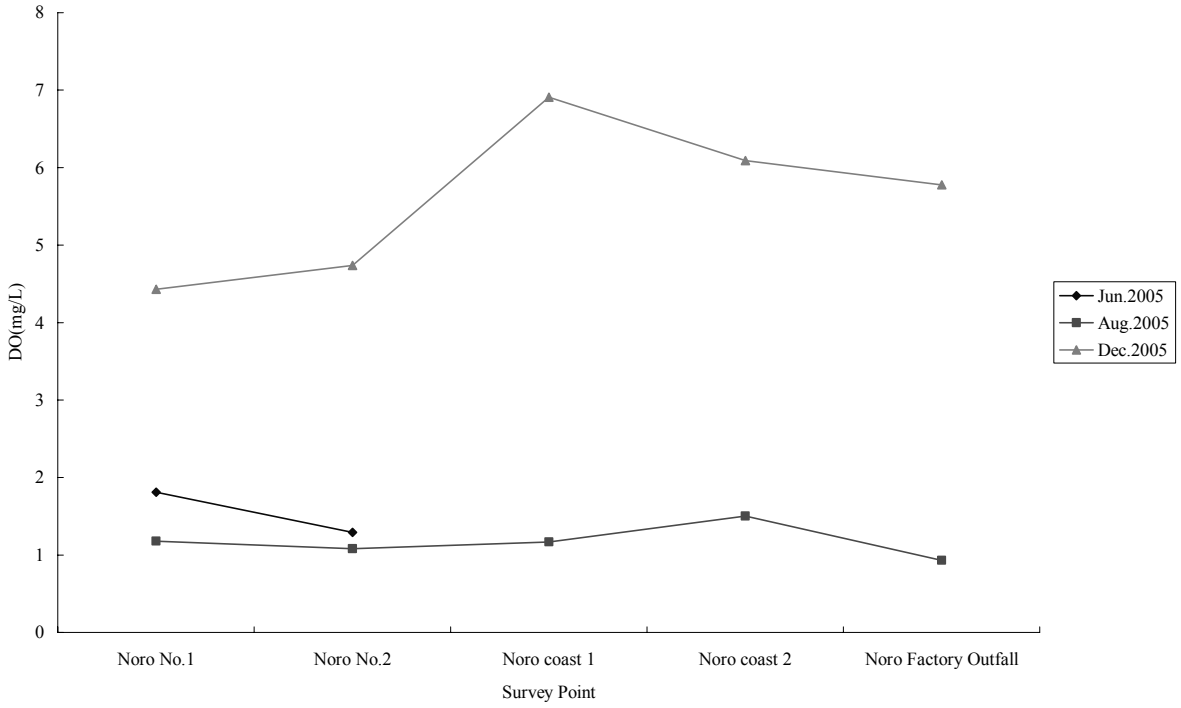
Table C1.1-2 Results of Field Water Quality Survey

Survey Month \ Survey Items		Water Temperature (℃)	Electric Conductivity (mS/m)	Turbidity (NTU)	pH	DO (mg/L)	COD (mg/L)
June.2005	No.1	25.4	10.0	8	7.6	1.81	-
	No.2	25.5	8.0	10	7.6	1.29	-
August 2005	No.1	25.1	8.2	10	7.4	1.18	6
	No.2	25.2	7.6	10	7.2	1.08	7
	Coast1	30.9	-	8	8.2	1.17	3
	Coast2	28.8	-	12	7.4	1.50	3
	Factory outfall	28.7	-	18	7.8	0.93	5
November 2005	No.1	25.9	11.5	1	6.1	4.43	9
	No.2	25.9	10.4	2	6.3	4.74	9
	Coast1	31.5	-	1	8.0	6.91	2
	Coast2	31.0	-	6	7.8	6.09	2
	Factory outfall	30.6	-	7	7.9	5.78	2

Source : JICA Study Team

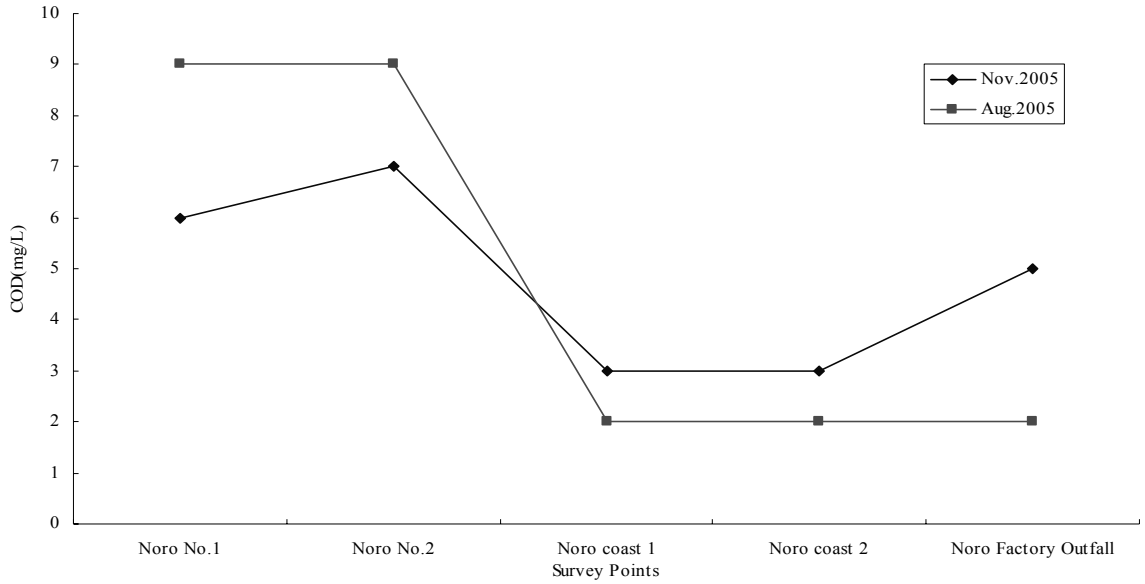
The result of field water quality survey is summarized as below.

- At survey point No.1 and No.2, each survey result did not show remarkable change.
- DO values at survey point No.1 and No.2 showed around 1mg/L in June and August 2005 in the dry season and in November 2005 in the rainy season, DO value around 4mg/L. Although the result of discharge measurement of the rainy season was less than June, less water contamination was found in the rainy season.
- COD value of survey points Coast1, Coast2 and Factory outfall (NORO taiyo) ranged from 3 to 5 in August 2005 and was 2mg/L in November 2005. COD value of Factory outfall ranged from 2 to 5. It is considered that this was caused by the wastewater drainage from the factory.



Source : JICA Study Team

Figure C1.1-4 Results of DO Measurement in Noro



Source : JICA Study Team

Figure C1.1-5 Results of COD Measurement in Noro

2) Results of water quality analysis in Lab

Water analysis samples were collected from upstream area of the Ziata intake point, tap of Noro and Noro Taiyo bore. Field water quality survey points and water sampling points for water quality analysis in laboratory are shown in Figure C1.1-6.The results of water quality analysis in lab are shown in Table C1.1-3.

Water Source:

The analysis results did not exceed WHO guideline value. Total Coliform Bacteria was 0(MPN/mL) at each sampling point.

Tap Water:

The analysis result did not exceed WHO guideline value. Total Coliform Bacteria was detected from the tap water.

3) Evaluation of Water Quality

Regarding water quality survey and analysis in White River, the evaluation can be summarized as below:

- According to the results of water quality analysis, tap water of Noro system has no problem.

Table C1.1-3 Results of Water Quality Analysis in Laboratory in Noro

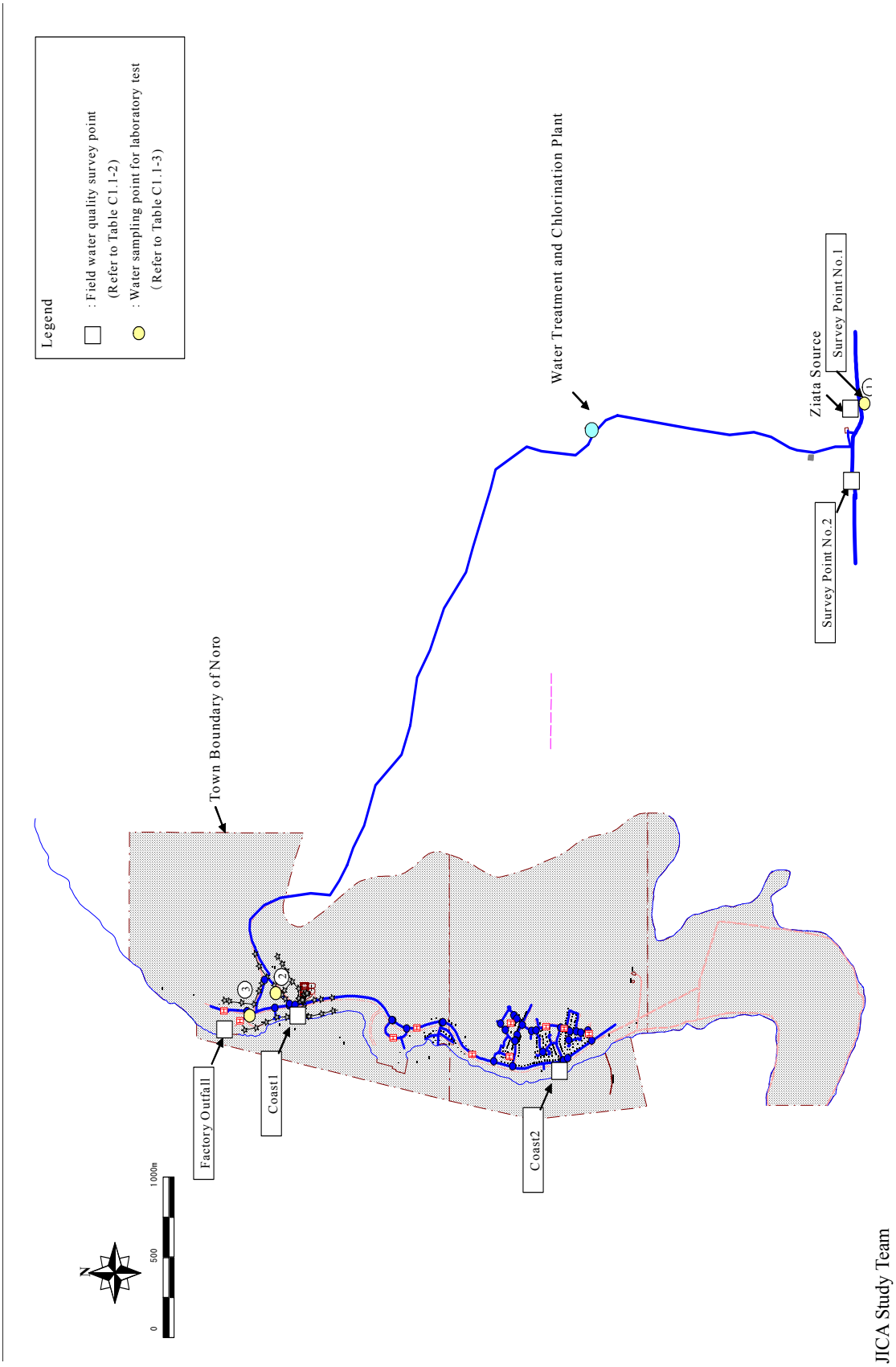
	WHO Guideline(3rd edition,2004)	Australia Drinking Water guideline(1996)	① Zinta River Intake	② Tap of SIWA Office	③ Existing Bore(Taiyo)
Source			○		○
Tap				○	
Nitrate	**50**	**50**	2.010	1.005	0.050
Nitrite	**3**	**3**	0.072	0.034	0.014
Nitorogen-ammonia	-	-	1.750	0.260	0.003
Mn	**0.4**	**0.5**	0.066	0.066	0.071
Fe	-	-	0.036	0.041	0.029
K	-	-	0.091	0.017	0.024
Total hardness	-	-	56.000	62.000	73.000
SO4	-	-	0.007	0.002	0.001
Cyanide	**0.07**	**0.08**	-	-	-
Zn	-		0.052	0.032	0.006
Cl2	-	-	0.000	0.400	0.000
Cl	**5**	**5**	0.005	0.015	0.022
F	**1.5**	**1.5**	0.017	0.013	0.008
Ca	-	-	23.000	31.000	46.000
Mg	-	-	27.000	27.000	22.000
Cu	**2**	**2**	0.032	0.032	0.002
Pb	**0.01**	**0.01**	0.000	0.000	0.000
As	**0.01**	**0.007**	-	-	-
P	-	-	0.140	0.110	0.000
Cr	**0.05**	**0.05**	0.008	0.005	0.015
I	-	-	0.001	0.001	0.000
Al	-	-	0.024	0.024	0.033
Benzotriazole	-	-	0.000	0.000	0.000
Phenol	-	-	0.000	0.000	0.000
Total Coliform			0.000	0.000	0.000

Note: unit of the above is as follows;
- MPN /mL for Total Coliform Bacteria
- mg/L for other items

Source : JICA Study Team

(d) Water Right

The Government is now under negotiation with landowners. The landowners request charges not for water right but for land-lease of water source. The negotiation is proceeding well, and it will be concluded in the near future. But it is still not clear whether the land will be sold or leased to SIWA. Water intake volume will be increased in the future following increased water demand. However, under the current contract, charges for water will be kept constant regardless of water intake volume.



Source : JICA Study Team

Figure C1.1-6 Field Water Quality Survey Points and Water Sampling Points for Water Quality Analysis in Laboratory in Noro

(d) Socio-economic Survey

In Solomon Islands, the employers such as Sol Taiyo generally pay the cost of housing, water, etc. of employees. Therefore, the percentage of living rent free is very high in Noro (57%), while the percentage of owner-occupied dwellings is relatively low. 60% of respondents live in the area for less than 5 years. Residential area is newly developed after ethnic tension, especially for private companies' employees. The average household size is smallest in the target area of the Study (5.0 persons). Major type of toilet is flush same as in Honiara and the other provincial centers. The number of paid workers per household is largest in the provincial centers (1.9 persons). The average monthly income is 2,170 Solomon Islands Dollars (SI$). It is almost same as that of low income households in Honiara (SI$2,007).

Regarding water supply, combination of piped water and rain tanks is major source of water supply. The ratio dependent on rainwater for drinking use is very high (80% of drinking water). The average water consumption volume is 173 L/d/HH (or 24LCD). This consumption is much less than the actual water consumption records of 197LCD, even taking into account the water losses inside the house. It is supposed that the interviewees misunderstood the questions from the surveyor of the Team or they believe to consume only such amount.

Over 50% of the households pay less than SI$50 per month for water supply. Almost half of households show the willingness to use the additional standing pipes and give the first priority to water for improvement of living conditions.

Major sewer system is septic tank. There is no sewer connection. Almost half of the households have the experiences of disease caused by drinking water. There are a few cases of skin infections by water in Noro because of wastewater from factories. All the respondents think that water source should be conserved in order to avoid contamination of water.

Monthly water bill averages SI$68.89, 3.2% in Noro. Willingness to pay (WTP) additionally for better water supply is SI$42.07. Total WTP is SI$110.96, 5.1% of average monthly income. However, ATP is SI$86.80 in Noro (4% of average monthly income), so that the tariffs should be set at less than ability to pay (ATP).

(4) Water Supply System

(a) Population and Served Ratio

According to the national census, the population of Noro in 1999 is 3,482 and 479 households. The population in 2005 is estimated as 4,109 and 563 households using annual growth rate in the whole Solomon of 2.8%.

Basic data for water supply by SIWA in Noro are as follows.

Table C1.1-4 Basic Data for Water Supply of Noro in 2005

Area	Water Source	April	May	June	Average		Remarks
NORO	Water distribution	61,800	60,600	58,900	**60,433**	m^3/month	
	Water distribution	2,060	2,164	1,963	**2,063**	m^3/day	
	Water sales	1,600	806	867	**1,091**	m^3/day	
	Water sales ratio	78	37	44	**53**	%	
	NRW ratio				**47**	%	
	Leakage ratio (*estimated*)				**40**	%	
	Water distributed - domestic use	824	866	785	**825**	m^3/day	
	Water distributed - commercial use	1,236	1,299	1,178	**1,238**	m^3/day	60% of total distribution
	Water consumption for domestic	494	519	471	**495**	m^3/day	
	Water consumption for commercial	742	779	707	**743**	m^3/day	
	Water distributed for domestic including leakage				**330**	LCD	
Pop. : 3,482 (1999)	Water consumption for domestic				**198**	LCD	
House : 479 (1999)	Customer (2005) : Domestic	231	no.				
(7.3/household)	Commercial	20	no.				
Pop. : 4,109 (2005)	(Total)	251	no.				
House : 563 (2005)	Served pop. (2005)	2,498	cap.				65 families of Soltai staff
	Service ratio :	61	%				is added.

Source : SIWA

(b) Existing water supply system

Existing water supply system in Noro is as shown in Figure C1.1-7 and consists of the following facilities.

Table C1.1-5 Existing Water Supply Facilities in Noro

Item	Description
Water source	Ziata creek, yield 10,970m^3/day
River pump	2,600m^3/day
Water treatment plant (rapid sand filter)	2,300m^3/day
Clear water pump at WTP to high level tank	2,300m^3/day
High level storage tank	900m^3 x 1unit

Source : SIWA

(c) Issue to be solved

As shown in Table C1.1-5**,** the served ratio is 61% in 2005. Soltai Fishing & Processing Limited and other commercial customers are using about 60% (1,238m^3/day) of the total water supply (2,063m^3/day). This means that 825m^3/day is delivered to the domestic customer. So the average water supply per capita per day for domestic customer is 330LCD (including 40% leakage) and water consumption for domestic customer is 198LCD.

Existing surface water source (Ziata Creek) has much enough capacity for the whole water demand in Noro. The current water demand accounts for only 17% of the potential volume of the water source. Therefore, new water source development will not be needed.

For the existing water supply system in Noro, there are no outstanding problems.

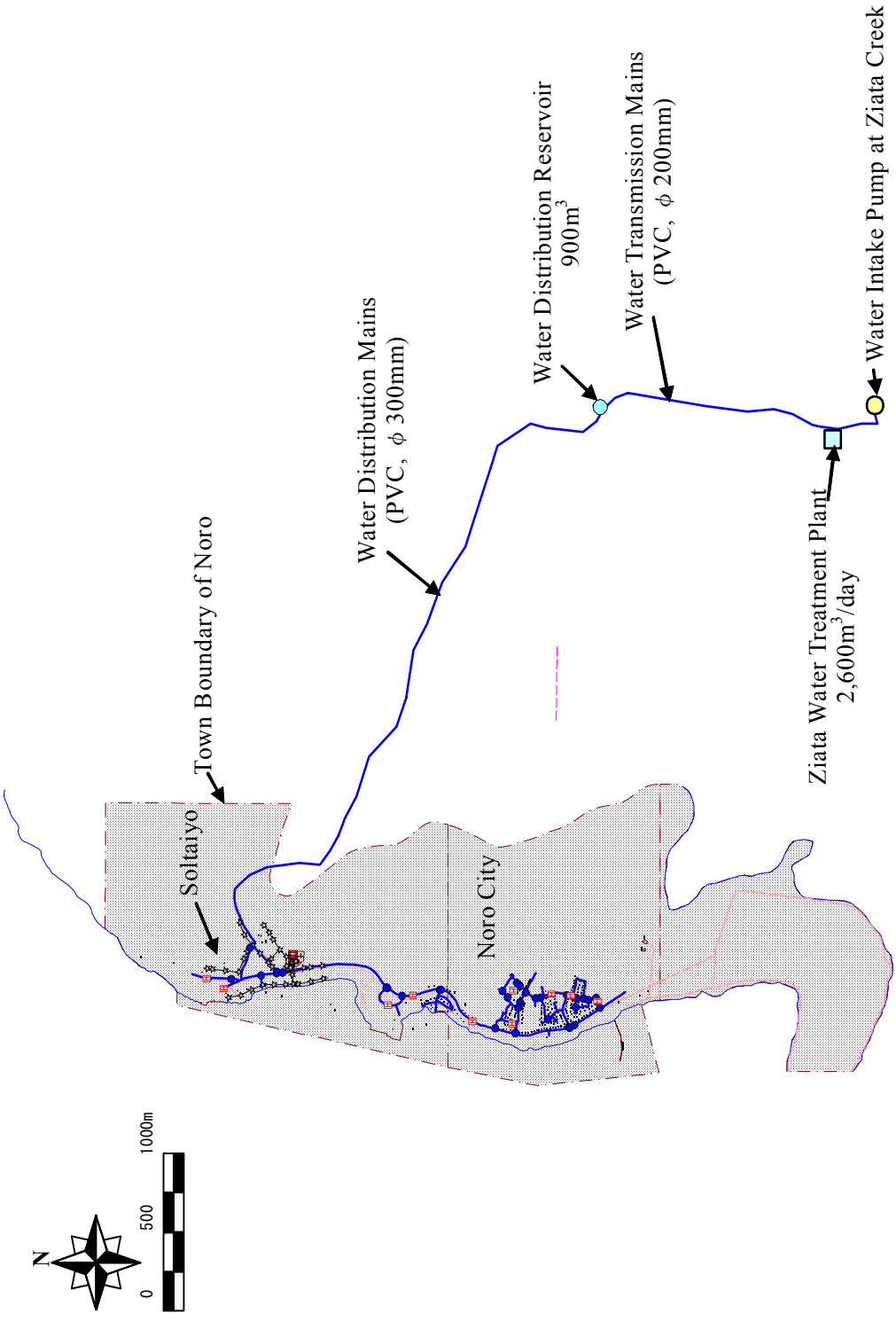


Figure C1.1-7 Existing Water Supply System in Noro (Year 2005)

Source : JICA Study Team

(5) Water Sources

Water Source:

The analysis results do not exceeds WHO guideline value. Total Coliform Bacteria is 0(MPN/mL) at each sampling points.

Tap water:

The analysis results of these bore do not exceed WHO guideline value.

(6) Sewerage System

(a) Current Situation

In Noro, residential and commercial properties are served by septic tanks. Soltai Fishing & Processing Limited, formerly known as "Solomon Taiyo" has its own wastewater treatment system for both industrial wastewater and sewage. However, after Japanese staff had gone back to Japan during the ethnic tension, the wastewater treatment system has been closed down. Industrial wastewater generated from processing factory is discharged into the sea without any treatment.

(b) Issues to be solved

For wastewater treatment of residential and commercial water use, septic tanks can be applied. On the other hand, wastewater generated from Soltai Fishing & Processing Limited needs be treated by factory wastewater treatment plant and treated water shall be discharged into the lagoon-type wastewater treatment.

Both Solomon Government and Western Province should provide Soltai Fishing & Processing Limited with a fund for operating and maintaining factory wastewater treatment plant and pumping station. Maintenance of sewer mains and the lagoon-type wastewater treatment plant should be managed by SIWA.

C1.2 Mid-term Facility Improvement Plan

(1) Water Demand Projection

SIWA is desirous that the service ratio of Noro should be increased up to 67%. Since the per capita consumption for domestic use is 198LCD in 2005, it is assumed that the same amount is also applied for 2010.

Therefore, water demand projection for Noro in 2010 is estimated as in Table C1.1-6.

Table C1.1-6 Water Demand Projection for Noro in 2010

Category	Year 2010							Maximum Daily Water Demand
	Population	Customer [A]	Effective Water Consumption	Served Pop.	Served Ratio	Per Capita Consumption	Water Distributed	
	(No.)	(No.)	(m^3/year)	(No.)	(%)	(LCD)	(LCD)	(m^3/day)
Domestic		308		3,170		198	330	1,046
Commercial		21					(Er = 0.6)	1,301
Total	**4,718**	**329**		**3,170**	**67%**			**2,347**
				([A] x1.2x 7.3)			Capacity of existing facility	2,600
				Required expansion of the facility				**-253**

Notes :
1. Effective water ratio is set as 60% in 2010.
2. In Noro, Soltaiyo has its own water reservoir and water supply system. It is distributing water to the factory and households of Soltaiyo staff. It is assumed that 65 families of Soltaiyo have been supplied by this system.
3. It is assumed that commercial customers in Noro consume 60% of total consumption, based on the actual data from SIWA.
4. It is assumed that commercial customers in Noro should be increased by 1.0% up to 2010.
5. Population growth rate of 2.8% is applied based on 1999 national census.

Source : JICA Study Team

As shown in the above table, the existing source has enough capacity for the water demand in 2010. Therefore, new source development is not required for Noro.

(2) Potential Projection of Water Sources Development

(a) Surface water and spring

Volumes of water source and water demand in Noro are shown in Table C1.1-7 .

Table C1.1-7 Potential Exploitation of Noro

Water resource	Potential projection	
	Water volume	Occupation rate
Volume of water source	0.127m^3/s(10,970m^3/day)	100%
Current extraction	0.022m^3/s(1,900m^3/day)	17.3%
Water demand	0.021m^3/s(1,800m^3/day)	16.4%
Potential of exploitation	0.042m^3/s(3,629m^3/day)	33.0%

Source : JICA Study Team

River flow volume on water intake point of Noro source is about 0.127m^3/s (10,970m^3) and in that point about 0.022m^3/s (1,900m^3/s) is extracted for domestic use in Noro area. Water demand of Noro area is exceeding 1,800m^3/day (0.021m^3/s) including domestic demand and commercial demand. This figure is almost the same as the result of this survey 0.022m^3/s (1,900m^3/day). On the basis, the source will have no problems in meeting the demands at present (2005). Volume of intake water accounts for only 17% of the river flow. Thus, further exploitation of water on this river can be expected.

If 33.3% of river flow is developed, 0.042m^3/s (3,629m^3/day) of water can be withdrawn for Noro water demand. This creek has never been dried up.

(b) Groundwater

Geological formation in the site of the purification plan and reservoir tank comprises mudstones, which is underlain by limestone and basaltic lava with high permeability. It is proposed to drill new boreholes in the site above. Advantage of drilling new boreholes in the site is as follows.

- Groundwater development potential in the site seems much higher than water demand in year of 2010. From one borehole, 800m^3/day of groundwater is expected.
- Drilling new borehole in the existing purification plant can reduce cost for connection between new borehole and the current water supply system.
- Purification plant is facing main regional road between Noro and Munda. Drilling machine can easily access to the site, which can reduce cost for drilling.
- Proposed borehole is located outside of Noro town area. However, drilling point is within the sites for the current purification plant. Therefore, lease of the new site is not necessary.

(c) Optimum Water Resources

1) Selection of Water Resources

Based on the results of analysis on development potential of the surface water and groundwater, it was concluded that both surface water and groundwater have enough potential for water demand in year of 2010. Development potential of water resources is summarized in Table C1.1-8.

Table C1.1-8 Water Demand for 2010 and Water Resources Development Potential

Area	Water demand for 2010 (m^3/day)	Water to be newly developed*1 (m^3/day)	Water development potential			
			Type of water source	Remaining potential*2 (m^3/day)	Water quality	Landowner-ship
Noro	2,347	284	Surface -water	3,629	Purification plant is necessary	Customary land
			Ground-water	More than 2,350	Chlorination only	Town area

Note 1. Water to be newly developed = Water demand in 2010 - Current water extraction from existing sources (2,063)
2. Remaining potential＝Development Potential－Current water extraction
Source : JICA Study Team

The current water source for water supply for Noro is Ziata River. To meet water demand in year of 2010, it is recommended that additional water should be taken form the current water intake-point of Ziata River. Reasons are as follows.

- The Study Team carried out discharge measurement of Ziata River in dry season of 2005. It is concluded that even in dry season flow rate of Ziata River is much enough for water demand of Noro in year of 2010.
- The existing facilities of water-intake/treatment/conveyance have enough capacity to meet water demand of year of 2010. Therefore, expansion of the current facilities for water supply is not necessary.

As mentioned above, surface water has enough potential for water demand of 2010. On the other hand, groundwater should be noticed in the future because of reason below.

- Groundwater is favorable than surface water in terms of water quality.
- Boreholes can be drilled within the site of the current purification plant with high successful rate. Yield of 800m^3/day can be expected from one borehole in the site.
- Use of groundwater is better than use of surface water in stability of water supply in terms of water right, which will cause troubles between SIWA and landowners relating to payment.

(3) Policy for Improvement of Water Supply System

In Noro, it has been found that the existing water source and water distribution facilities will be able to serve for the demand of the target year 2010. Therefore, the facility improvement plan for Noro is not required

(4) Plan for Sewerage System

There is the sewerage system in some part of Noro. However, this system is exclusively for the private company. This company has its own treatment system. Meanwhile, most of the residents use a household septic tank. Since the sewage discharge volume from the residents is small, the environmental pollution from the sewage has not been found.

Therefore, a plan for sewerage system improvement is not formulated in this study.

C2 AUKI

C2.1 Existing Conditions

(1) Natural Conditions

(a) Topography and geology

Auki is located in hill-side of Tertiary limestone. This limestone is classified as Suaba chalk deposit of Maraita Group. Rock is compact and poor in porosity except where fractures are densely developed. There are many sinkholes in hills behind Auki. Water comes out from caves and disappears into cracks in the bottom of sinkholes. Group of sinkholes has formed special topography that can be called as cockpit karst. Sinkholes extend in lines along dominant fractured zone of NNW-SSE and NW-SE direction.

(b) Climate

Annual average temperature of Auki is 26.6℃. Monthly average temperature is 27.1℃ in January and 25.8℃ in July, showing almost constant temperature throughout year. Annual precipitation of Auki is 3,271mm. Precipitation is 406mm in January and 212mm in July, showing much precipitation throughout a year.

(2) Socio-economic Conditions

Auki is located in the north-west of Malaita Island, Malaita Province. Population in Auki is around 4,000. Major industry in Auki is fishing and agriculture. There is no large factory such as Soltai in Noro.

(3) Field Surveys

(a) Surface Water Survey

Surface water discharge measurement points are shown in Figure C2.1-2. The results of the Surface water discharge measurement are shown in Table C2.1-1 and Figure C2.1-7.

In Auki area, water resources are existed along the Kwaibala River.

Five (5) flow measurement points are selected along the river. Survey point No.1 and No.2 are located along the tributary of Kawaibala River whose spring point is Lebagunali spring. Field water discharge was conducted in June for a measurement in the dry season, and in November 2005 for a measurement in the rainy season.

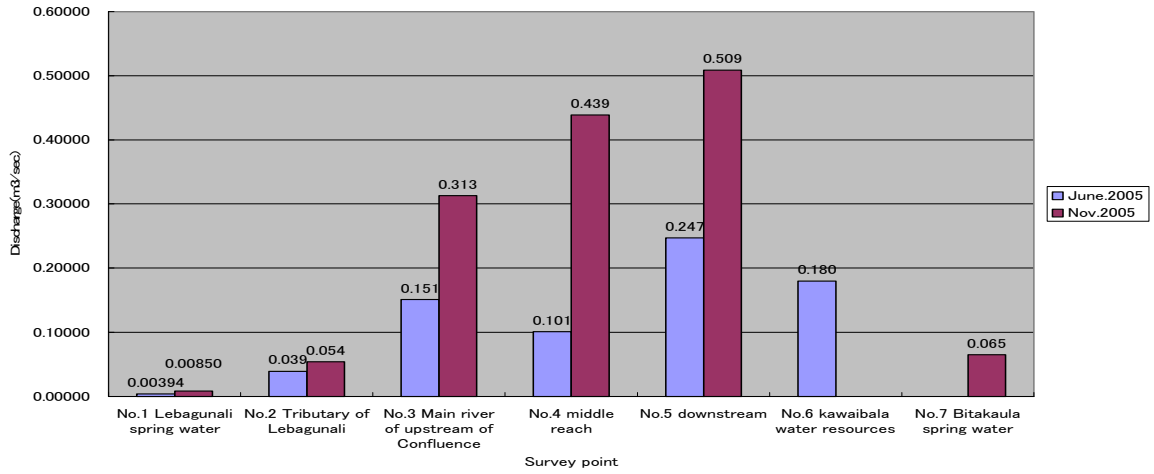
The results of surface water discharge measurement are summarized as below.

- Discharge along the Kawaibala River except Kawaibala water resource, discharge of rainy season is larger than discharge of dry season.
- Survey point No.3 is located at main Kawaibala River just upstream area of confluence of Lebagnale tributary. Therefore, Discharge No.2 plus No.3 is similar to discharge No4. In dry season, discharge No.4 is less than discharge No.2 plus No.3. The reason of this situation is the infiltration into ground.
- In rainy season, discharge No.4 is larger than discharge No.2 plus No.3. This means that water is spring out from river side between survey point No.3 and No.4.
- On the other hand, at survey point No.6, Kawaibala water resource, discharge of rainy season was less than dry season. This means that groundwater recharge by rain fall is not adequate to raise the groundwater level and to increase base flow at beginning of the rainy season.

Table C2.1-1 Results of Surface Water Discharge Measurement in Auki

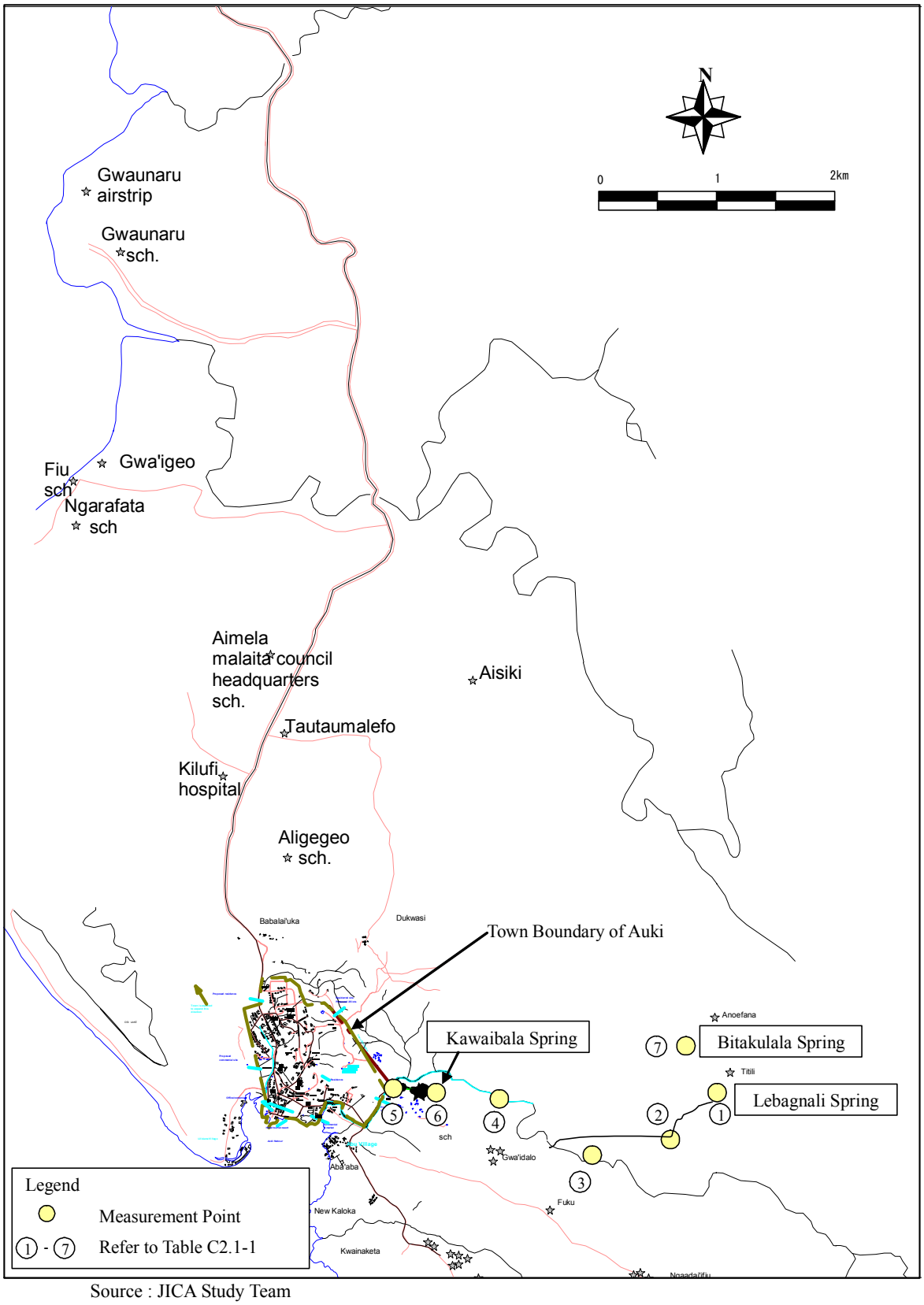
No	Survey Month	Name	Water flow (m^3/s)	Comment
No.1	June 2005	Lebagnali spring water	0.004	Spring water
No.2		Tributary of Lebagnali	0.039	Few spring points at tributary.
No.3		Main river of upstream area of Confluence	0.151	Discharge of the Kawaibala River before confluence
No.4		middle reach	0.101	
No.5		downstream area	0.247	
No.6		kawaibala water resources	0.180	No effluent from spillway
No.1	November 2005	Lebagnali spring water	0.0085	Spring water
No.2		Tributary of Lebagnali	0.054	Few spring points at tributary.
No.3		Main river of upstream area of Confluence	0.313	Discharge of the Kawaibala River before confluence
No.4		middle reach	0.439	
No.5		downstream area	0.509	
No.6		kawaibala water resources	0.006	No effluent from spillway
No.7		Bitakaula spring water	0.065	

Source : JICA Study Team



Source : JICA Study Team

Figure C2.1-1 Results of Water Discharge Measurement in Auki



Source : JICA Study Team

Figure C2.1-2 Surface Water Discharge Measurement Points in Auki

(b) Groundwater Survey

1) Hydrogeology of Auki

Auki is located in limestone area. Limestone in Auki is usually compact, and fractures have been developed only in fracture zone with faults. There are many sinkholes, which have formed watershed together with the neighboring sinkholes. This topography is called cockpit Karst.

2) Water sources

There are some springs and caves in the bottom of sinkholes. Regional groundwater table in the area may be obtained by connecting bottom of many sinkholes, elevation of which may correspond to the regional groundwater level. Spring water in the bottom of sinkholes is currently used by villagers. Study Team visited Bitakaula Spring that is located at 2.5km the north west of Auki. This spring is comes from a cave in the bottom of sinkhole, which is the biggest sinkhole of Auki area. Amount of water from the spring is 150m3/day when it was surveyed in June 2005. Promising water sources for water supply is groundwater from sinkholes and boreholes. Characteristics of sinkholes and boreholes for water sources are summarized in Table C2.1-2.

Table C2.1-2 Sinkholes and Boreholes

Type		Merit / Demerit for water sources
Sinkhole	Merit	• Water can be easily taken from simple facility such as small weir. • Sinkholes are distributed in hills with higher elevation than that of Auki. Water from sinkholes can be distributed by gravity, though pumping up is necessary to get over the watershed from bottom of sinkhole.
	Demerit	• Most of sinkholes are located in the north of Auki. Yield of spring in bottom of each sinkhole is usually small. • Distance between Auki and sinkholes is 1.4～3km. Long pipeline is necessary to deliver water from the sinkholes to Auki. • Water from spring in sinkholes will be decreased during dry season, and water will be turbid by strong rainfall. • Sinkholes are located in customary land, and it will cause problems in water right.
Groundwater	Merit	• Limestone is distributed in Auki, and it is promising to drill boreholes within town area. In this case, payment for water right is not necessary. • Drilling boreholes seems highly successful with expected yield of 800m^3/day per one borehole. • Groundwater is used only by SIWA within Auki town area. Therefore, there may be no environmental problem by new groundwater development for SIWA Water supply
	Demerit	• The only existing borehole is located in provincial hospital far from Auki. Few geological surveys were conducted in the past, which resulted in few information and data on hydrogeology and groundwater of Auki. • Auki is located in seaside, and over-pimping from boreholes will cause sea water intrusion into boreholes.

Source : JICA Study Team

(c) Water Quality Survey

Water quality survey in Auki consists of field water quality survey and water quality analysis in laboratory. Field water quality survey was conducted by the Team with cooperation of SIWA. Water quality analysis was conducted by SIWA in his laboratory.

Field water quality survey was conducted on June, August and November 2005 for investigations of surface water in dry season and rainy season. Water quality analysis in lab was conducted in June 2005.

1) Result of field water quality survey

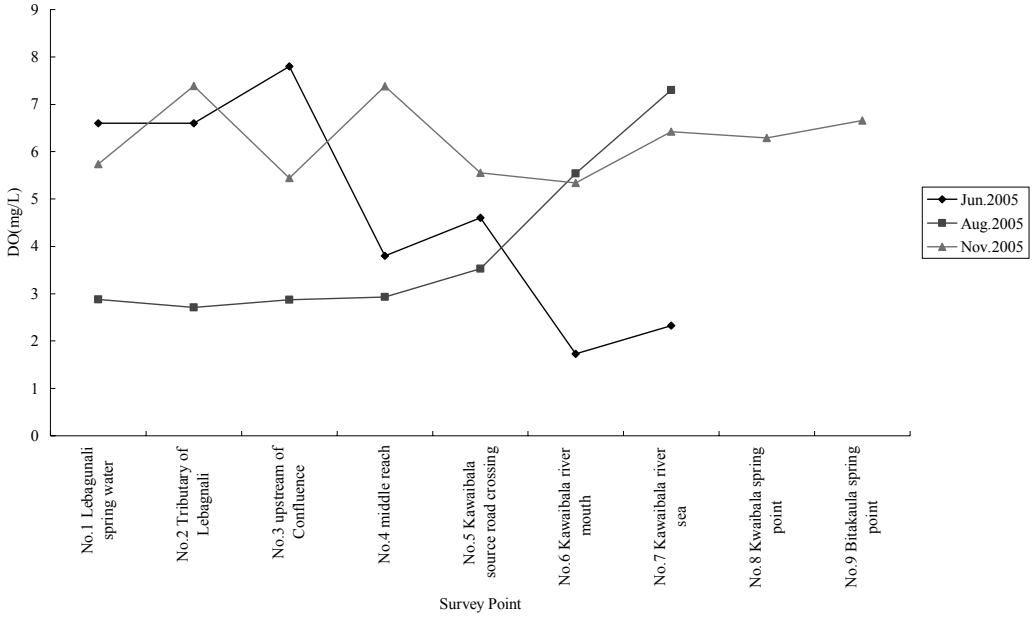
Field water survey points were selected from the upper, middle and downstream area of the Kawaibala River, Lebagunali Spring and Kawaibala Spring.

The field water quality survey points are shown in Figure C2.1-5. The results of field water quality survey are shown in Table C2.1-3.

Table C2.1-3 Results of Field Water Quality Survey

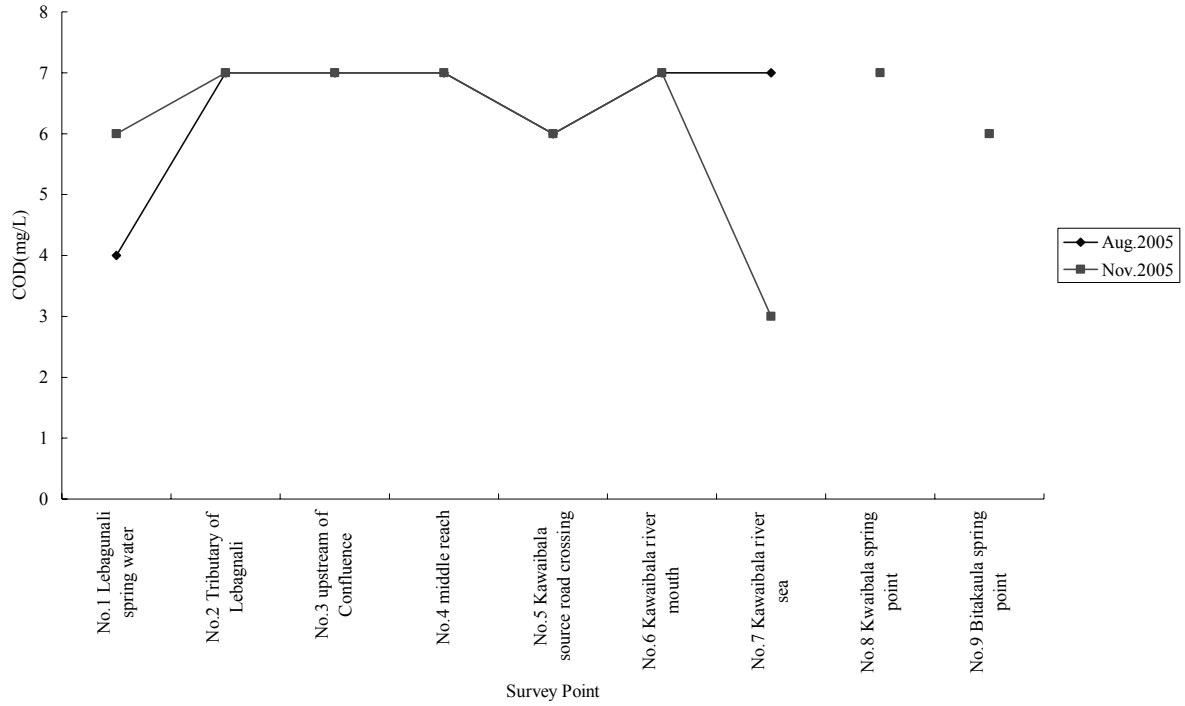
Area	Survey Month	Water Temperature (℃)	Ec (ms/m)	Turbidity (NTU)	pH	DO (mg/L)	COD (mg/L)
No.1	June 2005	24.6	40.0	14	7.6	6.6	-
No.2		25.3	20.0	14	7.8	6.6	-
No.3		24.6	40.0	14	7.6	7.8	-
No.4		27.1	38.0	14	7.9	3.8	-
No.5		24.7	60.1	10	7.7	4.6	-
No.6		26.2	-	11	8.0	1.7	-
No.7		28.6	-	14	8.0	2.3	-
No.8		-	-	-	-	-	-
No.1	August 2005	24.8	35.6	4	7.6	2.9	4
No.2		24.8	41.0	4	7.7	2.7	7
No.3		24.5	34.7	1	7.9	2.9	7
No.4		24.7	35.0	3	7.9	2.9	7
No.5		26.3	36.1	2	7.8	3.5	6
No.6		26.3	99.5	3	7.8	5.5	7
No.7		30.5	-	33	7.9	7.3	7
No.8		-	-	-	-	-	-
No.1	November 2005	24.8	34.3	6	7.8	5.7	6
No.2		25.0	37.0	6	7.3	7.4	7
No.3		25.6	37.1	3	8.3	5.4	7
No.4		25.7	32.7	7	8.0	7.4	7
No.5		25.8	32.7	7	8.0	5.6	6
No.6		27.0	-	5	7.9	5.3	7
No.7		30.7	-	1	7.5	6.4	3
No.8		26.6	35.4	7	7.1	6.3	7
No.9		26.6	41.8	5	7.3	6.7	6

Source : JICA Study Team



Source : JICA Study Team

Figure C2.1-3 Results of Do Measurement in Auki



Source : JICA Study Team

Figure C2.1-4 Results of COD Measurement in Auki

DO and COD value along the river and sea are shown in Figure C2.1-3 and Figure C2.1-4 respectively.

The result of DO and COD measurements is summarized as below.

- COD survey curried out in August and November 2005, and DO survey curried out in June, August and November 2005.
- DO values showed variable results each surveys. However, for survey point No.5 and NO.6 located downstream area of Kawaibala River, DO value was decreased except August. That result indicates that Kawaibala River is contaminated in downstream area of the river.
- COD value indicates the contamination of sea and pond. In general, COD value less than 2mg/L indicate no contamination of the water. At the survey point No.7 (at sea), COD value was not less than 2mg/L for the surveying period. It shows that seawater is slightly contaminated.

2) Results of water quality analysis in lab

The results of the water quality analysis are shown in Table C2.1-4. The water sampling points for water quality analysis is shown in Figure C2.1-6.

Water analysis samples were collected from Kawaibala Spring, Gallery Source, Bitakaula Spring Lebagunali Spring and taps of Auki.

Water Source:

The analysis results did not exceed WHO guideline value except for Total Coliform Bacteria. Total Coliform Bacteria is more than 200(MPN/mL) at Kawaibala Spring, Gallery Source, Bitakulala Spring and Alegegeo school sinkhole. And Total Coliform Bacteria was 43 (MPN/mL) at Lebagnal Spring.

Tap Water:

The analysis results of these bores did not exceed WHO guideline value. Total Coliform Bacteria was 0 (MPN/mL) for the tap water of SIWA office.

Phenol was detected at Kawaibala spring and Bitakulala spring. Phenol dose not exist naturally. It shows a contamination by human activities. However, the cause of Phenol existence was not detected.

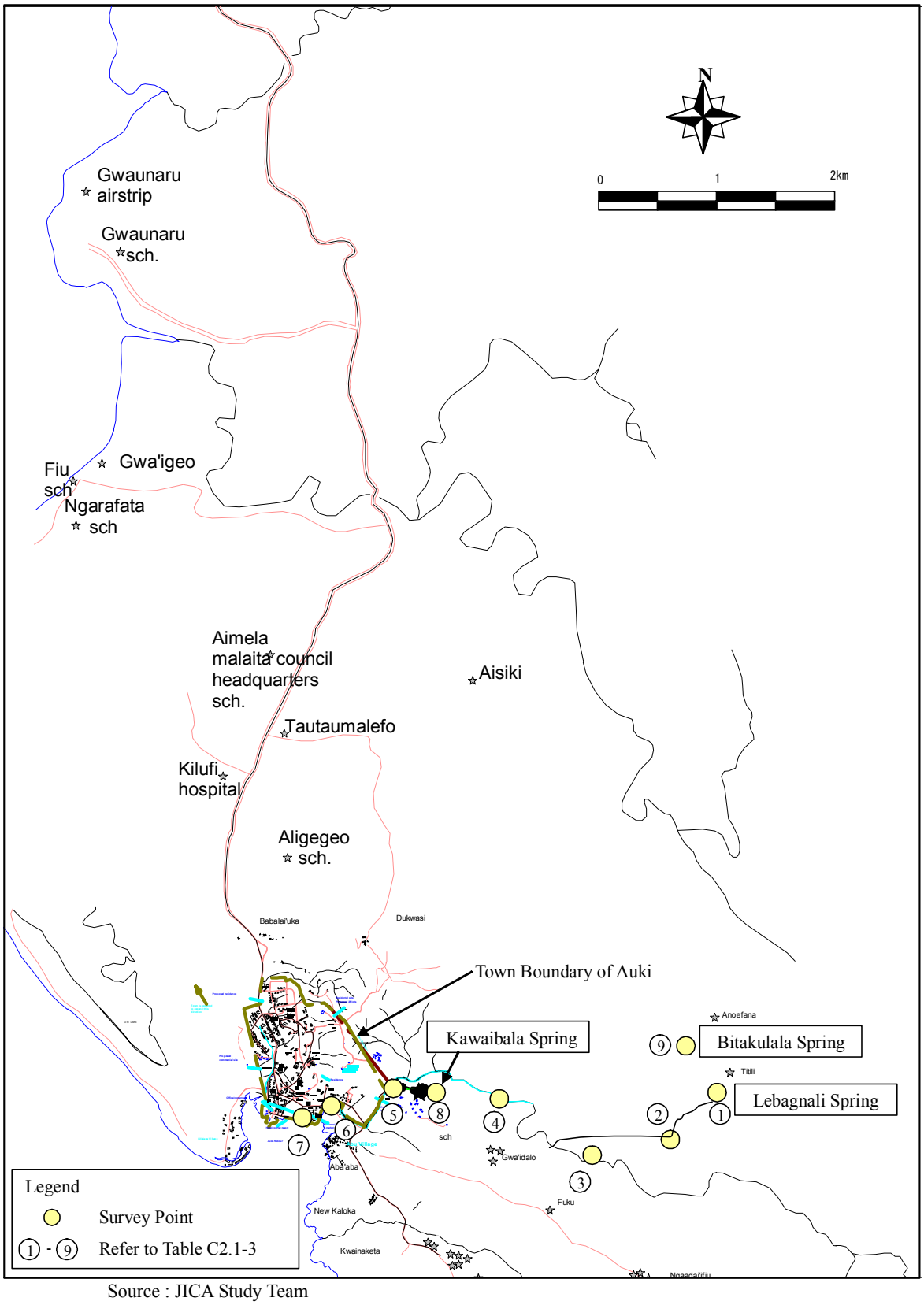
3) Evaluation of Water Quality

Regarding water survey and analysis in Auki, the evaluation results can be summarized as below:

- According to the results of water quality analysis, tap water does not have problem.
- Total Coliform Bacteria was detected at all the spring points. However, it was not detected from the tap water of SIWA office.
- Phenol was detected at Kawaibala spring and Bitakulala spring. Phenol dose not exist naturally. Although the cause of Phenol existence is uncertain, it is considered that some of contaminations by human activity are exist.

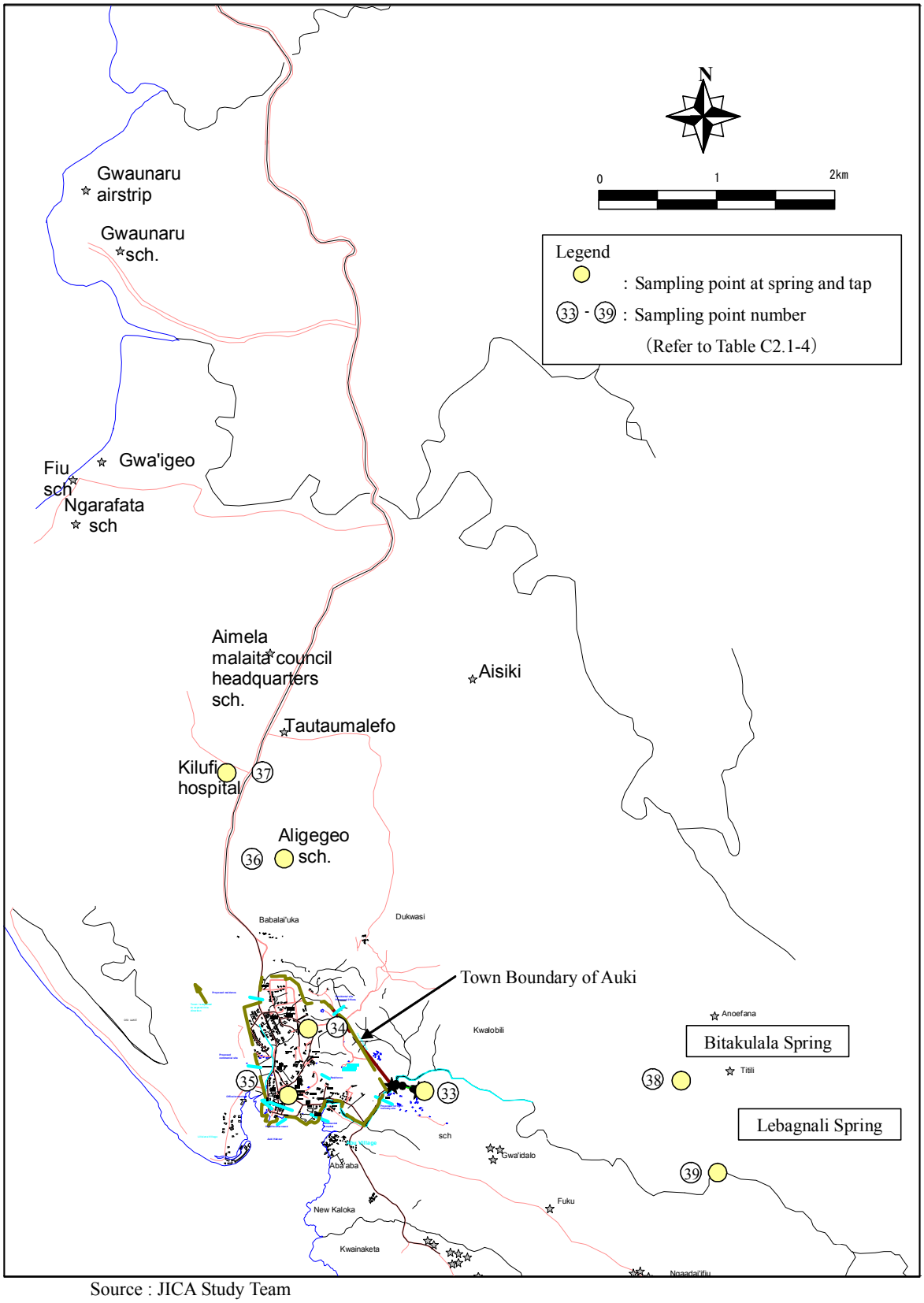
(d) Water Right

The current water source and pipeline are located in customary land. SIWA paid SI$70,000 at first to landowners. In addition to it, SIWA pays SI$16,500 every year to the landowners for land lease. The payment began in 1996 with contract period of 15 years. Renewal of the contract will be done in 2010. The contract will be renewed without any trouble because SIWA has good relation with the landowners so far, though charge will be increased.



Source : JICA Study Team

Figure C2.1-5 Field Water Quality Survey Points in Auki



Source : JICA Study Team

Figure C2.1-6 Water Sampling Points for Water Quality Analysis in Laboratory in Auki

Table C2.1-4 Results of Field Water Survey in Auki

	WHO Guideline (3rd edition, 2004)	Australia Drinking Water guideline (1996)	㉝ Kawaibala spring	㉞ Gallery source	㉟ Tap of SIWA office	㊱ Aligegeo School sinkhole	㊲ Kilfi Hospital Tap water	㊳ Bitakulala spring	㊴ Lebagnal spring
Source			○	○		○		○	○
Tap					○		○		
Nitrate	50	50	1.03	0.33		0.10	0.37	2.31	0.96
Nitrite	3	3	0.04	0.00		0.00	0.26	0.03	0.01
Nitorogen-ammonia	-	-	0.08	0.00		0.00	0.61	0.10	0.00
Mn	0.4	0.5	0.66	0.03		0.00	0.01	0.03	0.01
Fe	-	-	0.03	0.00		0.01	0.04	0.03	0.04
K	-	-	0.10	0.00		0.23	0.01	0.06	0.04
Total hardness	-	-	97.00	34.20		117.00	49.00	67.00	66.00
SO4	-	-	0.04	0.33		0.05	0.09	0.00	0.01
Zn	-		0.01	0.00		0.03	0.01	0.02	0.03
Cl2	-	-	0.00	0.00		0.00	0.00	0.00	0.00
Cl	5	5	0.38	0.00		0.05	0.01	0.01	0.01
F	1.5	1.5	0.02	0.00		0.01	0.00	0.06	0.01
Ca	-	-	40.50	23.00		74.13	26.00	36.00	32.00
Mg	-	-	29.00	3.10		56.00	19.00	39.00	25.00
Cu	2	2	0.00	0.06		0.08	0.07	0.00	0.04
Pb	0.01	0.01	0.00	0.00		0.00	0.00	0.00	0.00
Cr	0.05	0.05	0.03	0.00		0.03	0.03	0.01	0.03
I	-	-	0.00	0.00		0.00	0.00	0.00	0.00
Al	-	-	0.01	0.00		0.07	0.00	0.02	0.06
Benzotriazole	-	-	0.00	0.00		0.00	0.00	0.00	0.00
Phenol	-	-	0.00	0.00		0.00	0.00	0.00	0.00
Total Coliform			>200	>200	0.00	>200		>200	43.00

Note: unit of the above is as follows;
- MPN /mL for Total Coliform Bacteria
- mg/L for other items

Source : JICA Study Team

(e) Socio-economic Survey

Major types of dwelling in Auki is "rented" (77%) and the percentage of owner-occupied dwellings is very low (20%). Over 70% of households live in the area over 5 years. The average household size is larger than the other provincial centers (6.7 persons). Major type of toilet is flush same as in Honiara and the other provincial centers. The number of paid workers per household is 1.3 persons. The average monthly income is SI$1,184. It is lower than that of low income households in Honiara (SI$2,007).

Regarding water supply, combination of piped water and rain tanks is major source of water supply. The ratio dependent on piped water for drinking use is very high (77% of drinking water). The average water consumption volume is 99 L/d/HH (or 15LCD). This consumption is much less than the actual water consumption records of 197LCD, even taking into account the water losses inside the house. It is supposed that the interviewees misunderstood the questions from the surveyor of the Team or they believe to consume only such amount because over 80% of households interviewed are not satisfied with the current consumption volume of water billed by SIWA.

Over 90% of the households pay less than SI$50 per month for water supply. 90% of households show the willingness to use the additional standing pipes. In Auki, request of additional facility is very high because many households are not satisfied with water volume and think they do not have enough water at moment. 77% of the households think that water is most important for improving living conditions.

Major sewer system is septic tank. There is no sewer connection. Over 80% of the households have the experiences of disease caused by drinking water. All the respondents think that water source

should be conserved in order to avoid contamination of water.
Monthly water bill averages SI$20.61, 1.7% in Auki. Willingness to pay (WTP) additionally for better water supply is SI$13.70. Total WTP is SI$34.31, 2.9% of average monthly income. ATP is SI$47.36 in Auki (4% of average monthly income). Although total WTP is less than ATP in Auki, change of water use should be taken into consideration for increasing the tariff because the current low water bill result from rationing of water supply.

(4) Water Supply System

(a) Population and Served Ratio

According to the national census, the population of Auki in 1999 is 4,022 and 594 households. The population in 2005 is estimated as 4,747 and 698 households using annual growth rate in the whole Solomon of 2.8%.

Basic data for water supply by SIWA in Auki are as follows.

Table C2.1-5 Basic Data for Water Supply of Auki in 2005

City	Water Source	April	May	June	Average	Remarks
AUKI	Water distribution	14,300	13,700	14,000	**14,000** m^3/month	
	Water distribution	477	489	467	**478** m^3/day	
	Water sales	238	245	233	**239** m^3/day	
	Water sales ratio	50	50	50	**50** %	
	NRW ratio				**50** %	
	Leakage ratio (*estimated*)				**40** %	
	Water distributed - domestic use	286	294	280	**287** m^3/day	
	Water distributed - commercial use	191	196	187	**191** m^3/day	40% of total distribution
	Water consumption for domestic	172	176	168	**172** m^3/day	
	Water consumption for commercial	114	117	112	**115** m^3/day	
	Water distributed for domestic including leakage				**104** LCD	
Pop. : 4,022 (1999)	Water consumption for domestic				**63** LCD	
House : 594 (1999)	Customer (2005) : Domestic	337	no.			
(6.8/household)	Commercial	60	no.			
Pop. : 4,747 (2005)	(Total)	397	no.			
House : 698 (2005)	Served pop. (2005)	2,750	cap.			
	Service ratio :	58	%			

Source : SIWA

(b) Existing water supply system

Existing water supply system in Auki is as shown in Figure C2.1-7 and consists of the following facilities.

Table C2.1-6 Existing Water Supply Facilities in Auki

Item	Description
Water source	Kwaibala spring, yield 500m^3/day
Booster pump station	400m^3/day
Low level tank	180m^3 x 2units
High level pump station	580m^3/day
High level storage tank	200m^3 x 1unit

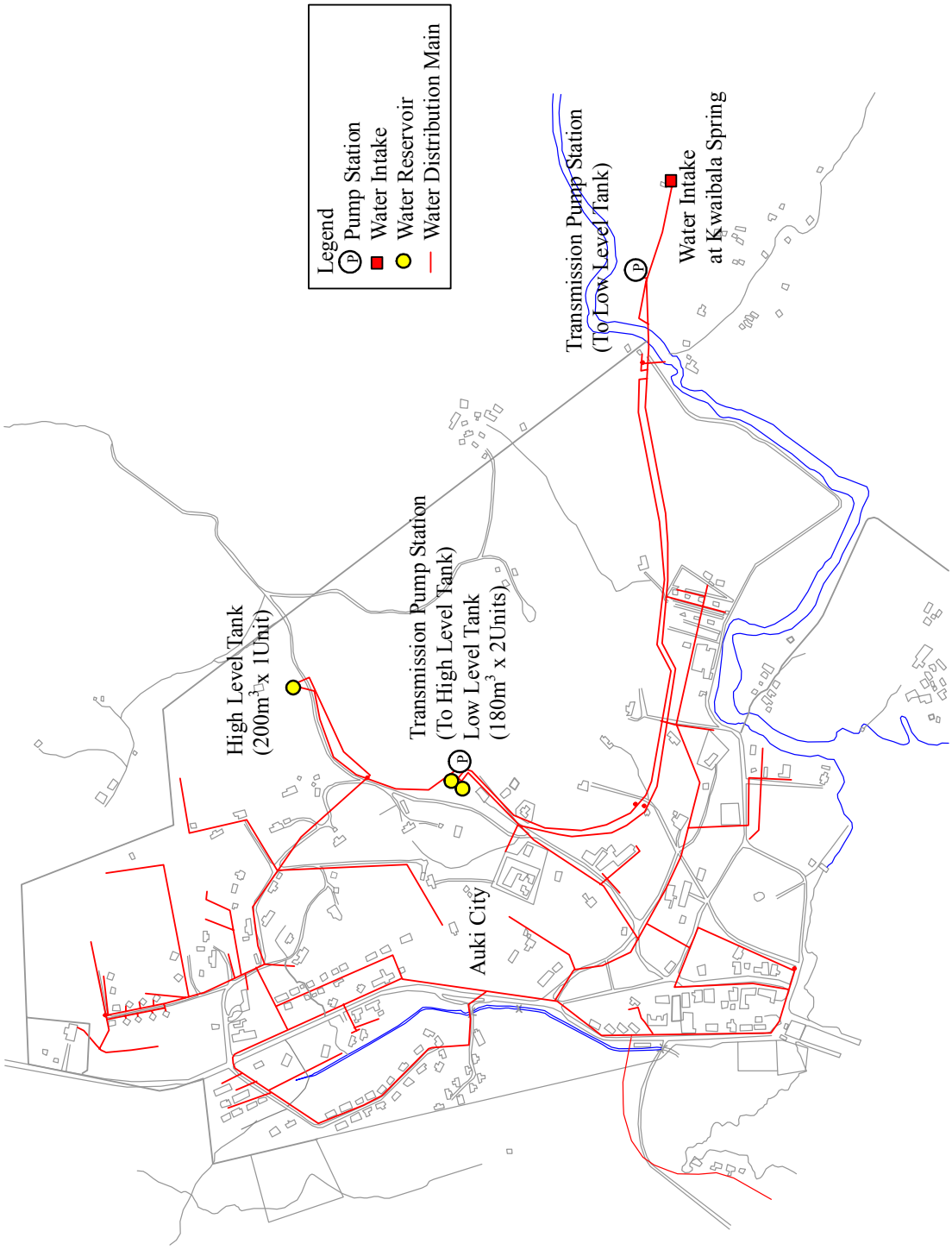
Source : JICA Study Team

(c) Issue to be solved

As shown in Table C2.1-6**,** the average water supply per capita per day for domestic customer is

104LCD (including 40% leakage). Actual available water per person is only 63LCD. This is because the yield of water source is much short of the actual demand.

Therefore, development of new groundwater source will be required in the facility improvement plan for the year 2010.



Source : JICA Study Team

Figure C2.1-7 Existing Water Supply System in Auki (Year 2005)

(5) Water Sources

Water Source:

The analysis results did not exceeds WHO guideline value. Total Coliform Bacteria was more than 200(MPN/mL) at Kawaibala Spring, Gallery Source, Bitakulala Spring and Alegegeo school Sinkhole. And Total Coliform Bacteria was 43 (MPN/mL) at Lebagnal Spring.

Tap water:

The analysis results of these bore did not exceed WHO guideline value. Total Coliform Bacteria was 0 (MPN/mL) for the tap water of SIWA office.

Phenol was detected at Kawaibala spring and Bitakulala spring. Phenol dose not exist naturally. It shows a contamination by human activities. However, the cause of Phenol existence was not detected.

(6) Sewerage System

(a) Current Situation

Auki has a small reticulated sewer system, which is not in operation because the outlet pipe runs through customary land and no agreement has yet been reached with the owners of the land to operate the outlet pipeline. Each household uses a septic tank for treatment of its domestic wastewater.

(b) Issue to be solved

There are no outstanding issues related to the sewage.

C2.2 Mid-term Facility Improvement Plan

(1) Water Demand Projection

SIWA is desirous that the service ratio of Auki should be increased up to 67% which is the same target level as Honiara city in 2010. Since there are no accurate data for the per capita consumption for domestic use, it is assumed as the same amount as in Honiara city.

Therefore, water demand projection for Auki in 2010 is estimated as in Table C2.2-1.

Table C2.2-1 Water Demand Projection for Auki in 2010

Category	Year 2010							Maximum Daily Water Demand
	Population	Customer [A]	Effective Water Consumption	Served Pop.	Served Ratio	Per Capita Consumption	Water Distributed	
	(No.)	(No.)	(m^3/year)	(No.)	(%)	(LCD)	(LCD)	(m^3/day)
Domestic		449		3,663		160	267	977
Commercial		63					(Er = 0.6)	651
Total	**5,450**	**512**		**3,663**	**67%**			**1,628**
				([A] x 1.2 x 6.8)		Exist. intake capacity		478
				New source required other than surface water				**1,150**

Notes : 1. Effective water ratio is set as 60% in 2010.
2. It is assumed that commercial customers in Auki consume 40% of total water supply, based on the actual data from SIWA.
3. Population growth rate of 2.8% is applied based on 1999 national census.

Source : JICA Study Team

As shown in the above table, the existing source is short of the water demand in 2010. Therefore, new source development is required for Auki.

(2) Potential Projection of Water Sources Development

(a) Surface water and spring

Volumes of water source and water demand in Auki are shown in Table C2.2-2.

Table C2.2-2 Potential exploitation of Auki

Water resource	Potential projection	
	Water volume	Occupation rate
Volume of water source	$0.012m^3/s(1,037m^3/day)$	100%
Current extraction	$0.012m^3/s(1,037m^3/day)$	100%
New Water resources	$0.039m^3/s(3,370m^3/day)$	100%
Potential of exploitation	$0.039m^3/s(3,370m^3/day)$	100%

Source : JICA Study Team

Water source of Auki is Kwaibala spring. Yield of spring flow is reported to be $0.012m^3/s$ ($1,037m^3/day$ or 12L/s). However, this source is almost exploited fully. As spring water volume has been decreased in yield recently, restriction of water supply of two (2) hours per day had been experienced. Therefore, new water source will have to be exploited to meet the water demands.

In this study, Lebagnali Spring was investigated to identify the possibility as an alternative resource. Water volume of spring is about $0.004m^3/s$ (4L/s). However, water volume of whole Lebagnali tributary is estimated about $0.039m^3/s$ (39L/s), whose origins are springs existed along the river.

Most of this source is considered to be exploited. Because this river is a small tributary of Kwaibala River, the water volume of which accounts for only 25.2% at the confluence of Kwaibala river flow volume($0.151m^3/s$). Therefore, even if all of the Lebagnali river flow is developed, any problem will not be occurred in the environmental aspect and the social aspect.

(b) Groundwater

Lime stone is distributed in the wide area including Auki town area. Groundwater development is promising, and drilling boreholes may be successful. New boreholes should be drilled in the site of Low Level Tank of the current water supply system of SIWA. Merit of groundwater development is summarized below.

- Low Level Tank is located within Auki town area, and it has good access for drilling machine. It can reduce cost for drilling.
- There is an existing water tank near the proposed boreholes. Therefore, proposed boreholes can be easily connected with the current water supply system. It can reduce cost for connection.
- Proposed new boreholes are located within town area of Auki. It will prevent problems in water right and site acquisition between SIWA and landowner.

(c) Optimum Water Source

1) Selection of water sources

Based on the results of analysis on development potential of the surface water and groundwater, it has been concluded that both surface water and groundwater have enough potential for water demand in year of 2010. Development potential of water resources is summarized in Table C2.2-3.

Table C2.2-3 Water Demand of year 2010 and Water Resources Development Potential

Area	Water demand in year of 2010 (m^3/day)	Water to be newly developed *1 (m^3/day)	Water development potential			
			Type of water source	Remaining potential*2 (m^3/day)	Water quality	Landowner-ship
Auki	1,628	1,150	Surface-Water	3,369	Chlorination only	Customary land
			Ground-water	More than 1,200	Chlorination only	Town area

Note 1. Water to be newly developed = Water demand in 2010 – Current water extraction from existing sources (478)
2. Remaining potential＝Development potential－Current water extraction from existing sources
Source : JICA Study Team

Groundwater development is proposed for water supply to meet the water demand of year 2010 of Auki because of reason below.

- Water sources development of 1,150$m^{3/}$day is necessary to meet water demand of year of 2010. This is small amount that can be obtained from just two boreholes.
- Groundwater is more favorable than surface water in terms of water quality.
- Boreholes can be drilled within the site of the current reservoir tank, which can reduce cost for connection.
- In case of water intake from surface water/spring, intake point will be located at customary land. Consequently, SIWA will be requested to pay for water right to landowners. Additionally, trouble in water intake is likely to happen between SIWA and landowners. On the other hand, groundwater can be developed within Auki town area, which will prevent payment for water right and trouble in water intake.

2) Groundwater development plan

Drilling Point

Drilling point is located in site of Low level tank of SIWA. Two boreholes are proposed near the tank. This site belongs to SIA, and behind the site there is small valley that is public area. It is proposed that one borehole should be located within SIA site, and another in the public area behind the site. SIWA needs land lease from SIA for drilling.

Hydrogeology of drilling points

Aquifer of borehole comprises Suaba chalk Formation. There are many sinkholes developed around drilling site. It is presumed that cave system was developed underground connecting sinkholes, inside which groundwater is flowing. Boreholes drilled in such geological situation are promising to get enough groundwater.

Site of Low Level Tank, where boreholes are proposed, is located in marine terrace that has higher elevation than coastal alluvial plain. This terrace comprises Suaba chalk Formation. Proposed boreholes seem to have high stability against sea-water intrusion because they are located on limestone that makes basement-rock in this area.

Specification of borehole

Specification of proposed borehole is as shown Table C1.1-8. Amount of new groundwater development is proposed 1,200m^3/day. Distance between the proposed boreholes and the shoreline is 600m. Yield of 1,200m^3/day will not cause sea water intrusion into aquifer.

Table C2.2-4 Specification of Proposed Borehole in Auki

Depth	Diameter	Planned yield	Number of wells	Total yield	Distance between wells	Aquifer
100m	8 inch	600m^3/day	2	1,200m^3/day	100	Limestone

Source : JICA Study Team

(3) Plan for Water Supply System

(a) Policy for Improvement of Water Supply System

The improvement plan for Auki shall be formulated in the following basic policy.

Table C2.2-5 Basic Policy for Water Supply Improvement in Auki

Current Situation	Improvement Plan
Capacity of the existing water source is much short of the water demand. At present, daily water consumption of the domestic customers is only 63LCD.	Two (2) boreholes shall be developed in the existing Low Level Tank inside the electric power station. For the location of the boreholes, see Figure C.2.2-1.

Source : JICA Study Team

(b) Facility Improvement Plan

In Auki, project for rehabilitating water intake dam, and constructing water transmission mains and reservoir funded by Asian Development Bank (ADB) is under way and will be completed within the year 2006. Therefore, after completion of the ADB project, the water supply facilities will be able to serve for the demand of the target year 2010 except the water source capacity.

The contents of the ADB project are as follows.

- Rehabilitation and improvement of intake dam structure
- Upgrading of transmission pump station
- Installation of water transmission (or rising) main
- Construction of water distribution reservoir

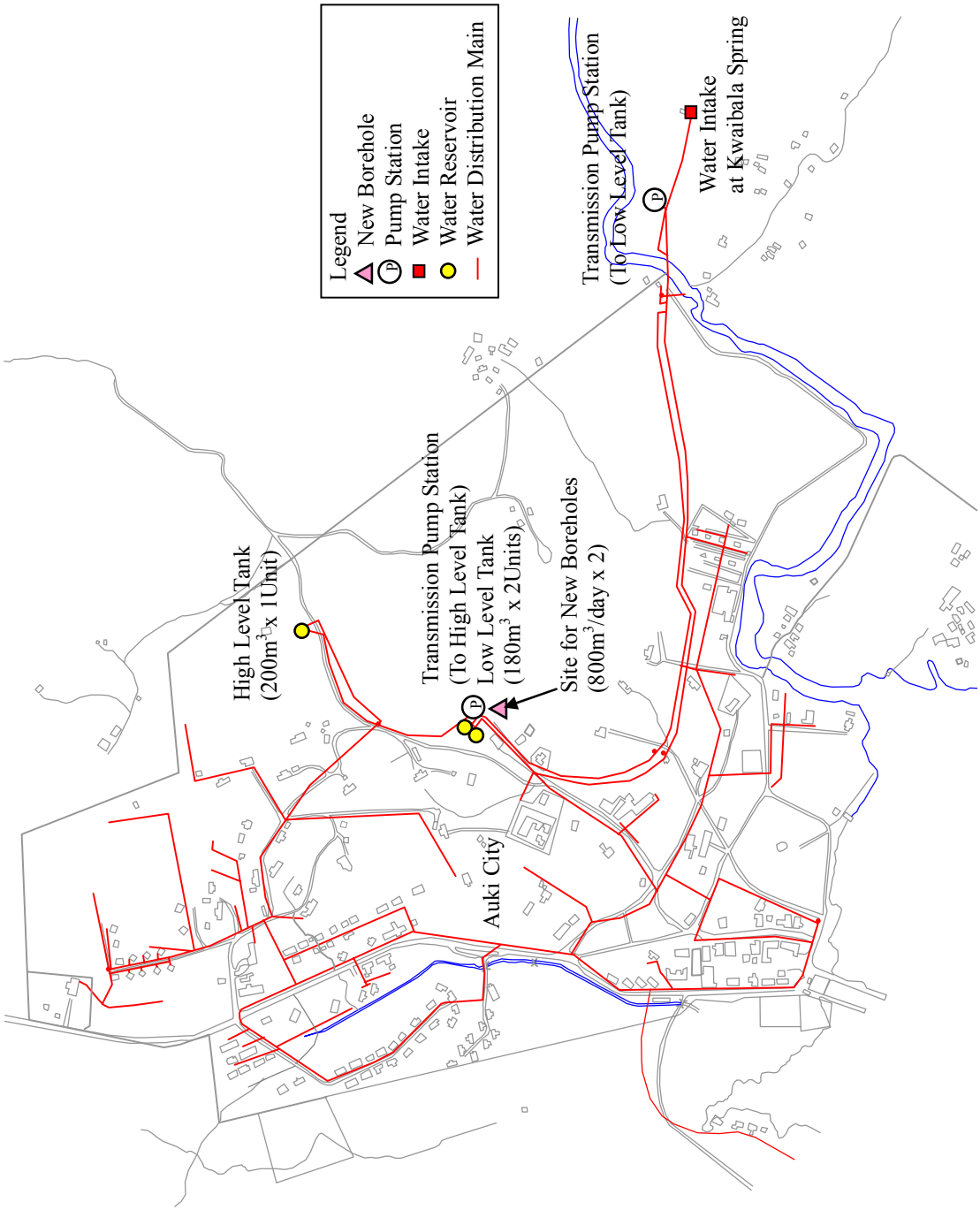
The facilities to be constructed in the ADB project are shown in Figure C2.2-1.

As the new water source, two (2) boreholes will have to be developed in the premises of Low Level Tank as shown in Figure C2.2-1. Specifications for borehole and pump are as shown in Table C2.2-6.

Table C2.2-6 Specifications for Bores and Bore Pumps

Item	Specification
Depth of bore	100m
Casing size	200mm
Safe yield	800m^3/day
Lifting capacity of pump	600m^3/day/unit
Head of pump	50m
Power consumption	7.5kW/unit

Source : JICA Study Team



Source : JICA Study Team

Figure C2.2-1 Location of New Boreholes in Auki (Year 2010)

(4) Cost Estimation

Water supply system improvement plan for Auki includes following components.

Water source development (two boreholes)

The cost for the water source development in Auki is estimated as follows.

Table C2.2-7 Cost Estimate for Water Supply System Improvement in Auki

Component	Quantity	Amount (US$)
Water source development in Auki		166,000/borehole
- Borehole drilling work	2 nos.	
- Procurement of submersible bore pump	3 units	
- Water conveyance pipeline (150mm PVC)	150m	
Total		332,000

Source : JICA Study Team

(5) Project Implementation Program

SIWA is desirous of implementing facility improvement project in Auki following the improvement project in Honiara.

The project implementation program is shown in Table B2.6-1.

(6) Risk Analysis for the Project

Two (2) boreholes will be developed in Auki for the water demand of 2010. The borefield will be located inside the Power Station of SIEA Auki.

There will be two risks for implementing this project, that is, political risk and technical risk.

Political risk

The political risk is either that the land lease will not be permitted by SIEA or that it will be permitted but at an exorbitant lease price. However, since there is SIWA's water reservoirs and pump station located in the proposed site and size of the new borefield sites is small, the risk is assessed as low.

Technical risk

Impact on groundwater environment by new groundwater development will be negligible because of reason below.

- Amount of groundwater to be developed is only 1,200m^3/day. This is small amount compared with the total development potential of groundwater basin covering Auki.
- There is no groundwater use within Auki except for small pumping-up by SIWA. Therefore, there is no impact on groundwater use other than SIWA by new groundwater development.
- Site for borehole drilling is located at 600m from the shoreline. Pumping rate of about 1,200 m^3/day will not cause sea-water intrusion into aquifer.

Sea-water intrusion is only risk in terms of groundwater environment. Regular monitoring of water quality (electric conductivity) of groundwater from boreholes should be conducted to evaluate effect of sea-water intrusion. If salinity of the groundwater increases, pumping-rate from the boreholes should be decreased.

C3 TULAGI

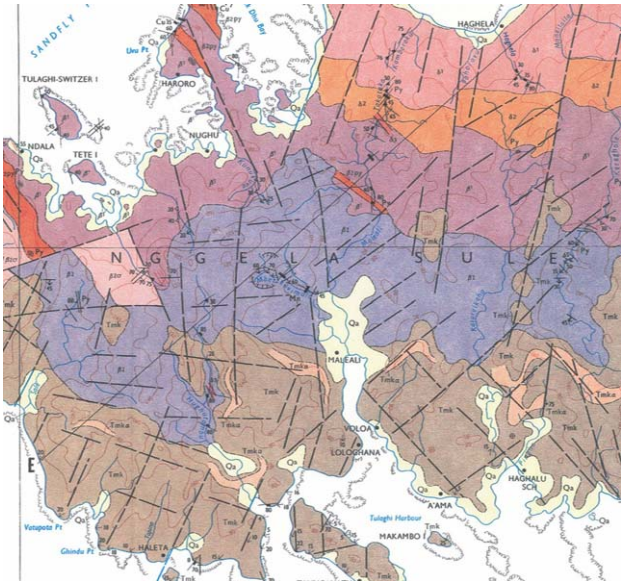
C3.1 Existing Conditions

(1) Natural Conditions

1) Topography and geology

Tulagi is located in Tulagi Island, of which geology comprises Kombuana sandstone of Oligocene to Pliocene of the Tertiary. Kombuana sandstone originated from pyroclastic material. Tulagi Island extends NW-SW direction with 3.3km-length and 0.7km-width with area of 2.3 km^2. Drainage system is not developed because of too small drainage area. Most of the lands show hilly topography, which has gentle slopes with the top altitude of 31m. Slopes of hills directly face the sea without beach in the most part of the island. Tulagi is located in the narrow coastal plain. There is Nggela Sule Island in 250m across the narrow strait in the north of Tulagi Island.

South-west part of Nggela Sule Island, near Tulagi Island, comprises Naghotano Volcanic rocks of Oligocene of the Tertiary, which is overlaid in unconformity by Kombuana Sandstone of Pliocene of the Tertiary. Naghotano Volcanic is basaltic rock. Drainage systems are highly developed in the southern part of the island, where rivers usually flow from the north to the south. Main rivers in Nggela Sule Island near Tulagi Island are Maliali River and Hughufomban Creek.



Legend

Stratum		Mark		Date
alluvium			Qa	Holocene
Mboli Bed	Kambuana Sandstone		Tmk	Late Stage Oligocene ~ Pleistocene
	Soghonara Lava		Tmkα	
Naghotano Volcanics			β 2	Eocene ~ Oligocene
Hanesavo Bed			β 2 1	
Naghotano Volcanics			β 2 σ	
Vatilau Leucogabbro			σ 3	Oligocene ~ End Oligocene
Kasika Metabasics			β 1	

Source : Geology of Tulagi, MNR

Figure C3.1-1 Geological Map of Tulagi

(2) Socio-economic Conditions

Tulagi is located in Tulagi Island, Central Province. Population in Tulagi is around 1,300. Before

World War II, Tulagi was capital of Solomon Islands. Soltai had a base for fishery before ethnic tension. Now it is moved to Noro. Major industry in Tulagi is fishing. There is no factory but a shipyard which is only one in Solomon Islands.

(3) Field Surveys

(a) Surface Water Survey

Surface water discharge measurement points are shown Figure C3.1-3 in. The results of the surface water flow discharge measurement are shown in Table C3.1-1 and Figure C3.1-2.

In Tulagi island, water source is transmitted via submergible pipe line from Maliali river which is on adjacent island of Ngella Sule. Water volume surveys were carried out at water resource and downstream area of the river. Discharge measurement was conducted in June in the dry season and November 2005 in the rainy season.

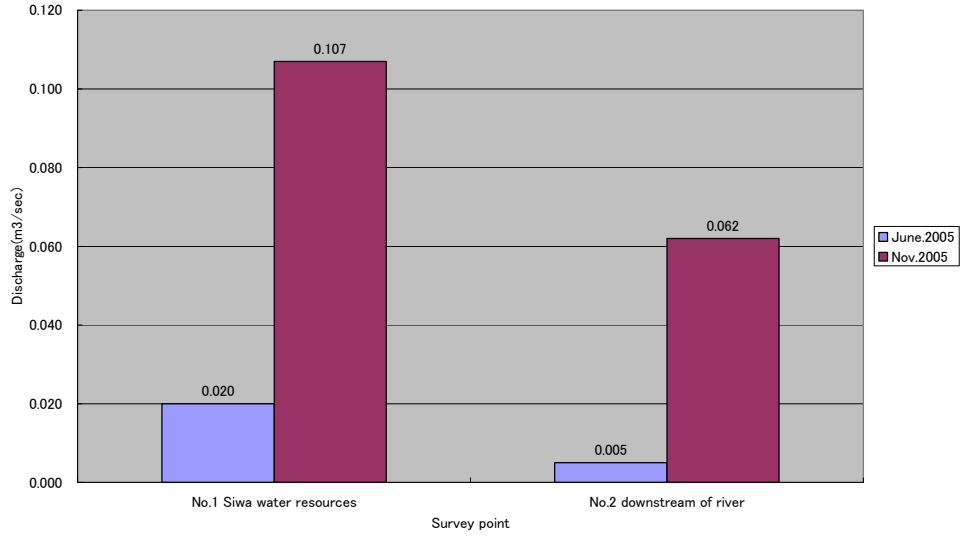
The results of water flow discharge measurement are summarized as below.

- In Dry season, Water discharge of resource is about 0.020m^3/s, which is said to originate in spring existed in upstream area.
- Water flow of the downstream area of river is only 0.005m3/s, river width is about 1.8m, and maximum depth is 2cm. In rainy season, Water discharge of resource is about 0.107m^3/s and 0.062m^3/s at downstream area.
- Each season, Most of water flow is presumed to infiltrate into the ground between upstream to downstream area. Discharge of the dry season is less than the rainy season.

Table C3.1-1 Results of Surface Water Discharge Measurement

Area	No	Name	Water flow (m^3/s)	Survey Date	Comment
Tulagi	No.1	SIWA water resources	0.020	8 Jun. '05	Intake from river
	No.2	Downstream area of river	0.005		
	No.1	SIWA water resources	0.107	6 Dec '05	Intake from river
	No.2	Downstream area of river	0.062		

Source : JICA Study Team



Source : JICA Study Team

Figure C3.1-2 Results of Surface Water Flow Discharge Measurement in Tulagi

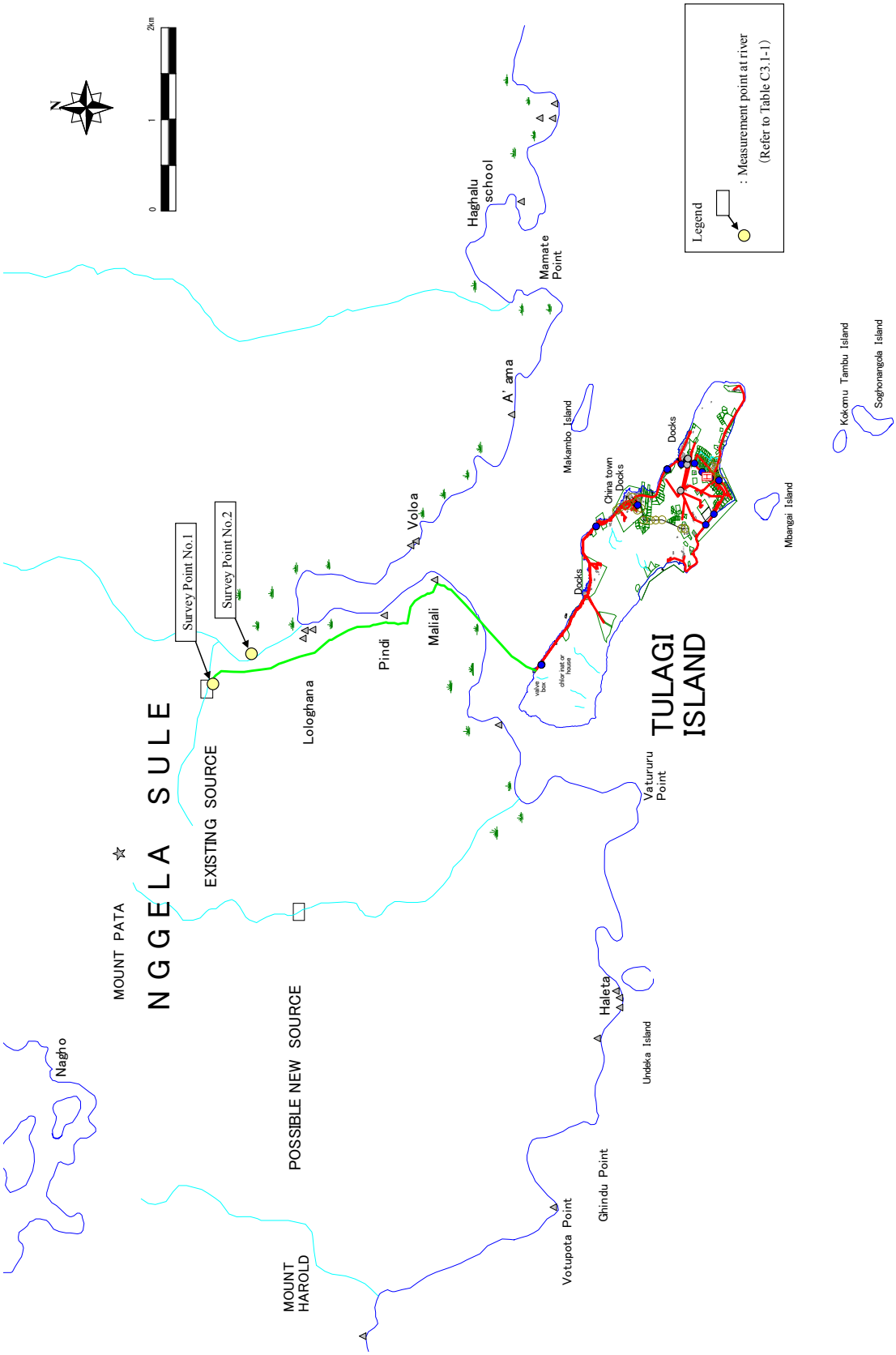


Figure C3.1-3 Surface Water Discharge Measurement Points in Tulagi

Source : JICA Study Team

(b) Groundwater Survey

Tulaghi Island is a small island surrounded by sea. Groundwater development will easily cause sea water intrusion. MNR drilled four test-boreholes with 4m depth in 1987 at Talinganivatu site in the south of the island. The result of drilling is as follows.

• Talinganivatu area is located in small coastal plain with alluvial sand. Test wells were drilled targeting the sand layer, and pumping test was carried out.

- In the test well point, sand layer is overlaid by impermeable clay layer with thickness of 1.5m.
- Sand layer forms aquifer. But sea water has intruded into the sand aquifer in deep part, and lens of fresh water is floating over sea water (see Figure B1.3-10(1)).
- Increase of yield from boreholes will easily cause increase of sea water concentration of the groundwater, and water quality immediately become unsuitable for drinking.

Aquifer of Tulaghi Island is being intruded by sea water all around the island because the island is very small. If groundwater is pumped-up from boreholes in the island, sea water will easily intrude into boreholes. Therefore, groundwater development is impossible except for small development for domestic water supply. Groundwater development should be planned not in Tulaghi Island but in Nggela Sule Island that is located on the opposite side of the sea.

(c) Water Quality Survey

Water quality survey in Tulagi consists of field water quality survey and water quality analysis in laboratory. Field water quality survey was conducted by the Team with cooperation of SIWA. Water quality analysis was conducted by SIWA in his laboratory.

Field water quality survey was conducted on June, August and December 2005 for investigations of surface water and ground water quality in dry season and rainy season. Water quality analysis was conducted from June to July for investigation of surface water and ground water quality in dry season.

1) Result of water quality survey

Water survey points were selected from existing water source and downstream area of the Maliali river.

The field water quality survey points and the water sampling points for water quality analysis is shown in Figure C3.1-5.The results of DO measurement are shown in Figure C3.1-4.

The results of the field water quality survey are shown in Table C3.1-2.

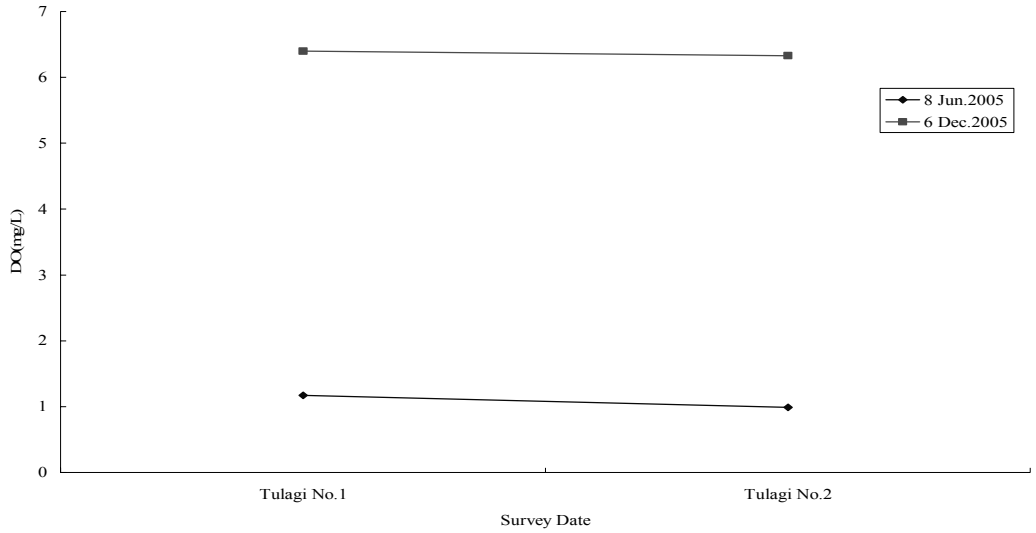
Table C3.1-2 Results of Field Water Quality Survey in Tulagi

Area	Survey Month	Water Temperature (℃)	Ec (mS/m)	Turbidity (NTU)	pH	DO (mg/L)	COD (mg/L)
No.1	June 2005	25.4	18.0	12	8.4	1.2	-
No.2		25.4	34.1	0	8.0	1.0	-
No.1	August 2005	25.5	21.2	11	8.1	-	-
No.2		25.7	27.9	11	7.3	-	-
No.1	December 2005	25.6	11.2	5	8.2	6.4	7
No.2		26.1	10.8	4	8.7	6.3	7

Source : JICA Study Team

The water quality item of DO indicated the tendency of river water contamination.

DO value of Dec.2005 was larger than June 2005. It means that river water is clean, when rain water discharge is increased in the rainy season.



Source : JICA Study Team

Figure C3.1-4 Results of DO Measurement in Tulagi

2) Results of water quality analysis in lab

Water analysis samples were collected from existing water source and existing bore (back ground of school). The results of the water quality analysis in laboratory are shown in Table C3.1-3.

Water Source:

Only chromium analysis result of the existing water source sample exceeded the WHO guideline value.

The results of the other items of the existing water source and the existing bore did not exceed the WHO guideline value except for Total Coliform Bacteria.

Total Coliform Bacteria was more than 200(MPN/mL) at the existing bore (back ground of school). However, this bore is not used at present.

Tap Water:

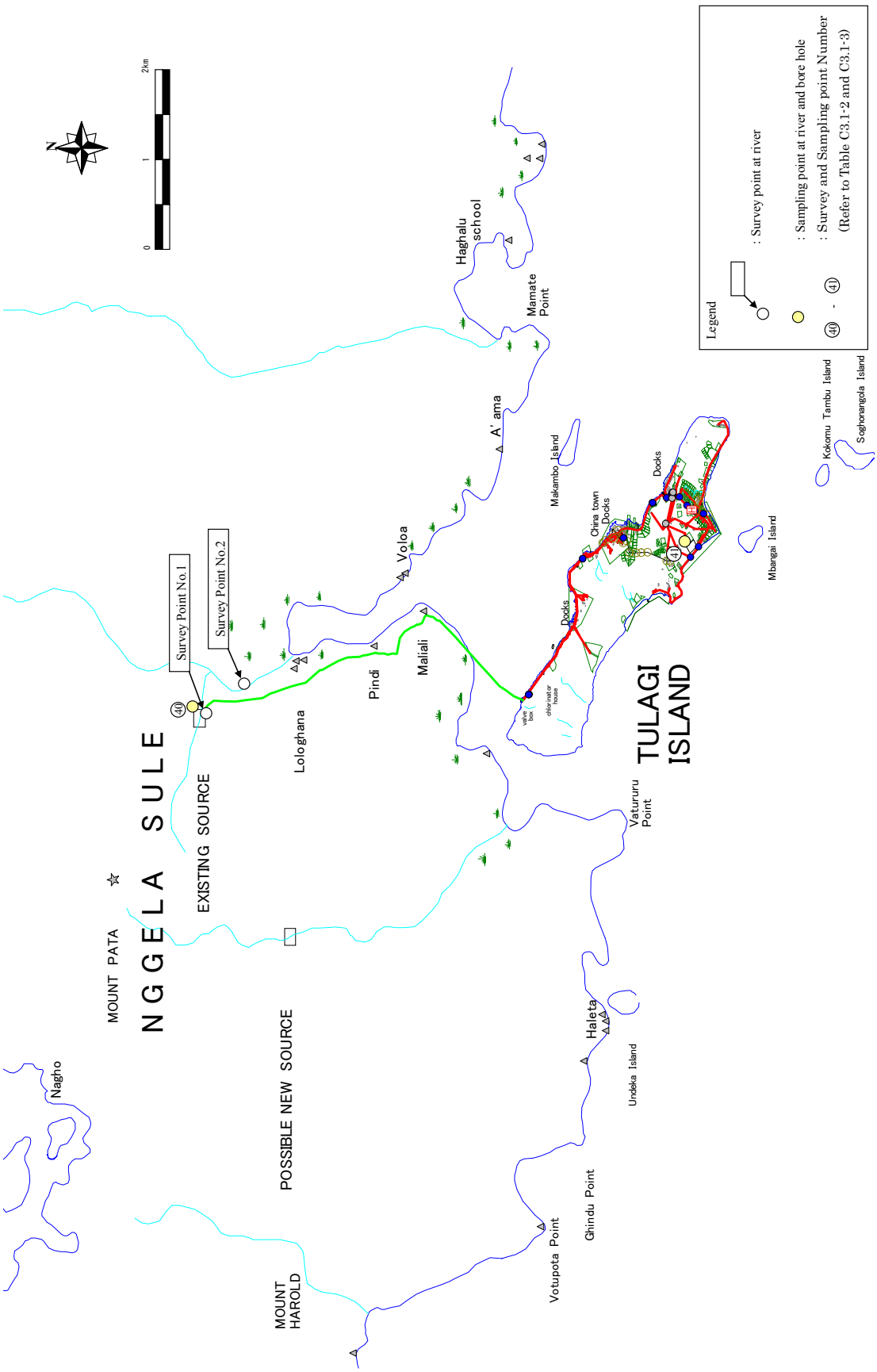
Water quality sample was not colleted in this survey.

According to the water quality analysis that was done by SIWA from 1996 to 1999, chromium content was detected. However, it did not exceed the WHO guideline value.

3) Evaluation of Water Quality

Regarding water survey and analysis in Tulagi, the evaluation can be summarized as below:

- According to the results of water quality analysis, chromium analysis result of the existing water source sample exceeded the WHO guideline value. Results of the other analysis items did not exceed the WHO guideline value.
- In general, it is considered that chromium is formed with Ultra basic rocks or serpentine. According to the geological map of the Florida Island, geology around the upper reach of the Maleali River consists on Ultra basic rocks and serpentine. It is considered that high concentration of chromium is cause by the geological distribution.



Source : JICA Study Team

Figure C3.1-5 Field Water Quality Survey Points and Water Sampling Points for Water Quality Analysis in Tulagi

Table C3.1-3 Results of Water Quality Analysis in Tulagi

Tulagi	WHO Guideline(3rd edition,2004)	Australia Drinking Water guideline(1996)	㊵ Existing water source	㊶ Existing Bore
Source			○	○
Tap				
Nitrate	50	50	1.2710	0.2300
Nitrite	3	3	0.0114	0.0042
Nitorogen-ammonia	-	-		0.0000
Mn	0.4	0.5	0.0080	0.2060
Fe	-	-	0.1090	0.0062
K	-	-		0.0000
Total hardness	-	-	136.0000	140.0000
SO4	-	-	0.0030	4.0400
Zn	-		0.0610	0.0880
Cl2	-	-	0.0000	0.0000
Cl	5	5	0.0110	0.2700
F	1.5	1.5	0.0030	0.0000
Ca	-	-	62.0000	63.1100
Mg	-	-	38.0000	56.6000
Cu	2	2	0.0170	0.0980
Pb	0.01	0.01	0.0000	0.0000
P	-	-	0.0450	0.0064
Cr	0.05	0.05	0.0630	0.0310
I	-	-	0.0095	0.0000
Al	-	-	0.0370	0.0037
Benzotriazole	-	-	0.0000	0.0000
Phenol	-	-	0.0000	0.0000
Total Coliform			-	>200

Note: unit of the above is as follows;
- MPN /mL for Total Coliform Bacteria
- mg/L for other items

Source : JICA Study Team

(d) Water Right

The Solomon Islands Government has already bought land for water source and pipeline from landowners. Therefore, payment for water-right and land-lease will not be needed any more.

(e) Socio-economic Survey

Major types of dwelling in Tulagi are "rented" and "Rent free" (40% each). 40% of households live in the area over 5 years. The average household size is 5.3 persons. Major type of toilet is flush same as in Honiara and the other provincial centers. The number of paid workers per household is 1.3 persons. The average monthly income is the lowest in the provincial centers (SI$1,025). It is almost half as much as that of low income households in Honiara (SI$2,007).

Regarding water supply, combination of piped water and rain tanks is major source of water supply. The ratio dependent on rainwater for drinking use is 50%. The average water consumption volume is 942 L/d/HH (or 152LCD). This consumption is reasonable compared with the actual consumption record taking into account the water losses inside the house.

It is the largest in the provincial centers. 80% of households are satisfied with current consumption volume of water. Half of the households pay SI$50 - 100 per month for water supply. 60% of households show the willingness to use the additional standing pipes. Priority of water is relative low in Tulagi. Households think food and house is also important for improving living conditions as well as water.

Major sewer system is septic tank. There is no sewer connection. 30% of the households have the experiences of disease caused by drinking water. All the respondents think that water source should be conserved in order to avoid contamination of water.

Monthly water bill averages SI$56.38, 5.5% in Tulagi. Willingness to pay (WTP) additionally for better water supply is SI$23.33. Total WTP is SI$79.71, 7.8% of average monthly income. ATP is SI$41.00 in Tulagi (4% of average monthly income). It is difficult to increase the tariff in Tulagi because the current monthly water bill is more than ATP. Public education for water conservation should be carried out to control the demand.

(4) Water Supply System

(a) Population and Served Ratio

According to the national census, the population of Tulagi in 1999 is 1,333 and 216 households. The population in 2005 is estimated as 1,573 and 254 households using annual growth rate in the whole Solomon of 2.8%.

Basic data for water supply by SIWA in Tulagi are as follows.

Table C3.1-4 Basic Data for Water Supply of Tulagi in 2005

City	Water Source	April	May	June	Average	Remarks
TULAGI	Water distribution	16,300	15,900	16,700	**16,300** m^3/month	
	Water distribution	543	568	557	**556** m^3/day	
	Water sales	7,000	6,000	6,000	**6,333** m^3/day	
	Water sales ratio	43	38	36	**39** %	
	NRW ratio				**61** %	
	Leakage ratio (*estimated*)				**50** %	
	Water distributed - domestic use	326	341	334	**334** m^3/day	
	Water distributed - commercial use	217	227	223	**222** m^3/day	40% of total distribution
	Water consumption for domestic	163	170	167	**167** m^3/day	
	Water consumption for commercial	109	114	111	**111** m^3/day	
	Water distributed for domestic including leakage				**314** LCD	
Pop. : 1,333 (1999)	Water consumption for domestic				**157** LCD	
House : 216 (1999)	Customer (2005) : Domestic	143	no.			
(6.2/household)	Commercial	20	no.			
Pop. : 1,573 (2005)	(Total)	163	no.			
House : 254 (2005)	Served pop. (2005)	1,064	cap.			
	Service ratio :	68	%			

Source : SIWA

(b) Existing water supply system

Existing water supply system in Tulagi is as shown in Figure C3.1-6 and consists of the following facilities.

Table C3.1-5 Existing Water Supply Facilities in Tulagi

Item	Description
Water source	Maliali river, yield 1,000m^3/day
Receiving tank	10m^3 x 2units
Booster pump station to Intermediate tank	500m^3/day
Intermediate tank	7m^3 x 1unit
Booster pump station to High level tank	500m^3/day
High level tank	100m^3 x 1unit

Source : SIWA

(c) Problem to be solved

As shown in Table C3.1-5, the yield of water source is enough for the actual demand in 2005. The only problem in Tulagi water supply system is that there is no disinfection facility. Installation of the chlorination injection facility is urgently needed and therefore proposed in "Urgent Rehabilitation Plan" of PART I in this report.

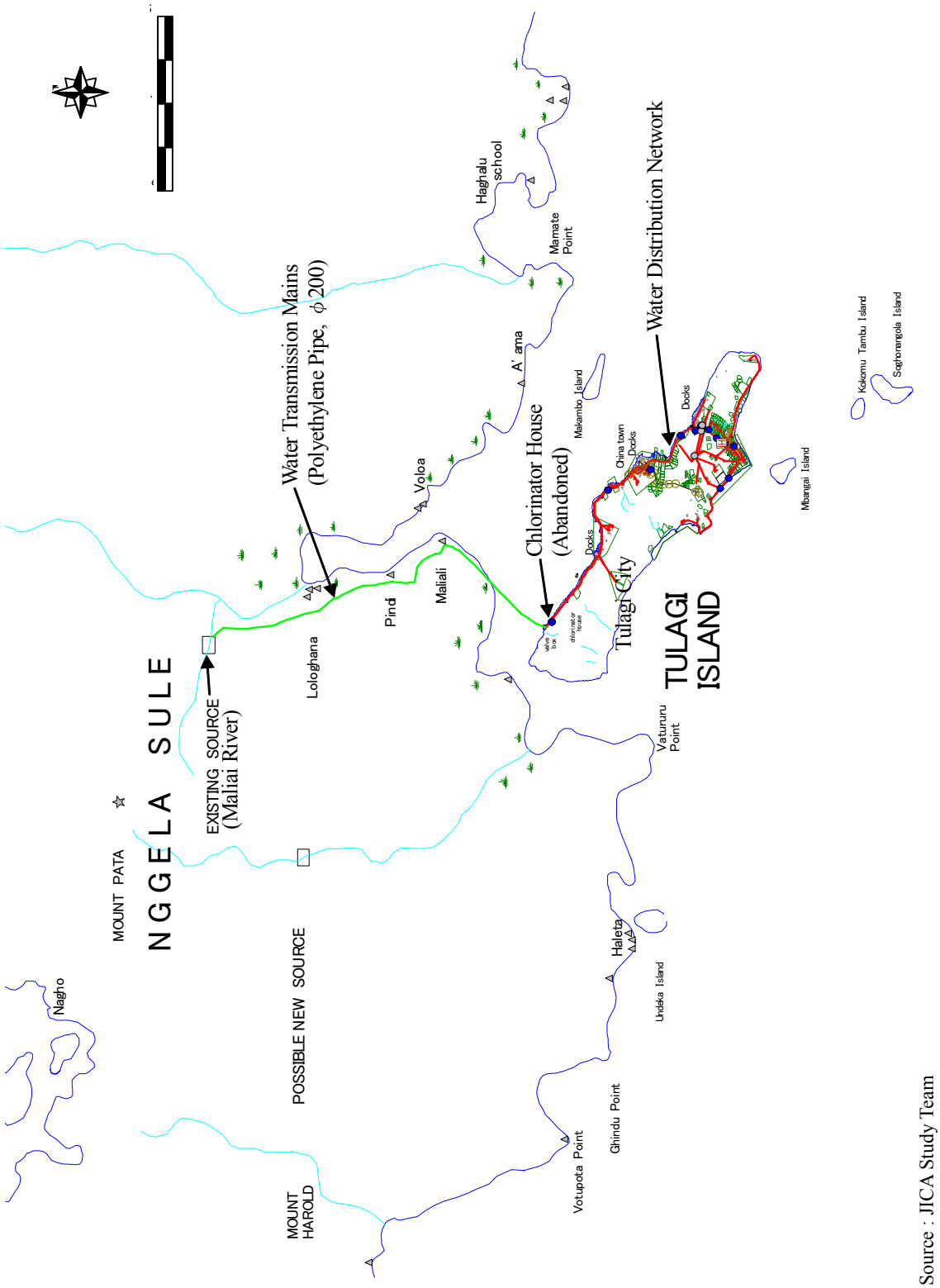


Figure C3.1-6 Existing Water Supply System in Tulagi (Year 2005)

Source : JICA Study Team

(5) Water Sources

Water Source:

Only chromium analysis result of the existing water source sample exceeded the WHO guideline value.

The results of the other items of the existing water source and the existing bore did not exceed the WHO guideline value.

Total Coliform Bacteria was more than 200(MPN/mL) at the existing bore (back ground of school). However, this bore is not used at present.

Tap water:

Water quality sample was not colleted in this survey.

According to the analysis done by SIWA from 1996 to 1999' results, chromium content were detected, but it did not exceed the WHO guideline value.

(6) Sewerage System

Tulagi is served by septic tanks and no reticulated sewer system exists. There are no outstanding problems related to the sewage in Tulagi.

C3.2 Mid-term Facility Improvement Plan

(1) Water Demand Projection

SIWA is desirous that the service ratio of Tulagi should be increased up to 68% which is the same target level as Honiara city in 2010. Since there are no accurate data for the per capita consumption for domestic use, it is assumed as the same amount as in Honiara city.

Therefore, water demand projection for Tulagi in 2010 is estimated as shown in Table C3.2-1.

Table C3.2-1 Water Demand Projection for Tulagi in 2010

Category	Year 2010							Maximum Daily Water Demand (m^3/day)
	Population (No.)	Customer [A] (No.)	Effective Water Consumption (m^3/year)	Served Pop. (No.)	Served Ratio (%)	Per Capita Consumption (LCD)	Water Distributed (LCD)	
Domestic		181		1,345		157	314	422
Commercial		24					(Er = 0.5)	282
Total	**1,806**	**205**		**1,345**	**74%**			**704**
				([A] x 1.2 x 6.2)		Exist. source	potential	1,000
							New source required	**-296**

Notes : 1. Effective water ratio is set as 50% in 2010.
2. It is assumed that commercial customers in Tulagi consume 40% of total water supply, based on the actual data from SIWA.
3. Population growth rate of 2.8% is applied based on 1999 national census.

Source : JICA Study Team

As shown in the above table, the existing source has enough capacity for the water demand in 2010. Therefore, new source development is not required for Tulagi.

(2) Potential Projection of Water Sources Development

(a) Surface water and spring

Volume of water source and water demand in Tulagi are shown in Table C3.2-2.

Table C3.2-2 Potential exploitation of Turagi

Water resource	Potential projection	
	Water volume	Occupation rate
Volume of water source	0.020m^3/s(1,728m^3/day)	100%
Current extraction	0.0024m^3/s(207m^3/s)	12.0%
Water demand	0.005m^3/s(432m^3/s)	25.0%
Potential of exploitation	0.0066m^3/s(570m^3/s)	33.3%

Source : JICA Study Team

River flow at Intake point of Tulagi, which is located on Maliali river in Ngella Sule, is approx. 0.020m^3/s. From this flow, about 0.0024m^3/s is extracted as of 1987 investigation. It accounts for only 12% of river flow.

This volume is enough to accommodate the water demand in Tulagi area of 0.005m^3/s (5L/s) which is also occupied only 25% of river flow. Compared with Honiara area, water demand occupation rate is lower in potential of exploitation water volume. If development of water extract is same rate with 33% of Kombito area, 0.0066m^3/s (570m^3/day) is expected.

However it is reported that the source had experience of depletion. Therefore new source is expected to exploit. A prospective water resource had found on Hughutambu creek in same Island Ngella Sule. Water flow of this source was 0.003m^3/s (3L/s) at least by existing report, and that this source is reported not to deplete when existing source was depleted in 1994.

(b) Groundwater

As mentioned in C3.1-(3), groundwater development is not adequate in Tulaghi Island.

(c) Optimum Water Sources

The current water source of a river is enough for water demand of year of 2010. Therefore, new water source is not necessary so far. Water demand and water development potential is summarized in Table C3.2-3.

Table C3.2-3 Water Demand of year 2010 and Water Resources Development Potential

Area	Water demand in year of 2010 (m^3/day)	Newly developed water*1 (m^3/day)	Water development potential			
			Type of water source	Remaining potential*2 (m^3/day)	Water quality	Landowner-ship
Tulagi	704	148	Surface water	1,728	Chlorination only	Customary land
			Ground-water	Negligible	Chlorination only	-

Note 1. Water necessary to be developed = Water demand in 2010 – Current extraction of groundwater (556)
2. Remaining water development potential＝Development Potential－Current extraction of groundwater
Source : JICA Study Team

(3) Policy for Improvement of Water Supply System

In Tulagi, it has been found that the existing water source and water distribution facilities will be able to serve for the demand of the target year 2010. Therefore, the facility improvement plan for Tulagi

is not required except for disinfection facility because there is no chlorination disinfection facility in the water supply system at present. The disinfection facility is urgently needed for the safe water supply. Therefore, provision of the facility has been examined in "Urgent Rehabilitation Plan" of PART F in this report.

Policy of the improvement plan for Tulagi is as mentioned in Table C3.2-4. The improvement plan for Tulagi is examined as an urgent rehabilitation plan in PART F in this report.

Table C3.2-4 Basic Policy for Water Supply Improvement in Tulagi

Current Situation	Improvement Plan
There are no outstanding problems in Tulagi for water supply except the lack of chlorination injection facility.	Chlorination facility is indispensable to secure the safety of the drinking water in the water distribution network. Therefore, provision of the chlorination facility is proposed in PART F of this report as an urgent rehabilitation plan.

Source : JICA Study Team

(4) Plan for Sewerage System

There is no sewerage system in Tulagi. Most of the people have a household septic tank. Since the sewage discharge volume is small, the environmental pollution from the sewage has not been found.

Therefore, a plan for sewerage system improvement is not formulated in this study.