CHAPTER 6 GROUNDWATER RESOURCES DEVELOPMENT PLAN

6.1 PLANNING BASIS

In this Study, the highest priority of the allocation of the water use is for domestic use. Therefore, the planning basis needs to be consistent with the design criteria, coverage plan and water supply system plan made by the National Water Supply and Drainage Board (NWSDB), the responsible organization for the planning, design construction and operation of both urban and rural water supply schemes in Sri Lanka.

(1) Groundwater Development Plan for the Pilot GNDs

The plan for the Pilot GNDs for the target year 2010 is proposed for a standard water supply level. The water supply level is to be selected from the three levels of Level 1 (hand pump), Level 2 (yard tap) and Level 3 (direct connection), based on the groundwater development potential and socio-economic conditions of the Pilot GNDs.

Regarding a standard of water supply level of Level 2, NWSDB has intention to change "Stand Post" to "Yard Tap" which is a hydrant with installed at the land of each house. Since the water supply amount of Yard Tap is regulated under the standard consumption rate of 45 liter/capita/day that is same unit consumption rate with the Stand Post, same design criteria of Level 2 can be applied. In this report therefore, a term of Yard Tap is adopted for the Level 2 water supply scheme.

The unit consumption rates of 140 liter/day/capita for the Level 3 (direct connection) and 45 later/day/capita for the Level 2 (yard tap) were adopted, in accordance with Design Guide (NWSDB 1989).

(2) Groundwater Resources Development Plan for the Study Area

The plan for the whole Study area will cover the development potential estimated by macro hydrogeological evaluation.

(3) Coverage Ratio of Population

In this Study, the coverage ratios of 100% for the all GNDs were adopted, to corresponds the national goal that is to provide access to safe drinking water to all by the year of 2010 (NPD, 2002).

6.2 PROJECTION OF FUTURE WATER DEMAND

6.2.1 CONDITIONS FOR THE ESTIMATION

Future water demand in 2010 of the Study area was estimated based on the population and related socio-economic conditions data. The estimation was carried out by GND basis. The basic criteria for the water demand projection provided by the Planning and Design Division of National Water Supply and Drainage Board (NWSDB) were adopted for the estimation.

6.2.2 FUTURE WATER DEMAND OF THE STUDY AREA

The projected future water demand of each GND of Hambantota and Monaragala is presented in Appendix E of the Supporting Report.

The total water demand is estimated as 249,970 m^3/day. On the other hand, some areas have already been supplied water by existing water supply schemes and can be expected to be supplied water in the year 2010. Therefore, the actual water demand to be covered by the Study is estimated as 95,268 m^3/day in Monaragala, 115,183 m^3/day in Hambantota (i.e., total 210,451 m^3/day for the two districts). The distribution of the water demand of 2010 is shown in *Figure 6.1*.

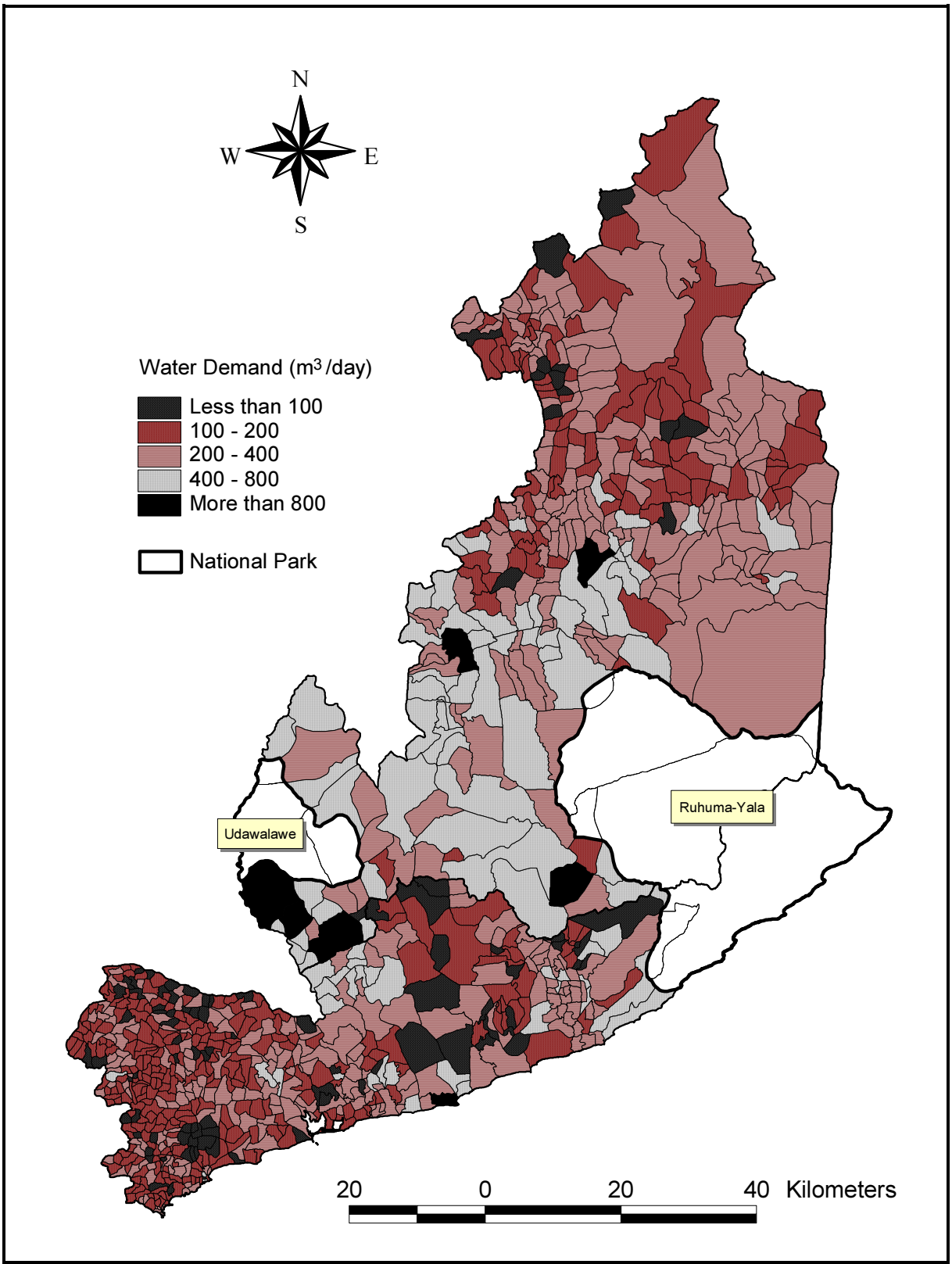

FIGURE 6.1 DISTRIBUTION WATER DEMAND (2010)

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6.2.3 FUTURE WATER DEMAND OF THE PILOT GNDS

The projected future water demand of each Pilot GND is summarized in the *Table 6.1*.

Table 6.1 Future Water Demand in Pilot GNDs (2010)

GN Division Name	Plan (by NWSDB)						Project Water Demand 2010	
	Population 2010		Cover-ed	Total Demand	level 2 (Y.T.)	level 3 (D.C.)	Popula-tion	**Demand**
	No.	Density Nos/km^2	No.	m^3/day	%	%	No.	**m^3/day**
MONARAGALA								
M1 Hambegamuwa	2,170	13.7	0	469	20	80	2,170	**469**
M2 Bodagama	1,801	86.0	0	389	20	80	1,801	**389**
M3 Hulandawa L	2,270	312.9	0	491	20	80	2,270	**491**
M4 Unawatuna	2,427	285.4	503	633	10	90	1,924	**563**
M5 Yalabowa	1,980	412.4	1,194	480	10	90	786	**313**
M6 Badalkumbura	1,380	709.7	1,119	334	10	90	261	**178**
M7 Sevanagala	6,085	368.3	0	1,315	20	80	6,085	**1,315**
HAMBANTOTA								
H1 Keliyapura	668	26.6	1,070	160	0	100	(402)	**11**
H2 Vitarandeniya	1,633	249.7	2,240	380	10	90	(607)	**66**
H3 Talunna	1,224	276.2	485	274	10	90	739	**206**
H4 Wediwewa	1,699	84.7	0	352	20	80	1,699	**352**
H5 Tammennawewa	1,754	88.3	2,132	523	0	100	(377)	**225**
H6 Pahala Mattala	424	36.9	241	118	10	90	183	**84**
H7 Siyambalagasvila N	1,049	576.5	1,180	252	0	100	(131)	**87**
H8 Ranna West	1,792	643.5	790	395	10	90	1,001	**284**

The Pilot GNDs of Keliyapra, Vitarandeniya, Tammennawewa and Siyambalagasvila North have the future water supply plans, to be constructed before the target year of 2010. The estimation of water demand of such existing plans was made by only direct connection's (Level 3) domestic consumption rates of 140 liter/day/capita; the demands of non-domestic and non-revenue water (NRW) are not estimated. Therefore, the project demand generated is a slight amount, although the demand shows negative value. The Pilot GND of Unawatuna, Yalabowa and Badalkumbura have existing water supply schemes. Therefore, the estimated project demand is the demand of the stranded area in the GND.

6.3 GROUNDWATER RESOURCES DEVELOPMENT PLAN

6.3.1 DEVELOPMENT PLAN IN THE STUDY AREA

(1) Promising Areas for Groundwater Resources Development Plan

The promising area for the groundwater resources development in Hambantota and Monaragala district was determined by the groundwater evaluation as described in *Chapter 5*. *Figure 6.2* shows the promising area for the groundwater resources development and the distribution of water demand (2010) in the Study area.

(2) The Demand and Area covered by the Plan

The GNDs distributed within the promising areas for the groundwater development resources plan were extracted to determine the amount and area of the demand to be covered by the plan. The results are summarized in *Table 6.2*.

Table 6.2 The Demand and Area Covered by the Plan

Hambantota District

Aquifer Type		Number of GNDs	Demand (m^3/day)	Area (km^2)
Upper Fractured Aquifer	Very good	69	11,405	147.29
	good	153	27,487	616.80
Lower/Deeper Fractured Aquifer	Very good	3	436	5.75
	good	126	26,323	520.28
Subtotal		**351**	**65,651**	**1,290.28**

Monaragala District

Aquifer Type		Number of GNDs	Demand (m^3/day)	Area (km^2)
Upper Fractured Aquifer	Very good	84	22,445	1,465.28
	good	115	32,764	1,957.11
Lower/Deeper Fractured Aquifer	Very good	42	10,767	302.18
	good	55	22,539	894.40
Subtotal		**296**	**88,514**	**4,618.97**

Total of Hambantota and Monaragala

	Number of GNDs	Demand (m^3/day)	Area (km^2)
Grand Total	**647**	**154,165**	**5,909.25**

In Hambantota district, the demand amount is estimated as 65,651 m^3/day for 351 GNDs with an area of 1,290 km^2, while Monaragala district is estimated as 88,514 m^3/day for 296 GNDs with an area of 4,618.97 km^2.

(3) Comparison Between Present Water consumption and Production Volume by the Plan.

The results of questionnaire survey reveal that average water consumption is 19 liter/day/capita in Hambantota district and 35 liter/day/capita in Monaragala district. The consumption rate for the water supply levels are defined by the design criteria of NWSDB, that is 45 liter/day/capita for Level 1 (hand pump) and Level 2 (yard tap), 45 liter/day/capita for Level 3 (direct connection). The present consumption rates therefore, are lower than any levels of design criteria of NWSDB.

On the other hand, by the development plan, following production volume is expected. In the planned area of Hambantota district, 17.28% of total population that is 46,369 peoples can be supplied 45 liter/day/capita by the yard tap, and 82.72% of population that is 221,982 peoples can be supplied 140 liter/day/capita by the direct connection. Thus, total production volume of 33,164m^3/day/capita for the 268,350 peoples can be developed. In the planned area of Monaragala district, 17.98% of total population that is 68,282 peoples can be supplied 45 liter/day/capita by the yard tap, and 82.02% of population that is 311,535 peoples can be supplied 140 liter/day/capita by the direct connection. Thus, total production volume of 46,687m^3/day/capita for the 379,817 peoples can be developed.

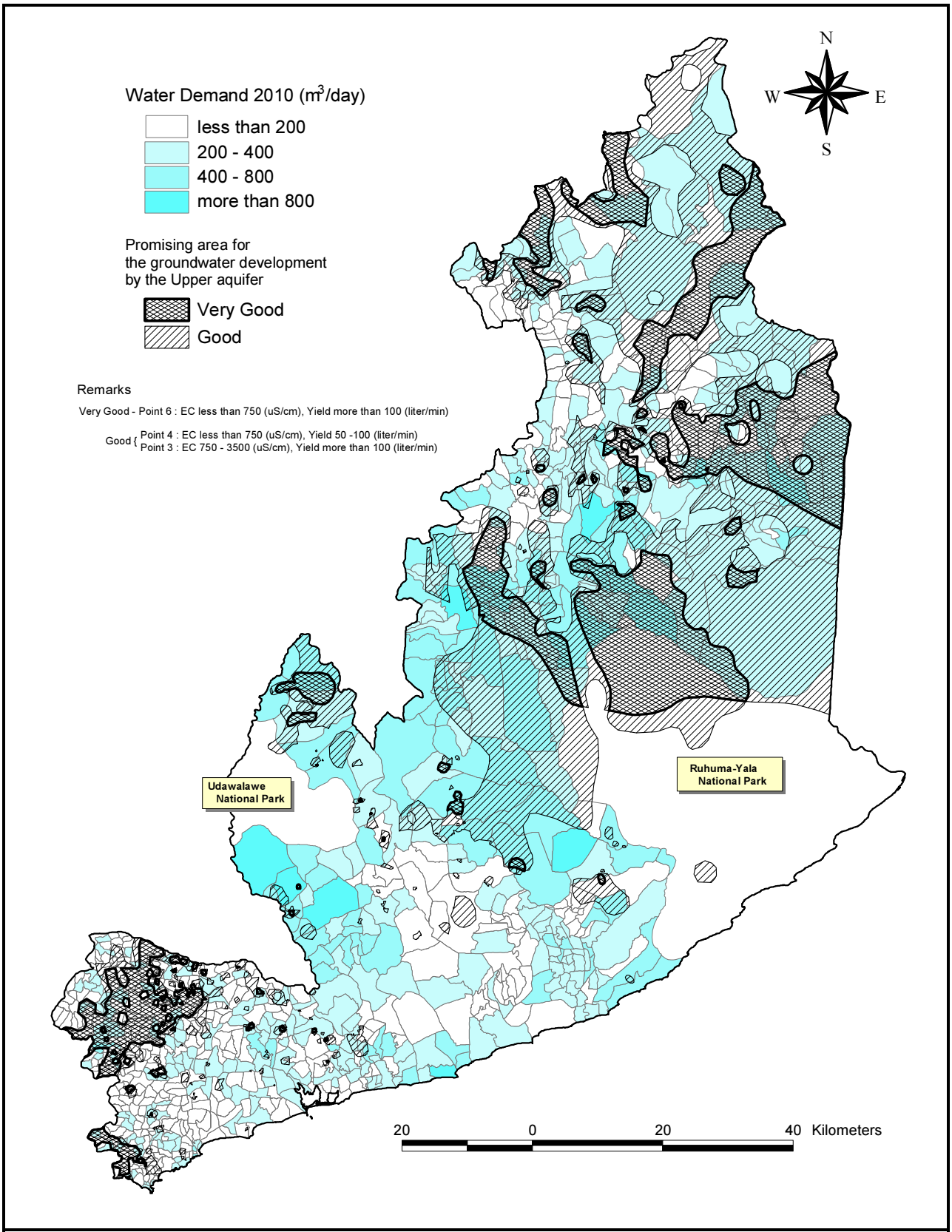

FIGURE 6.2(1) DISTRIBUTION OF PROMISING AREA OF UPPER FRACTURED AQUIFER FOR THE GROUNDWATER DEVELOPMENT AND WATER DEMAND (2010)

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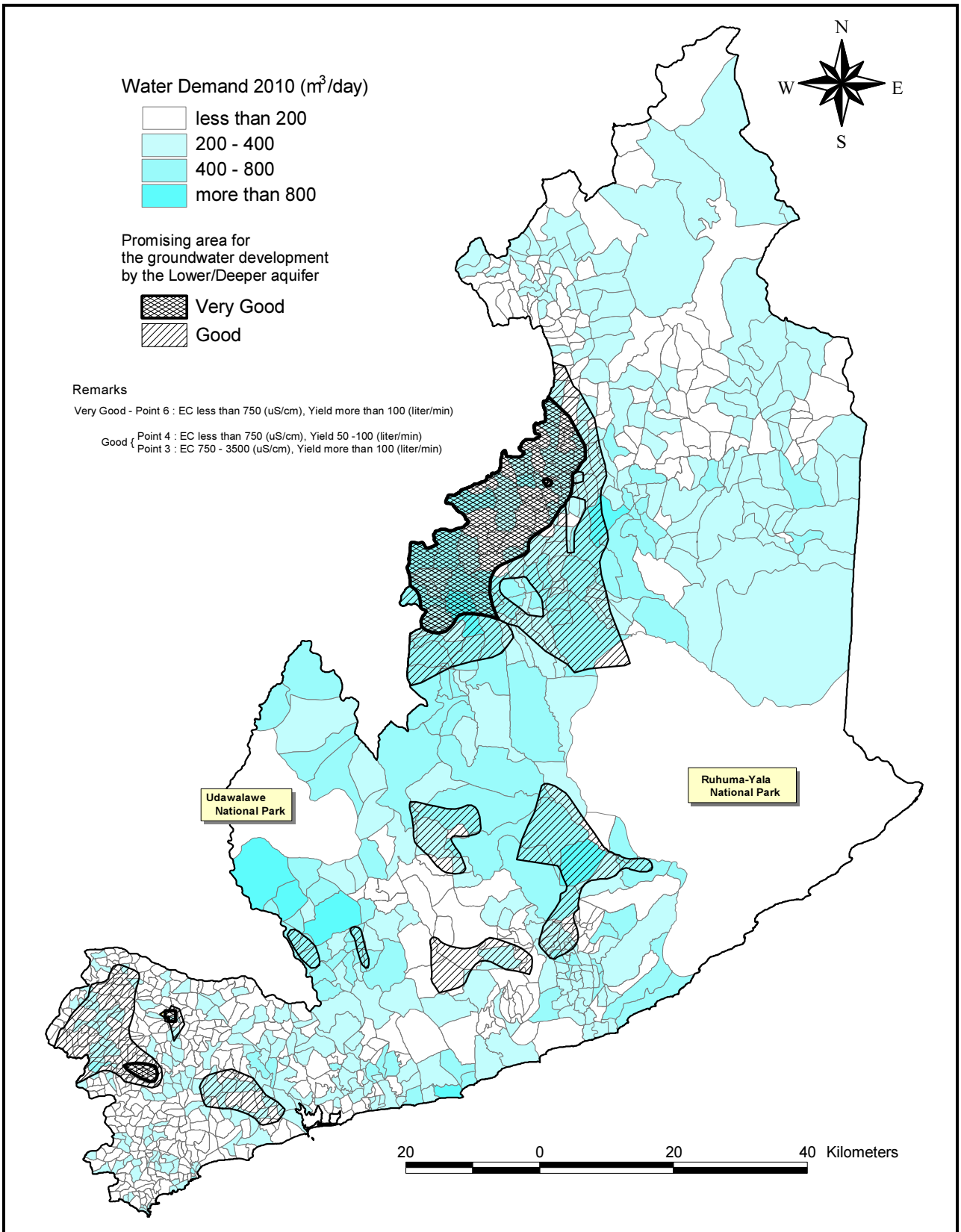

FIGURE 6.2(2) DSTRIBUTION OF PROMISING AREA OF LOWER/DEEPER FRACTURED AQUIFER FOR THE GROUNDWATER DEVELOPMENT AND WATER DEMAND (2010)

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(3) Drilling Program for Groundwater Development

Drilling programs for the production wells is examined based on the groundwater development plan. *Table 6.3* shows the required number of wells by aquifer type. A total of 468 wells for the Upper Fractured Aquifer and a total of 193 wells for the Lower/Deeper Fractured Aquifer are estimated.

Table 6.3 Required Number of Wells by Aquifer Type

	District	Demand (m^3/day)	Number of Wells
Upper Fractured Aquifer	Hambantota	38,892	193
	Monaragala	55,209	275
	Total	**94,101** m^3/day	**468 wells**

Remark: Expected well yield of 201 m^3/day (an average of 586 existing wells with 12 hours operation/day) was adopted

	District	Demand (m^3/day)	Number of Wells
Lower/Upper Fractured Aquifer	Hambantota	26,759	86
	Monaragala	33,306	107
	Total	**60,065** m^3/day	**193 wells**

Remark: Expected well yield of 312 m^3/day (an average of 7 test wells with 12 hours operation/day) was adopted

Based on the estimated number of the wells, the drilling programs are examined below.

1) For the Upper Fractured Aquifer

Considering the required depth of the wells, two drilling rigs owned by WRB or NWSDB can be assigned for the program. Approximately 7.8 years period will be required for drilling a total of 468 wells for the Upper Aquifer.

2) For the Lower/Deeper Fractured Aquifer

Implementation can be planned by a drilling rig with necessary equipment capable of drilling to 200 m depth with 8 inches hole diameter. Approximately 7.5 years period will be required for drilling a total of 193 wells for the Lower/Deeper Aquifer.

(4) Proposed Candidate Areas for the Development Plan

The promising area for the groundwater development is largely distributed in the Monaragala and partly in Hambantota. Considering the distribution of each type of aquifer and regional convenience and efficiency for the drilling program, the proposed candidate areas for the development are divided into the following six blocks as shown in *Figure 6.3.*

1) Bibile-Madulla Block

Total Area : 1,303 Km^2

Population 2010 : 79,702

Demand 2010 : 15,531 m^3/day

Implementation : By existing drilling team by WRB or NWSDB

2) Monaragala-Siyambalanduwa Block

Total Area : 1,722 Km^2

Population 2010 : 140,139

Demand 2010 : 29,685 m^3/day

Implementation : By existing drilling team by WRB or NWSDB

3) Badalkumbura-Wellawaya Block

Total Area	:	1,055 Km^2
Population 2010	:	157,096
Demand 2010	:	32,571m^3/day
Implementation	:	Mainly by newly established drilling division in WRB Monaragala, partly by existing drilling team by WRB or NWSDB.

4) Wellawaya- Lunugamwehera Block

Total Area	:	1,318 Km^2
Population 2010	:	108,338
Demand 2010	:	20,393 m^3/day
Implementation	:	Mainly by newly established drilling division in WRB Monaragala, partly by existing drilling team by WRB or NWSDB.

5) Thanamalwila Sub-Block

Total Area	:	215 Km^2
Population 2010	:	13,351
Demand 2010	:	2,885 m^3/day
Implementation	:	By existing drilling team by WRB or NWSDB

6) Katuwana-Weeraketiya Sub-Block

Total Area	:	445 Km^2
Population 2010	:	181,637
Demand 2010	:	34,170 m^3/day
Implementation	:	Mainly by existing drilling team by WRB or NWSDB, partly by newly established drilling division in WRB Monaragala

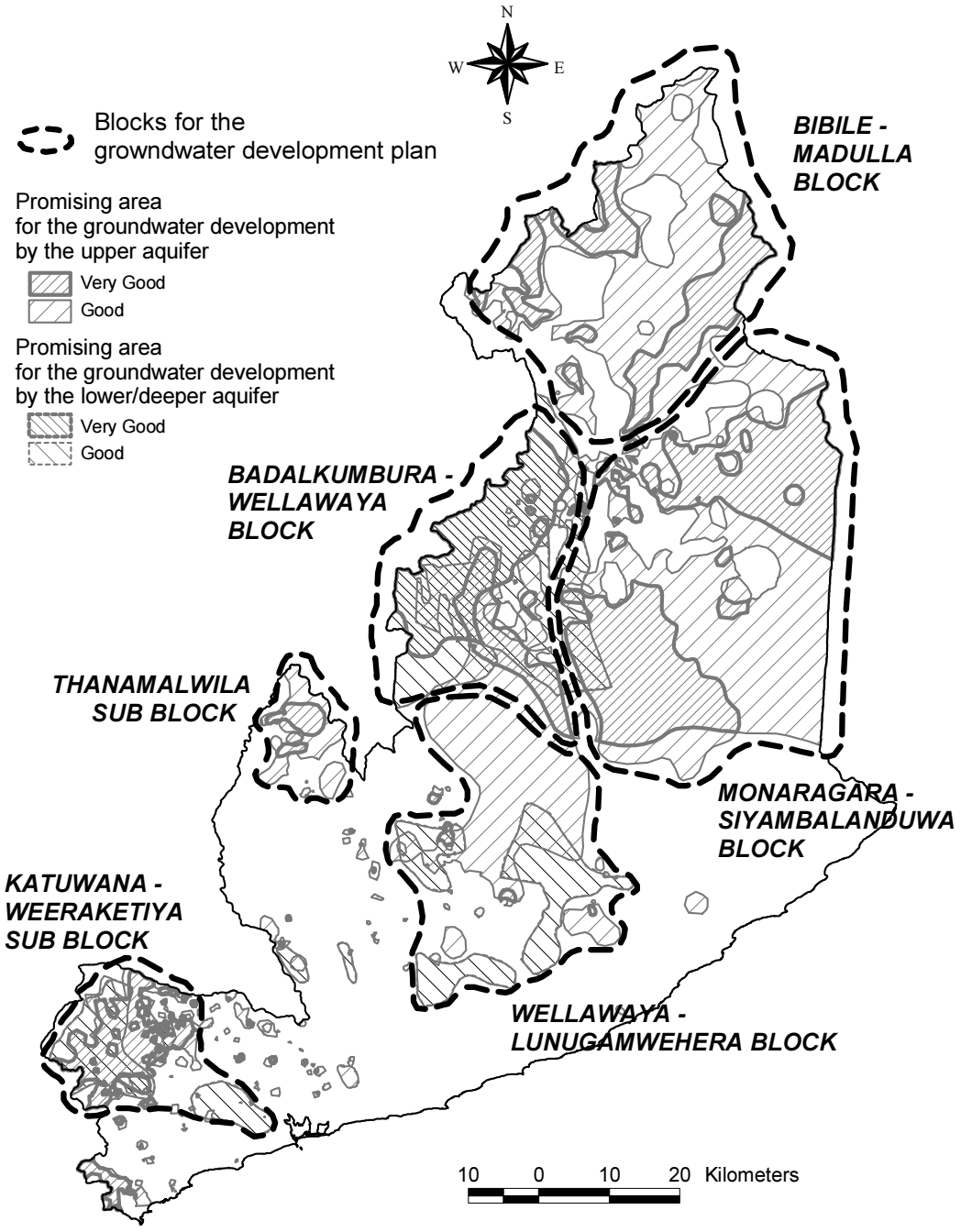

FIGURE 6.3 PROPOSED CANDIDATE AREA FOR THE GROUNDWATER DEVELOPMENT PLAN

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6.3.2 PLANNING PROCEDURE

In this Study, the groundwater development plan for the Pilot GNDs will be made mainly for domestic use. The extractable amount of groundwater depends on hydrogeological conditions of each area. The procedure used by this Study, therefore, will be basically adopted for the development planning of other GNDs. *Figure 6.4* shows the proposed planning procedure for the groundwater resources development. The proposed procedure consists of three stages: (1) Hydrogeological Investigation, (2) Master Plan and (3) Feasibility Study and Design.

The Study covered by this project as above mentioned is: (1) Hydrogeological Investigation and (2) Master plan. The feasibility study and design is required for the project implementation.

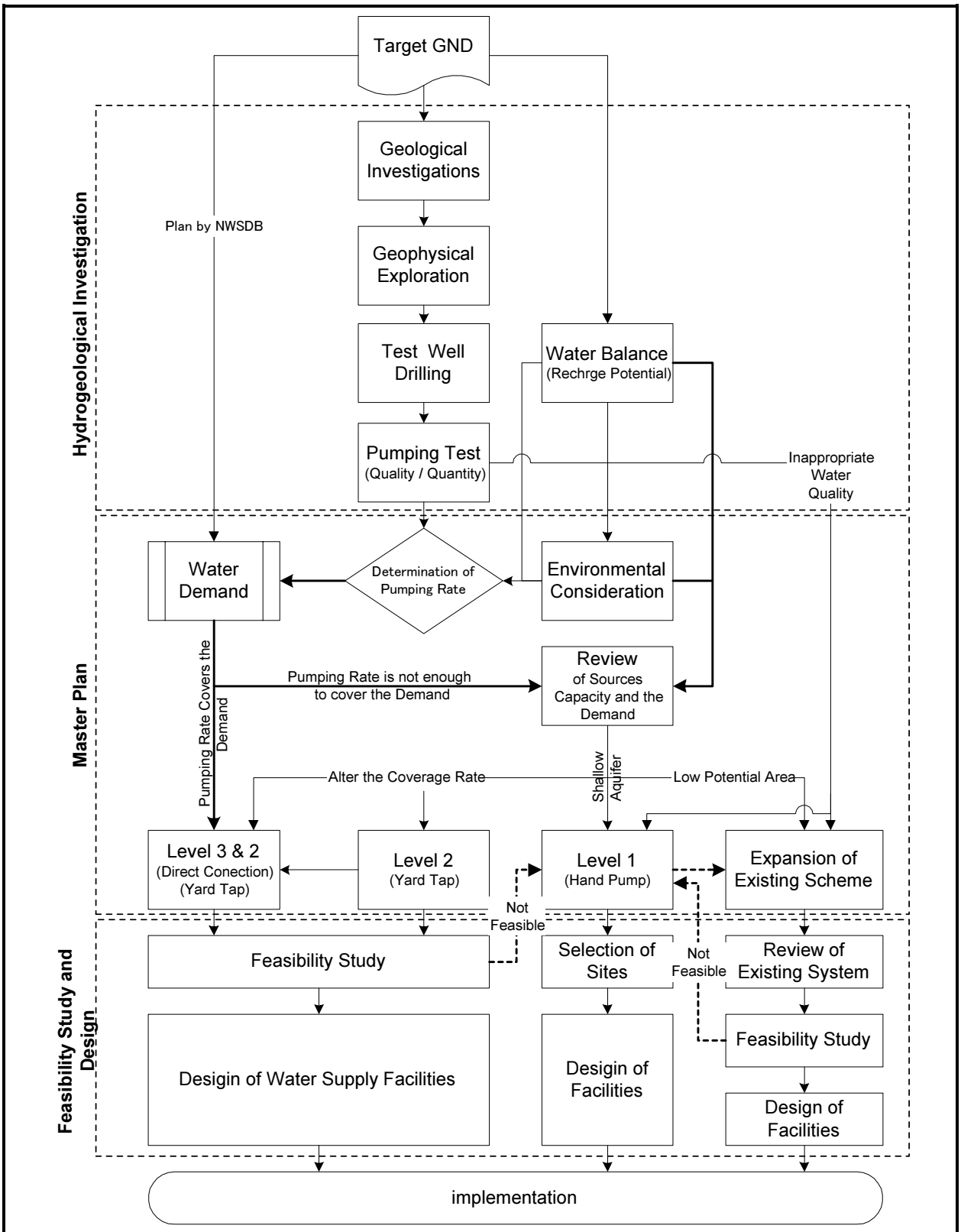

FIGURE 6.4 FLOW OF GROUNDWATER RESOURCES DEVELOPMENT

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6.4 PILOT PLAN

6.4.1 WATER SUPPLY SYSTEM PLAN

Measure of the conveyance facilities plan (that is, the levels of water supply scheme) were determined in accordance with the future water demand estimated and groundwater potential both of quality and quantity. The following are the determined water supply system plans for the groundwater resources development plans.

(1) Combination System of Level 3 (Direct Connection) and 2 (Yard Tap)

This system plan is the combination system of yard tap and direct connection. Water is pumped up by submersible pump(s) in the well(s) to an elevated tank and sent to both yard taps (level 2) and houses (level 3).

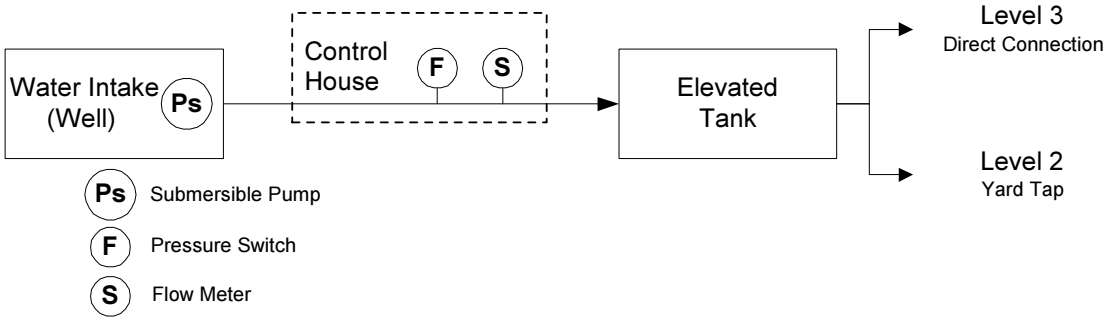

Figure 6.5 Conceptional Diagram of Combination System of Level 2 and 3

(2) Level 3 (Direct Connection) System

This system plan is water distribution through the direct connection only. Water is pumped up by submersible pump(s) in the well(s) to an elevated tank and sent to each house.

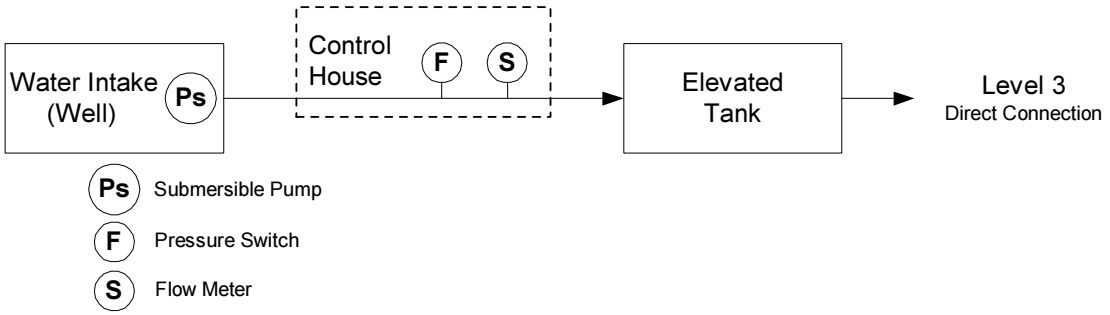

Figure 6.6 Conceptional Diagram of Level 3 System

(3) Level 2 (Yard Tap) System

This system plan is water distribution through yard tap only. Water is pumped up by submersible pump(s) in the well(s) to an elevated tank and sent to several yard taps.

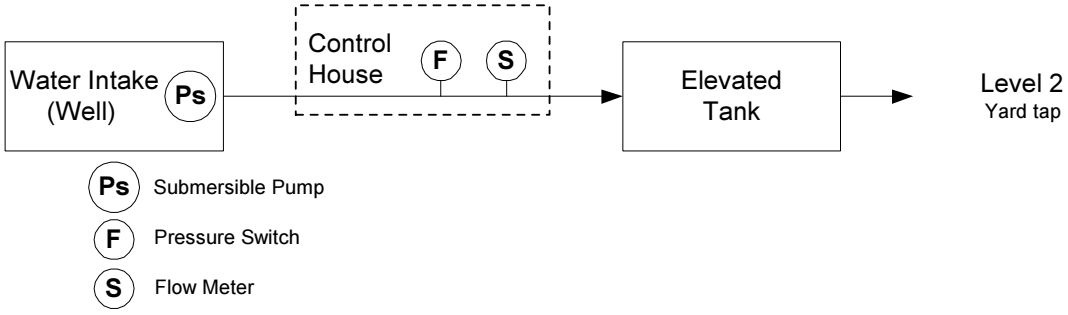

Figure 6.7 Conceptional Diagram of Level 2 System

6.4.2 GROUNDWATER RESOURCES DEVELOPMENT PLAN

Based on the future water demand estimated by *section 6.2.3*, and groundwater potential evaluation by *Chapter 5*, the groundwater resources development plans for the Pilot GNDs are formulated as shown in *Table 6.4*.

As a result, the combination system of level 3 and 2 with the original coverage plan was adopted for the four GNDs of Yalabowa, Badalkumbura, Talunna and Tammennawewa. For the other GNDs, the coverage plan was altered due to the limitation of source capacity. In the Hambantota district, three GNDs (Keliyapura, Wediwewa and Siyambalagasvila North), it is difficult to make the plan by both shallow and deep groundwater resources due to the inappropriate water quality and low source capacity. In these GNDs, however, expansion of existing system will be the feasible option because the GNDs are situated close to the main scheme of Hambantota and amount of the demand is comparatively small.

In Tammennawewa, a considerable amount of the source capacity to cover the future water demand was confirmed. However, due to the inappropriate water quality, an uneconomical water treatment plant by osmosis process for the rural water supply is required. Water supply for miscellaneous use is one of the feasible options.

For the GNDs without test well, source capacity was estimated by the groundwater evaluation made by the Chapter 5. For water quality, the GND ranked as “good” (less than 750 μ S/cm of EC value), the system plan is made without treatment system. However, since the parameters of Iron (Fe3+) and Fluoride (F-) will not affect the EC value, water quality must be examined from the obtained water samples from drilled wells.

Table 6.4 Groundwater Development Plan in Pilot GND (1/2) Monaragala District

Pilot GND	Plan NWSDB			Source Potential			Groundwater Development Plan					
							Water Supply Plan			Facility Plan		
	System		**Dema-nd**	By test well	Estimati-on[1]	Water Quality[2]	System (Corrected)		**Supply Amount (Corrected)**	No. of wells	Required treatment plant determined by the water quality	Remarks
	level 2	level 3	**2010**				level 2	level 3				
	%	%	**m^3/day**	m^3/day	m^3/day		%	%	**m^3/day**			
M1 Hambegamuwa	20	80	**469**	N.A.	***72.00***	*Good*	100	0	**174**	3		
M2 Bodagama	20	80	**389**	**316.80**	N.A.	Alkalinity & F^-	45	55	**316**	1	Defluoride pH control	
M3 Hulandawa L	20	80	**491**	N.A.	***72.00***	*Good*	100	0	**182**	3		
M4 Unawatuna	10	90	**563**	N.A.	***72.00***	*Good*	100	0	**148**	2		
M5 Yalabowa	10	90	**313**	**439.20**	N.A.	Alkalinity	10	90	**313 plus 1GND**	1	pH control	It is possible to supply the water amount of 126 m^3/day to neiboring GNDs.
M6 Badalkumbura	10	90	**178**	**684.00**	N.A.	Fe^{3+}	10	90	**178 plus 2GND**	1	Iron Removal	It is possible to supply the water to neiboring GNDs of Pussellawa (320 m^3/day demand) and Kalagaha Kivula (145 m^3/day demand)
M7 Sevanagala	20	80	**1,315**	**61.20**	N.A.	pH & Pb	100	0	**174**	3	Coagulation Sedimentation and filtration	Considering the cost, the treatment plant of coagulation sedimentation and filtration is not recommended. However, since the considerable amount of source capacity was found, detailed feasibility study is required.

Remarks
1) Estimated yield by the hydrogeological evaluation
2) Water quality,
Good: EC value is less than750 µS/cm
Fair: EC value is between 750 to 3,500µS/cm
3) Expansion of "Existing Scheme" is recommended
N.A. Not applicable

Table 6.4 Groundwater Development Plan in Pilot GND (2/2) HambantotaDistrict

Pilot GND	Plan NWSDB			Source Potential			Groundwater Development Plan					
							Water Supply Plan			Facility Plan		
	System		Dema-nd	By test well	Estimati-on[1]	Water Quality[2]	System (Corrected)		**Supply Amount (Corrected)**	No. of wells	Required treatment plant determined by the water quality	Remarks
	level 2	level 3	**2010**				level 2	level 3				
	%	%	**m^3/day**	m^3/day	m^3/day		%	%	**m^3/day**			
H1 eliyapura	0	100	**11**	**0.72**	N.A.	Inappropriate	0	100	E.S [3]	N.A		Groundwater development is not applicable. Expansion of existing WS scheme is recommended.
H2 Vitarandeniya	10	90	**66**	N.A.	***36.00***	*Fair*	35	65	**36**	1	Water quality analysis is required	Determination of water treatment system is required.
H3 Talunna	10	90	**206**	**298.80**	N.A.	Hardness & Ca^{2+}	10	90	**206 plus**	1	Crystallization	
H4 Wediwewa	20	80	**352**	**1.08**	N.A.	Inappropriate	20	80	E.S	N.A		Groundwater development is not applicable. Expansion of existing WS scheme is recommended.
H5 Tammennawewa	0	100	**225**	**311.04**	N.A.	Inappropriate	0	100	**225 plus**	1	Crystallization and reverse osmosis	Considering the cost, the treatment plant of revers osmosis is not recommended. However, since the considerable amount of source capacity was found, detailed feasibility study is required.
H6 Pahala Mattala	10	90	**84**	**76.32**	N.A.	Desirable	20	80	**76**	1		
H7 Siyambalagasvila	0	100	**87**	**0.75**	N.A.	Inappropriate	0	100	E.S	N.A		Groundwater development is not applicable. Expansion of existing WS scheme is recommended.
H8 Ranna West	10	90	**284**	N.A.	***72.00***	*Fair*	84	16	**71**	1	Water quality analysis is required	Determination of water treatment system is required.

Remarks
1) Estimated yield by the hydrogeological evaluation
2) Water quality,
Good: EC value is less than750 µS/cm
Fair: EC value is between 750 to 3,500µS/cm
3) Expansion of "Existing Scheme" is recommended
N.A. Not applicable

6.5 GROUNDWATER MONITORING PLAN

(1) Proposed Monitoring Items and Frequency

Proposed monitoring items and frequency of monitoring are as follows:

1) 10 test wells (for lower/deeper fractured aquifer)

- Monitoring items: water level and water quality.
- Frequency of Monitoring: once every two months.

2) 30 selected exiting wells (for upper fractured aquifer)

- Monitoring items: water level and water quality.
- Frequency of Monitoring: once every two months (If it is difficult, at least twice a year in each rainy and dry season is recommended).

(2) Proposed Organization in Charge of Monitoring

It is proposed that Monaragala regional office should have responsibility of the monitoring (i.e., for direct measurement and sample collecting). Since the office doesn't have laboratory, water quality analysis should be conducted in the laboratory in Colombo.

(3) Monitoring of New Production Wells

In case new wells and water supply facility will be constructed based on the result of this Study, the following monitoring is recommended to examine the proper pumping rate for the operation and to gain further hydrogeological data.

Monitoring Item	Frequency	Remarks
Water level	Everyday	O & M person of facility checks by using water measurement pipe installed inside of well.
Water quality	Once every two months	By WRB geologists

6.6 OPERATION, MAINTENANCE AND MANAGEMENT PLAN

6.6.1 OPERATION AND MAINTENANCE PLAN FOR PROPOSED WATER SUPPLY SCHEMES

The categorization for organization in charge of operation and management of water supply scheme is shown in *Table 6.5*. As for rural water supply scheme of which water supply area stretches over several GNDs, it is proposed that Pradeshiya Sabha is appointed as the management organization.

Table 6.5 Categorization for Operation & Management Organization

	Pradeshiya Sahba	Community Based Organization	Consumer Society
Scale of Scheme	Less than 6,000 population, Less than 1,000 connectoins, or Less than 1,000 m3/day capacity Water supply area stretches over several GNDs	Less than 6,000 population, Less than 1,000 connectoins, or Less than 1,000 m3/day capacity Water supply area limits to only one GND	Tube Well with Hand Pump

Human resources requirement for operation and maintenance of facility plan is shown in *Table 6.6*.

Table 6.6 Human Resources Requirement of Each Facility Plan

Type	Facility	O & M person
1	Treatment Plant (elaborate) Elevated Tank Submersible & Transmission Pump Transmission & Distribution Pipe	Technical Officer (PT*) 1 Treatment Plant Caretaker 4 Pump Opretor 1, Watcher 1, Plumber 1
2	Treatment Plant (simple) Elevated Tank Submersible & Transmission Pump Transmission & Distribution Pipe	Technical Officer (PT) 1 Treatment Plant Caretaker 2 Pump Opretor 1 Watcher 1, Plumber 1
3	Treatment Plant (very simple) Elevated Tank Submersible & Transmission Pump Transmission & Distribution Pipe	Technical Officer (PT) 1 Treatment Plant Caretaker 1 Pump Opretor 1 Watcher 1, Plumber 1
4	Elevated Tank Submersible & Transmission Pump Transmission & Distribution Pipe	Technical Officer (PT) 1 Pump Opretor 1 Watcher 1, Plumber 1
5	Hand Pump	Caretaker 2

Remarks: *: Part-time basis

This proposal is only general; therefore, it is recommended that after finishing feasibility study, NWSDB, committee and user itself hold substantial discussions from primary planning stage and determine proper facility plan and achievable management, operation and maintenance plan through discussion.

6.6.2 Proposed Plan for Operation and Maintenance of Drilling Machines to be Donated

Drilling machines used in this Study are recommended to be utilized for the further groundwater study in the country where development of deeper fractured aquifer is required. In Sri Lanka the study of deeper fractured aquifer has not been conducted yet except in this Study.

6.7 Organization, Institution and Human Resources Development Plan

6.7.1 Strengthening of WRB Drilling Division

(1) New Establishing of Drilling Division in Monaragala

In order to conduct drilling of lower/deeper aquifer according to drilling program of groundwater development plan, one drilling rig with necessary equipment capable of drilling to 200 m depth with 8 inches hole diameter will be needed.

For completing the program, it is recommended to organize a drilling division possessed of a complete set of drilling equipment in Monaragala regional office.

(2) Appropriate Budget Allocation for Maintenance & Repairs of Drilling Machines

Haploid number of drilling machines that WRB possesses is malfunction condition at present. Work Shop of WRB has enough technical capabilities to repair them, however, it is difficult to get necessary spare parts for repairing mainly due to shortage of finance.

For effective drilling activity using existing machines and equipments to satisfy the annual demand to WRB, it is recommended to increase budget allocation for maintenance and repairs of drilling machines.

6.7.2 CAPACITY BUILDING OF PRADESHIYA SABHA

At present, Pradeshiya Sabha is in a more weakened state among the organizations managing water supply schemes judging from site visits and comparison with other organizations. It is mainly due to deficiency of technical capability of PS staffs. Training program to them should be conducted. NWSDB is sequentially conducting training program to PS, therefore, it is recommended that NWSDB continues and proceeds with this plan further.

If training program for Pradeshiya Sabha staff will be conducted, shortage of human resources of PS will still cause inadequate situation of capacity of operation and management. It is necessary that measures be improved for securing human resources; for example, by improving labour conditions and/or creating an attractive work environment in the area.

6.8 EVALUATION OF GROUNDWATER RESOURCES DEVELOPMENT PLAN

6.8.1 SOCIO-ECONOMIC ASPECT

(1) Remedy Social Unfairness

The availability of existing water source restricts the improvement of the water supply system by present operation of NWSDB. In the Study area, 84% of population in Monaragala, and 77% of population of Hambantota are living in areas where water supply improvement plans were precluded. From this point of view, it would be judged as social unfairness is generated by the availability of the existing water source.

Development of the groundwater, therefore, has significant merit to remedy the social unfairness by providing safe drinking water to such unattended inhabitants in the Pilot GNDs.

(2) Mitigation of the Labor to Obtain Water

The time differences between the present water source and development plan that is Level 3 (direct connection) and Level 2 (yard tap) are estimated. The results suggest that there are significant impacts to mitigate the labor by the Plan. The range of time difference between the present water source and the plan shows 17 to 86 minutes. Considerable impacts are observed even in Level 2 plan.

It is concluded that the development plan will contribute the huge socio-economic benefit to the inhabitants by the mitigation of the labor to obtain water.

(3) Health Care

In the Hanbantota and Monaragala districts, there are actual and substantive problems in the health sector that water-borne diseases of the “Typhoid Fever”, “Malaria”and “Shigellosis” are considerably high than the country average.

The national programme for the control of diarrhoeal diseases, especially water born diarrhoeas were mainly managed with the use of intra-venous fluid therapy for dehydration. As a result, although the mortality rate due to the diarrhoeal diseases has come down dramatically, the morbidity rate has not decreased comparably (MOH 1998). This fact reveals that there is a limit to eradicate the diarrhoeal diseases by medical practice. Social environmental factors, especially in rural area playing major role in keeping the morbidity rate high.

The contribution of safe water supply by the groundwater development is estimated to be huge for the both Monaragala and Hambantota districts.

(4) Other Benefits

The other benefits, related to the socio-economic aspect, are quoted as 1) improvement of living standard, 2) stabilization of the people's livelihood in rural area, 3) contribution to tourism promotion and 4) land value hiking.

6.8.2 FINANCIAL ASPECT

Financial aspects are discussed by assuming that the NWSDB’s tariff level is applied to Development Plan proposed.

(1) Income Level

In Monaragala district, the ratio of water tariff to mean income of the house connection water supply system is 2.6%, and that for the yard tap system is 0.7%. In Hambantota, the ratio of water tariff to mean income of the house connection water supply system is 2.5%, and that for the yard tap system is 1.1%.

(2) Affordability of Pilot GNDs

Using the actual average monthly water tariffs of Hanbantota and Monaragala, ratio of water tariff to mean income of both level 3 and 2 are estimated for the Pilot GNDs. In all the GNDs except Talunna, the ratios for the Level 3 exceed 2.5%. This is due to lower income level of Pilot GNDs, thus it is suggested that the present tariff level by NWSDB is not affordable in some of GNDs.

On the other hand, most World Bank's projects recommend to make a tariff of water supply and sanitation services in rural development less than 4% of a monthly household income in consideration of affordability. Therefore, it is suggested that the ratios of water tariff to mean income presented in section 1) (2.5 to 2.6%) are regarded as affordable level because Development Plan proposed covers water supply service only.

(3) Willingness to Pay

The average water tariffs of existing water supply system of level 2 are 30 Rs in Monaragala, 50 Rs in Hambantota district. An average water tariff of existing water supply system of level 3 is 108 Rs in both districts.

Willingness to pay that meets the development plan is only Talunna. On the other hand, in Monaragala district, average amount of willingness to pay is 33 Rs that over the average water tariffs of existing water supply system of level 2. Additionally, 11% of population has the willingness to pay for level 3.

In Monaragala district, average amount of willingness to pay is 73 Rs that over the average water tariffs of existing water supply system of level 2. Additionally, 39% of population has the willingness to pay for level 3.

The result suggests that there is willingness to pay that afford at least water tariff of level 2 plan, although their income level is low. Furthermore, considerable portion of the population revealed the willingness to pay that afford the level 3 plan.

This could suggest people's eagerness to water.

6.8.3 ENVIRONMENT ASPECT

According to the IEE (Initial Environmental Examination) procedure from the guideline of JICA, the groundwater resources development plans for 15 Pilot GNDs are evaluated from viewpoint of the environmental consideration.

The proposed scheme are the small-scale rural water supply systems, the amount of water supply by is a range of 36 m3/day to 316 m^3/day. The range of population of the Pilot GNDs is 400 to 6,000, and net population density of 13 Pilot GNDs range from 1.5 persons/ha to 28 persons/ha with average 7 persons/ha.

From above evaluation conditions, the potential environmental impacts in the all Pilot GNDs by the project implementation are identified and evaluated as IEE. The results of the IEE indicate the implementation of the development plan will not cause significant negative impacts to the environment in the Study area.

6.8.4 OVERALL EVALUATION

The results of socio-economic evaluation indicate that the development plan will rather contribute to the economic activities and improvement of public health condition. As the overall evaluation, it is concluded that the development plan is the effective measures to, 1) mitigate the labor to obtain water, 2) cover the growing water demand, 3) solve the health problems caused by the water born diseases and 4) cover the seasonal or annual deficit as well

as future shortage of water to sustain the welfare of the people and the development of the country.

Considering the expected benefits and concerns above, it is recommended that to start the water supply service with Level 2 and gradually convert to Level 3 in accordance with an increase of people's income level; this option may encourage the financial independence of the water supply service

CHAPTER 7 CONCLUSION AND RECOMMENDATION

7.1 CONCLUSION

(1) Hydrogeology

On the basis of hydrogeological study, the fractured aquifer in the area was categorized into three parts: namely, the upper fractured aquifer, the lower fractured aquifer, and the deeper fractured aquifer. This was the first groundwater study that confirmed the occurrence of a productive aquifer below 100 m. The test well drilling confirmed the occurrence of the productive lower fractured aquifer in three test wells: No.M-2 Bodagama, No.M-3 Badalkumbura, No.M-4 Yalabowa. A productive deeper fractured aquifer was confirmed by the drilling of test well No.H-2 Talunna. Pumping test and water level fluctuation suggest that the deeper fractured aquifer is connected with the upper fracture in the area.

(2) Groundwater Evaluation

Based on the results of the hydrogeological study, two hydrogeological maps covering the Hambantota and Monaragala districts have been prepared: namely, the hydrogeological map for the upper fractured aquifer and the hydrogeological map for the lower and deeper fractured aquifer. These maps will be revised with the further accumulation of hydrogeological data. In addition, groundwater evaluation maps have been provided based on the hydrogeological maps to contribute to the development plan.

These maps were first prepared in Sri Lanka, and most important achievement by the Study since they serve as the basis for future groundwater development and insure the efficient use of investment of two districts.

(3) Groundwater Resources Development Plan

The promising areas for the groundwater resources development were determined by the provided groundwater resources evaluation maps. The amount of the water demand, and the area that are covered by the promising area of the groundwater development were extracted. The total demand amount covered by the promising areas in two districts was estimated as 154,165 m3/day. This amount is the total water demand of year 2010 for 647 GNDs covering an area of 5,909 km2.

(4) Drilling Program for the Development Plan

To cover the demand, it is estimated that 600 to 700 wells will be required to be newly drilled in both Upper and Lower/Deeper Fractured Aquifers.

(5) Plan Plan

Groundwater development plans for 15 Pilot GNDs are proposed. Proposed water supply schemes differ with the GND, since the hydrogeological properties such as extractable yield and water quality differ in area.

(6) Evaluation of Groundwater Development Plan

The results of socio-economic evaluation indicate that the development plan will contribute to the economic activities and improvement of public health condition.

(7) Operation and Management Plan

Concerning each proposed water supply scheme level, organizations in charge of operation, maintenance and management were proposed and personnel organization of them was also

proposed.

(8) Organization, Institution and Human Resources Development Plan

The following is proposed as the items to be strengthened and improved.

- To organize a drilling division in Monaragala regional office of WRB.
- To increase budget allocation of WRB for maintenance and repairs of drilling machines.
- To conduct training program and measures for securing human resources to Pradeshiya Sabha staffs.

(9) Drilling Technique Transferred

Through the study, drilling method and equipment for the deep well (depth to 200m) were first introduced in Sri Lanka. Considering the capacity of the organization and technical ability of the drillers in WRB, transferred technology and equipments is adequately available for the extending hydrogeological studies to the areas where deep groundwater development is required as well as groundwater development of the Study area.

7.2 RECOMMENDATION

(1) Further Hydrological Study

For the estimation of groundwater recharge, hydrological data such as rainfall, evaporation and surface water runoff is essential to verify the water balance. It is recommended therefore, to conduct further hydrological study based on the additional measurements of river discharges and rainfalls, especially in the upstream basin of discharge measurement point. It is also recommended to measure the hydrological data in small catchments with land use of forest and agriculture. These data will help for the understanding of the groundwater potential in a sustainable manner of the development.

(2) Further Hydrogeological Study

Fractured aquifer in hard rock is unevenly distributed even in the promising areas. Therefore, geophysical survey is essential to select a well location. The hydrogeological map will be revised when these data collected in the future.

(3) Priority Area for the Future Groundwater Study

The result of groundwater evaluation shows the central area of Monalagara, namely Buttala and its surroundings, has a good potential for groundwater development. While not so many tube wells have been drilled, this is a considerable area to be given priority for the future groundwater study of the Lower/Deeper aquifer.

(4) Drilling of Wells with the Depth of more than 70 meters

As part of the above study, it is recommended to drill more test and production wells to explore the lower and deeper fractured aquifer below 70 m. The JICA Study proved the practicability to obtain water with the volume of hundreds litres per minute or more from an aquifer below 70 m in some areas. This amount is both quantitatively and economically sufficient to be exploited for regional water supply use. The study area, however, has been studded with only nine test wells drilled to deeper aquifer at the present. The further drilling of wells with the depth of more than 70 m is valuable for planning a development. It will provide the additional hydrogeological information in the area and confirm the feasibility of the future development. The appropriate drilling sites shall be determined as described in the next section.

(5) Determination of the Drilling site

On the implementation stage of the development plan, to determine the promising drilling sites, it is recommended that a geophysical survey will be carried out by the following procedure.

- A main survey line is set to be orthogonal to geological structure extracted by the preliminary geological study.
- The areas with the resistivity of less than 400 ohm-m are recommended as a drilling point of a production well in Monaragala, while the areas with the resistivity between 100 to 400 ohm-m are recommendable in Hambantota.

(6) Drilling Program

The following drilling programs are recommended:

- For the Upper Aquifer, two rigs owned by WRB or NWSDB are proposed to assign for the program. Approximately 7.8 years period will be required for drilling a total of 468 wells for the Upper Aquifer.
- For the Lower/Deeper Aquifer, one drilling rig with necessary equipment capable of drilling to 200 m depth with 8 inches hole diameter is proposed to assign for the program. Approximately 7.5 years period will be required for drilling a total of 193 wells for the Lower/Deeper Aquifer.

(7) Water Supply Plans for Unpromising Areas

Promising areas for the groundwater development are identified by the groundwater evaluation, accordingly groundwater development plan was made. On the other hand, the areas other than promising areas could be categorized as low potential areas for the groundwater development. In such areas, water supply shall be planned in combination with the surface water and groundwater. In central to northern part of Monaragala low potential areas due to low yield are distributed. In these areas, conventional groundwater development by hand pump wells or the surface water development are the manners left. In southern part of Monaragala and most of area of Hambantota, low potential areas due to inadequate water quality are widely distributed. The combination with expansion of existing scheme and surface water development is the recommendable manner for these areas. For Hambantota district, Walawe Ganga would have potential resources to supply the area where the groundwater potential is low. A groundwater development block of "Badalkumbura-Wellawaya Block" situated in western part of Monaragala where highest groundwater yield is confirmed would have potential resources to the Hambantota district, though it will require feasibility study. However, the groundwater development is not absolutely impossible for such low groundwater development potential areas. The groundwater evaluation maps were prepared on the basis of limited regional data; thus it is anticipated that the extractable groundwater yield will vary from place to place. However, even in such areas, groundwater development would be required due to social factors. In such cases, careful geological and geophysical investigation is required to select the location of wells.

(8) Implementation of the Plan

Considering the expected socio-economic benefits, it is recommended that to start the water supply service with Level 2 and gradually convert to Level 3 in accordance with an increase of people's income level. This option may encourage the financial independence of the water supply service.

(9) Operation, Maintenance and Management

The operation and maintenance plan proposed by the Study is a fundamental principle; therefore, it is recommended that after finishing the feasibility study, NWSDB, committee and users will discuss from the primary planning stage and determine the proper facility plan and achievable management, operation and maintenance plan.