SUPPORTING 8 DATABASE SYSTEM OF THE WELLS

8.1 EXISTING DATABASE SYSTEMS

For the management of existing wells, WRB and NWSDB have separately constructed their own database systems at present. The database, however, should be usable by both organizations for the effective exploitation and maintenance of groundwater resource. The Study team has updated and integrated these databases, along with the GIS systems. The existing conditions of these database systems identified are summarized as follows.

8.1.1 WRB SYSTEM

The dBASE system was applied as their database. The system consists of "technical database" which covers the technical information of wells, and "chemical database" which covers the groundwater quality. ArcInfo GIS system (Version3.5.2) has been introduced, and utilized as the tools for the reference of the well data. Digitized maps in a scale of 1:63,360 have been prepared by WRB, in the format available for MapInfo system. These maps are covering the whole land of Sri Lanka, including the information on road, railway, streams, district boundary, coastal boundary, lakes and towns. The UTM (Universal Transverse Mercator) projection is applied as the coordinate system for the digital maps.

8.1.2 NWSDB SYSTEM

NWSDB has applied the Access system for their database. This system consists of more than 20 database tables related to the well information such as drilling, lithological, chemical analysis, pumping test, and cost. Likewise, ArcView (Version3.1) is applied as the GIS system. An input system called "Tube Well Information System" is used for the operation of the system. The digital data of topographic maps (in scales of 1/250,000 and 1/50,000, issued by the Survey Department), geological maps (in scale of 1/100,000, issued by the Geological Survey and Mines Bureau (GSMB)) and landsat imagery are used on the system. In addition, the distribution of lineament interpreted from the aerial photographs and the well data stored by the database can be utilized by the system. The Sri Lanka National Grid is applied as the coordinate system of the ArcView.

8.1.3 A COMPARISON OF THE SYSTEMS

The major difference of the system is the utilization of the map information such as geological map, landsat imagery, aerial photographs and lineament. WRB has not utilized those information yet, while NWSDB has utilized them. The two organizations have applied different systems of database, GIS, and coordinate system. Such differences are shown in *Table 8 .1*.

Table 8.1 The Differences of the Database Between WRB and NWSDB

Items	WRB	NWSDB
Database Software	dBASE	Access (with a input system)
GIS Software	ArcInfo Ver.3.5.2	ArcView Ver3.1
Coordinate System	UTM	Sri Lanka National Grid
Topographical Map	1/63360 (Made by WRB)	1/250,000 and 1/50,000 (Issued by Survey Department)
Geological Map	Unexploited	1/100,000 (Issued by GSMB)
Landsat Imagery	Unexploited	In use
Aerial photographs	Unexploited	In use (Puttalam, Anuradhaputra Areas)
Lineament	Unexploited	In use

8.2 EXISTING CONDITION ON UTILIZATION OF THE SYSTEM

The differences in the GIS system utilization by the two organizations are described as follows.

8.2.1 UTILIZATION OF THE SYSTEM ON WRB

The system was used as the reference of well number on ArcInfo. The well database was not utilized with the well coordinates data to operate the GIS system of ArcInfo. The location maps of wells in a format of Shapefile were applied for ArcInfo. Therefore, the translation of the locality information from the database to the GIS system is not applicable. The principle usage of database and GIS system on WRB were as follows.

- To check the well code number that is displayed by the ArcInfo
- To check the well location that is listed in the database

8.2.2 UTILIZATION OF THE SYSTEM ON NWSDB

The system was utilized for the selection of well drilling sites and provision of various maps. The maps provided by the system were as follows.

- Distribution of the wells classified by its depth
- Distribution of the wells classified by the groundwater quality
- Geological Maps classified by the well yield.

8.3 INTEGRATION ON THE WELL DATABASE

8.3.1 NECESSITY OF THE INTEGRATION OF THE SYSTEMS

The advantage of the application of the GIS system is the availability of geographical evaluation by linking various kinds of spatial information. The data and information utilized by both organizations however, is limited to geology and hydrogeology. The other necessary data to utilize the system efficiently, such as statistic, meteorological and water usage, are not adopted at present in either system. Both organizations have their own database for wells, and different GIS software. Such difference restricts the data sharing between the organizations. It is important therefore, that these two databases should be combined together to enable and utilize the system more efficiently. However, the necessary data for the groundwater development and management, namely elevation, topographical, geological and hydrogeological information have not been utilized. It is also necessary to add these information to the database. In this regard, the Study team has modified and updated the system as follows.

8.3.2 UPDATE OF THE DATABASE

For the purpose of updating of the database, the Study Team reviewed the items in both databases of the two organizations. The items covered by each database are shown in *Table 8.2* and *Table 8.3(1) and (2)*. As shown in the tables, the NWSDB database covers most of the items than in the WRB database. Furthermore, the geological data and locality information are installed on the compatible format of the GIS system. Actually, NWSDB uses the well data with the GIS system by importing the well data from the database to ArcView. Consequently, updating of the database was recommended by the modification of the NWSDB System. The additional items required for the updating of the database systems are described in *subsection 8.4.3*.

Table 8.2 Contents of WRB Database

Technical Data		Chemical Data	
Items of WRB database	Name in NWSDB database	Items of WRB database	Name in NWSDB database
NMCODE	----	NMCODE	NWELLNO
OLD_NO	OLDWELLNO	OLD_NO	OLDWELLNO
DISTRICT	DISTRICT_CODE	DATES	WAMPLEDATA
PROJECT	SCHEMENAME	DISTRICT	DISTRICT_CODE
ELECTO	ELECT_CODE	PROJECT	SCHEMENAME
VILLAGE	VILLAGE	LOCATION	LOCATION
LOCATION	LOCATION	PH	PH
RIG_NO	include WELLNO	ELECON	ELECON
N_O_D	----	NA	----
METHOD_OF	DRILLTYPE	K	----
T_B_OB_BIT	Drilling Bit Data (data table)	CA	CALCIUM
B_B_ROCK_D	Drilling Bit Data (data table)	CL	CHLORIDES
OVER_DEP	OB_DEPTH	TDS	TOTDISSOL
TOTAL_DEP	TOTAL_DEPTH	TOTALK	TOTALK
CASE_DIA	DIAMETER	TOTHARD	TOTHAARD
BLANK_DEP	CASE_FROM	MG	MAGNESIUM
SCREEN_DEP	CASE_TO	SO4	SULPHATE
DATE_C	BEGDATE	HCO3	----
DATE_E	ENDDATE	F	FLUORIDES
W_LEVEL	SWL	TOTIRON	TOTIRON
YIELD	FINAL YIELDLPM	COLOUR	COLOR
LITHOLOGY	Lithology (data table)	TURBIDITY	TURBIDITY
FRACTURE_Z	Fracture Log (data table)	CALCHARD	CALCHARD
LITHO_2	include Lithology	NO3	NITRARES
REMARKS	----	NO2	NITRITE
TOPO_NAME	MAP_USED	NH4	ALBAMONIA FREEAMONIA
COODI	X&Y_COORDINATE	MN	MANGANESE
----	----	TOTCOLI	TOTCOLI
----	----	FEACALCOLI	FEACALCOLI
----	----	APPEARANCE	----
----	----	TEMPERATUR	----
----	----	ODOUR	----
----	----	TASTE	----
----	----	PURPOSE	USERTYPE
----	----	REMARKS	----

Table 8.3 (1) Contents of NWSDB Database (1/2)

1. Screen Log	2. Ream Data	3. Pumping Test Parameter	4. Pumping Test Results	5. Pump Details
s_Generation	s_Generation	PumptingTestNo	WELLNO	s_Generation
s_GUID	s_GUID	----	PUMPDATE	s_GUID
WELLNO	WELLNO	----	WELLLOSS	s_Lineage
s_Lineage	REAM_ORDER	----	AQIFERLOSS	WELLNO
SCRNO	s_Lineage	----	TRANSMISSIDITE	PUMPHEADNO
TOP	REAM_NO	----	STORAGE	INST_DEPTH
BOTTOM	DIA_REAM	----	PUMPINGRATE	PUMPTYPE
TYPE	DEP_REAM	----	DURATION	RISERTYPE_CODE
MATERIAL	----	----	WATERLEVEL	RIS_LENGTH
LENGTH	----	----	INSTALLDEPTH	CONNRODDIA
----	----	----	----	CONNRODLENGTH
----	----	----	----	CYLTYPE_CODE
----	----	----	----	CYLDEPTH
----	----	----	----	INST_SWL
----	----	----	----	INSTALDATE
----	----	----	----	IRONREMPLTTYPE_CODE
6. Lithology	**7. Gravel Pack**	**8. General**	**9. Fracture Log**	**10. Elaped Time**
s_Generation	WELLNO	s_Generation	s_Generation	CODE
WELLNO	NO	WELLNO	WELLNO	ELAPTIME
ROCKNO	GP_FROM	AGENCON_CODE	FRAC_NO	24HRS
s_GUID	GP_TO	s_GUID	s_GUID	48HRS
FROM	GP_TYPE	AGENMAIN_CODE	FRAC_DEPTH	72HRS
s_Lineage	----	WELL_CATEGORY_CODE	s_Lineage	----
TO	----	FUNDING_CRITERIA_CODE	FRAC_YIELD	----
ROCKTYPE	----	s_Lineage	FRAC_EC	----
COLOUR	----	PROJNAME_CODE	LOSSCIRCULATIONDEPTH	----
GRAINSIZE	----	ORDERNO	----	----
WEATHERING	----	REQMADE	----	----
11. 3T NEW WELLS	**12. Drilling Bit Data**	**13. Cost Details**	**14. Constant Test Mast**	**15. Constant Test Detail**
s_Generation	s_Generation	s_Generation	EVENTNO	EVENTNO
s_GUID	WELLNO	s_GUID	WELLNO	WELLNO
WELLNO	BIT_ORDER	WellNo	TYPE	ELAPEDTIME
HPREPARE_DATE	s_GUID	ItemNo	ANGLE	PUMPING
HPREHABILI_DATE	BIT_NO	s_Lineage	DISTANCE	RECOVERY
s_Lineage	s_Lineage	Rate	----	----
WELLFLUSH_DATE	BIT_DIA	Quantity	----	----
CSFORM_DATE	BIT_DEPTH	Total	----	----
CSREG_DATE	REAM_ORDER	----	----	----
FESIBILITY_DATE	REAM_NO	----	----	----
DRILL_DATE	DIA_REAM	----	----	----
PUMPINST_DATE	DEP_REAM	----	----	----
CARETRAIN_DATE	BIT_FROM	----	----	----
CARE TAKER NAME	BIT_TO	----	----	----
CARE TAKER_ADD1	BIT_ENDDIA	----	----	----
CARE TAKER_ADD2	----	----	----	----
CARE TAKER_ADD3	----	----	----	----

Commonage items with WRB system

Table 8.3 (2) Contents of NWSDB Database (2/2)

16. Well Construction	17. Chemical Data	18. Drilling Case Data	19. Well ID	20. Pumping Test Data
s_Generation	s_Generation	s_Generation	s_Generation	EVENTNO
s_GUID	s_GUID	WELLNO	WELLNO	WELLNO
WELLNO	WELLNO	NO	OLDWELLNO	START_DATE
s_Lineage	s_Lineage	TYPE	NWELLNO	RATE 1
SWL	SAMPLEDATE	s_GUID	s_GUID	RATE 2
BEGDATE	SAMPLEDEPTH	SLOTSIZE	PROJOFFICE_CODE	RATE 3
ENDDATE	SAMPLETIME	CASE_FROM	PROVINCE_CODE	RATE 4
CASEDIA_CODE	COLOR	CASE_TO	s_Lineage	RATE 5
CASELENGTH	TURBIDITY	DIAMETER	DISTRICT_CODE	RATE 6
ROCKDIA	PH	s_Lineage	DSDIV_CODE	TIME 1
TOTAL_DEPTH	ELECON	----	GSDIV	PUMPING RATE
FINAL YIELDLPM	CHLORIDES	----	ELECT_CODE	START_TIMEE
FINAL FIELD_COND	TOTALK	----	VILLAGE	----
WELLSTATUS_CODE	FREEAMONIA	----	LOCATION	----
REASON_ABN_CODE	ALBAMONIA	----	X_COORDINATE	----
WATER STRUCK DEPTH	NITRATES	----	Y_COORDINATE	----
DRILLTYPE_OB	NITRITE	----	MAP_USED	----
DRILLTYPE_ROCK	FLUORIDES	----	MAP_SCALE	----
DAYS_DRILL	PHOSPHATE	----	GEOLOGICAL_USED	----
OB_DEPTH	TOTDISSOL	----	GEOLOGICAL_SCALE	----
TIME_OB	TOTHARD	----	X_METRIC	----
TIME_ROCK	CALCHARD	----	Y_METRIC	----
DRILLINGCOST	TOTIRON	----	ELEVATIONMSL	----
CASE TYPE	MAGNESIUM	----	USERTYPE	----
----	SULPHATE	----	SCHEMENAME	----
----	MANGANESE	----	SOURCE	----
----	DISSIRON	----	----	----
----	TOTCOLI	----	----	----
----	FAECALCOLI	----	----	----
----	FILTIRON	----	----	----
----	TOTRESIDUE	----	----	----
----	CALCIUM	----	----	----
----	OXYGEN	----	----	----
----	HYSUL	----	----	----
----	FIXEDIRON	----	----	----
21. Hand Pump Repairs	22. Hand Pump Repairs	23. Soil Log	24. STEP DATA	----
WELLNO	WELLNO	WELLNO	EVENT NO	----
POSITION	DATE	SOILNO	PUMPING RATE	----
SPARE PARTS	----	FROM	LPM 1	----
SQTY	----	TO	LPM 2	----
COST	----	SOIL_TYPE	LPM 3	----
TOTAL	----	COLOUR	LPM 4	----
----	----	GRAINSIZE	LPM 5	----
----	----	ANGULARITY	LPM 6	----
----	----	SORTING	----	----

Commonage items with WRB system

8.3.3 ADOPTED COORDINATES SYSTEM

As previously described, UTM coordinate system was applied to the WRB database, and the "Sri Lanka National Grid" coordinate system was applied to the NWSDB database. The standard system of coordinates adopted by ArcView is latitude and longitude. An advantage of this standard system is the wide applicability to various projections. All digital maps issued in Sri Lanka, however, have been adopted to the "Sri Lanka National Grid". Considering the convenience of the system operation, the Sri Lanka National Grid was adopted to coordinate the system for the Study. The details of the Sri Lanka National Grid coordinates system are as follows.

Geographic Coordinate System	:	Transverse Mercator
Datum	:	Kandawala
Basis of Coordinate	:	X---80.7717104444 degree = 200,000 m
		Y--- 7.0004802777 degree = 200,000 m
Scale Factor	:	0.9999238418

8.4 PREPARATION OF GEOGRAPHIC INFORMATION SYSTEM (GIS)

8.4.1 COLLECTION OF DIGITAL MAPS

Digital maps (topographic and geological maps) that covers certain parts of Sri Lanka are available with the ArcView system. The collected digital maps are shown in *Table 8.4*. The original coordinates system of the "Sri Lanka National Grid" is commonly used in Sri Lanka.

Table 8.4 Collected Digital Maps

Type of Map (Scale of Base Map)	Items included	Base Map Sheet No	Publisher
Topographical (1/250,000)	Administrative Boundary (DSD) Cities and Villages Contour of elevation Forest and Lagoon Railway and Road Stream and Tank	1,2,3,4 (These covers whole Sri Lanka)	Survey Department
Geological (1/100,000)	Geological Structure Road Stream and Tank Contour of elevation	14,17,18,20,21	Geological Survey & Mines Bureau
Topographical (1/50,000)	Land Use	69,70,76,77,82,83,84,87,88,89,91,92	Survey Department
	Road	56,57,63,64,69,70,76,77,78,84,82,83, 87,88,89,91,92	
	Contour of elevation	82,83,84,87,88,89,91,92	

8.4.2 PREPARATION OF BASE MAPS

Considering the purpose of the GIS system applied for the groundwater development, the maps and data lists in *Table 8.5* are required. Since the WRBs digital maps are provided by the UTM coordinates system, it is necessary to convert the coordinates system to the Sri Lanka National Grid. A software of the "Projection Utility" was utilized for the conversion.

Table 8.5 The Provided Maps

Map/Data	Source	Specification	Format
GND Boundary	District Office	Hambantota (1:63360,1999) Monaragara	Shapefile
Geological Maps	Atlas / Survey Department	1:1,650,000 / 1:500,000	Shapefile
Catchment Area (1)	Atlas/Survey Department	1:250,000/1:50,000	Shapefile
Catchment Area (2)	Made by Study Team	1:50,000	Shapefile
Landsat Imagery	Landsat ETM+	B:G:R = 1:4:5	Image file
Lineament (1)	Landsat ETM+	B:G:R = 1:4:5, 1:200,000	Shapefile
Lineament (2)	Aerial photographs	Approximately 1:20,000	Shapefile
Elevation Grid	United State Geological Survey	30 second mesh elevation data(approximately 900m)	Shapefile
Rainfall gage station	Meteorology Department & Irrigation Department	37Points in latitude/longitude 1 point in Imperial grid. 20 points on a Map	Shapefile
Pan-Evaporation station	Irrigation Department	13 points on a Map	Shapefile
River gage station	Irrigation Department	Irrigation Imperial Units 56 points	Shapefile
Irrigation water volume gage station	Irrigation Department	Irrigation Drawing Map 34 points on a Map	Shapefile
Temperature gage station	Meteorology Department	19 points on digital Map	Shapefile
Topographical Map	Maps and Location of Wells created by WRB	1:63360	Shapefile
Geomorphological Map	United State Geological Survey	Rifer to 30sec grid elevation data (approximately 900km)	Shapefile
Water Supply System	NWSDB	Existing water supply system and improvements plan	Shapefile

Note, Atlas : Atlas of Sri Lanka,
Shapefile : ArcView Standard File,
Landsat ETM+ : Sensor name of observation device

8.4.3 STRUCTURE OF DATABASES

Periodical update of the data is an essential task for the database. For this purpose, it is desirable to establish the database from the Arc View Shapefiles alone. In the GIS system, since the data is the locality information, it is desirable that the record (or the data) format shall be treated as the position. In this study, the population data was recorded as the Shapefile within the GND boundary. The observational data, such as rainfall, river discharge, temperature and evaporation were recorded as the Shapefile within each observation station. Most of the data, except tube wells have no locality information in its database. These database, however, correspond to each Shapefile which has locality information described in *Table 8.6*. The *Table 8.6* shows the outline of the database.

Table 8.6 The List of Database Developed

Database	Source	Specification	Format
Tubewell Database	WRB / NWSDB / JICA Study Team	Tube well data,	Access
Population	Statistical Department District Office	Census in 2001	Shapefile
Rainfall	Irrigation / Meteorology Department	Monthly	Access
Pan-Evaporation	Irrigation Department	Monthly	Access
River Discharge	Irrigation Department	Monthly	Access
Irrigation Water Volume	Irrigation Department	Yearly	Access
Temperature	Irrigation Department	Monthly Average for the period 61 to 90	Access

The developed database with the recorded items and technical information by the Study are summarized as follows, and the properties of recorded data in the database are shown in *Appendix I.*

(1) Tube Wells (Main Database)

Out of the tube wells data recorded by WRB database, the tube wells located in the Study area was converted to the Access format. The database of WRB was divided into six tables of WELL ID, Well Construction, Chemical Data, Drilling Case Data, Lithology and Fracture Log. The steps of the procedure of the conversion are shown in *Appendix J.* In the WRB database, the locality information of the tube wells is recorded as its latitude and longitude. However, the input error has been detected from the database. In the newly developed database therefore, XY-coordinates obtained from the WRB digital maps were recorded. Well coordinate data in latitude and longitude were kept as the field of X-coordinate and Y-coordinate respectively. In the WRB database, there are some items which are not included in the NWSDB database. These data were stored with additional data, with items needed for future utilization of the system for the groundwater development. The data apart from the Study area are still in the existing database. Since the utilization on the GIS system of the WRB is difficult, further work for the conversion are required.

(2) Additional Data

The additional data includes two items, i.e., the data needed for the future utilization of the system, and the data which are not included in the NWSDB database. These additional data were integrated to the main database.

The additional items are described as follows.

1) Elevation of the wells

The elevation of the tube well is an essential item to examine the hydrogeological conditions, such as groundwater level and groundwater flow mechanism. The interval of elevation contour line of existing topographical map is 100 feet. Such interval would be too rough for the hydrogeological examination. Therefore, 30-minute intervals of the elevation grid data issued by USGS were used for the readings of the elevation. The elevation of tube wells were registered into the ELEVATIONMSL field in Well ID table of the main database.

2) The methods of the measurement of the elevation

The adopted methods for the elevation measurement by the Study were registered to the ELV_METHOD field in Well ID table of the main database.

- Topographic survey including referential GPS survey: registered as the name of

"Survey"

- Reading by the 30-minute mesh data issued by USGS: registered as the name of "USGS"

3) Geological Classification

Geological condition was classified into Overburden, Hard Weathered Rock, Weathered Rock and Fresh Rock by the hydrogeological considerations. To identify the depth to the bottom of each classified units, three fields, namely DEP_SOIL, DEP_HW_ROCK and DEP_W_ROCK were registered in Well Construction table.

4) Hydrogeological Classification

The hydrogeological classification was registered to the AQIFER TYPE field in Well Construction Table of the main database.

(3) Population

As the population data, the results of census implemented in July 2001 (Census 2001) were registered into the property data of GND Boundary Shapefile.

The item of G_N_CODE includes the DSD Code and the GND cord number. The list of GND codes and GND names are shown in *Appendix K*.

(4) Observation Data

The database is divided to the separate tables by the each observation year. The monthly observatory data were registered at each divided table. Locations of the observatory stations are shown in *Data Book G.*

1) Rainfall

There are a total of 38 observatory stations of rainfall in Sri Lanka, which consists of 37 stations of the Meteorological Department and the other station of the Irrigation Department. The 51 years observations is recorded since 1951.

2) Pan-Evaporation

There are two observatory stations of pan-evaporation of the Irrigation Department which exists in the Study area. One is Nakkala and the other is Timbolketiya. The available data of the observations is a six year period from 1992 to 1999, except the year of 1994 and 1995.

3) River Discharge

There are eight observatory stations of river discharge of the Irrigation Department which exists in the Study area. The available data of the observations is a 11 year period from 1989 to 1999.

4) Irrigation Water Volume

There are 31 observatory stations of the irrigation water volume of the Irrigation Department which exists in the Study area. The available data of the observations is a three year period from 1998 to 2000.

5) Temperature

There are 19 observatory stations of the temperature of the Meteorological Department which exists in the Study area. The available data is a 30 year period from 1961 to 1990. This data consists of the monthly mean, the monthly minimum mean and the monthly maximum mean.

The collected data and the base maps were stored in the D drive in computer provided by the JICA. The structure of the folder and recorded contents are shown in *Appendix L*.

8.5 BUILDUP OF GIS

8.5.1 DESIGN OF THE GIS SYSTEM

Based on the conditions of the Study area and the availability of data, a development plan for the GIS system for the groundwater development is proposed in this section. The design of the GIS system development is shown in *Figure 8.1*.

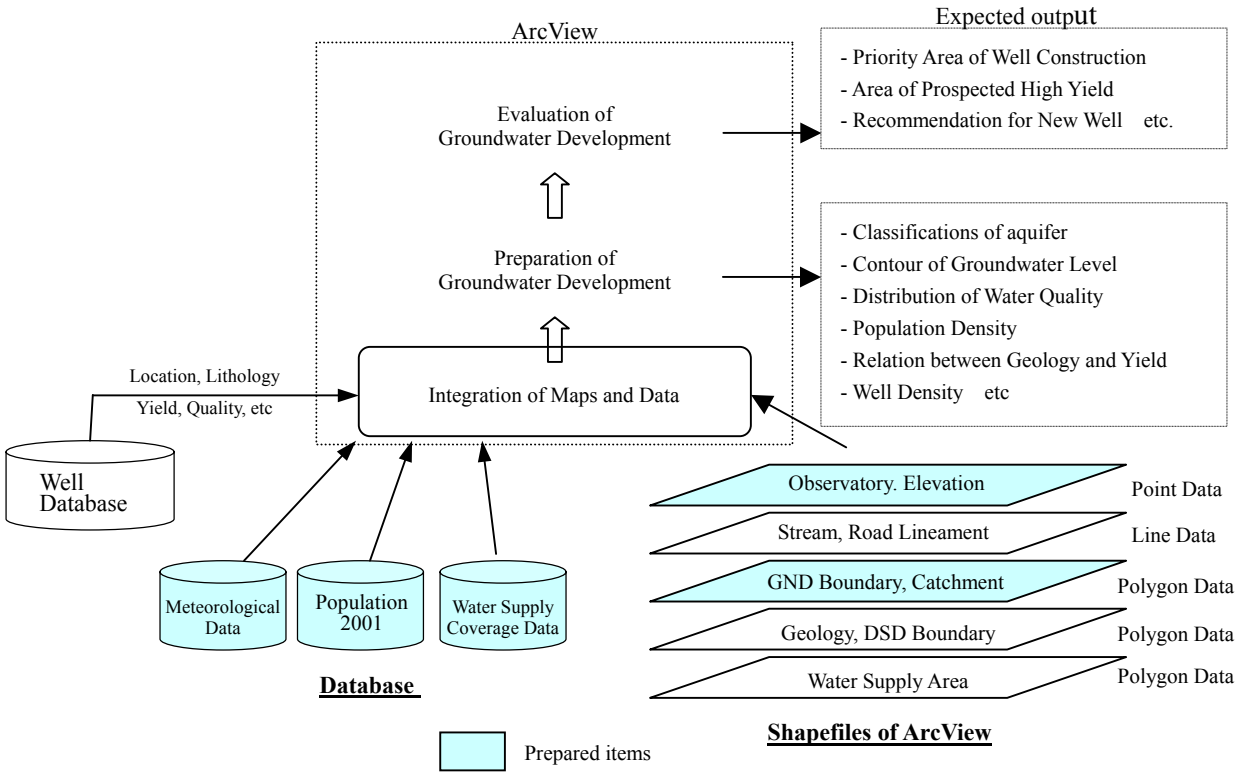

Figure 8.1 Design of GIS System Development

The well database in the Access system has already been provided by the NWSDB. However, all data is not necessary for the operation of GIS. The databases for "population" and "meteorological" have been newly proposed by the Study Team, as these are necessary elements for the GIS system. Furthermore, spatial data and information, such as observatory, elevation, stream, road, lineament, GND boundary, geology and catchment are proposed to supplement the Shapefiles. The preparation and evaluation of groundwater development plan will be carried out based on the integration of this data and information obtained. The expected output of the GIS system are also shown in *Figure 8.1*.

8.5.2 PROPOSED UTILIZATION OF THE GIS SYSTEM FOR GROUNDWATER DEVELOPMENT

GIS is a system that can be presented and analyzed with the geographic information in relation among the data such as the social economic, natural environment, resources and other spatial items. The display of varying data and spatial analysis will be in a position to do, after the integration of the various database and maps. Following two steps would be considered for the GIS utilization.

(1) Preparation of Groundwater development

The necessary elements for the discussion of the groundwater development will be abstracted, based on the preparation of the variety of maps showing the distribution and/or interpretation of the data and information related to the wells, water demand, observatories, topography and

geology.

(2) Evaluation of Groundwater Development

Based on the maps provided by above step-(1), evaluation will be made by providing the variety of maps showing the priority area of groundwater development, potential of groundwater and feasibility of the development.

8.5.3 OUTPUTS OF GIS SYSTEM

The functions of GIS system are widely applicable for multiplicity of the purpose. In this study, the system was applied to provide the maps showing the locations and distributions of the various types of factors. All of the maps, presented in each chapter in this report, are provided by the GIS system. The list of figures prepared by the system is shown in *Table 8.7.*

Table 8.7 Items of GIS Work

No.	Type of Figure (Map)	Overlay Maps and Data		Procedure
		Symbols	Data and/or Maps	
1	Location maps	Optional data		Display the selected optional data.
2	Topographic map	**A**	USGS elevation mesh data	Create the contour lines using the ground elevation of **A**.
		B	District boundary map	
2	The contour line map of groundwater level	**A**	Existing 30 wells data	Create the contour lines using the groundwater elevation of **A**.
		B	DSD boundary map	
3	Distribution map of groundwater qualities	**A**	Tube wells database	Classify the water quality using the values of **A**.
		B	DSD boundary map	
4	Population density map	**A**	GND Boundary map (Area of GND)	1. Coordinate the population data of **B** to **A**. 2. Calculate population density on the coordinated table.
		B	Population database	
5	Lineament density Map	**A**	Lineament map	Calculate lineament density (total length of lineament in one km^2) using **A**.
6	Distribution map of geology classified by the yield	**A**	Geological map	1. Classify the wells by the geological regions using **A** and **B.** 2. Average up the well yield at each geology. 3. Classify the geology by well yield.
		B	Tube wells database	
7	Relationship between lineament and well yield	**A**	Lineament map	1. Calculate the distances between wells and lineaments using **A** and **B**. 2. Prepare the relation graphs between the distances to the lineaments from each wells and yields of the wells
		B	Tube wells database	
		C	DSD boundary map	
8	Classification map of groundwater level	**A**	Tube well database	1. Interpolate groundwater level using the groundwater levels of **A** and **B**. 2. Classify the area by the depths to the groundwater levels.
		B	Teat well data	

8.6 WORKSHOP

The 1st workshop on the basic usage of GIS (by ArcVIew3.2) was held on 26th, November. The 2nd workshop on the basic analysis of GIS was held on 29th , July 2002. These workshops were held at the Study Team office. The subjects of the lecture were as follows.

1st workshop (Basic Usage)

- Introduction of GIS and basic operation of the system
  Explanation of available data type (point, line, polygon) and basic operation of the software
- Operation method of the Tables
  Editing work of the tables attached to Shapefile.
  Compilation of the tables from the external sources.
- Utilization of image data

Creation of Shapefile with the use of image data.

- Utilization of the function of Layout
  Creation of the maps by means of the function of layout

2nd workshop (Basic Analysis)

- Basic operations
- Data selection by field value and overlay theme.
- Creation of contour and grid
- Geographical processing
- Table operation and calculation
- Utilization of sample extensions and avenues

The handouts used for the Workshops are attached to *Appendix M*.

8.7 RECOMMENDATION

In this study, the database was build up to corresponding to the GIS system. A couple of problems however, have been left unsolved. The followings are the subject for a future study.

8.7.1 MAINTENANCE OF DATABASE

The integration of the database of the tube wells in Monaragala and Hambantota districts are completed under the study. In the future, the unification of the all tube wells data of entire country will be required. The data of location are given incorrectly to a great number of the tube wells. The data of location are the fundamental information for the GIS system. The corrections of location data for such tube well are also proposed.

8.7.2 INTRODUCTION OF NETWORK SYSTEM

In NWSDB, each computer is connected by Local Area Network (LAN) system. Accordingly, the data such as the database and the base maps is able to share, through the intermediary of server machine terminal computers.

Data sharing is important tools to extend the groundwater management to the national level, since the information and data related to the groundwater is cover a broad range of topics. The future problems for the WRB may lie in this region.

The *Table 8.8* shows the conceivable methods of the data sharing of today, and general evaluation of their adaptabilities in terms of groundwater data management in Sri Lanka.

Table 8.8 Method of Data Sharing and their Adaptabilities

No	Method of Data sharing \ Utilization		Within the office	Between the offices	Between head office and regional office
1	By hand	Diskette	Fair	Inconvenience	Infeasible
2	By internet	E-mail	Impractical	Fair	Fair
3		Internet Server	Impractical	Practical	Practical
4	By LAN		Convenient	Infeasible	Infeasible
5	By leased line (Intranet)		Convenient	Convenient but not economical	Convenient but not economical

Currently, the utilization of leased line is a most convenience method of for any utilization, but not feasible considering the utility of the system in Sri Lanka. Therefore, the installation of LAN system with the accessible function to the Internet will be recommended as an eligible system for

WRB. Accordingly, data sharing between WRB and NWSDB can be available through Internet. The conceptual plan of such network system can be presented as *Figure 8.2*.

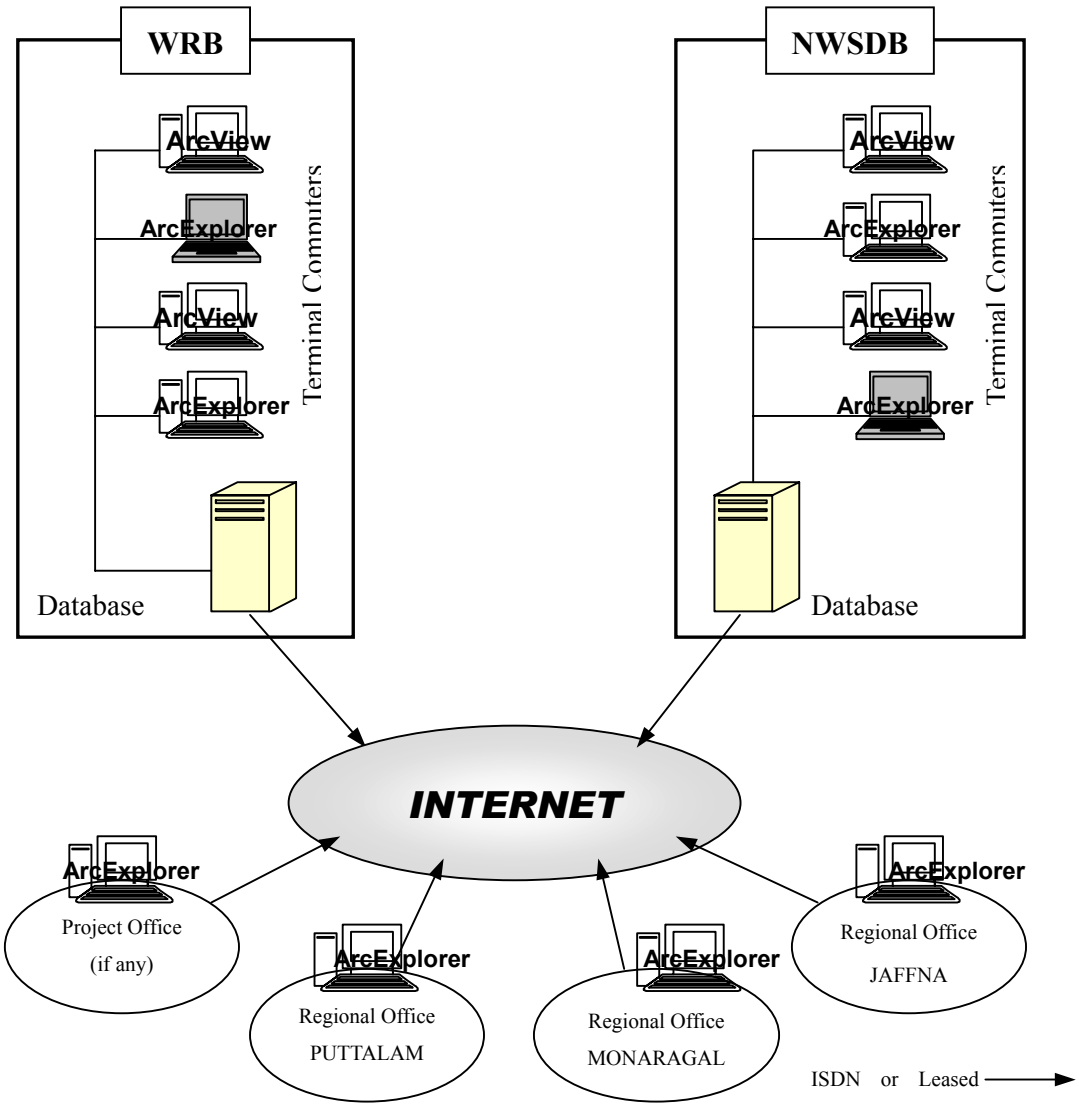

Figure 8.2 Conceptual Plan of Network System

SUPPORTING 9 ENVIRONMENTAL CONSIDERATION

9.1 ENVIRONMENTAL CONSIDERATION IN SRI LANKA

(1) Explanation of EIA/IEE in Sri Lanka

In Sri Lanka, the EIA process was first introduced through the legislation of the Coast Conservation Act No 57 of 1981. This was confined to only a 300 m strip of land along the coastal zone of the island. Subsequently an EIA system for the whole country was administratively introduced in January 1984, by a decision of the Cabinet of Ministers. It was made applicable to all development activities including public and private sector projects.

The statutory introduction was made by an amendment to the National Environmental Act (Act No 56 of 1988). As required by this amendment projects that should undergo the EIA process and the procedures and methods to be adopted were gazetted on 24th June 1993 and are contained in Gazette Extra-ordinary No 772/22. The process is managed and monitored by the Central Environmental Authority and implemented through 17 State Agencies. A unique feature of the EIA process is that it is an open process allowing for public participation in decision making.

Under the provisions of the NEA, the EIA process applies only to "Prescribed Projects" which have been specified by the Minister in charge of the subject of Environment in Gazette Extra-ordinary No 772/22 of 24th June 1993.

The details of the EIA/IEE process is provided in "Guidance for Implementing the Environmental Impact Assessment (EIA) Process" (Central Environmental Authority, Ministry of Forestry and Environment, 1998). The outline of the EIA/IEE process is illustrated in *Figure 9.1*.

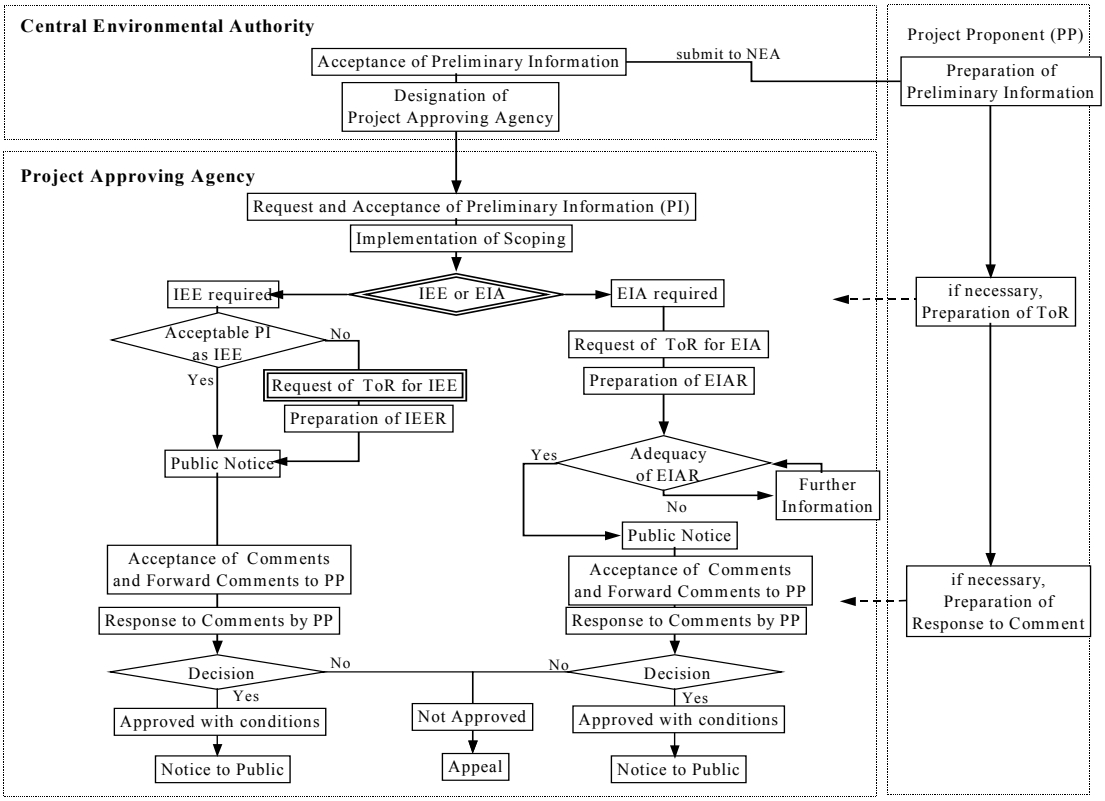

Figure 9.1 Environmental Impact Assessment Procedure in Sri Lanka

(2) Classification of Groundwater Development Project as "Prescribed Project"

According to the "Prescribed Project" based on Gazette Extra-ordinary No 772/22 of 24th June 1993, the groundwater development project could be classified under the category of Water Supply. The Water Supply category covers following two types of projects:

- All groundwater extraction projects of capacity exceeding 1/2 million cubic meters per day
- Construction of water treatment plants of capacity exceeding 1/2 million cubic meters per day

The groundwater development projects are apparently of the first type, and may be of the second type if groundwater requires a water treatment. However, the groundwater development project based on the development plan of the Study is to be excluded from the Prescribed Project in terms of a scale of the capacity. According to the results of the test well drilling, the successful yield observed is approximately 500 l/min, which is equivalent to 720 m^3/day if continuously extractable through the day. Even supposing to develop 100 wells with a similar yield in a limited area, a total yield is far less than the capacity criteria, 1/2 million cubic maters per day, of the Prescribed Project above.

Therefore, a groundwater development project based on the Study is hardly eligible as the Prescribed Project in term of a scale of capacity.

The Study will propose a groundwater development plan based on the results of the deep aquifer exploration. Since the Study is not going to propose specific projects, neither EIA nor IEE procedures above mentioned would be obliged in the Study.

However, information on the environmental impacts of the groundwater development would be one of essential factors when the plan is materialized as projects. Therefore, the Study gives environmental consideration to the groundwater development plan to be proposed by the Study.

A particularity of the groundwater development plan in the Study is to target aquifers as deep as 200 m. There have been no such deep wells in the country before the Study. Therefore, the groundwater extraction in the Prescribed Project must assume the extraction from shallow aquifers or deep aquifers with some tens meters of depth.

In other words, the Prescribed Project may not assume projects like the deeper groundwater development in the Study. The groundwater development projects based on the Study may be the one to be regarded as a new type of projects that current Prescribed Project does not cover. Therefore, the Study decided to apply IEE procedures so as to avoid unexpected environmental issues caused by a new type of projects.

Since the groundwater development project of the Study is not under the current environmental legal framework, the procedures not necessarily follow the IEE procedures applied to the Prescribed Project exactly.

The Study compared two IEE procedures; "the Environmental Guidelines for Infrastructure Projects (JICA, 1992)" and "Guidance for Implementing the Environmental Impact Assessment Process (CEA, Sri Lanka, 1998)". The Guidelines by JICA covers wider technical aspects than the Guidance of CEA, Sri Lanka, while which covers wider administrative aspects. The Study adopts the IEE procedures according to the Guidelines of JICA on the assumption that the Guidance of CEA will be applied again in the course of the actual implementation of the project.

9.2 ENVIRONMENTAL CONSIDERATION OF GROUNDWATER DEVELOPMENT PLANS (INITIAL ENVIRONMENTAL EXAMINATION)

9.2.1 INTRODUCTION

Generally, the IEE (Initial Environmental Examination) study is required as one of important performance needed consideration of negative impacts on natural, physical, ecological and socio-economic environment and approval of the Master Plan.

Generally speaking, construction of new water supply facilities and new operation works are certain to cause some effects on the environment. In general, most impacts are considered to be positive, but some might be negative, and monitoring and mitigation measures would be required. Environmental impacts caused by the projects are identified according to the relations with existing environmental conditions at the planning sites.

According to the IEE procedure from the guideline of JICA, the section presents summary of groundwater development plan, evaluation of the potential environmental impacts, and its mitigation measures and monitoring are described below.

9.2.2 DESCRIPTION OF DEVELOPMENT PLANS

The groundwater development plans for 15 pilot GNDs in Monaragala and Hambantota districts are formulated in the Study. Outline of plans and required facilities are summarized below.

(1) Outline of Plans

- The purpose of these plans is establishment of water supply system for 15 pilot GNDs.
- The water source of water supply is groundwater from the new production well.
- Object areas of these plans are following pilot GNDs (See, *Figure 9.2*).

Monaragala district includes seven GNDs of Hambegamuwa (M1), Bodagama (M2), Hulandawa Left (M3), Unawatuna (M4), Yalabowa (M5), Badalkumbura (M6) and Sevanagala (M7). Hambantota district includes eight GNDs of Keliyapura (H1), Vitarandeniya (H2), Talunna (H3), Wediwewa (H4), Tammennawewa (H5), Pahala Mattala (H6), Siyambalagaswila North (H7) and Ranna West (H8).

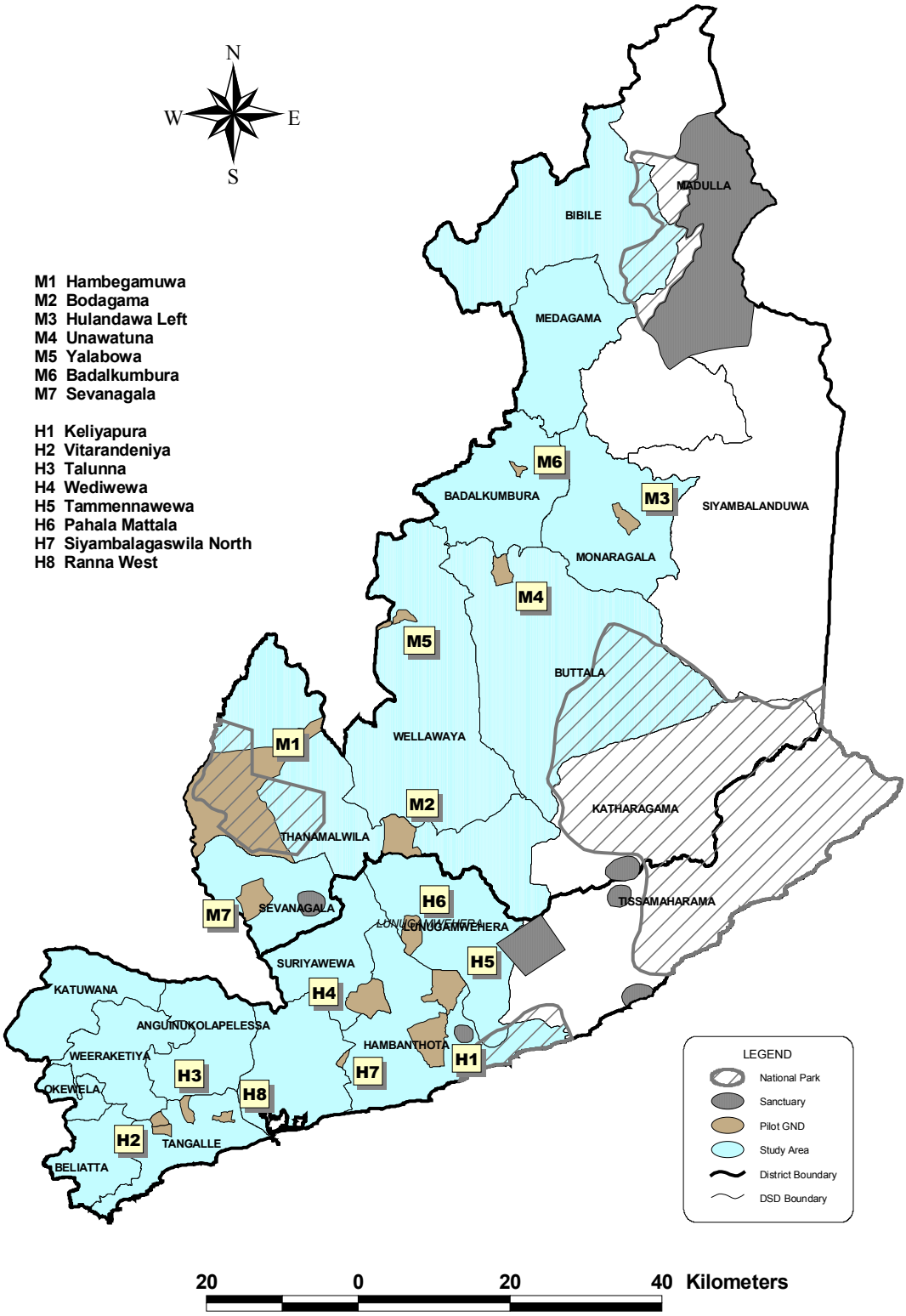

FIGURE 9.2 LOCATION MAP OF THE NATURAL RESERVE AND PROTECTION AREA

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(2) Required Facilities

Basically, the following five components are required for the rural water supply system by the groundwater sources.

- Production well and water intake facilities (Number of well)
- Treatment facilities (if necessary)
- Transmission facilities (if necessary)
- Elevated tank / Reservoir
- Distribution facilities

The details of the groundwater development plans are described in *Chapter 6* of the main report, and the components of water supply facilities each pilot GNDs are shown in *Table 9.1*.

Table 9.1 Component of Water Supply Facilities in 15 Pilot GNDs

Pilot GNDs	Production well and water intake facilities	Treatment facilities	Transmission facilities	Elevated tank / Reservoir	Distribution facilities
Hambegamuwa(M-1)	Three (**3**) New well and water intake facilities	No facilities	Required	Required	Stand post
Bodagama(M-2)	One (**1**) New well and water intake facilities	**Defluoride & Removal of T-Alkalinity**	Required	Required	House-connection & Stand post
Hulandawa Left(M-3)	Three (**3**) New well and water intake facilities	No facilities	Required	Required	Stand post
Unawatuna(M-4)	Two (**2**) New well and water intake facilities	No facilities	Required	Required	Stand post
Yalabowa(M-5)	One (**1**) New well and water intake facilities	**Removal of T-Alkalinity**	Required	Required	House-connection & Stand post
Badalkumbura(M-6)	One (**1**) New well and water intake facilities	**Deferrization**	Required	Required	House-connection & Stand post
Sevanagala(M-7)	Three (**3**) New well and water intake facilities	**Removal of Heavy Metals**	Required	Required	Stand post
Keliyapura(H-1)	No proposed facilities in this Study				
Vitarandeniya(H-2)	One (**1**) New well and water intake facilities	No facilities	Required	Required	House-connection & Stand post
Talunna(H-3)	One (**1**) New well and water intake facilities	**Softening**	Required	Required	House-connection & Stand post
Wediwewa(H-4)	No proposed facilities in this Study				
Tammennawewa(H-5)	One (**1**) New well and water intake facilities	**Desalination (RO)**	Required	Required	House-connection
Pahala Mattala(H-6)	One (**1**) New well and water intake facilities	No facilities	Required	Required	House-connection & Stand post
Siyambalagaswila North (H-7)	No proposed facilities in this Study				
Ranna West(H-8)	One (**1**) New well and water intake facilities	No facilities	Required	Required	House-connection & Stand post

9.2.3 SITE DESCRIPTION

The Existing condition of Monaragala and Hambantota districts, and 15 Pilot GNDs are described below.

(1) Social Environment

1) Population

Monaragala district is consists of 11 DSDs, and 11 DSDs are further divided into 323 GNDs, and Hambantota is consisted of 11 DSDs and 576 GNDs.

The existing population in Monaragala and Hambantota districts are 396,173 and 525,370, respectively (Refer to *Supporting 4* in this report).

In Monaragala, Sinhalese, Sri Lanka Tamil, Indian Tamil and Sri Lanka Moor population comprises of 94.5 %, 1.4 %, 1.9 % and 2.0 % respectively. In Hambantota, Sinhalese, Sri Lanka Tamil, Indian Tamil and Sri Lanka Moor population comprises of 97.1 %, 0.4 %, 0.1 % and 1.1 % respectively. Predominance of Sinhalese to other ethnic groups is significant in both districts.

The religious affiliations in Monaragala district show that out of the total population 94.4 % are Buddhists, 3 % are Hindus, 2.1 % are Muslims, 0.6 % are Roman and other Christians. In Hambantota, the ratio of Buddhists is 96.9 %, Hindus is 0.3 %, Muslims is 2.5 % and Roman and other Christians are 0.4 % (Refer to *Supporting 4* in this report).

2) Land Use

The total land area of Monaragala district is 5,659 km2. A considerable portion is covered by forest and Others (51%) and paddy/other plantations (37%). Built-up land and Homesteads are accounted for only 9 %.

The total land area of Hambantota district is 2,625 km2. Similarly, a considerable portion is covered by forest and Others (37 %) and paddy/ other plantations (43%). Built-up land and Homesteads are accounted for only 15.5 %. A ratio of land use is shown in the below table.

Land Use of the Study Area

Land Use Category	Monaragala District		Hambantota District	
	km^2	%	km^2	%
Built-up Land	0	-	24	0.9
Homesteads	509	9.0	383	14.6
Agricultual (Paddy)	216	3.8	320	12.2
Agricultual (Others)	1,878	33.2	810	30.8
Forest + others	2,886	51.0	963	36.7
Water bodies	170	3.0	125	4.8
Total	5,659	100	2,625	100

3) Water Source

The water sources in the two districts can be categorised into groundwater or surface water. The groundwater, which can be extracted from tube wells, dug wells and springs, is mainly utilised for the domestic purposes. The surface water, which can be extracted from rivers, streams and tanks, is mainly utilised for an irrigation purpose.

The ratio of population served by pipe water in the Monaragala and Hambantota districts are 12 %, 28 %, respectively. The ratio that population use the tube and dug wells in the both districts is approximately 70 %. On the other hand, shares of population rely on the other sources, which include river, tank and stream are 18 % in Monaragala district and 3 % in Hambantota district. It is considered that the share of population utilise the other sources

increased in the dry season because some dug wells become deteriorate of groundwater quantity and quality in the dry season.

4) Existing Water Supply System

There are nine existing water supply systems in Monaragala district. Only a part of one pilot GND of Yalabowa in Wellawaya DSD, is covered by the Wellawaya scheme. The water sources of the schemes are rivers and tanks except in Buttala. The scheme in Buttala DSD has extracted water from a river and two wells.

There are 21 existing water supply systems in Hambantota District. There are five schemes sourced by a well and two schemes sourced by a spring, so that a total of seven schemes in the district, which depend their sources on groundwater (Refer to *Supporting 4*).

(2) Natural Environment

1) Weather Condition

The Study area is affected mainly by the northeast monsoon. Mountain areas where rainfall is larger than that of the flat areas are located in the west and the north. Almost all of the Study area, except the northern part of Monaragala District, is flat with an altitude less than 150 m.

Major features of distribution of average rainfall are summarized as follows.

- The mountain slope areas facing to the northeast have a large rainfall depth with an average annual rainfall of 3,000 mm or less, while the slope facing to the southwest have smaller rainfall of less than 2,000 mm.
- The southern coastal area has a small average annual rainfall of 1,100 to 800 mm.
- Average annual rainfall in the inland flat areas ranges from 1,500 to 1,000 mm.
- Monthly rainfall distribution is large from October to January in general.

Most of the 15 Pilot GNDs are located in the hilly areas with elevation of 375 m to 30 m for Monaragala and 25 m to 40 m for Hambantota. In these areas, it is difficult to get the water by dug wells in the dry season.

The temperatures in Monaragala and Hambantota districts do not show a large variation during the year. Low temperature is usually observed during October to December. The high temperature is normally observed between August and September. The average annual temperatures of Monaragala and Hambantota are about 27oC and 28oC, respectively.

2) Topographical and Geological Condition

Most of the Study area is a gentle slope area at the elevation of 200 m or less. Northern part of the Study area is hilly at the elevation of 200 m or above partially mountainous at the elevation of 400 m or above. The southern part slopes gently to the coastal area.

The area with the distribution of Highland Complex is mountainous and the area with the distribution of Vijayan Complex is a hilly or gentle slope area. Rocks of the Vijayan Complex underlie widely in the area while the Highland Complex is restricted to the northwestern hilly part and western part of the Study Area. The highland Complex rocks also occur in the form of outliers within the Vijayan Complex. Recent sediments occur in the southern and southeastern coastal belt (Refer to *Supporting 1*).

3) Groundwater Condition

Based on the database of wells, approximately 1,700 tube wells exist in the Study area, and the well yield is tabulated below.

Range of Yield	Number of Wells	Ratio
More than 800 liters/min.	10	0.6 %
From 400 to 800 liters/min.	33	1.9%
From 200 to 400 liters/min.	103	6.0 %
From 100 to 200 liters/min.	182	10.6 %
From 20 to 100 liters/min.	576	33.4 %
Less than 20 liters/min.	819	47.5 %
Total	1,723	100.0 %

The proportion of wells that have less than 20 liters/minute of yield is less than 50 %. The fact suggests that the severe condition of groundwater resources use in the Study area.

Moreover, the major problems of groundwater quality in the existing tube well for drinking water are listed below (Refer to *Supporting 5*).

- High values of EC, Total Hardness and ionized substances that do not satisfy the criteria for drinking water are distributed in the central part to the western part of Hambantota.
- High concentrations of fluoride and total iron are distributed in the western part of Hambantota to the western part of Monaragala and the northern part of Monaragala.

4) Fauna and Flora

The natural reserve and protection area in Sri Lanka is classified four categories as strict natural reserve, national park, nature reserve and sanctuary. Basically, human activities in the previous three categories are prohibited by law. However, the sanctuary may include state and private land, and protection given to wildlife but human activity is also permitted. Therefore, it is necessary that attention should be paid to overlap with planning site and Sanctuary (Lyn de Alwis, 1997).

The natural reserve and protection areas in Monaragala and Hambantota districts are shown in *Figure 9.2*. From the figure, 15 Pilot GNDs do not overlap with the sanctuary area.

(3) 15 Pilot GNDs

Table 9.2(1) to (4) presents detail information as planning site description and land use conditions of 15 Pilot GNDs, respectively.

Table 9.2 (1) Profile of 15 Pilot GNDs (Planning Area)

Pilot GND		Hambegamuwa (M 1)	Bodagama (M 2)	Hulandawa Left (M 3)	Unawatuna (M 4)
District / DS Division		Monaragala/Thanamalwila	Monaragala /Thanamalwila	Monaragala / Monaragala	Monaragala / Buttala
Population (persons)		2,046	About 1,300	3,749	2,257
Pop. Density		4.8 persons/ha	4.5 persons/ha	7.0 persons/ha	7.0 persons/ha
Numberof family		475	201	519	576
Land Use	Total Area	158.03 km^2	20.93 km^2	7.26 km^2	8.51 km^2
	Build up + Homestead	2.7%	13.9%	73.6%	38.1%
	Agricultural (Paddy)	0.6%	1.7%	12.9%	17.5%
	Agricultural(Others)	7.0%	44.3%	6.7%	25.5%
	Forest area and others	78.4%	38.7%	6.7%	3.8%
	Water bodies	11.3%	1.3%	0.0%	15.2%
Elevation/ Topography		30m / Flat	90m / Flat	120m / Flat with gentle slope	170m / Hilly
Groundwater recharge potential		Medium	Medium	Medium - Low	High
Name of River / Tank		Rivers: Mau Ara Tanks: Hambegamuwa	Rivers: Small streams Tanks: Small tanks	Rivers: Hulandawa Oya, Irrigation canal Tanks: None	Rivers: Kuda Oya, Menik Ganga Tanks: Yudagonawe
Water Source	House Connection	0%	4%	0%	0%
	Stand Post	0%	0%	3%	0%
	Tube well	25%	24%	3%	0%
	Dug well	75%	72%	94%	100%
	Others	0%	0%	0%	0%
Number of the Existing Tube Well		11	13	0	0

Note: Population density is calculated from divided population by areas of build up and homestead.

Table 9.2 (2) Profile of 15 Pilot GNDs (Planning Area)

Pilot GND		Yalabowa (M 5)	Badalkumbura (M 6)	Sevanagala (M 7)
District / DS Division		Monaragala /	Monaragala / Sevanagala	Monaragala / Badalkumbura
Population (persons)		1,280	4,661	1,337
Pop. Density		5.3 persons/ha	28.2 persons/ha	3.6 persons/ha
Number of family		Unknown	Unknown	575
Land Use	Total Area	4.8 km^2	1.95 km^2	16.52 km^2
	Build up + Homestead	50.2%	84.6%	22.2%
	Agricultural (Paddy)	3.8%	0.0%	9.6%
	Agricultural (Others)	12.5%	8.2%	65.7%
	Forest area and others	32.3%	7.2%	2.1%
	Water bodies	1.3%	0.0%	0.4%
Elevation/ Topography		30-50m / Flat with gentle slope	60m / Flat	375m / Hilly
Groundwater recharge potential		High	High	Medium
Name of River / Tank		Rivers: Kirindi Oya and its tributary Galamela Ara Tanks: small 2 tanks	Rivers: Mau Ara, Walawe Ganga Tanks: Habaralu and Mohagama	Rivers: Menik Ganga, Kuda Oya (Kumbukkan Oya system) Tanks: None
Water Source	House Connection	0%	4%	0%
	Stand Post	57%	7%	12%
	Tube well	0%	0%	0%
	Dug well	43%	82%	88%
	Others	0%	7%	0%
Number of the Existing Tube Well		0	0	8

Note: Population density is calculated from divided population by areas of build up and homestead.

Table 9.2 (3) Profile of 15 Pilot GNDs (Planning Area)

Pilot GND		Keliyapura (H 1)	Vitarandeniya (H 2)	Talunna (H 3)	Wediwewa (H 4)
District / DS Division		Hambantota / Hambantota	Hambantota/Tangalle	Hambantota/Tangalle	Hambantota/Sooriyawewa
Population (persons)		553	687	981	1,857
Pop. Density		2.9 persons/ha	1.5 persons/ha	3.7 persons/ha	35 persons/ha
Number of family		240	Unknown	280	397 consists of 4 villages
Land Use	Total Area	25.1 km^2	6.52 km^2	4.43 km^2	20.06 km^2
	Build up + Homestead	7.5%	68.6%	60.3%	2.6%
	Agricultural (Paddy)	4.4%	7.2%	4.7%	2.2%
	Agricultural (Others)	10.4%	19.3%	25.7%	59.6%
	Forest area and others	73.6%	2.5%	7.0%	33.3%
	Water bodies	4.1%	2.5%	2.3%	2.2%
Elevation / Topography		25m / Flat with gentle slope	35m / Rolling hills	30m / Hilly	30m / Flat with long gentle slope
Groundwater recharge potential		Low	Low	Medium - Low	Low
Name of River / Tank		Rivers: None Tanks: Keligama and small tanks	Rivers: Urubokka Oya, Small river Tanks: Tanks	Rivers: Urubokka Oya and its small tributary Tanks: None	Rivers: Two small rivers Tanks: Many small tanks
Water Source	House Connection	0%	0%	0%	0%
	Stand Post	0%	0%	5%	10%
	Tube well	47%	47%	0%	0%
	Dug well	53%	53%	90%	70%
	Others	0%	0%	0%	20%
Number of the Existing Tube Well		0	12	0	5

Note: Population density is calculated from divided population by areas of build up and homestead.

Table 9.2 (4) Profile of 15 Pilot GNDs (Planning Area)

Pilot GND		Tammennawewa (H 5)	Pahala Mattala (H 6)	Siyambalagaswila North (H 7)	Ranna West (H 8)
District / DS Division		Hambantota/Hambantota	Hambantota / Lunugamvehera	Hambantota / Hambantota	Hambantota / Tangalle
Population (persons)		1,089	430	1,328	1,550
Pop. Density		7.8 persons/ha	8.1 persons/ha	14.4 persons/ha	8.8 persons/ha
Number of family		Unknown	83	272	410
Land Use	Total Area	19.88 km^2	11.5 km^2	1.82 km^2	2.52 km^2
	Build up + Homestead	7.0%	4.6%	50.5%	69.8%
	Agricultural (Paddy)	5.8%	3.2%	25.3%	27.0%
	Agricultural (Others)	20.8%	15.3%	24.2%	3.2%
	Forest area and others	37.5%	72.9%	0.0%	0.0%
	Water bodies	28.8%	4.0%	0.0%	0.0%
Elevation/Topography		30m / Flat with gentle slope	40m / Flat	25m / Flat and a little higher than surrounding areas	25m / Hilly with long slope down to Urubokka Oya.
Groundwater recharge potential		Low	Medium - Low	Medium	Medium - Low
Name of River / Tank		Rivers: One small river Tanks: Badagiriya and small tanks	Rivers: Malala Oya, Two small rivers Tanks: Many small tanks	Rivers: Walawe Ganga Tanks: Ridiyagama through irrigation canal	Rivers: Urubokka Oya Tanks: None
Water Source	House Connection	0%	0%	5%	3%
	Stand Post	83%	90%	0%	86%
	Tube well	0%	0%	0%	0%
	Dug well	10%	10%	95%	11%
	Others	7%	0%	0%	0%
Numberof the Existing Tube Well		1	17	1	0

Note: Population density is calculated from divided population by areas of build up and homestead.

9.2.4 CONSIDERATION OF POTENTIAL ENVIRONMENTAL IMPACTS

The section presents potential environmental impacts that may be caused by the project implementation. According to the project components and the environmental information, potential environmental impacts are identified by the screening items as prescribed in the Environmental Guidelines for Infrastructure Projects (JICA, 1992). Based on the results of screening, the identified environmental impacts are evaluated their significance, and defining the study items for the next study stage (such as Feasibility Study or Detail Design Study).

(1) Identification of Potential Environmental Impacts

According to 23 viewpoints of social, natural and pollution aspects, the potential environmental impacts by the project implementation are evaluated and are show in *Table 9.3(1) and (2)*

According to the evaluation, following items are would be expected as potential environmental impacts by the project implementation.

- Resettlement:	Resettlement due to land occupancy.
- Economic Activities:	Loss of production base and change of economic structure.
- Traffic and Public Facilities:	Impacts on school, hospitals and present traffic conditions, such as a traffic jams and accidents.
- Cultural Property:	Loss or decrease of the value of cultural assets, such as templates, shrines and archeological assets.
- Public Health Condition:	Worsening of health and sanitary condition.
- Waste:	Generation of sludge and waste.
- Soil Erosion:	Topsoil erosion by rainfall water after land reclamation and deforestation.
- Groundwater:	Decline of groundwater level caused by overdraft.
- Fauna and Flora:	Obstruction of breeding and extinction of species due to the changes of habitat conditions.
- Noise and Vibration:	Noise and vibration generated by drilling rig, vehicles and operation of water treatment plant.
- Land Subsidence:	Land subsidence caused by the lowering of water table.

Table 9.3 (1) Identification of Potential Environmental Impacts

Environmental Items			Construction stage	Operation stage	Remarks (Reason)
Social Environment	1	**Resettlement** Resettlement due to land occupancy	**P**	-	Potentially expected for the sites of production well, treatment facilities and reservoir tank / elevated Tank.
	2	**Economic Activities** Loss of production base and change of economic structure	**P**	-	Potentially expected. The same reason with '1-Resettlement'
	3	**Traffic and Public Facilities** Impacts on school, hospitals and present traffic conditions, such as a traffic jams and accidents	**E**	-	Expected. The construction vehicles and machinery can affect traffic on the local roads.
	4	**Division of Communities** Separation of regional communities by hindrance of regional traffic	-	-	Not expected.
	5	**Historical or cultural site** Loss or decrease of the value of cultural assets, such as templates, shrines and archeological assets	**P**	-	Potentially expected. The same reason with '1-Resettlement'
	6	**Water Rights and Rights of Common** Obstruction of fishing rights, water rights, and rights of common	-	-	Not expected.
	7	**Public Health Condition** Worsening of health and sanitary condition.	-	**P**	Potentially expected. Water-bone disease might be caused by supplied water. Potentially expected. Stagnation of wastewater from stand post.
	8	**Waste** Generation of construction waste, surplus soils, sludge and domestic wastes	-	**E**	Expected. Chemical sludge and liquid waste are generated from purification facilities, if purification method of RO, removal of heavy metals and deferrization with coagulation are introduced.
	9	**Risk of disaster** Increase of risk of cave-in, ground failure and accidents	-	-	Not expected.
Natural Environment	10	**Topography and Geology** Change of valuable topography and geology due to excavation and earthfill	-	-	Not expected.
	11	**Soil Erosion** Topsoil erosion by rainfall water after land reclamation and deforestation	**P**	-	Potentially expected for the construction sites of transmission pipe and other facilities.
	12	**Groundwater** Decline of groundwater level cause by the overdraft.	-	**P**	Potentially expected.
	13	**Hydrological Situation** Changes of river discharge and riverbed condition due to filling work and drainage inflow	-	-	Not expected.

E: The potential environmental impacts are **E**xpected.
P: It is not clear that potential environmental impacts are **P**otentially expected or not.
- : There are no environmental impacts.

Table 9.3 (2) Identification of Potential Environmental Impacts

Environmental Items			Construction stage	Operation stage	Remarks (Reason)
Natural Environment	14	**Coastal Zone** Coastal erosion and change of coastal vegetation due to the changes of habitat conditions	-	-	Not expected.
	15	**Fauna and Flora** Obstruction of breeding and extinction of species due to the changes of habitat conditions	**P**	-	Potentially expected for the construction sites of well/pump facilities, reservoir tank and transmission pipe.
	16	**Meteorology** Change of micro-climate, such as temperature, wind, etc., due to large-scale reclamation and construction	-	-	Not expected.
	17	**Landscape** Change of topography and vegetation due to reclamation. Deterioration of aesthetic harmony by structures.	-	-	Not expected.
Pollution	18	**Air Pollution** Pollution caused by exhaust gas or toxic gas from vehicles and factories	-	-	Not expected.
	19	**Water Pollution** River/stream pollution caused by wastewater.	-	-	Not expected.
	20	**Soil Contamination** Contamination caused by discharge or diffusion of wastewater drainage or toxic materials.	-	-	Not expected.
	21	**Noise and Vibration** Noise and vibration generated by drilling rig, vehicles and operation of water treatment plant	**E**	-	Expected mainly during construction works
	22	**Land Subsidence** Land subsidence caused by the lowering of water table	-	**P**	Potentially expected for the overdraft of groundwater.
	23	**Offensive Odor** Generation of offensive odor and exhausted gas	-	-	Not expected.

E: The potential environmental impacts are **E**xpected.
P: It is not clear that potential environmental impacts are **P**otentially expected or not.
- : There are no environmental impacts.

(2) Sources of Potential Environmental Impacts and Mitigation Measures

From above section, the selected potential environmental impacts are evaluated from a viewpoint of their significance, and defining the study items for the next study stage.

1) Resettlement/ Economic Activities/ Cultural Property

Potential impacts:	Resettlement, interrupt of economic activities and demolition of cultural property
Project activities:	Land acquisition for production well / water intake facilities, treatment facilities and reservoir tank/elevated tank.
Objective period:	Construction stage

Generally, resettlement may be caused by land acquisition for above project components. However, the required land area in this plan is limited, and population density (population/Build up + Homestead area) of 15 Pilot GNDs range from 1.5 persons/ha to 35 persons/ha with average 10 persons/ha. Therefore, land acquisition for this project is not difficult from the aspect of site condition. It is expected that no houses will be demolished or no people will be displaced by this plan.

It is necessary that attention should be paid to project site condition as land use, economic activities, traffic and public facilities and cultural property in the next study stage.

2) Traffic and Public Facilities

Potential impacts:	Obstruction of traffic and public facilities
Project activities:	The construction vehicles and machinery may be affect traffic at the roads. Especially, installation of transmission lines and distribution pipes
Objective period:	Construction stage

According to the general condition of 15 Pilot GNDs, it can be assumed that the present traffic volume on the roads is very few, and the impact would not so serious as a traffic jam would happen. However, it is necessary that a traffic survey should be carried out the planning area and the traffic condition will be grasped.

As mitigation measures, during the construction period, watchman will be put at the site to control the traffic, and schedule of the transport of construction material should be controlled.

3) Public Health Condition

Potential impacts:	Water-bone disease from water supply system Stagnation of wastewater from stand post
Project activities:	Water supply works
Objective period:	Operation stage

The water supply system will generally bring huge beneficial effects on public health condition, living condition and economic condition. However, it would be considered risk of water-bone disease through the water supply system.

Basically, the groundwater of deep aquifer is no contamination of microorganism, while it can be presume to contain the fluoride and toxic substances. Therefore, appropriate treatment facilities and its operation would be required. Moreover periodical supplied water quality analysis would be required for the safe water supply system.

Stagnation of wastewater from stand post can cause unhygienic condition and breeding points for mosquitoes. Therefore, the design criteria for stand post in the next study stage

will be required the consideration from aspects of water supply and water drainage system. And it will be recommend that operation/maintenance of stand post should be managed by the community members.

4) Waste

Potential impacts: Environmental pollution is caused by improper disposal of sludge and liquid waste.

Project activities: Purification facilities (Reverse osmosis and coagulation-sedimentation process)

Objective period: Operation stage

Chemical sludge and liquid waste are generated from purification method of reverse osmosis and coagulation-sedimentation process. However, it is difficult to introduce these purification methods for the rural water supply system from economic and technical aspects. It is suggested that further detail feasibility study is required. Therefore, it is necessary to prepare proper disposal scheme for chemical sludge and liquid waste, if above the purification methods are introduced.

5) Groundwater Problems/ Land Subsidence

Potential impacts: Decline of groundwater level and deterioration of groundwater quality are caused by overdraft.

Project activities: Groundwater pumping

Objective period: Operation stage

Basically, the proposed yield of groundwater in the plan is determined within the limited exploitable capacity in the planning area. Therefore, the groundwater yield would never cause land subsidence and never damage the existing groundwater level. However, it would be considered that the groundwater condition is strongly effected local weather condition.

Consequently, mitigation measurements for these problems are listed as follow. The above dangerousness will be avoided by the following measurements even for the harsh weather conditions.

- To keep within the proposed yield of production well.
- To grasp of groundwater condition as groundwater level and groundwater quality by a periodical monitoring.

In this section, sensitiveness for overdraft of groundwater in the GNDs is evaluated. Assuming that the sensitiveness of above problem is evaluated by the following parameters.

i) Groundwater recharge potential

The estimated groundwater recharge potential by hydrological study in this report.

ii) Population in the GNDs

Assuming that population is the capacity of required water consumption.

iii) Number of the existing tube wells in the GNDs

Assuming that the water level will be depressed by the pumping of multiple wells. It is appropriate that the distance between the existing well and production well is selected as a parameter for the estimation of damage by overdraft. Therefore, number of production well and the existing wells are selected as parameter for this evaluation.

iv) Existence of production well for other water supply scheme in DSDs

Assuming that the water level will be depressed by the pumping of multiple wells.

From viewpoint of the sensitiveness of above problem, GNDs are categorized by score of above parameters. The criteria of score are assumed as below.

Parameters	Criteria of Score for Parameters		
	0 point	1 point	2 points
Recharge potential	low	medium	high
Population	less than 1,000	from 1,000 to 2,000	more than 2,000
Number of Existing well	no well	1 to 10	more than 10
Existance of production well for other water supply scheme	No	-	Yes

The results of scoring are shown in *Table 9.4*, and the result of its evaluation are summarised as below.

i) Three GNDs, namely Vitarandeniya (H2), Wediwewa (H4), Tammennawewa (H5), are selected as high sensitive GND. The reason that the above GNDs are situated in the low recharge potential area and the existence of production well for other water supply scheme in the same DSD.

ii) Second sensitive group includes three GNDs of Siyambalagaswila North (H7), Ranna West (H8) and Hambegamuwa (M1). The situation of Siyambalagaswila North (H7) and Ranna West (H8) are the similar of the above GNDs. The Hambegamuwa (M1) belongs this group because of the population and number of well.

iii) As further study in the next study stage, special attention should be paid to estimate the limited exploitable capacity for the above high risk GNDs.

Table 9.4 Evaluation of Sensitiveness for Overdraft

Name of GND	Groundwater recharge potential		Population in GND		Number of Well in GND		Existence of Production well in DSD		Total
	Level of recharge	Score	Population (persons)	Score	Number of Well	Score	Yes/No	Score	Score
Hambegamuwa (M-1)	Medium	1	2,046	2	11	2	No	0	**5**
Bodagama (M-2)	Medium	1	1,300	1	13	2	No	0	**4**
Hulandawa Left (M-3)	Medium - Low	2	3,749	2	0	0	No	0	**4**
Unawatuna (M-4)	High	0	2,257	2	0	0	Yes	2	**4**
Yalabowa (M-5)	High	0	1,280	1	0	0	No	0	**1**
Badalkumbura (M-6)	High	0	4,661	2	0	0	No	0	**2**
Sevanagala (M-7)	Medium	1	1,337	1	8	1	No	0	**3**
Keliyapura (H-1)	Low	2	553	0	0	0	Yes	2	**4**
Vitarandeniya (H-2)	Low	2	687	0	12	2	Yes	2	**6**
Talunna (H-3)	Medium - Low	2	981	0	0	0	Yes	2	**4**
Wediwewa (H-4)	Low	2	1,857	1	5	1	Yes	2	**6**
Tammennawewa (H-5)	Low	2	1,089	1	1	1	Yes	2	**6**
Pahala Mattala (H-6)	Medium - Low	2	430	0	17	2	No	0	**4**
Siyambalagaswila N. (H-7)	Medium	1	1,328	1	1	1	Yes	2	**5**
Ranna West (H-8)	Medium - Low	2	1,550	1	0	0	Yes	2	**5**

Parameters	Criteria of Score for Parameters		
	0 point	1 point	2 points
Recharge potential	low	medium	high
Population	less than 1,000	from 1,000 to 2,000	more than 2,000
Number of Existing well	no well	1 to 10	more than 10
Existence of production well for other water supply scheme	No	-	Yes

6) Soil Erosion

Potential impacts: Soil Erosion

Project activities: Construction of treatment facilities, transmission line, reservoir tank/elevated tank and stand post

Objective period: Construction stage

Soil erosion may occur due to clearance of vegetation and excavation when constructing treatment facilities, transmission line and reservoir tank/elevated tank. Soil erosion can be minimised by proper refilling of trenches and allowing re-growth of a vegetation cover or reinstatement the construction site.

7) Fauna and Flora

Potential impacts: Damage to fauna and flora

Project activities: Land acquisition for production well / pumping facilities, treatment facilities and reservoir tank/elevated tank.

Objective period: Construction stage

The planning sites (15 Pilot GNDs) do not include the sanctuary areas for the natural conservation. Moreover, it is assume that the required land areas are limited, and are situated in the homestead area and road. Consequently, no damage of fauna and flora are expected by these projects. However, it is desired that proper refilling of trenches and allowing re-growth of a vegetation cover or reinstatement the edges of the roadways for protection of soil erosion.

8) Noise and Vibration

Potential impacts: Construction of production well

Project activities: Drilling of well

Objective period: Construction stage

During construction stage of well, the work will generate noise and vibration to some extent. However, the period of construction is limited (according to the drilling works of the test well in this Study, the term of drilling works is less than two weeks), and potential impacts should be minimized by the working time which will be limited only in the daytime of weekdays.

9.2.5 CONCLUSION

Overall evaluation of results of the environmental consideration are summarised in *Table 9.5*. Conclusions of the Initial Environmental Examination are as follows:

- As conclusion, Environmental Impact Assessment (EIA) for this plan will not be required.
- Basically, the implementation of this plan will not cause significant negative impacts to environment in the planning area, except overdraft and contamination of supplied water. The overdraft and contamination of supplied water rarely occur, while its damage must be significant negative impacts.
- Above potential impacts could be eliminated by following preparation and studies.
- As further study in the next study stage, attention should be paid to design the suitable pumping operation. For this consideration, it would be required accumulation of the continuous data of groundwater condition.
- Consequently, it would be required establishment of monitoring system for groundwater level and groundwater quality.
- Moreover, it would be required details field survey for information of determined construction site and its surrounding condition.
- Preparation of proper operation program for suitable yield of production well and for water quality management of supplied water.

Table 9.5 Overall Evaluation of the Potential Environmental Impacts

N	Item	Evaluation	Additional survey and Study for Next planning Stage
1	Resettlement	**C**	Detail field survey for planning site
2	Economic Activities	**C**	Detail field survey for planning site
3	Traffic and Public Facilities	**C**	Traffic survey and detail field survey for planning site
4	Split of Communities	**N**	
5	Cultural Property	**C**	Detail field survey for planning site
6	Water Rights and Rights of Common	**N**	
7	Public Health Condition	**C**	Enforcement of Monitoring (groundwater quality) Detail field survey for planning site (public tap)
8	Waste	**C**	Preparation of sludge and liquid waste disposal scheme.
9	Hazards (Risk)	**N**	
10	Topography and Geology	**N**	
11	Soil Erosion	**N**	
12	Groundwater	**C**	Enforcement of monitoring (groundwater table)
13	Hydrological Situation	**N**	
14	Coastal Zone	**N**	
15	Fauna and Flora	**C**	Detail field survey for planning site
16	Meteorology	**N**	
17	Landscape	**N**	
18	Air Pollution	**N**	
19	Water Pollution	**N**	
20	Soil Contamination	**N**	
21	Noise and Vibration	**C**	Detail field survey for construction site
22	Land Subsidence	**C**	Enforcement of monitoring (groundwater table)
23	Offensive Odor	**N**	

A – Serious impact is expected; **B** – Some impact is expected; **C** – Extent of impact is unknown and examination is needed. Impacts may become clear; **N** – No impact is expected. IEE/EIA is not necessary.

SUPPORTING 10 ORGANIZATION, MANAGEMENT AND OPERATION

10.1 GENERAL

Purposes of this chapter are to grasp the present system in order to i) propose suitable organization, management and operation plan relevant to groundwater development plan, ii) propose organization and institution plan for monitoring plan of groundwater development plan to manage and operate properly, and iii) propose appropriate plan of drilling machine to be donated.

10.2 ORGANIZATION RELATED TO WATER SECTOR

Brief overview of the organization related to this groundwater development plan is shown below.

10.2.1 WATER RESOURCES BOARD (WRB)

The Water Resources Board was established in 1966, under the Act No. 29 of 1964, as an advisory body to the subject Minister on all matters concerning the control and utilization of the Water Resources of Sri Lanka.

In 1978, the Groundwater Division of the Irrigation Department was transferred to the Water Resources Board and functions of the Board were expanded and commenced the implementation activities.

At present, WRB conducts the following activities:

- Geoscientific interpretation of the available data for groundwater resources development
- Hydrogeological investigations for the assessment of groundwater resources
- Identification of groundwater potential sites for agrowells
- Scientific siting of locations for deep tube wells
- Drilling of deep tube wells for extraction of groundwater for domestic, agricultural and industrial purposes
- Feasibility studies for groundwater resources development
- Analysis of water samples for chemical and physical characteristic
- Collection of hydrogeological data and preparation of maps

The staff number of WRB is 302 in July 1, 2002. Organization chart and income and expenditure account statement are shown in *Figure 10.1* and *Table 10.1*, respectively.

WRB reaps income from drilling works and hydrogeological investigations. These works were carried out on the request made by public and private sectors including District Secretaries and Divisional Secretaries. In case of drilling of tube wells for domestic use, WRB can install hand pump.

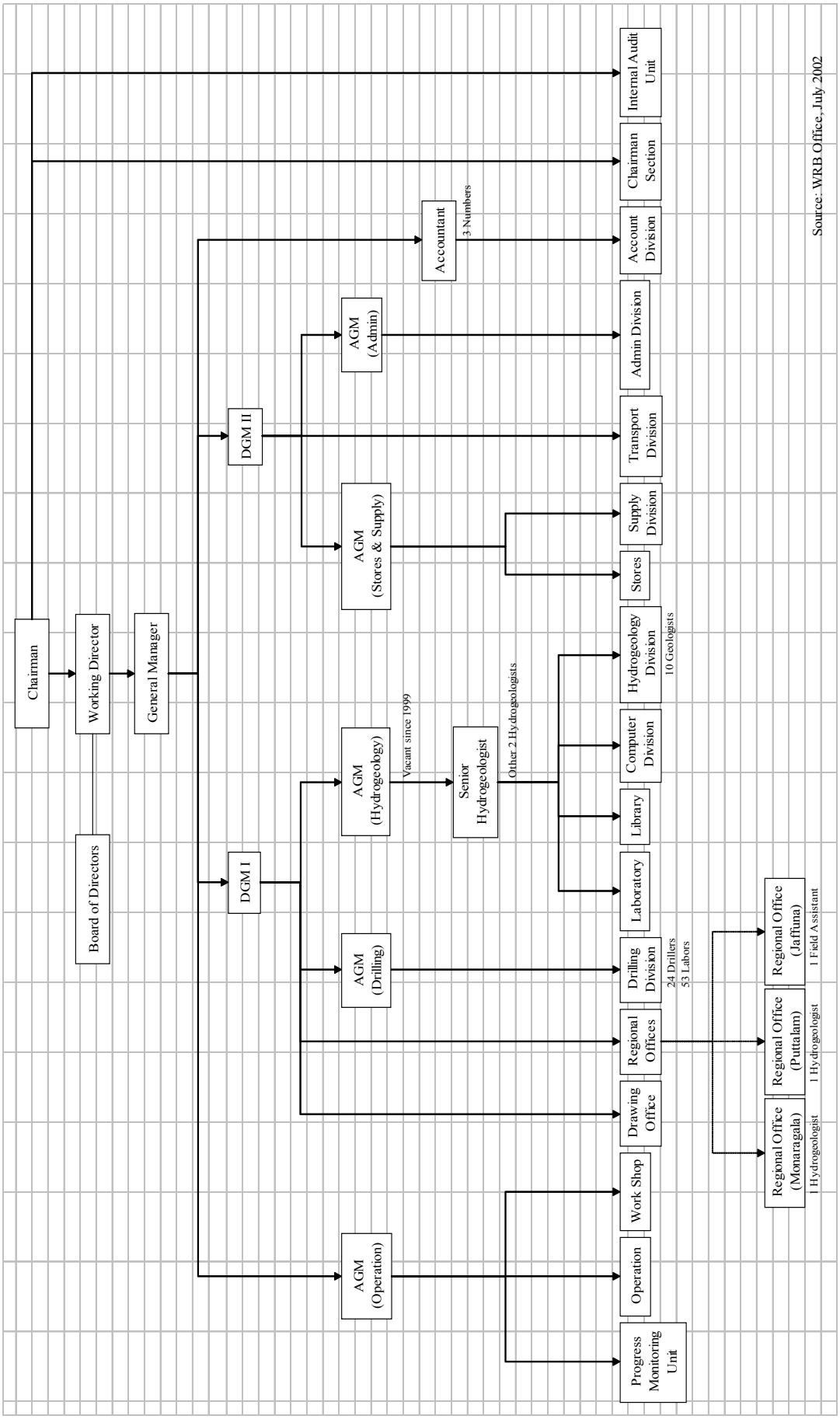


Figure 10.1 Organization Chart of WRB

Table 10.1 Income and Expenditure Account Statement of WRB in 1999, 2000

(Unit: Rs.)

Items	2000	1999
1. INCOME	**50,649,097**	**53,080,921**
1.1 INCOME FROM ACTIVITIES	28,896,632	33,184,668
a. Tube Wells & Other Construction	18,796,021	21,675,753
b. Groundwater Activities	3,100,824	4,132,501
c. Water Supply Scheme	4,096,059	3,883,129
d. Other Services	2,903,728	3,493,285
1.2 RECURRENT GRANT CONTRIBUTION FROM TREASURY	21,752,465	19,896,253
2. EXPENDITURE	**52,757,499**	**53,520,525**
2.1 OPERATIONAL	50,437,268	51,507,128
a. Personnel Emoluments	28,418,632	26,375,752
b. Board's Contribution to EPF & ETF	3,735,282	3,678,203
c. Maintenance & Repairs of Motor Vehicle	1,637,777	2,771,109
d. Maintenance & Repairs of Machinery	1,027,653	917,966
e. Maintenance & Repairs of Buildings	218,210	157,071
f. Office Equipment	184,253	160,259
g. Stores Consumption	6,357,734	8,134,490
h. Others	8,281,727	9,312,278
2.2 DEPRECIATION OF ASSETS	2,320,231	2,013,397
BALANCE	**▲2,108,402**	**▲439,604**

Source: WRB Annual Report 2000

10.2.2 NATIONAL WATER SUPPLY AND DRAINAGE BOARD (NWSDB)

The organization had its beginnings as a sub department under the Public Works Department. Subsequently in 1963, it was upgraded as the Water Supply and Drainage Department. In 1965 it became a division under the Ministry of Local Government. From 1970 this division functioned as a separate department under the Ministry of Irrigation Power and Highways and remained so until present Board was established in 1975.

The National Water Supply and Drainage Board which presently functions under the Ministry of Housing and Plantation Infrastructure is the principle authority for provision of safe and adequate drinking water and facilitation for provision of adequate sanitation in Sri Lanka. During the past 25 years the organization has considerably expanded its scope of activity. The employee numbers have increased from about 1,000 in 1975 to around 7,800 in 2000.

Organization chart and income and expenditure account statement are shown in *Figure 10.2* and *Table 10.2*, respectively.

The concrete activity of NWSDB is summarized as follows:

- Investigations for surface and groundwater sources
- Planning, design and construction of urban and rural sector water supply and sewerage schemes aimed at upliftment of the living condition of communities through increased coverage and for economic development.
- Operation and maintenance of water supply and sewerage facilities ensuring quality, reliability and satisfactory services.
- Supply of water to Local Authorities in bulk.
- Provision of technical assistance to Local Authorities, state agencies, and private/public sector for industrial establishment.
- Cost recovery activities for water supply and sewerage.
- Budgeting and financial control.
- Human resources administration and development.
- Publicity and consumer awareness programs on effective use of water and reduction of non-revenue water.

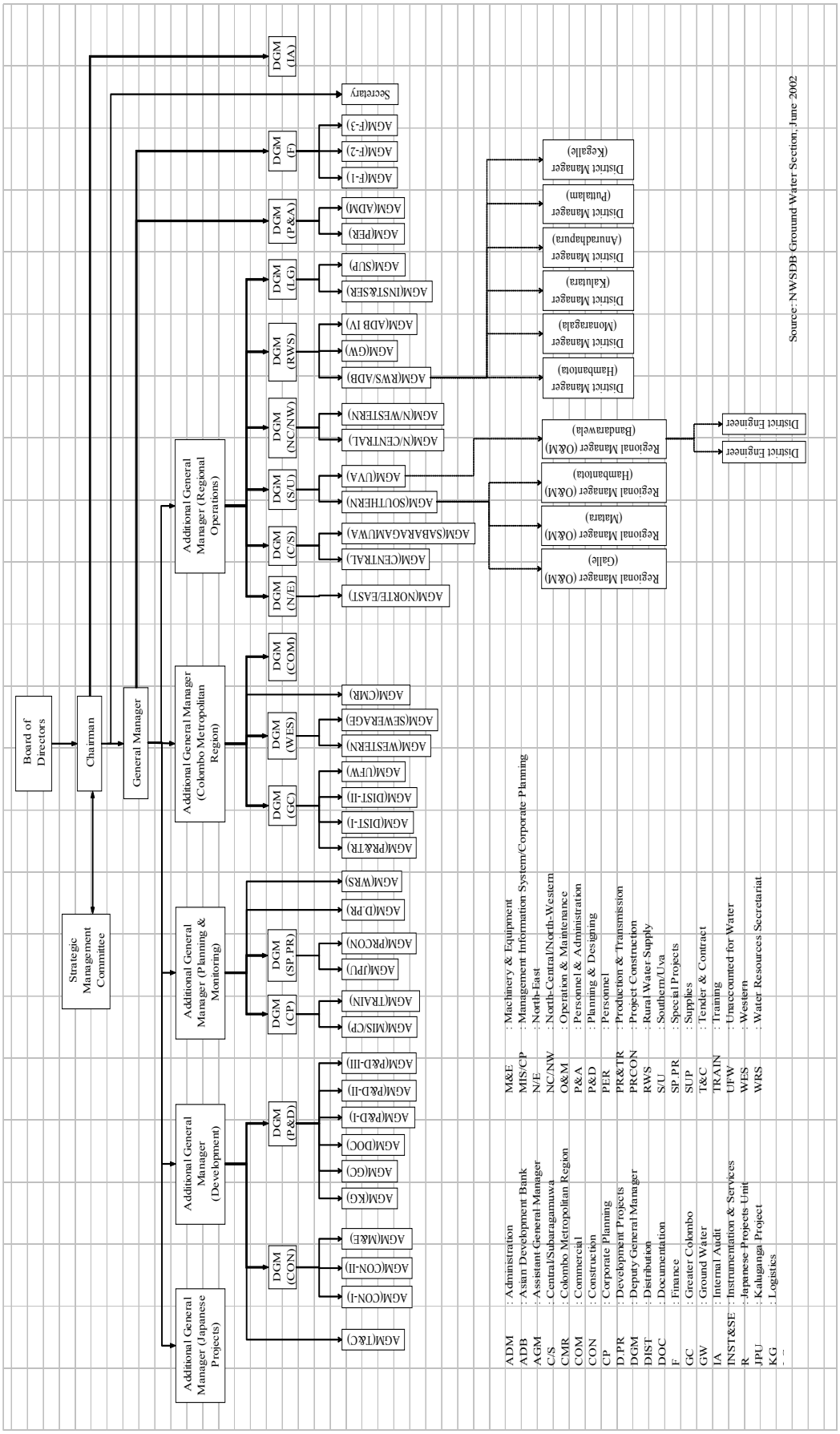


Figure 10.2 Organization Chart of NWSDB

Table 10.2 Income and Expenditure Account Statement of NWSDB in 1999, 2000

(Unit: Rs.)

Items	2000	1999
1. INCOME	**3,947,286,044**	**3,404,160,912**
1.1 SALE OF WATER	2,991,664,043	2,707,630,605
1.2 OTHER OPERATIONG INCOME	446,510,162	450,434,584
1.3 OTHER NON-OPERATING INCOME	213,243,032	219,095,723
2. EXPENDITURE	**4,821,808,646**	**4,353,254,045**
2.1 OPERATING EXPENSES	2,929,062,366	2,601,594,063
1) Direct Expenses	1,865,154,552	1,593,356,587
a. Personnel Cost	767,383,301	604,143,667
b. Pumping Cost	720,660,680	659,449,624
c. Chemicals	126,910,896	107,334,501
d. Repairs & Maintenance	114,195,582	98,004,914
e. Establishment Expenses	55,166,065	30,893,705
f. Rent, Rates, Taxes, Security & Other Expenses	80,838,028	93,530,176
2) Administration Overheads	398,718,445	356,600,638
a. Personnel Cost	226,785,548	199,939,480
b. Repairs & Maintenance	36,772,351	40,020,043
c. Establishment Expenses	64,577,491	63,694,395
d. Rent, Rates, Taxes, Security & Other Expenses	70,583,055	52,946,720
3) Depreciation & Amortization	575,637,165	510,155,139
4) Deferred Expenditure Amortized	21,291,119	22,233,459
5) Provision for Bad & Doubtful Debts	19,299,870	82,015,108
6) Retiring Gratuity	48,961,215	37,233,132
2.2 INTEREST CHARGES	501,492,535	413,455,797
2.3 PROVISION FOR IRRECOVERABLE STAFF DEBTS	0	3,628,809
2.4 INCOME TAX	0	0
2.5 TRANSFERS TO CAPITAL RECOVERY FUND	116,193,491	117,485,065
2.6 TRANSFERS TO STAFF WELFARE FUND	3,098,314	0
2.7 RETAINED INCOME BROUGHT FORWARD	*976,093,133*	*1,217,090,311*
BALANCE	**▲874,522,602**	**▲976,093,133**

Source: NWSDB Annual Report 2000

10.2.3 NATIONAL WATER RESOURCES AUTHORITY (NWRA), WATER RESOURCES COUNCIL (WRC), WATER RESOURCES TRIBUNAL (WRT)

According to "National Water Resources Policy and Institutional Arrangements (WRCS, 2000)," which applies to all fresh and brackish water in Sri Lanka, National Water Resources Authority (NWRA), Water Resources Council (WRC) and Water Resources Tribunal (WRT) will be established at the national level. The NWRA, WRC and WRT will together form the water sector apex body responsible for coordination, planning, regulation and monitoring national water resources and resolution of disputes in the water sector. The objective of water resources management is to ensure the use of water resources in an effective, efficient and equitable manner, consistent with the social, economic and environmental needs of present and future generations.

In order to make them effective in policy development, in water resource planning and regulation and in dispute resolution, the NWRA, WRC and WRT will be neutral with respect to sectoral interests and in a strong and authoritative position in government. These bodies will be parallel in terms of reporting directly to the chief executive of government (the President of Sri Lanka). In their areas of responsibility they will be considered to have a higher level of authority than other national water agencies. Those other agencies will all be subject to the oversight and direction of the NWRA, WRC and WRT.

This policy was approved by the cabinet of ministers on 28th March 2000, but is not published yet. It's contemplated that these bodies will function well in another few years.

10.3 OPERATION AND MAINTENANCE OF WATER SUPPLY SCHEMES

NWSDB is proceeding with preparing various manuals and guidelines for more efficient and sustainable water supply under the Asian Development Bank and NORAD funded Third Water Supply and Sanitation (Sector) Project. And, NWSDB is already starting actions along those manuals and guidelines.

According to the above, water supply schemes are classified broadly into the following three categories from the viewpoint of operation and maintenance:

- Schemes of tube well with hand pump
- Rural water supply schemes
- Urban water supply schemes

General description of each scheme and existing conditions, especially in Hambantota and Monaragala district, are shown below.

10.3.1 SCHEMES OF TUBE WELL WITH HAND PUMP

(1) Programme

Maintenance service is conducted in according with 3-tier maintenance system of hand pumps.

The 3-tier maintenance system is a programme to carry out the maintenance of hand pump tube wells in Sri Lanka. Three parties involved in the system are:

- Consumer Society
- Local Authority (Pradeshiya Sabha (PS)) (Refer to *section 10.3.2*)
- National Water Supply and Drainage Board

The major responsibilities of each party are as follows:

i) Consumer Society

- Appoint a caretaker. (Two caretaker for one tube well)
- Collection of funds for operation and maintenance.

- Do the caretaker attend the minor repairs and routine maintenance activities
- In case of repairs beyond the capacity of caretakers, obtain PS assistance.

ii) Pradeshiya Sabha

- Store the spare parts needed for operation and maintenance
- Attend to the maintenance and repairs beyond the capacity of caretakers
- Maintain the O&M records
- Initiate action on formation of consumer societies and get them registered in PS.
- Monitor the progress of Consumer Society work

iii) National Water Supply and Drainage Board

- Monitor the programme
- Provide the spare parts to PS at cost price
- Keep spare parts in stocks
- Provide technical assistance and training
- Conduct water quality testing when required

These parties are bounded by an agreement, which clearly states the responsibility of each party.

Consumer Society is organized by user community which actually uses the hand pump. It should be formed each and every well. Member of Consumer Society consists of the person above 18 years of age of user community. Following officials should be appointed as committee of the Consumer Society:

- President
- Vice president
- Secretary
- Assistant Secretary
- Treasurer
- Voluntary Health Worker (Male/Female)
- Two Committee Members
- Checking Officer of Accounts

The training to caretakers is done by NWSDB. Training period is two days, first day for theory and second day for practice.

(2) Existing Condition

Consumer Society usually consists of form 10 to 15 families. Maximum number of families is from 20 to 30.

Each Consumer Society has to pay Rs.200 to Local Authority for register every year in addition to the operation and maintenance cost. Operation and Maintenance cost of hand pump, mainly for spare parts, is around Rs.150/month. It is collected and stored by treasurer of Consumer Society.

In Hambantota district, 95 % of total number of hand pumps are already handed over to Local Authority from NWSDB. 60-70% of the Consumer Societies are functioning well also in view of tariff collection.

In Monaragala district, only 30 % are handed over to Local Authority. The prime problem is spare parts of hand pumps. In Sri Lanka eight types of hand pumps are used now. Therefore, NWSDB and Local Authority have to purchase and keep different kinds of spare parts. It cost a great deal for operation and maintenance and prevent the progression of programme. NWSDB is going ahead with replacing work from several types of hand pumps to the unified type (India

Mark III). At the time of June 2002, 16,000 hand pumps are uniform type among more than 20,000 hand pumps throughout the country. NWSDB intend to replace at least 500 hand pumps per year, but actual replacing number of 2001 was 200-300 due to shortage of funds.

10.3.2 RURAL WATER SUPPLY SCHEMES

(1) System

According to "the Presidential Task Force Report on Housing and Urban Development (May 1998)," responsibility of rural water supply scheme, which is a population of not more than 6,000, a limit of 1,000 connections or 1,000 m3/day capacity is supposed to be taken over by Pradeshiya Sabhas (PSs)* and Community Based Organizations (CBOs)**.

* Pradeshiya Sabha (PS) is Local Authority, which is the local government consists of the three types of institutions, Municipal Councils, Urban Councils and Pradeshiya Sabhas. The type of institution mainly depends on population density. Each Local Authority is a body corporate, with perpetual succession, with a council elected for three years. Their boundary is the almost same as the boundary of Divisional Secretary's Divisions.

** Community Based Organization (CBO) is the organization made by user communities mainly based on GND, small town and village, for each rural water supply scheme.

1) Schemes Directly Operated by PS

As for PS, concrete action for managing the schemes is conducted by Water Supply Unit created within PS.

The main roles and responsibilities of this unit for the schemes operated directly by PS are as follows:

- Making recommendations on new connections and providing them
- Making recommendations on extensions to schemes and implementing them
- Making recommendations on dis-connections and carrying out them
- Preparation of tariff structure and periodic updating
- Collection of tariff
- All operation and maintenance activities
- Regular monitoring of water quality and source yield
- Proper budgeting and record keeping on activities and expenses related to managing water supply
- Periodic monitoring of the performance of schemes

This unit may consist of the following officers:

- Technical officer (on full time basis)
- Community development officer (on part-time basis)
- Subject clerk (on part-time basis)

And, where necessary

- Water supply mechanics
- Hand pump mechanics/technicians
- Scheme caretakers/operators/plumbers

In addition, the inputs of the following officers may be required on part-time basis:

- Environmental Officer (Attached to Divisional Secretariat)
- Public Health Inspector

The number of personnel could vary depending on the extent of the work involved and the

geographical area of the PS.

The training to technical officer, water supply mechanics, hand pump mechanics /technicians and scheme caretakers/operators/plumbers is done by NWSDB. Training programme and period vary depending on position and scale of facility.

2) Schemes Directly Operated by CBO

The main roles and responsibilities of CBOs in managing schemes operated by CBOs are as follows:

- Sign and agreement between CBO and PS (In the case of small town schemes of large village schemes or hand pump programme, the NWSDB will also be a party to the agreement)
- Providing service connections
- Providing extensions/augmentation to scheme within the area of service
- Preparation of tariff structure and periodic updating
- Collection of tariff
- All operation and maintenance activities
- Selection of caretakers and other O&M staff
- Purchasing spare parts
- Purchasing of O&M equipment
- Proper record keeping on activities including financial management related to managing water supply
- Operating bank accounts on water supply management funds

CBO should appoint committee officials, which are the almost same as those of Consumer Society.

The training to Caretakers and other O&M staffs is done by NWSDB presently, although PS should do according to the manual. Training period varies depending on scale of facility.

In any cases, 20 % of total construction cost must be contributed by user communities, and also all the cost of operation and maintenance must be borne by themselves in principle.

(2) Existing Condition

1) Hand Over to PS

Although NWSDB intend to hand over existing rural water supply scheme to Pradeshiya Sabha, many schemes are being managed by NWSDB even now. This fact verify that the Pradeshiya Sabha doesn't have enough technical capability and human resources. NWSDB is proceeding the training programme, but it is not sufficient at present.

Table 10.3 shows the existing condition of personnel organization of typical PS water supply unit.

Table 10.3 Personnel Organization of Typical Pradeshiya Sabha Water Unit

Position	Number of Staff
Technical Officer	1
Community Development Officer	1
Subject Clerk	1
Water Supply Mechanics	1
Hand Pump Mechanics/Technicians	1
Scheme Caretakers/Operators/Plumbers	-
Environmental Officer	-
Public Health Inspector	-
Clerk	1

Source: NWSDB Groundwater Division

Actually, almost all of Technical Officers can't work on full time basis because they have other work, such as road construction, environment, etc. It is one of the reasons why quality of operation and maintenance by PS come down.

2) Treatment Facilities

The schemes with treatment facilities are not many among the schemes managed by Pradeshiya Sabha or CBO and the treatment plants are not more than chlorination and/or treatment plant to reduce the concentration of iron. It is because initial construction cost is high, maintenance cost is also high and skilled technical person is necessary. In the same reason, groundwater often uses as water resource in rural water supply schemes since groundwater ordinarily doesn't require the treatment facilities.

3) Tariff Structure

In general tariff is not cheaper than that of NWSCB in case of house connection. This is why number of connection is lower than that of NWSDB scheme.

In many cases, tariff is fixed because water meter is not installed due to initial cost and operation and maintenance cost.

Tariff of house connection is around Rs.200/family/month and of stand post is around Rs.25-30/family/month. (Data source: Monaragala District Manager's office)

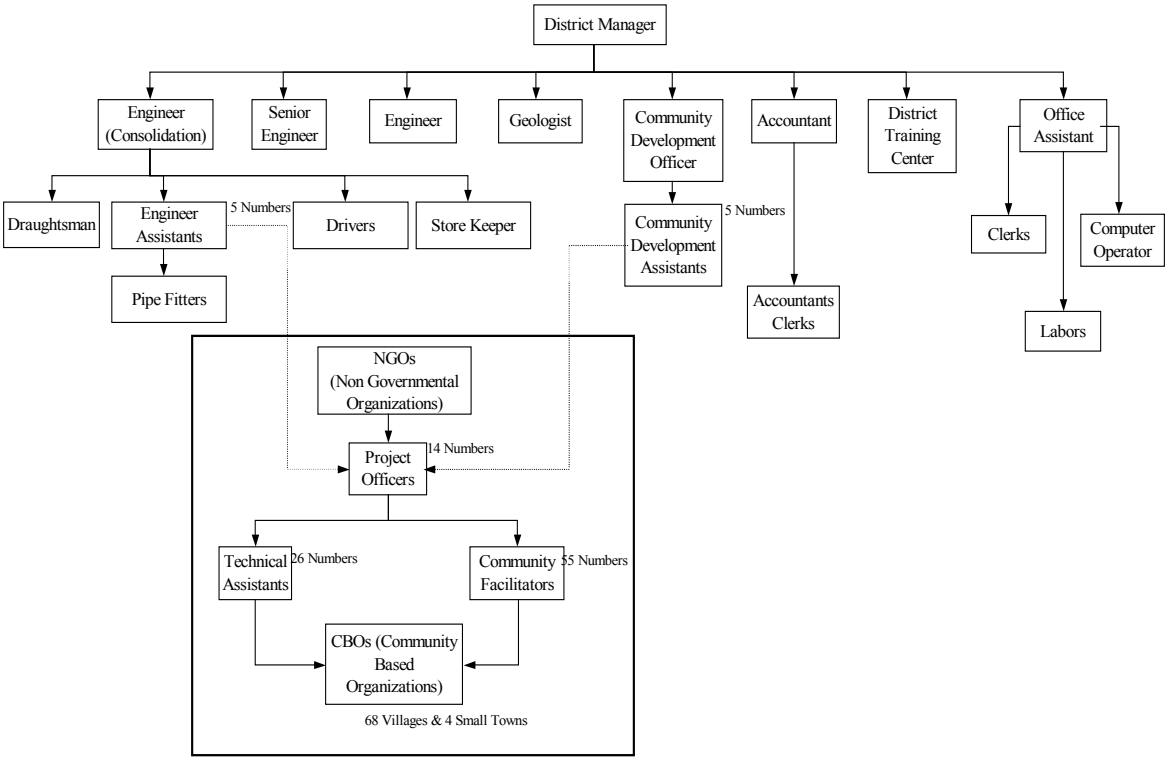
One or two officers collect tariff in the scheme managed by Pradeshiya Sabha, and in CBO one treasurer collects it.

4) ADB Programme

In Monaragala district, rural water supply schemes managed by CBOs are proceeding under District Manager's office of NWSDB. At present, CBOs are organized in 68 villages and four small towns in Monaragala.

District Manager's office is the organization that implement rural water supply scheme by using ADB fund, it exists in six districts and belongs to AGM (RWS/ADB) (Refer to *Figure 10.2*). Organization chart of Monaragala District Manager's office is shown in *Figure10.3*.

District Manager's office also conducts training programme to caretakers and O&M staffs of CBOs under District Training Officer.



Source: NWSDB Monaragala District Office, June 2002

Figure 10.3 Organization Chart of Monaragala District Manager's Office

10.3.3 URBAN WATER SUPPLY SCHEMES

(1) System

These schemes are mainly under the direct jurisdiction of NWSDB.

Operation and management of facilities are done by Regional Manager's office under Regional Support Center. There are six Regional Support Centers throughout the country. Administrative setup of Regional Support Center is shown in *Figure 10.4*.

In spite of scheme scale, one facility is normally operated by one technical officer, three operators and two labours, it's often the case that technical officer takes charge of two or three facilities.

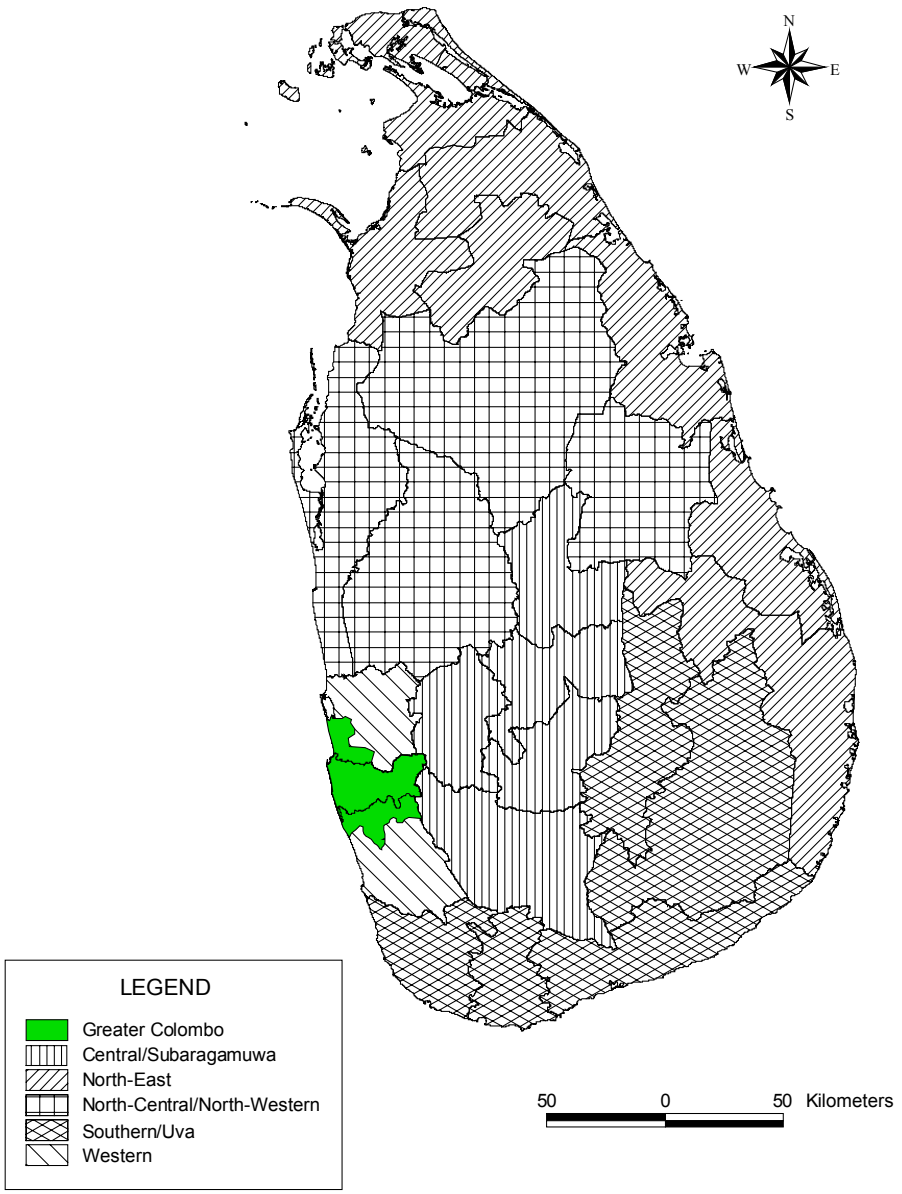


FIGURE 10.4 ADMINISTRATIVE SETUP OF REGIONAL SUPPORT CENTER

THE STUDY ON COMPREHENSIVE GROUNDWATER RESOURCES DEVELOPMENT | **JICA**

The same tariff structure shown in *Table 10.4* is used in the schemes managed by NWSDB. Water meter is installed to each house. Meter leader of NWSDB check the meter once a month and water bill is prepared. Payment is made in directly NWSDB office, bank and so on. Meter leader doesn't have a power to collect tariff.

Table 10.4 Tariff Structure of NWSDB (June, 2002)

Category	Price (Rs./month)
Domestic Use	
Fixed	50.00
1-10m^3	1.25/m^3
11-15m^3	2.50/m^3
16-20m^3	6.50/m^3
21-25m^3	20.00/m^3
More than 26m^3	45.00/m^3
Industrial & Commercial	
	42.00/m^3

Source: NWSDB Regional Support Center (S/U)

*In case that domestic consumption is 23m^3/month, tariff is Rs.167.5. (50.00 + 1.25 x 10+ 2.50 x 5 + 6.50 x 5 +20.00 x 3)

Even in case of new construction of schemes managed by NWSDB, 20 % of total construction cost must be contributed by user communities in principal.

(2) Existing Condition

Hambantota Regional Manager's office operates 19 water supply schemes. Number of house connection for domestic use is 26,500 and average tariff is Rs.108/family/month. Number of connection for non-domestic use (Industrial & Commercial) is 1,200.

Hambantota Regional Manager's office has 300 staffs for operation and maintenance. In Monaragala, water supply schemes are only six, accordingly, staffs are around 30 and there is no Regional Manager's office. Regional Manager's office in Bandarawela handles Monaragala and Badulla district.

10.4 MONITORING OF GROUNDWATER

10.4.1 MONITORING PROGRAMME

WRB conducts periodical well monitoring in several areas. One of the objectives of monitoring is to study the fluctuation of groundwater levels in particular areas due to extensive utilization of ground water resources for agricultural purposes.

The ongoing and completed monitoring programmes are shown in *Table 10.5* and *Figure 10.5*.

Table 10.5 Ongoing and Completed Monitoring Programmes (1998-2002)

Programme	Period	Frequancy	No. and Type of Well	Monitoring Items
Water Quality Monthly Monitoring Programme Koggala	1991-	Once a month	22 tube wells with 10m depth and one (1) dug well	Water Level, EC, pH, Ca^{2+}, Mg^{2+}, Fe(T), Cl^-, SO_4, HCO_3, Total Alkalinity, Total Hardness, TDS, Turbidity and Bacteria
Groundwater Monitoring in Prawn Farm Areas in Puttalam District	Sep.1998 - Jul.2001	Once a month	50 tube wells	Water Lecel, EC, pH, Na^+, K^+, Ca^{2+}, Mg^{2+}, Fe(T), Cl^-, SO_4, F^-, $CaCO_3$, Total Alkalinity, Total Hardness, TDS, Turbidity
Agrowell Monitoring Programmes in Anuradhapura District	Sep.1998 - Jul.2001	Once a month	95 agrowells	Water Level, EC, pH, (Na^+, Cl^-, NO_3, Na^+, and other chemical parmeters depending on EC value)
Agrowell Monitoring Programmes in Kurunegala District	Sep.1998 - Jul.2001	Once a month	80 agrowells	Water Lecel, EC for all samples, (pH, Na^+, K^+, Ca^{2+}, Mg^{2+}, Fe(T), Cl^-, SO_4, F^-, $CaCO_3$, Total Alkalinity, Total Hardness, TDS, Turbidity for selected samples depending on EC value)
Well Monitoring Programme in Selected Area of Vavunia and Jaffna Districts	1999-	Twice a month	Vavunia: four (4) tube wells, 76 dug wells Jaffna: 135 dug wells,	Water Level, EC
Well Monitoring & Water Sample Analysis Programme of Nawagathegama & Galgamuwa D.S.Division	Mar.2002-	Once a month	agrowells	Water level, EC, pH, Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, F, PO_4^{3+}, Total Hardness

Source: WRB Hydrogeology Division

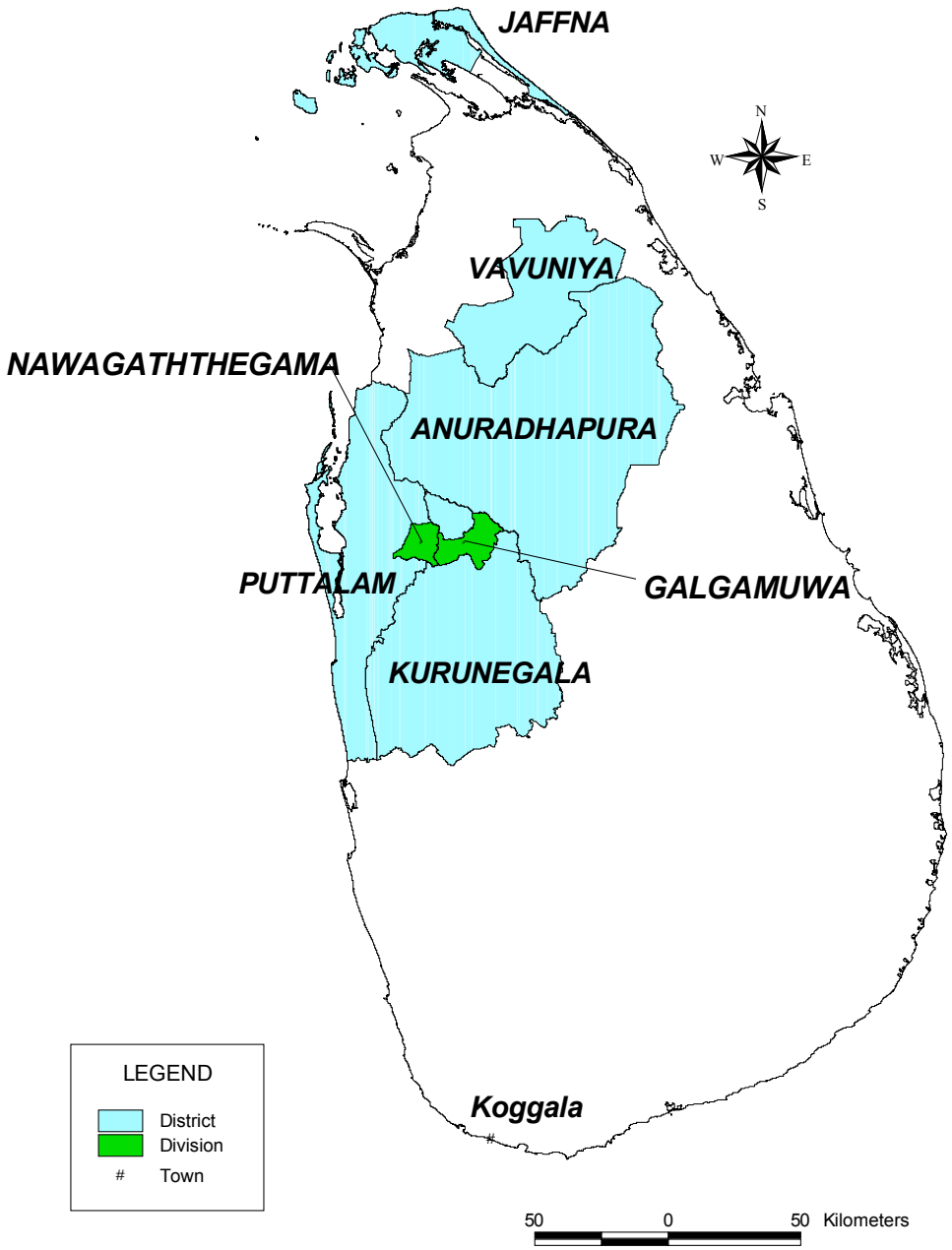


FIGURE 10.5 LOCATION MAP OF ONGOING AND COMPLETED MONITORING PROGRAMMES

THE STUDY ON COMPREHENSIVE GROUNDWATER RESOURCES DEVELOPMENT | **JICA**

10.4.2 ORGANIZATION AND MONITORING SYSTEM

Hydrogeology division has responsibility of monitoring works. Hydrogeology division has two hydrogeologists and 10 geologists except a senior hydrogeologist and two hydrogeologists in charge of regional manager. There is no staff who engages in only monitoring works. Some geologist takes charge of monitoring work together with other works. Maximum four days are period that one geologist engages in monitoring work per month.

Geologist or field assistant goes to the field once or twice a month, directly investigates water level, EC and/or pH and collects sample water for analysis. Sample water is analysed in laboratory of WRB in Colombo.

(1) Equipment

Equipments for monitoring and geophysical survey that WRB possesses are shown in *Table 10.6*. Major and minor repair is done by a technical expert of hydrogeology division.

Table 10.6 List of Major Equipments

Items	Operating Condition	Malfunction Condition
Monitoring		
EC meter	7	4
pH meter	2	–
Water level recorder (manual)	8	4
Geophysical Survey		
Resistivity meter	9	3
EM (Electro magnetic) meter	2	–
VLF (Very low frequency)	3	1
GPS	3	–

Source: WRB Hydrogeology Division

(2) Laboratory

The staffs of the laboratory are one chemist and four analysts except one analyst in Jaffna office.

The following items can be analysed in the laboratory:

Appearance, Temperature, Colour, Turbidity in JTU, pH value, Electric Conductivity (EC), Total Hardness (as $CaCO_3$), Total Alkalinity (as $CaCO_3$), Total Dissolved Solids (TDS), Sodium (as Na^+), Potassium (as K^+), Calcium (as Ca^{2+}), Magnesium (Mg^{2+}), Total Iron (as T-Fe), Chloride (Cl), Sulphate (as SO_4), Fluoride (F^-), Bicarbonate (as $CaCO_3$), Nitrate (as N).

Bacteria is analysed in central laboratory of NWSDB since WRB laboratory doesn't have the instrument for that.

The WRB laboratory can analyse average eight samples per day about the above all items. During the year 2000, 2,054 water samples collected from various parts of Sri Lanka and were analysed in the laboratory.

10.5 OPERATION AND MAINTENANCE OF DRILLING

10.5.1 ORGANIZATION FOR OPERATION OF DRILLING AND ACTIVITIES

Drilling division has responsibility of drilling works. The drilling division has 24 drillers including assistant drillers and 53 labours. These numbers include the staff of regional offices.

Major machines that WRB possesses are shown in *Table 10.7* and their further details, especially drilling machines, are shown in *Table 10.8*. Presently, seven drilling rigs are in operation but not in satisfactory conditions, since all of them are very old machines, which were donated in the beginning of 1980's mainly by Japanese fund.

Table 10.7 List of Major Machines

Items	Operating Condition	Malfunction Condition
Drilling Rig	7	7
Air Compressor	7	7
Separate Mud Pump	2	3
Small Centrifugal Pump	1	–
Submersible Pump	1	–
Lorry (Cargo Truck) with 12 ton Crane	4	2
Bowser Lorry with 12 ton Crane	2	2
Crane Truck	0	2
Car	7	2
Pick-up	7	1
Jeep	6	7

Source: WRB Drilling Division

When drilling of a tube well, the regular team formation is one driller, one assistant driller, eight labours including 24 hours watcher for security and two drivers, and the regular formation of machines is one drilling rig, one air compressor and one lorry (cargo truck) or one bowser lorry.

It usually takes four days to drill 40m-60m depths tube well. One day is for mobilization and three days are for drilling. In case of installing hand pump to a tube well, it takes one more day.

Actually, average operation capacity is five wells/rig/month and average operation rate is 120 days/rig/year (30 wells/rig/year). In addition, success rate to obtain the groundwater is around 90%.

Considering the present conditions of drilling machines and human resources of the division, operation capacity is considered as about 400 wells per year at the maximum, although the annual demand for the tube well drilling is more than 500 wells.

In 2000, 160 tube wells with average 40m-60m depths were constructed. 23 hand pumps were installed for some of these tube wells and repair work of 69 hand pumps was also conducted by drilling crew.

Table 10.8 Detailed List of Major Drilling Machines

WRB Rig No.	Type of Machine	Model of Machine	Year of Manufacture	Condition	Donated/Delivered Year	Project Name/Funds
1	Drilling Rig	Cas Drill 6000	1979	Malfunction from 1987	1979	Overseas Development Project/U.K.Funds
2	ditto	Tone TR. DS 300	1980	Malfunction from 1995	1980	Integrated Rural Development Project Hambantota/NORAD Funds
3	ditto	Tone Top 300	1980	Operating	1980	- /WRB
4	ditto	Tone Top 300	1980	Malfunction from 1995	1980	- /Regional Development Ministry Batticaloa, Sri Lanka
5	ditto	Tone Top 300	1981	Operating	1981	Integrated Rural Development Project, Kurunegala/World Bank Funds
6	ditto	Tone Top 150	1983	Malfunction from 2001	1983	- /Agrarian Services Department, under 2 K.R. Funds (Japan)
7	ditto	Tone Top 150	1983	Malfunction from 2000	1983	- /Agrarian Services Department, under 2 K.R. Funds (Japan)
8	ditto	Tone Top 150	1983	Malfunction from 1996	1983	- /Agrarian Services Department, under 2 K.R. Funds (Japan)
9	ditto	Tone Top 150	1983	Operating	1983	- /Agrarian Services Department, under 2 K.R. Funds (Japan)
11	ditto	Well Drill 300	1983	Operating[*1]	1983	- /Development Lottery Funds, Ministry of Planning
12	ditto	Koken FSW 300-L	1984	Operating	1984	- /Agrarian Services Department, under 2 K.R. Funds (Japan)
13	ditto	Koken FSW 200-S	1984	Malfunction from 1999	1984	- /Agrarian Services Department, under 2 K.R. Funds (Japan)
14	ditto	Koken FSW 200-S	1984	Operating	1984	- /Agrarian Services Department, under 2 K.R. Funds (Japan)
15	ditto	Koken FSW 200-S	1984	Operating	1984	- /Agrarian Services Department, under 2 K.R. Funds (Japan)

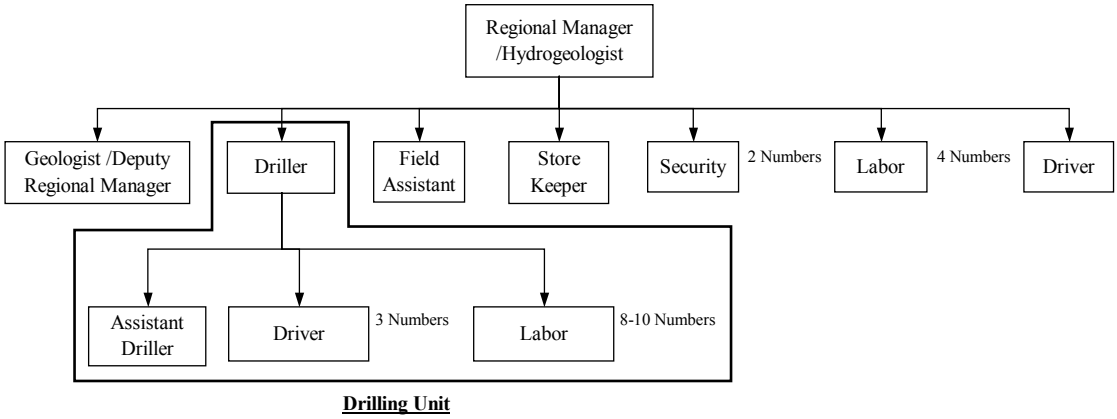
1) The drilling capacity of this machine is less than 30m, so that this machine has not been used for last 5 years.

WRB A/C No.	Type of Machine	Model of Machine	Year of Manufacture	Condition	Donated/Delivered Year	Project Name/Fund
2	Air Compressor	Air Man P.D.S.H. 500	1983	Operating	1983	- /Agrarian Services Department, under 2 K.R. Funds (Japan)
5	ditto	Air Man P.D.S.H. 500	1983	Malfunction from 1998	1983	- /Agrarian Services Department, under 2 K.R. Funds (Japan)
6	ditto	Air Man P.D.S.H. 500	1983	Operating	1983	- /Agrarian Services Department, under 2 K.R. Funds (Japan)
7	ditto	Air Man P.D.S.H. 500	1983	Malfunction from 1999	1983	- /Agrarian Services Department, under 2 K.R. Funds (Japan)
9	ditto	Sull Air 300	1983	Malfunction from 1995	1984	- /Development Lottery Funds, Ministry of Planning
10	ditto	Sull Air 300	1983	Malfunction from 1995	1984	- /Development Lottery Funds, Ministry of Planning
11	ditto	Air Man P.D.S.H. 700	1984	Malfunction from 1998	1984	- /Agrarian Services Department, under 2 K.R. Funds (Japan)
12	ditto	Air Man P.D.S.H. 700	1984	Malfunction from 1999	1984	- /Agrarian Services Department, under 2 K.R. Funds (Japan)
13	ditto	Air Man P.D.S.H. 700	1984	Malfunction from 1999	1984	- /Agrarian Services Department, under 2 K.R. Funds (Japan)
14	ditto	Air Man P.D.S.H. 700	1984	Operating	1984	- /Agrarian Services Department, under 2 K.R. Funds (Japan)
15	ditto	Air Man P.D.S.H. 700	1984	Operating	1984	- /Agrarian Services Department, under 2 K.R. Funds (Japan)
16	ditto	Air Man P.D.R. 370	1983	Operating	1983	- /WRB
17	ditto	Air Man P.D.R. 250	1983	Operating	1983	- /WRB
18	ditto	Air Man P.D.R. 250	1983	Operating	1983	- /WRB

Source: WRB Drilling Division

This 160 is far less than the maximum operation capacity of about 400, and annual demand of 500. It is mainly due to shortage of fund of both of central and local government to request the construction of tube well to the WRB.

In this Study, drilling staff of Monaragala regional office conducted drilling of test wells. The team formation is shown in *Figure 10.6*, the drilling unit is highlighted in the *Figure 10.6*. This drilling unit has sufficient technical capability and has acquired further skill to operate drilling machines through technical transfer by actual drilling works in this Study.



Source: WRB Monaragala Regional Office, June 2002

Figure 10.6 Organization Chart of WRB Monaragala Regional Office

10.5.2 ORGANIZATION FOR MAINTENANCE OF DRILLING AND ACTIVITIES

(1) Maintenance and Repair Work

Major repair is done by Work Shop at Ratmalana in Colombo and minor repair is done at site by drilling engineers themselves.

The staff number of Work Shop is seven except labours, three technical officers, one mechanical engineer in charge and three mechanics. They have sufficient skill and good consciousness.

Major repairs done by Work Shop in 2000 are as follows:

One lorry, one jeep, two drilling rigs, one air compressor.

Presently, some of drilling machines are malfunction condition as shown in *Table 10.7*, and these are in the process of repair.

As for drilling rigs, most of them has used from the beginning of 1980's as shown in *Table 10.8*. Presently, seven rigs are malfunction condition and four rigs of them have been under malfunction condition for more than five years. Work Shop has enough technical capabilities to repair them, however, it is difficult to get necessary spare parts for repairing. Although an agency of the rig company exists in Sri Lanka and route to get the spare parts is secured, finance is not enough to procure them.

The breakdown of expenditure for maintenance and repairs of machinery of *Table 10.1* is shown in *Table 10.9*. Since stocks are accounted for income, the actual expenditure of 2000 is around Rs.4.6 million. Among that, the expenditure for new spare parts is around Rs.2 million. It is for not only drilling rig but also other machine such as air compressor, water tank, etc.

Table 10.9 Breakdown of Expenditure for Maintenance and Repairs of Machinery

(Unit: Rs.)

Items	2000	1999
Maintenance, Repairs & Services etc.	4,576,349.48	5,544,866.62
Stocks as at End of Year	3,548,696.88	4,626,900.94
Total Expenditure	1,027,652.60	917,965.68

Source: WRB Annual Report 2000

Table 10.10 shows round cost of major spare parts of drilling rig. Most malfunctioned drilling rigs have many broken parts to need replacement, mainly hydraulic pump. For complete repair, it cost Rs.1.5 to 2 million per one drilling rig.

Table 10.10 Round Costs of Major Spare Parts of Drilling Rig

Items	Round Cost (Rs. Million)
Hydraulic Pump (Large)	0.6
Hydraulic Pump (Small)	0.3
Hose and Fitting	0.15
Bearing and Sealing	0.4
Mud Pump	0.075

Source: WRB Office

Presently, repairing works are conducted by using substitute parts made in local factory, since it is difficult to purchase genuine spare parts. It causes frequent failure.

(2) Storage

Idle machines and spare parts are stored in Ratmalana yard with 1.8-hectare area in Colombo under Store Section. The Ratmalana yard has well enough area and storehouse. WRB also has small yard and storehouse in Monaragala regional office, Puttalam regional office and Anuradhapura and Vavuniya project offices.

In case of long-time project, WRB can use any government land for storage near the project area, and then, temporary house is rented or built there for materials and equipments.

In this Study, the machines as shown in *Table 10.11* were used.

If these machines are donated to WRB, the drilling machines will be stored in Ratmalana yard or other yards depending on project.

In case of Monaragala regional office, the yard of Monaragala is almost enough space to park and keep the machines. And existing storehouse of Monaragala has a capacity to store at least machines and materials to avoid wet, such as generator, welder, electrical panel, spare parts, cement, and so on, although it need some improvements.

Table 10.11 List of Equipments Used in the Study

Item	Number
Drilling Equipment	
Drilling Rig	1 unit
Truck Mounted High Pressure Air Compressor	1 unit
Mast for Drilling Rig.	1 unit
Supporting Vehicles	
Cargo Truck with 6 ton Crane	1 unit
Cargo Truck with 3 ton Crane	1 unit
Supporting Truck with 3 ton Crane for Diesel and Water Tank	1 unit
Water Tank 1000 liter	1 pc.
Water Tank 2000 liter	1 pc.
Diesel Tank 5000 liter	1 pc.
Drilling Tools and Accessories	
Collapsible Working Water Tank, 5.0m^3	5 pcs
Collapsible Working Water Tank, 3.0m^3	5 pcs
Pumping Test Equipment	
Submersible Motor Pump, 200lit./min. x 150 mH	1 lot
Submersible Motor Pump, 500lit./min. x 80 mH	1 lot
Diesel Engine Generators for the above Test Pumping	1 unit
Borehole Logging Equipment	
Borehole Logging Equipment and Standard Accessories	1 set
Caliper Probe Equipment for Monitoring	1 set
Geophysical Survey Equipment	
Electrical Prospecting Equipment	1 set
Water Level Recorder Equipment for Test Wells	
Water Level Recorder	10 unit
Computer and Printer for Transmitting Data	1 set

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APPENDICES

Appendix A

Hydrogeological Study on the Drought in Hambantota 2001

HYDROLOGICAL STUDY ON THE DROUGHT IN HAMBANTOTA, 2001

1. GENERAL SITUATION

Hambantota District, with an area of 5,659 km^2 and a population of 525,000, is located in the Southern part of Sri Lanka along the coast of the Indian Ocean. Hambantota is the driest district in this country judging from the average annual rainfall distribution shown in " Atlas of Sri Lanka, 1997, page 17 ". Average annual rainfall in Hambantota ranges from 1500 mm to 800 mm, and the central/eastern part is dry with an average annual rainfall of about 1000 mm.

The river waters have been used mainly for irrigation by storing in many tanks since long time ago. The river waters of the Walawe Ganga together with the Urubokka Oya and Kirindi Oya, irrigate wide paddy field areas spread in their downstream basins. The areas between these paddy field areas are dry, and groundwater is used in the rural communities for domestic purpose.

According to the average monthly rainfall distribution, rainfall is large (100 mm to 190 mm) from Oct. to Nov. and the other months are small (40 mm to 90 mm). Drought in Hambantota occurs when the rainfall after the northeast monsoon which is small for 6 to 8 months until the next northeast monsoon comes.

2. DROUGHT OF 2001

The drought in 2001 is characterized as follows:

(1) Drought was severe especially in the areas along the Kirindi Oya and the Malala Oya.

(2) The minimum consecutive 6 months rainfall in 2001 of 108 mm was the second minimum, and close to the first of 104 mm in 1976, during the recent 50 years (refer *Table A-1* and *Figure A-1*). The third was 125 mm in 1992. The frequency of drought is about once every 20 years as analyzed in *Figure A-2*.

(3) Yearly rainfall from September of the previous year to October (712 mm) in 2001 was the 7th in the recent 50 years.

(4) During the recent 21 years, the six-month consecutive rainfall, from February to June, in 2001 was the 4th from the bottom. Therefore, frequency of the drought in 2001 was an order of once in five years.

(5) Domestic water supply in the rural areas has been enough in every dry season, though this year it was much severer than the normal years because of a long dry period.

Locations of the related rainfall stations and the distributions of the maximum, minimum and average monthly distributions are shown in *Figures A-3* and *A-4* respectively.

3. MAJOR PROBLEMS

(1) In the rural areas, people live in the hill areas using shallow wells, which are difficult to get water in the dry season.

(2) About 90 % of the water are used for irrigation. Water in the wells in many areas, rely on recharge from the tanks, irrigation canals, etc in the dry season.

(3) People are using the rivers, tanks and irrigation canals for washing and bathing. Therefore, they are affected by dry conditions in such surface water bodies.

(4) Bowsers distribute the drinking water during the drought. However, the volume of water is not enough and given only along the main roads.

5.4 RECOMMENDATIONS

(1) Water balance study in some small test catchments should be made for the management of water resources. Measurements of rainfall and stream discharge will be required to calculate evapo-transpiration values from forest, paddy fields, etc.

(2) In the rural areas, a new drinking water supply facility should be provided.

Table A-1 Yearly and Minimum Consecutive 6-Months Rainfalls

YEAR	Yearly Rain		6-M min. Rain		YEAR	Yearly Rain		6-M min. Rain	
Sep-Oct	(mm)	Order	(mm)	Order	Sep-Oct	(mm)	Order	(mm)	Order
51/52	901	17	268	19	77/78	878	14	272	20
52/53	798	9	305	27	78/79	954	23	163	5
53/54	1322	43	428	46	79/80	1014	28	428	45
54/55	1220	38	204	11	80/81	1028	30	310	29
55/56	568	2	187	9	81/82	1059	33	573	50
56/57	619	4	164	6	82/83	800	10	139	4
57/58	1410	46	276	22	83/84	975	26	246	16
58/59	899	15	403	44	84/85	876	13	337	36
59/60	936	21	323	34	85/86	1013	27	239	14
60/61	1471	48	547	49	86/87	928	19	240	15
61/62	1243	40	353	38	87/88	969	25	183	8
62/63	1249	41	459	48	88/89	625	5	322	32
63/64	1513	50	348	37	89/90	706	6	311	30
64/65	604	3	357	39	90/91	1350	44	299	26
65/66	1385	45	377	42	91/92	873	12	125	3
66/67	1130	35	333	35	92/93	846	11	323	33
67/68	938	22	239	13	93/94	1046	32	224	12
68/69	911	18	277	23	94/95	1190	37	365	40
69/70	1459	47	318	31	95/96	737	8	252	17
70/71	1036	31	275	21	96/97	1021	29	283	24
71/72	928	20	290	25	97/98	1144	36	197	10
72/73	1093	34	432	47	98/99	1243	39	305	28
73/74	967	24	260	18	99/00	1259	42	369	41
74/75	1476	49	396	43	00/01	712	7	108	2
75/76	479	1	104	1					
76/77	901	16	170	7	Average	1045		309	

Hambantota, 1951/52 – 2000.2001

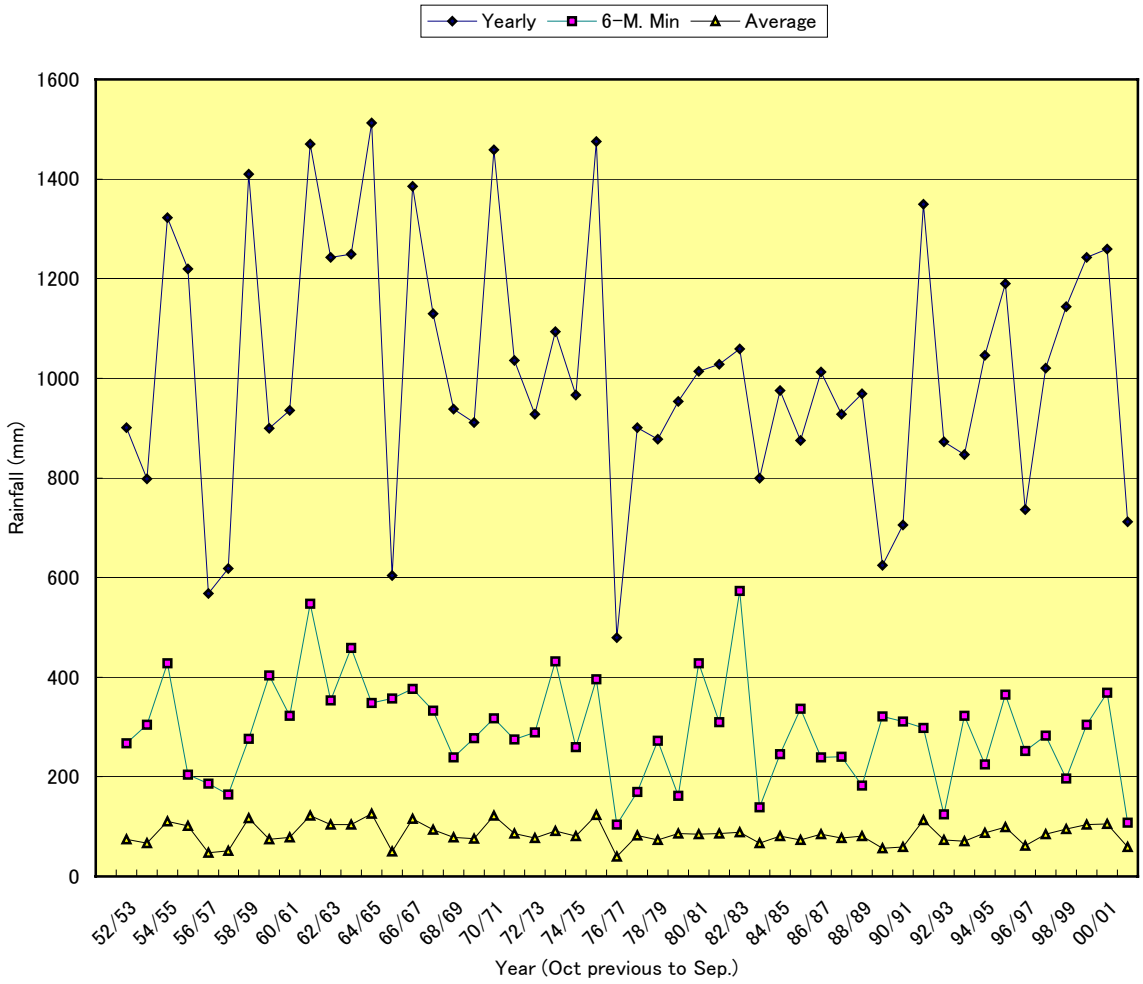

FIGURE A-1 YEARLY, &-MONTHS MINIMUM AND AVERAGE MONTHLY RAINFALLS, HAMBANTOTA (MM)

THE STUDY ON COMPREHENSIVE GROUNDWATER RESOURCES DEVELOPMENT | **JICA**

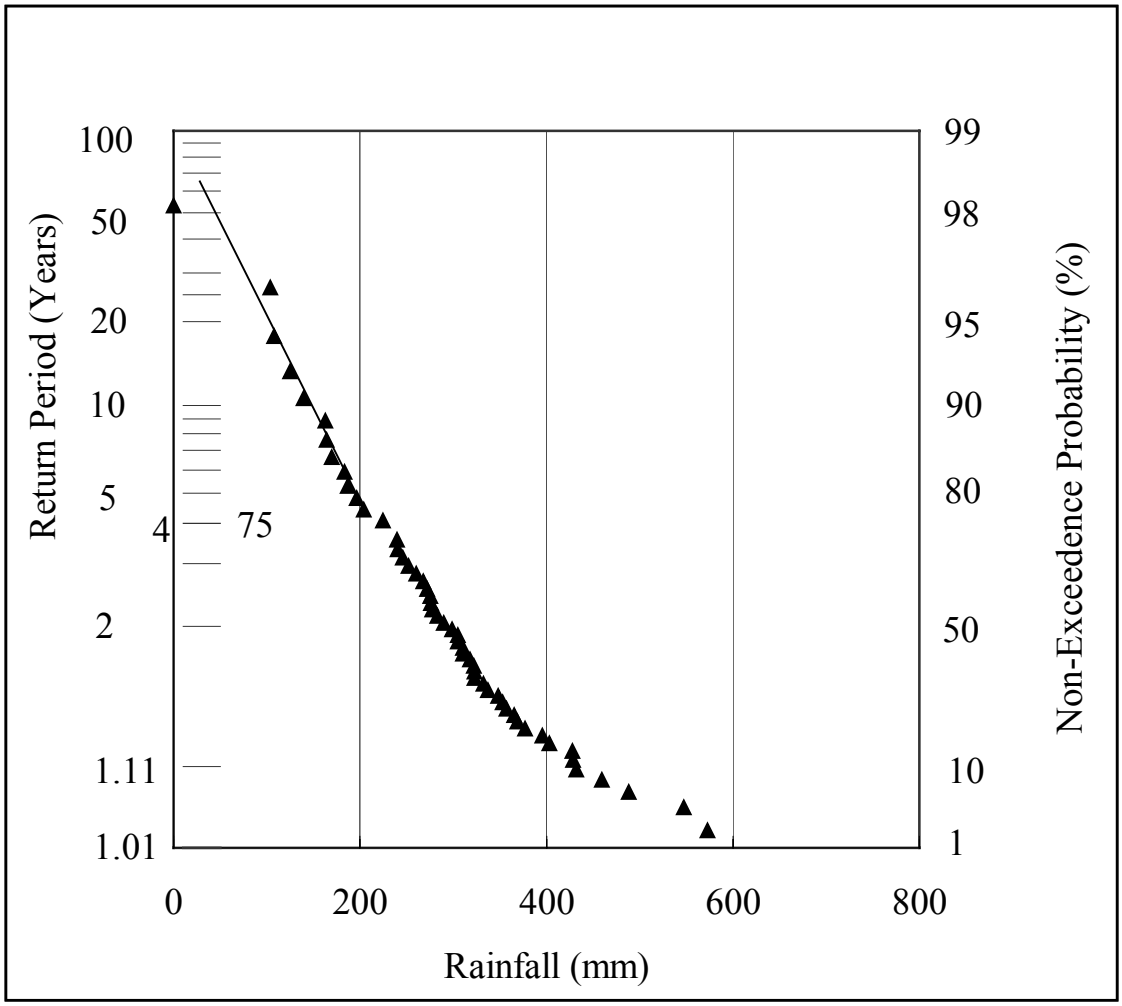

FIGURE A-2 GUMBEL'S DISTRIBUTION WITH THOMAS PLOT

THE STUDY ON COMPREHENSIVE GROUNDWATER RESOURCES DEVELOPMENT | **JICA**

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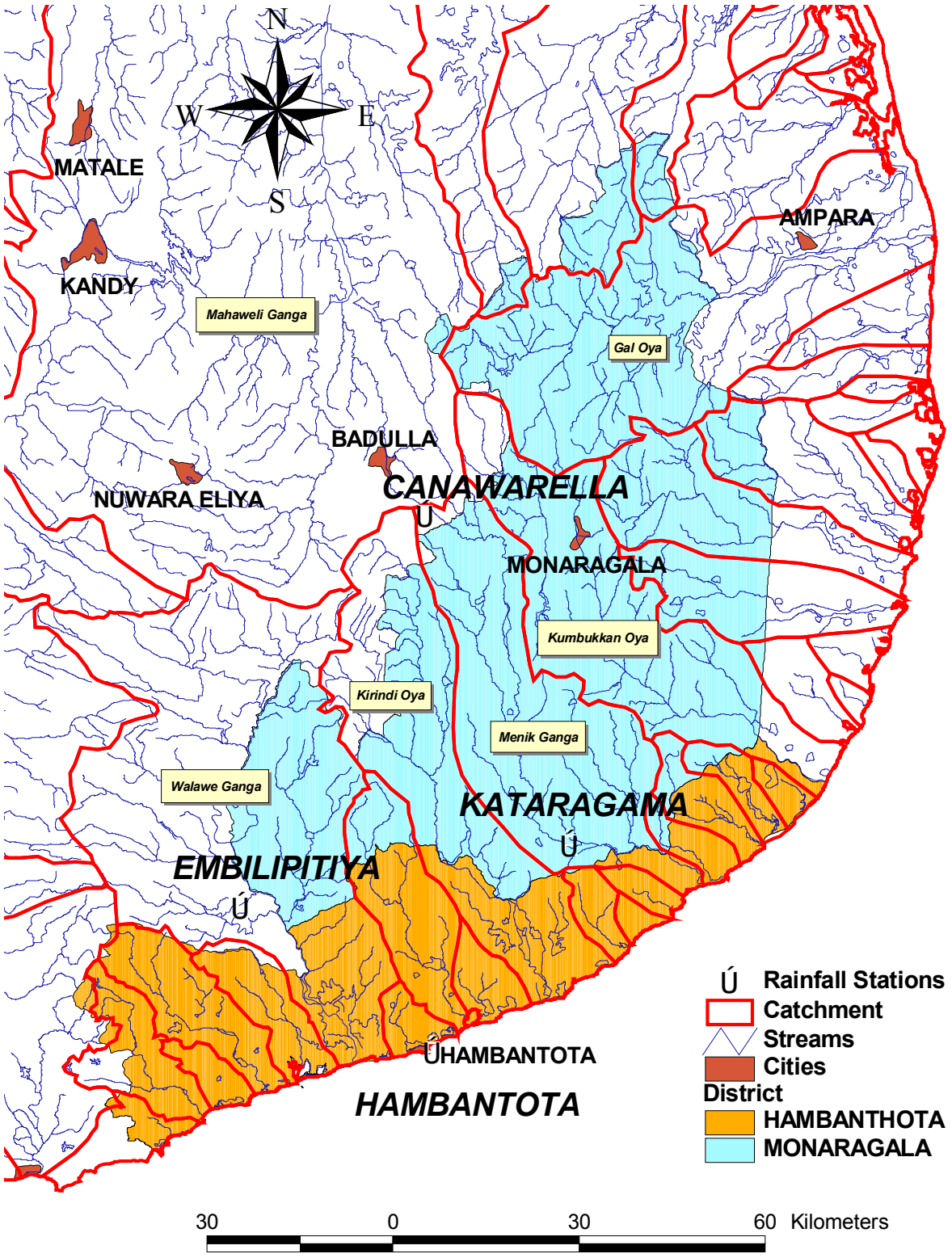


FIGURE A-3 LOCATION OF RAINFALL STATIONS

THE STUDY ON COMPREHENSIVE GROUNDWATER RESOURCES DEVELOPMENT	JICA

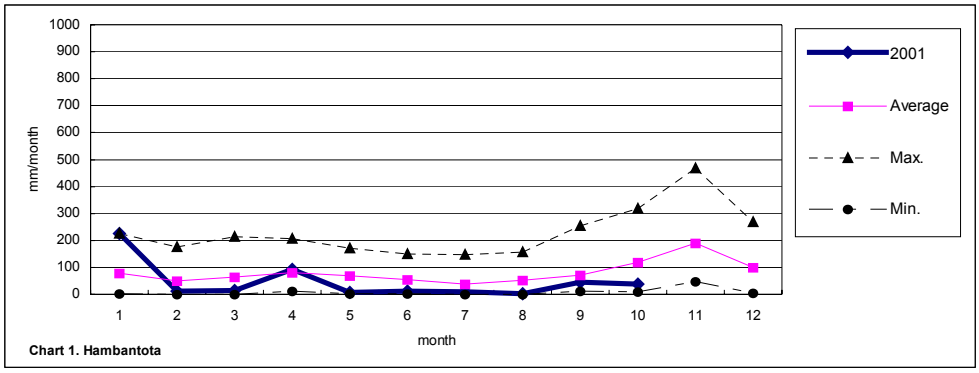


Chart 1. Hambantota

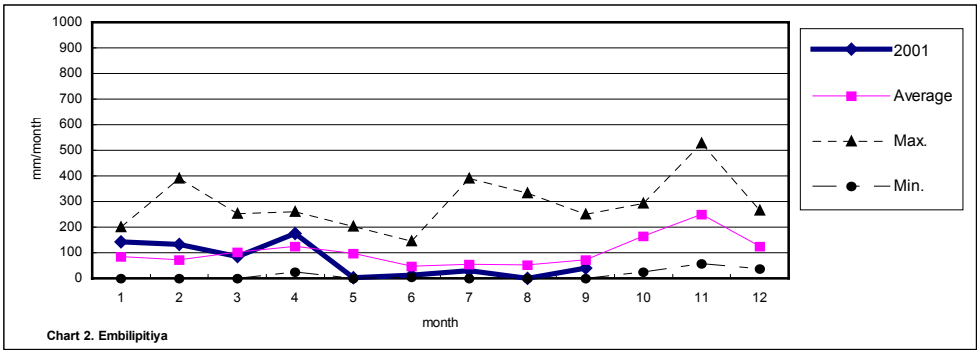


Chart 2. Embilipitiya

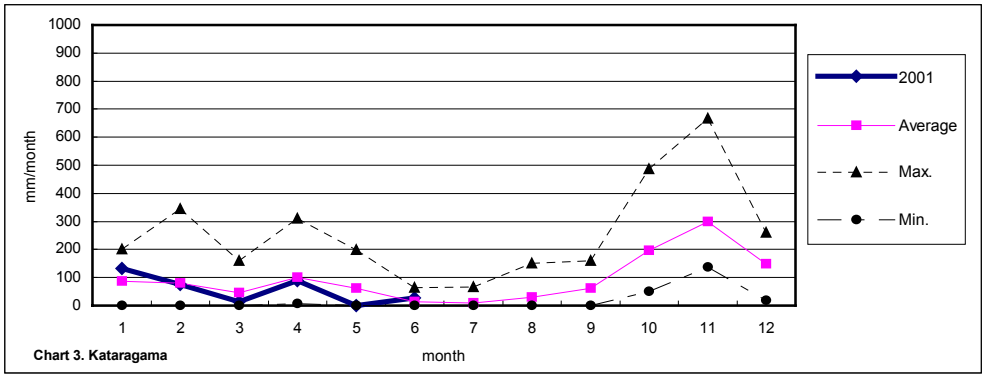


Chart 3. Kataragama

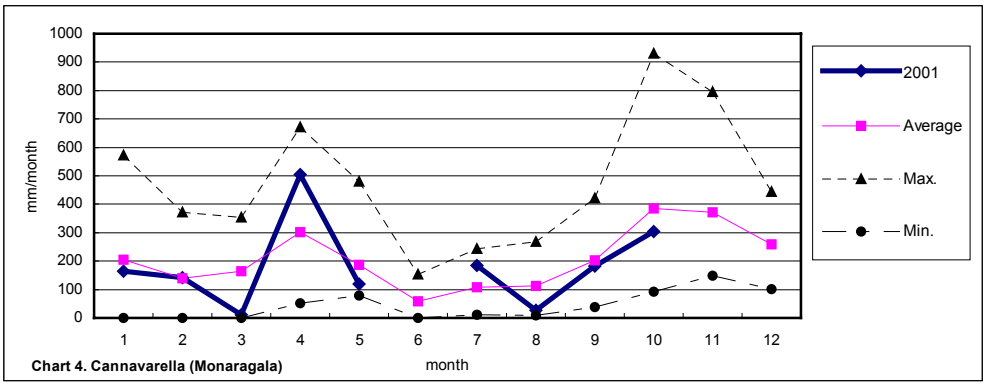


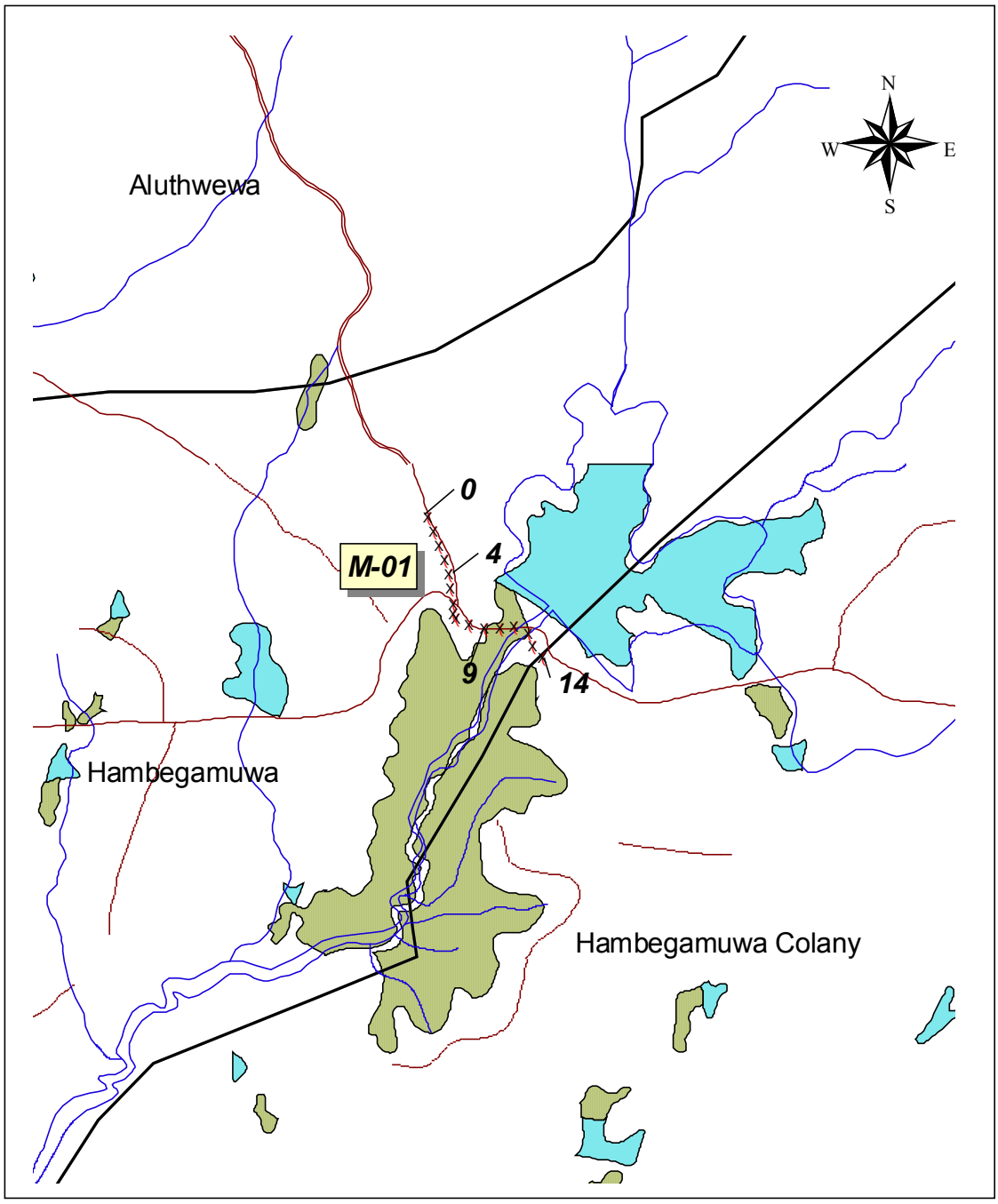
Chart 4. Cannavarella (Monaragala)

FIGURE A-4 AVERAGE MONTHLY RAINFALL AND MONTHLY RAINFALL OF 2001

THE STUDY ON COMPREHENSIVE GROUNDWATER RESOURCES DEVELOPMENT | **JICA**

Appendix B

Location Maps of the Geophysical Exploration Area



1 0 1 2 Kilometers

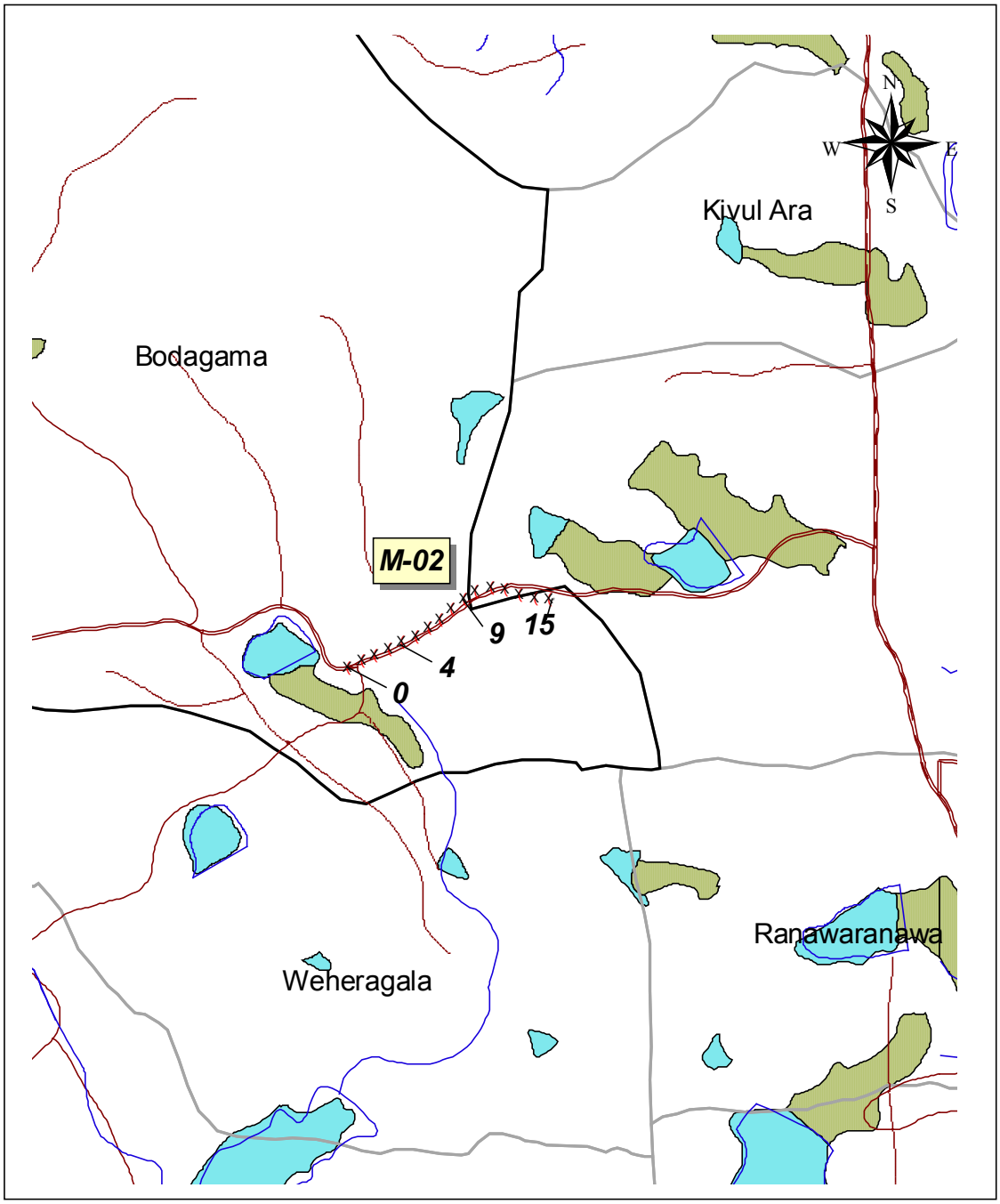
Geophysical Exploration Points
Pilot GND Boundary
GND Boundary

Road Class
Major Road
Minor Road
Jeep/Cart track
Foot Path

Land Condition
Streams
Tank
Inland Waterbodies
Paddy
Marsh & Swamps

FIGURE B.1 LOCATION MAP OF THE SURVEY AREA - HAMBEGAMUWA (M-01)

THE STUDY ON COMPREHENSIVE GROUNDWATER RESOURCES DEVELOPMENT | **JICA**



1 0 1 2 Kilometers

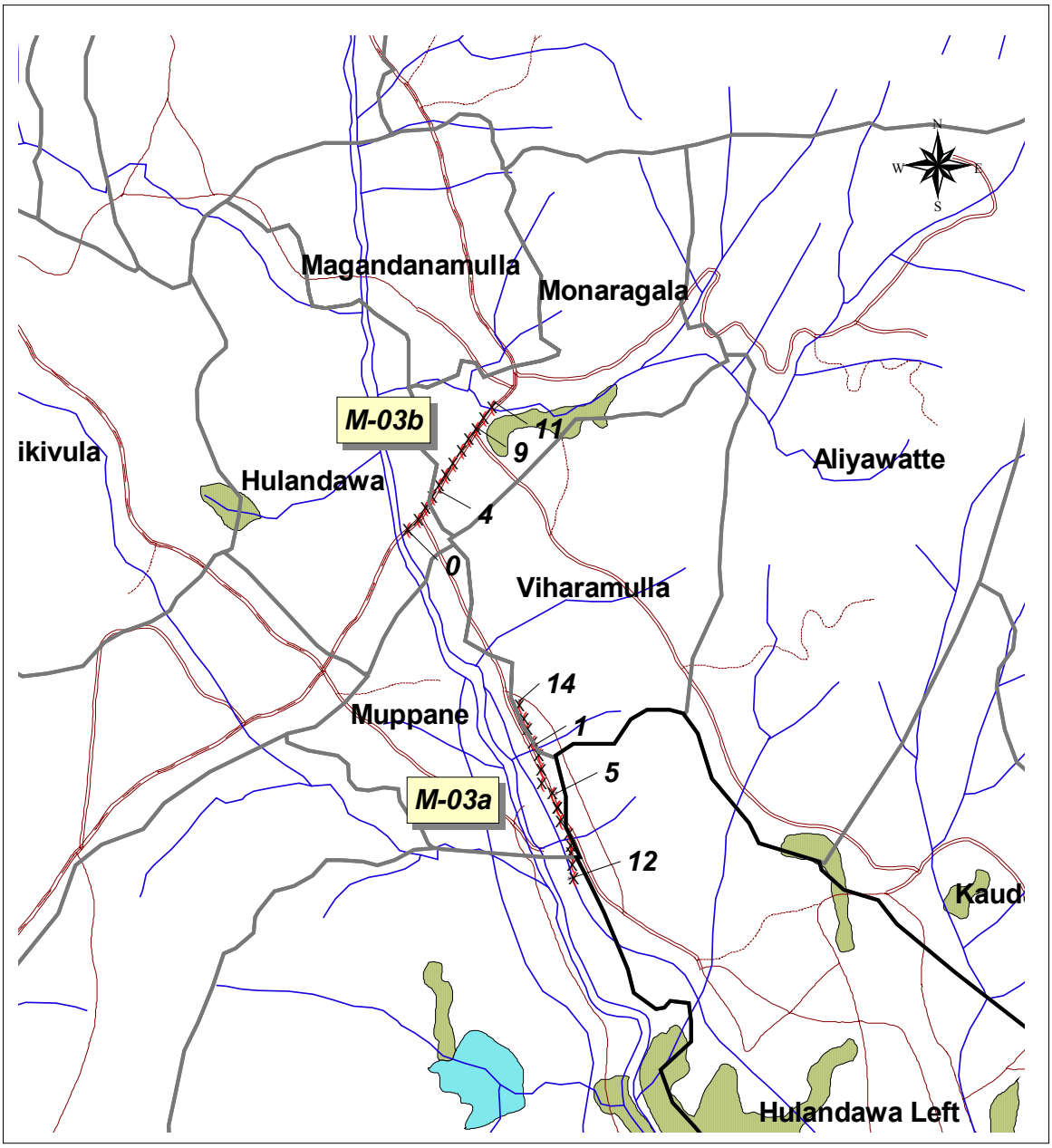
Geophysical Exploration Points
Pilot GND Boundary
GND Boundary

Road Class
Major Road
Minor Road
Jeep/Cart track
Foot Path

Land Condition
Streams
Tank
Inland Waterbodies
Paddy
Marsh & Swamps

FIGURE B.2 LOCATION MAP OF THE SURVEY AREA - BODAGAMA (M-02)

THE STUDY ON COMPREHENSIVE GROUNDWATER RESOURCES DEVELOPMENT | **JICA**



1 0 1 2 *Kilometers*

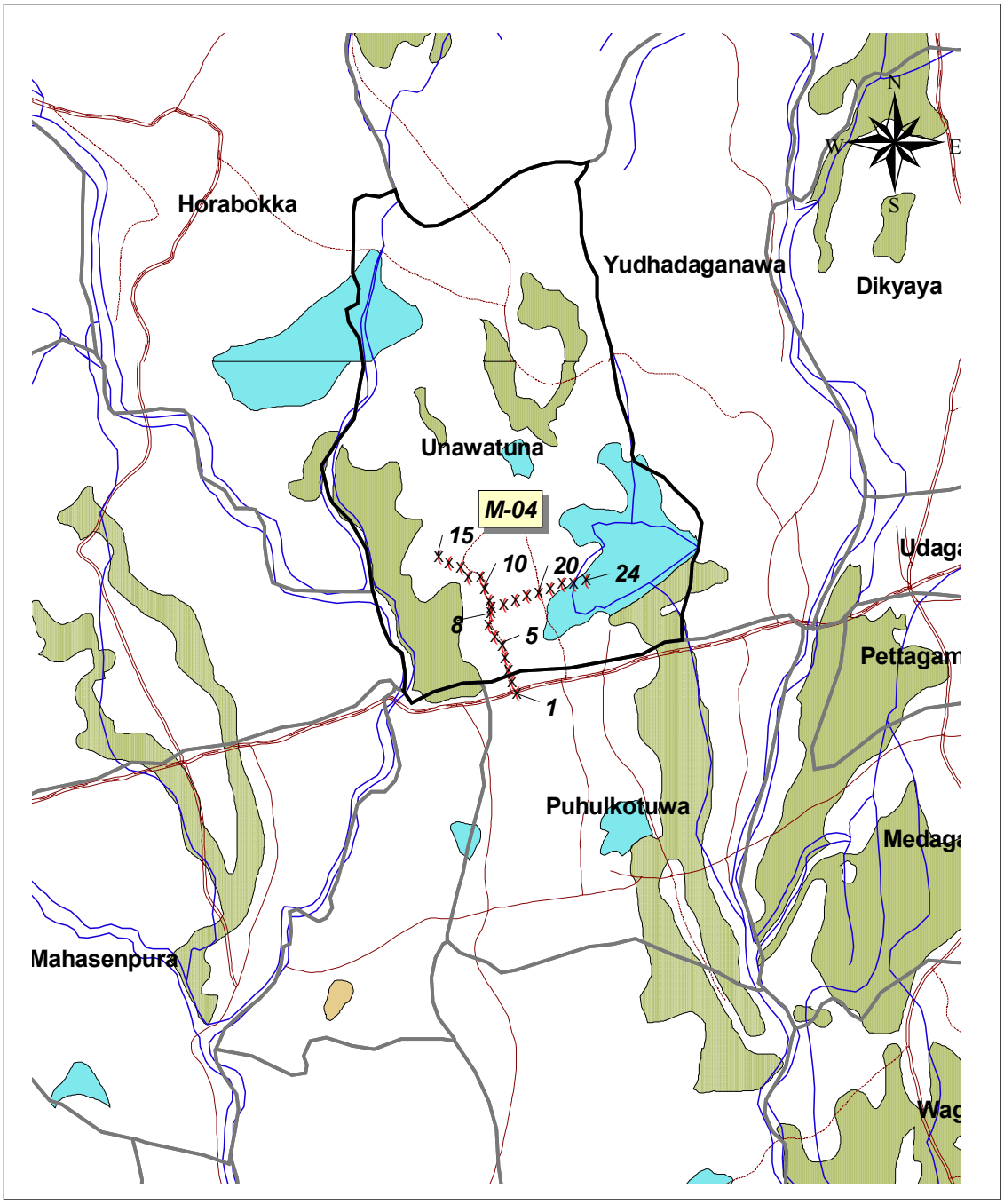
Geophysical Exploration Points
Pilot GND Boundary
GND Boundary

Road Class
Major Road
Minor Road
Jeep/Cart track
Foot Path

Land Condition
Streams
Tank
Inland Waterbodies
Paddy
Marsh & Swamps

FIGURE B.3 LOCATION MAP OF THE SURVEY AREA - HULANDAWA (M-03A, M-03B)

THE STUDY ON COMPREHENSIVE GROUNDWATER RESOURCES DEVELOPMENT | **JICA**



1 0 1 2 Kilometers

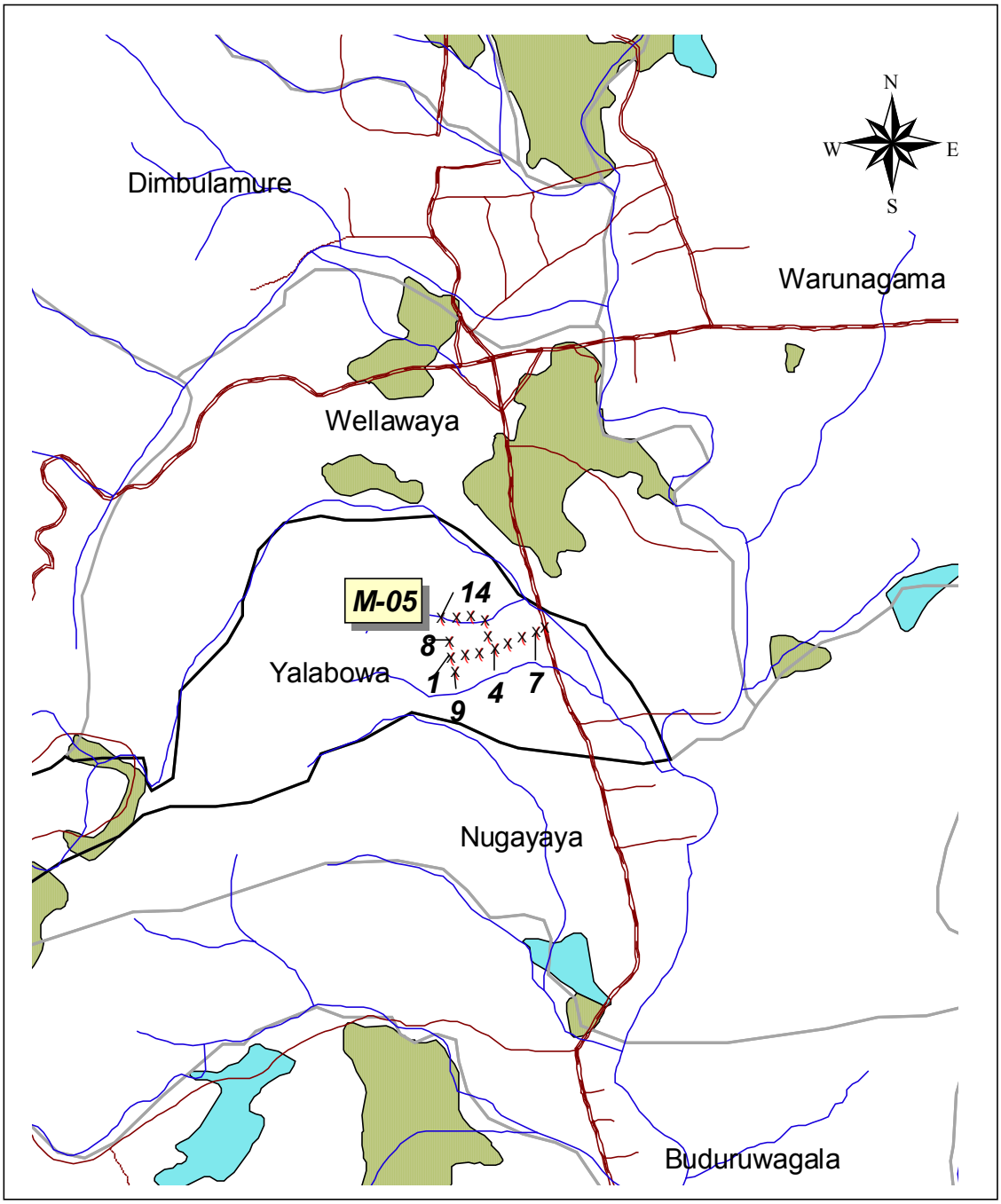
Geophysical Exploration Points
Pilot GND Boundary
GND Boundary

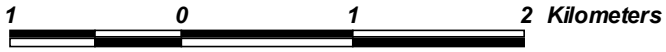
Road Class
Major Road
Minor Road
Jeep/Cart track
Foot Path

Land Condition
Streams
Tank
Inland Waterbodies
Paddy
Marsh & Swamps

FIGURE B.4 LOCATION MAP OF THE SURVEY AREA - UNAWATUNA (M-04)

THE STUDY ON COMPREHENSIVE GROUNDWATER RESOURCES DEVELOPMENT | **JICA**





Geophysical Exploration Points
Pilot GND Boundary
GND Boundary

Road Class
Major Road
Minor Road
Jeep/Cart track
Foot Path

Land Condition
Streams
Tank
Inland Waterbodies
Paddy
Marsh & Swamps

FIGURE B.5 LOCATION MAP OF THE SURVEY - AREA YALABOWA (M-05)

THE STUDY ON COMPREHENSIVE GROUNDWATER RESOURCES DEVELOPMENT | **JICA**

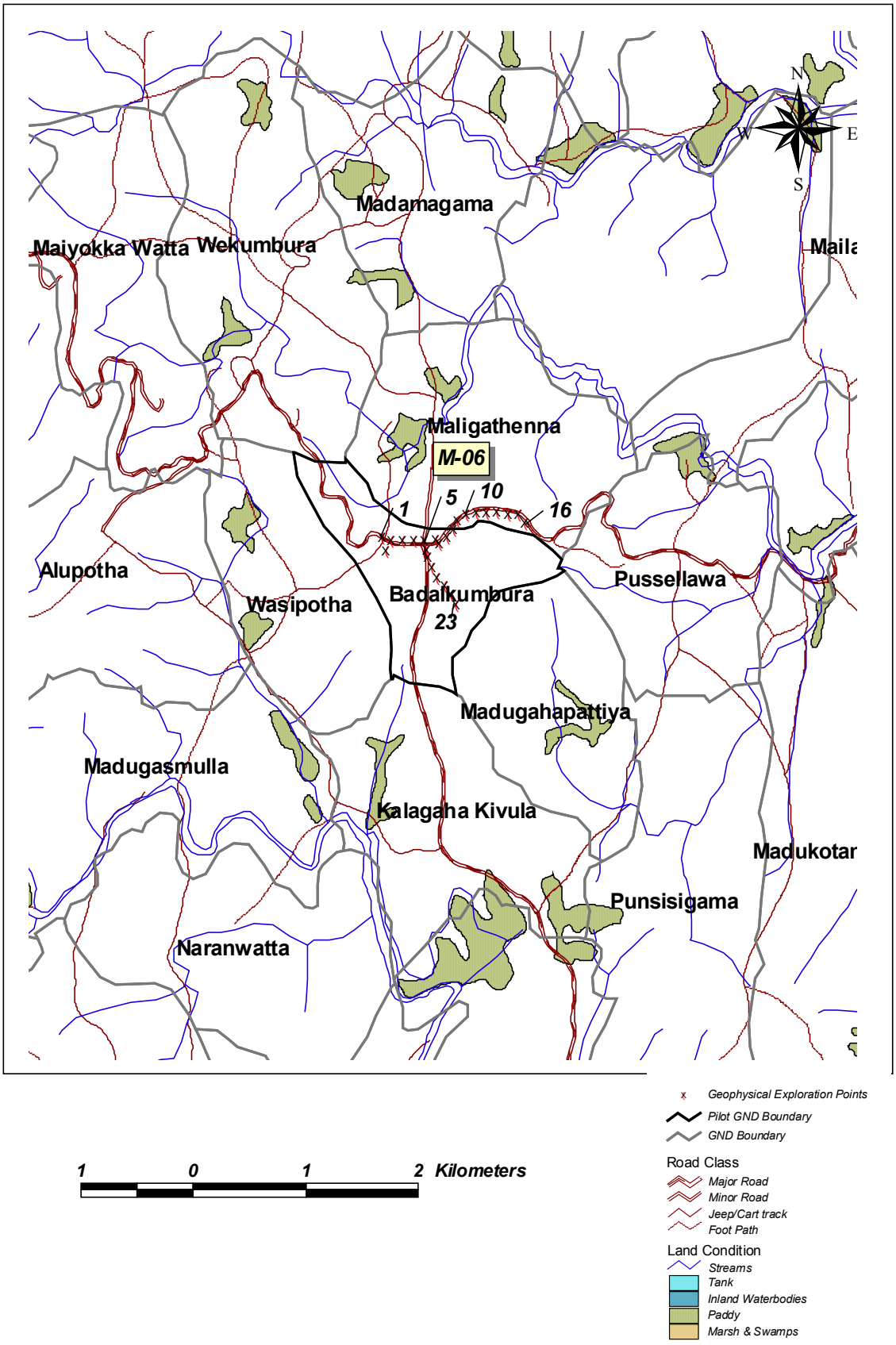
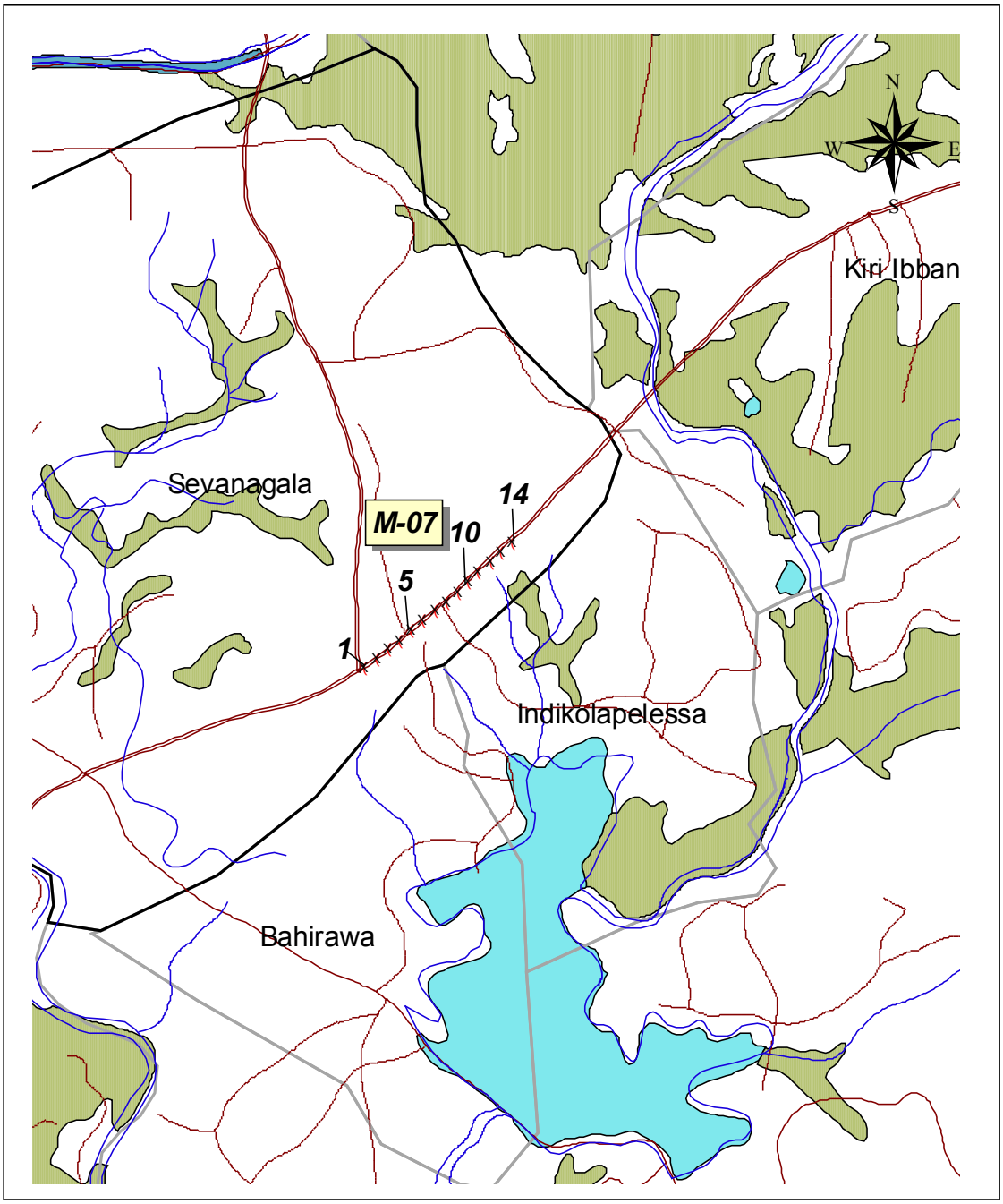


FIGURE B.6 LOCATION MAP OF THE SURVEY AREA - BADALKUMBLA (M-06)

THE STUDY ON COMPREHENSIVE GROUNDWATER RESOURCES DEVELOPMENT | **JICA**



1 0 1 2 *Kilometers*

Geophysical Exploration Points
Pilot GND Boundary
GND Boundary

Road Class
Major Road
Minor Road
Jeep/Cart track
Foot Path

Land Condition
Streams
Tank
Inland Waterbodies
Paddy
Marsh & Swamps

FIGURE B.7 LOCATION MAP OF THE SURVEY AREA - SEVANAGALA (M-07)

THE STUDY ON COMPREHENSIVE GROUNDWATER RESOURCES DEVELOPMENT | **JICA**

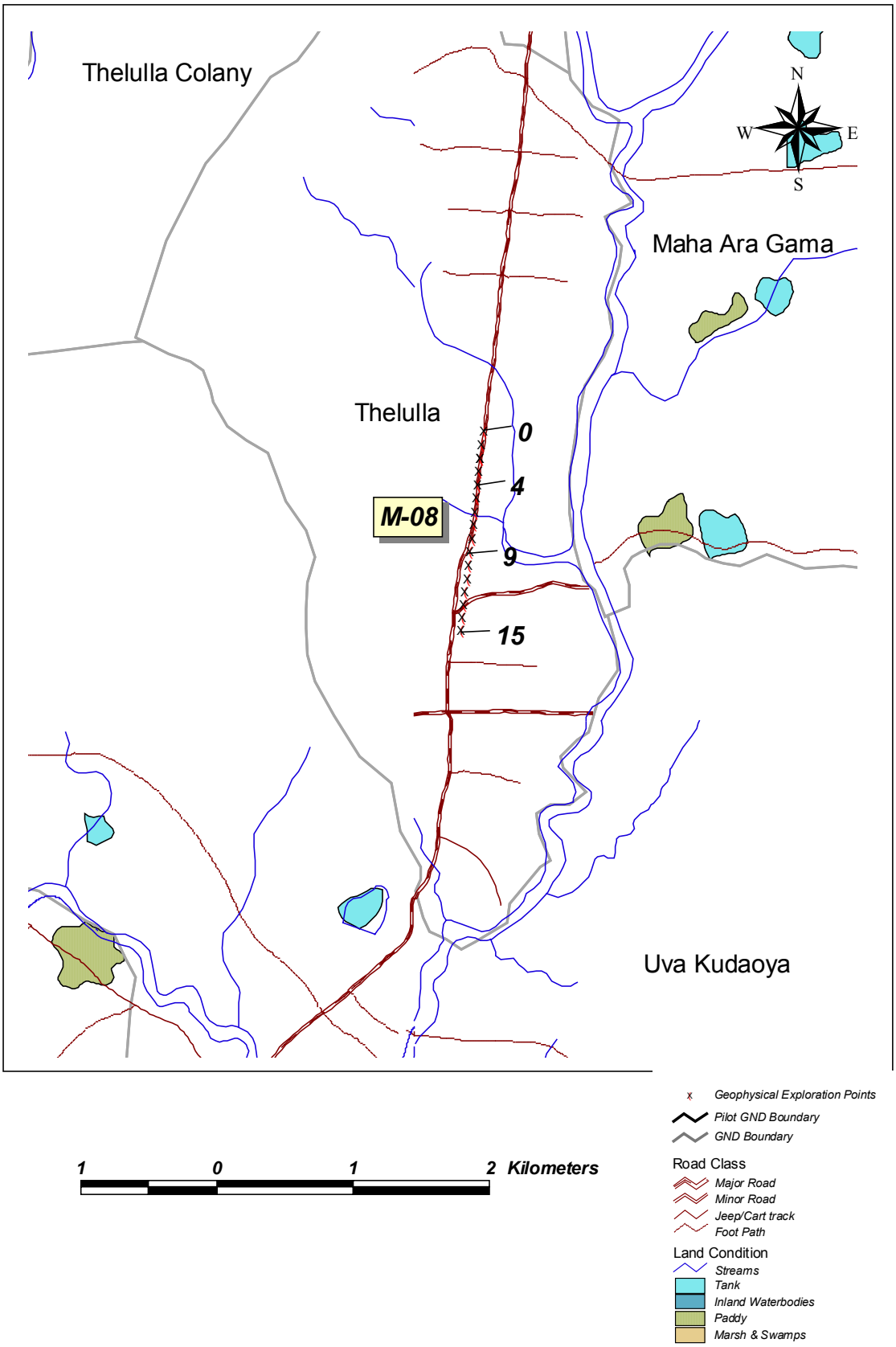
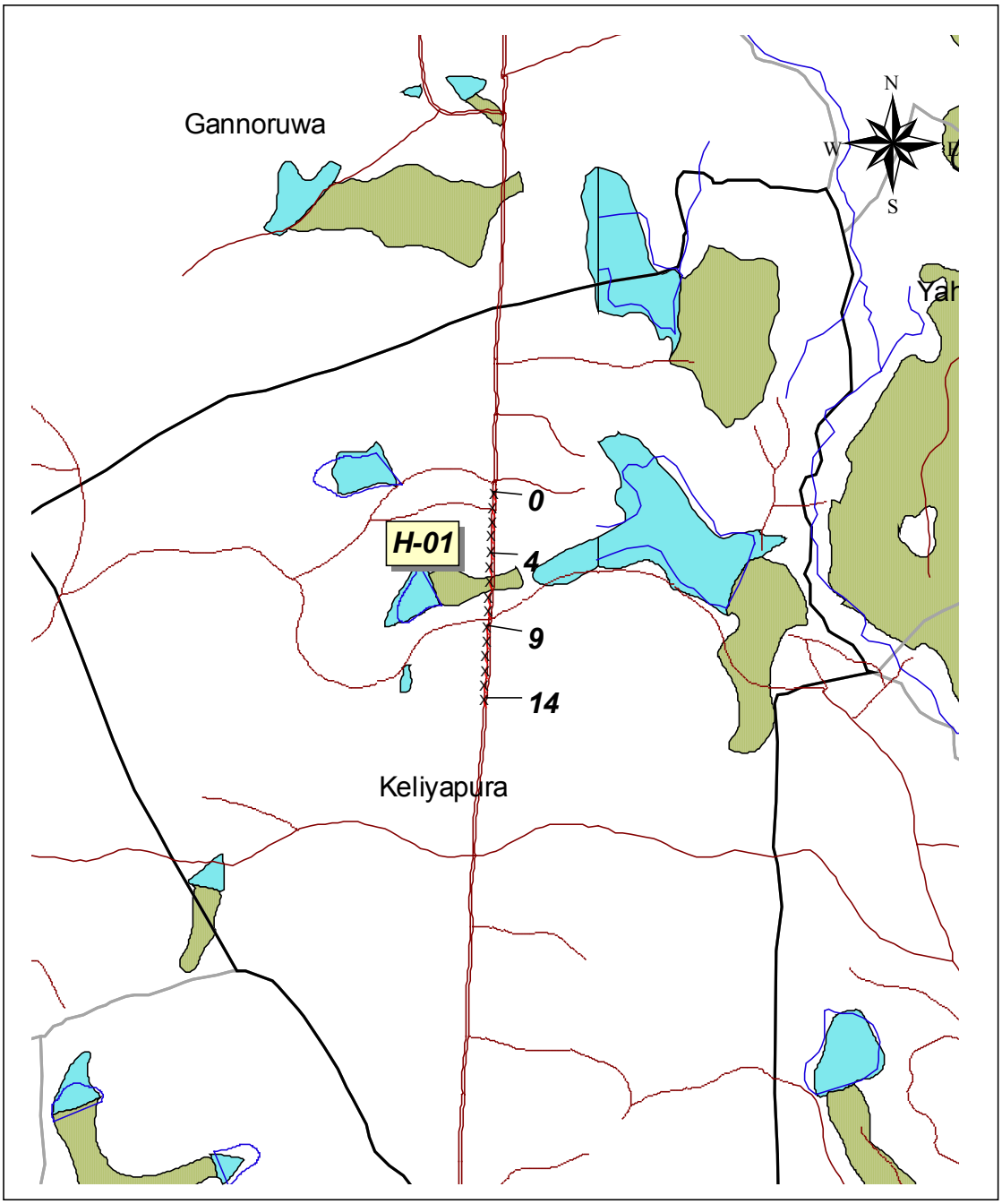
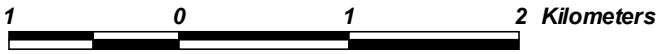


FIGURE B.8 LOCATION MAP OF THE SURVEY AREA - WATER SPRING (THELLULA) (M-08)

THE STUDY ON COMPREHENSIVE GROUNDWATER RESOURCES DEVELOPMENT | **JICA**





Geophysical Exploration Points
Pilot GND Boundary
GND Boundary

Road Class
Major Road
Minor Road
Jeep/Cart track
Foot Path

Land Condition
Streams
Tank
Inland Waterbodies
Paddy
Marsh & Swamps

FIGURE B.9 LOCATION MAP OF THE SURVEY AREA - KELIYAPURA (H-01)

THE STUDY ON COMPREHENSIVE GROUNDWATER RESOURCES DEVELOPMENT | **JICA**

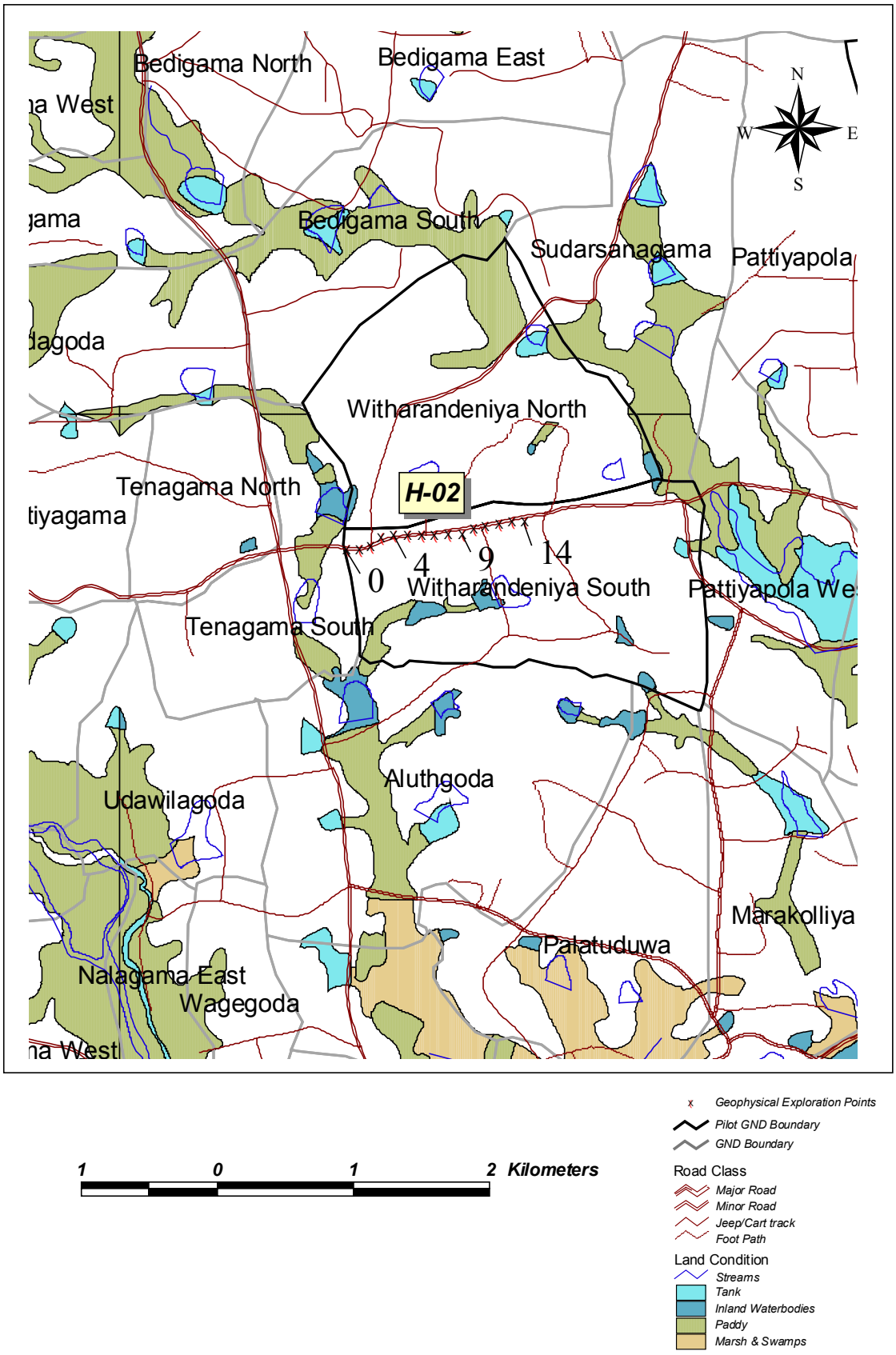
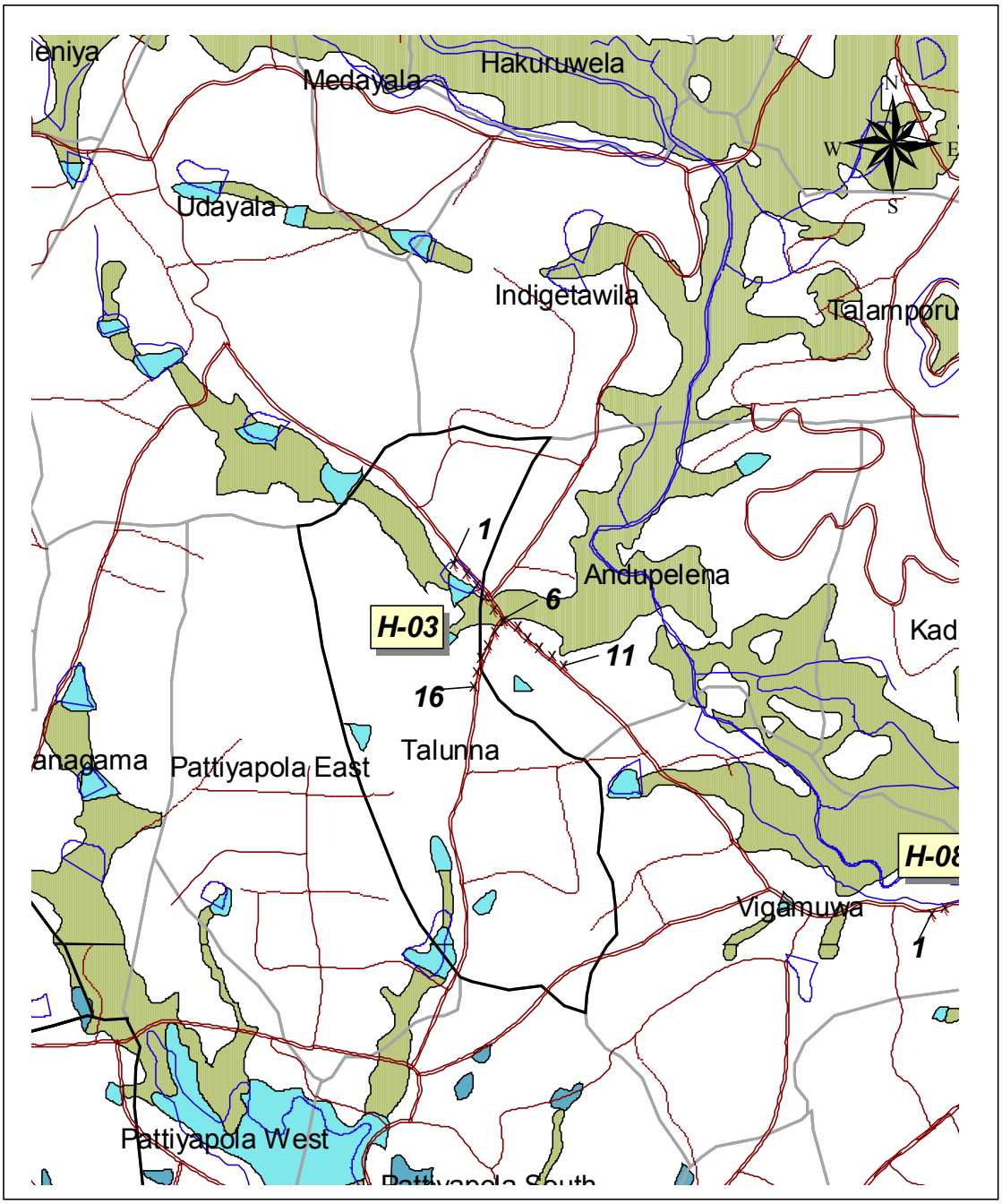


FIGURE B.10 LOCATION MAP OF THE SURVEY AREA - WITHARANDENIA (H-02)

THE STUDY ON COMPREHENSIVE GROUNDWATER RESOURCES DEVELOPMENT | **JICA**



1 0 1 2 *Kilometers*

Geophysical Exploration Points
Pilot GND Boundary
GND Boundary

Road Class
Major Road
Minor Road
Jeep/Cart track
Foot Path

Land Condition
Streams
Tank
Inland Waterbodies
Paddy
Marsh & Swamps

FIGURE B.11 LOCATION MAP OF THE SURVEY AREA - TALUNNA (H-03)

THE STUDY ON COMPREHENSIVE GROUNDWATER RESOURCES DEVELOPMENT | **JICA**