Union of Myanmar
Ministry of Progress of Border Areas and National
Races and Development Affairs

THE PREPARATORY SURVEY
ON
THE PROVISION OF EQUIPMENT FOR
RURAL WATER SUPPLY PROJECT
IN THE CENTRAL DRY ZONE
IN THE UNION OF MYANMAR

FINAL REPORT

March 2011

JAPAN INTERNATIONAL COOPERATION AGENCY(JICA)

KOKUSAI KOGYO CO., LTD.

PREFACE

Japan International Cooperation Agency (JICA) decided to conduct the Preparatory Survey on the Provision of Equipment for Rural Water Supply Project in the Central Dry Zone in the Union of Myanmar, and organized a survey team headed by Mr. Takeshi Nakano of Kokusai Kogyo Co., Ltd. between May 22, 2010 and December 17, 2010.

The survey team held a series of discussions with the officials concerned of the Government of Myanmar, and conducted a field investigation. As a result of further studies in Japan, the present report was finalized.

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

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Myanmar for their close cooperation extended to the survey team.

March, 2011

Mr. Shinya Ejima
Director General,
Global Environment Department
Japan International Cooperation Agency

SUMMARY

1. Outline of the Recipient Country

The Union of Myanmar (hereinafter referred to as "Myanmar") is located between latitude 10° and 28° north, has an area of approximately 680,000 km^2 (about 1.8 times that of Japan), and is characterised by a long landform sweeping north and south. It has land borders with China, Thailand, India and Bangladesh, and the total length of these borders is approximately 4,600 km. It faces the Gulf of Martaban, Bay of Bengal and Indian Ocean, the total length of coastline is approximately 2,000 km. The central dry zone in Myanmar is located in the central inland area, has an area of 77,000 km^2 and lies across three (3) administrative areas: Mandalay, Magway and Sagaing Regions. This consists of 93 townships and 16,324 villages with a population of around 19.7 million, which accounts for 33.7 % of the total population of Myanmar. The population density there is approximately three (3) times as many as the average in the country. The average altitude in the central dry zone is 350 to 380 m, and it slopes to the Irrawaddy River smoothly.

2. Background and Outline of the Project

(1) Upper Plan

The Department of Development Affairs, Ministry of Progress of Border Areas and National Races and Development Affairs (hereinafter referred to as "DDA") formulated a "Ten-year Project for Rural Water Supply" (hereinafter referred to as "Ten-year project") (2000-2001 to 2009-2010), which aims at "developing at least one water resource in every village". The Ten-year project was completed in March 2010, with slight changes made to the initial premise of the project. In actuality, the Ten-year project improved the water supply situation in the central dry zone to some extent, but the results were limited. From this perspective, DDA recognizes the necessity and continuation of water resources development in the central dry zone. Therefore, DDA selected villages that suffer from water shortages and formulated "A Five-year Project for Rural Water Supply" (hereinafter referred to as "Five-year project") (2011-2012 to 2015-2016) to complement the previous Ten-year project. DDA has set the objectives in the Five-year project to construct 826 deep wells, and specified 110 villages in which improvement of the water supply situation is to be given top priority and immediate attention due to water shortage, poverty and so forth.

(2) Current Conditions and Problems

Residents of the central dry zone in Myanmar mainly rely on shallow wells or small reservoirs from rainwater for their domestic water needs. In the dry season, those water resources may dry up and be impossible to use. In that case, the people are forced to use water resources located several kilometers away, which is quite strenuous work. In a period from 2000 to 2001, only 7,760 (47 %) of the total 16,324 villages were found to have water resources (including small ponds, etc.).

Under these circumstances, the Government of Myanmar made improvement of the water supply situation a top priority. Subsequently, DDA formulated a Ten-year project, which aims at "developing at least one water resource in every village". In actuality, the Ten-year project improved the water supply situation in the central dry zone to some extent, but there are still many villages in which one water resource is used by many households and both water quality and quantity is not sufficient as a potable water source.

Currently, DDA has nine (9) drillings rigs (mounted on trucks) and 35 machine drive rigs and uses them to develop groundwater (i.e. by drilling deep wells). However, damage and deterioration over the years has significantly degraded the capacity of these machines so that, even using their best rig, they are only able to drill around 180 m deep wells. In the central dry zone, there is evidence that many of the villages will require wells that exceed 181 m in depth and, therefore, it is almost impossible to develop the groundwater there with DDA's drilling rigs.

DDA also recognizes the importance of water quality, and they promote the supply of safe drinking water, carrying out analysis based on the "Proposed National Drinking Water Quality Standards". However, only 10 of the 28 items in the water quality standards are tested and the accuracy of the results is not precise due to insufficient equipment for analysis and poor training. As mentioned above, the structure of DDA for groundwater development requires strengthening.

(3) Objective of the Project

This Project aims at procurement of equipment and materials for groundwater development for 110 villages in the central dry zone, and implementation of technical assistance to develop the structure of DDA for water quality analysis to achieve the Project goal "to supply water through the entire year and elevate the living environment in the central dry zone".

(4) Related Project

JICA technical cooperation project "The Project on Rural Water Supply Technology in the Central Dry Zone in the Union of Myanmar" was implemented to DDA's staff from 2004 to 2006. The uplifted capability and experience through technical cooperation project are took advantage of in this Grant Aid Project.

3. Summary of the Survey and Contents of the Project

(1) Summary of the Survey

From the background mentioned above, Japan International Cooperation Agency (JICA) sent a survey team between May 22 and July 24, 2010, December 8 and 17, 2010 to Myanmar. The survey team conducted natural condition surveys (site reconnaissance, hydrogeological and geophysical survey and water quality analysis) and social condition survey at the target area in the central dry zone.

The summarized result of field survey in Myanmar and analysis in Japan are mentioned below.

1) Inspection of the Target Villages

A survey team was sent to Myanmar approximately two (2) years after the request, there were slight changes to the initial premise of the Project. Therefore, the relevancy of the contents of equipment and target 110 villages requested by DDA were inspected from the natural and social conditions. As a result, cooperation in 87 villages was judged a priority.

Table 1: Target Villages in the Project

Priority	No. of target village	Estimated drilling depth
Priority 1	65 villages	Deeper than 181 m
Priority 2	1 village	Deeper than 181 m
Priority 3	20 villages	61 to 180 m
Priority 4	1 village	61 to 180 m
Total	87 villages	***

2) Outline Design

The basic policy items of the outline design of this Project are given below. Consideration was given to cost reduction when setting the scale and specifications of the equipment procurement project as appropriate to DDA.

(1) Of the equipment for well drilling and the equipment and the materials for well construction requested by the Government of Myanmar, the equipment which has been deemed appropriate will be procured.

(2) Equipment will be procured for water quality analysis which is integral for DDA to move ahead with rural water supply planning.

(3) The technical assistance (soft component) will be implemented in order to strengthen the capability of operation and maintenance for the planned equipment procurement.

(2) Contents and Scale of the Project

1) Equipment Procurement

The Project targets 87 villages and will procure the following equipment which was judged as necessary.

Table 2: Equipment List

Category	No.	Item	Q'ty
A. Equipment for Well Drilling	A-1	Drilling rig mounted on truck	
	A-1-1	400 m deep drilling	1 unit
	A-1-2	300 m deep drilling	1 unit
	A-2	Drilling agent (Bentonite and CMC)	1 set
	A-3	Equipment for air lift pumping and pumping test	1 set
	A-4	Air compressor	1 unit
	A-5	Cargo truck with crane	2 units
B. Equipment and Materials for Well Construction	B-1	Casing pipe for deep well (for 87 wells)	
	B-1-1	4 inch	3,250 units
	B-1-2	10 inch	350 units
	B-2	Screen pipe and bottom plug (for 87 wells)	
	B-2-1	Screen pipe	170 units
	B-2-2	Bottom plug	95 units
	B-3	Submersible motor pump and diesel engine generator (for 87 villages)	
	B-3-1	TDH 300 m	9 sets
	B-3-2	TDH 250 m	18 sets
	B-3-3	TDH 200 m	22 sets
	B-3-4	TDH 150 m	31 sets
	B-3-5	TDH 100 m	7 sets
C. Equipment for Water Quality Analysis	C-1	Spectrophotometer	1 unit
	C-2	Water still	1 unit

2) Soft Component

In this Project, the soft component aims at "strengthening the structure and improving accuracy of water quality analysis", and the activities will begin with three (3) points described below, which are the outputs to achieve the objective of the soft component.

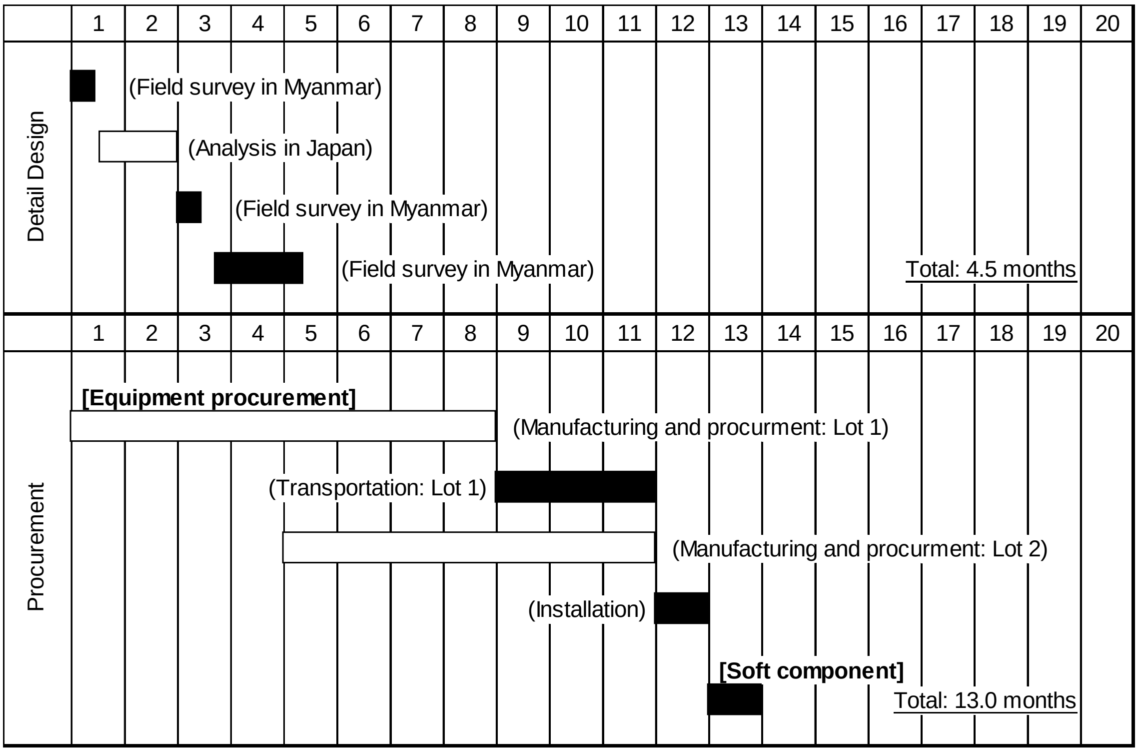
Result 1: Acquirement of techniques for water quality analysis (18 parameters)
Result 2: Master operation procedure, maintenance and management of the equipment
Result 3: Improvement of ledgers and manuals

4. Implementation Schedule and Project Cost

(1) Implementation Schedule

The following shows the implementation schedule of this Project.

Table 3: Implementation Schedule of the Project



(2) Project Cost

In order to implement this Project, the Project cost borne by Myanmar side is 50,798,500 Kyat.

5. Project Evaluation

(1) Relevancy

The Project implementation by Grant Aid is evaluated to be reasonable based on the result of this survey for the following reasons.

- Target of this Project is 98,058 peoples of 87 villages in the central dry zone, a considerable number of whom are in the “worse off” category.
- The villagers in the target villages use poor water sources (water quality and quantity). The implementation of this Project will enable the distribution of safe and sustainable water to the villagers and will contribute to improving their lives.
- DDA, as an implementing agency, has enough capability and experience in well drilling, rehabilitation, operation and maintenance, and takes enough budgetary steps. In addition, water supply facilities to be constructed by DDA in this Project are of a common level in Myanmar, and special techniques are not needed.
- DDA aims at “developing at least one (1) water resource in every village” as part of the Five-year project, implementation of this Project aims to achieve this objective.
- This Project is not a profit-earning project.

* Negative impact on environment is not generated by the Project implementation according to the Environment Impact Assessment (EIA).
* The Project implementation by Japanese Grant Aid scheme is not particularly difficult.

(2) Effectivity

1) Quantitative Impact

Quantitative impact to be expected by implementation of this Project is mentioned below.

Table 4: Quantitative Impact after Implementation of this Project

Indicator	Baseline (2010)	Target value (2016)
The village has the water source to be able to fetch sanitary and sustainable water in the target 87 villages	0 village (0 people)	87 villages (98,058 peoples)
Water quality parameters able to be analized at the DDA laboratory	10 parameters (not high accuracy)	18 parameters

2) Qualitative Impact

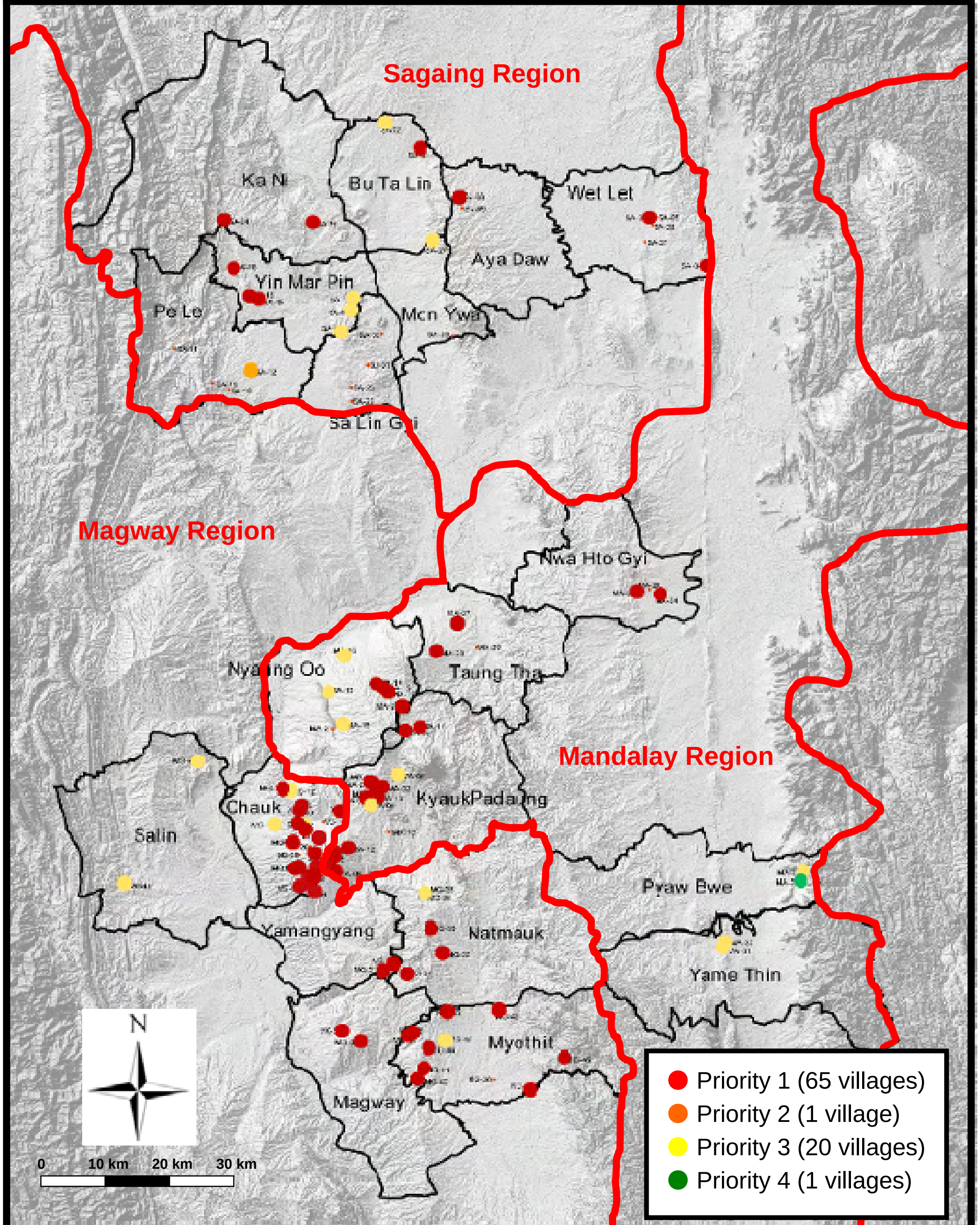
Quantitative impact to be expected by implementation of this Project is mentioned below.

* Mitigation of workload (time) for fetching water
* Mitigation of water related diseases
* Improvement of enrollment ratio of children
* Mitigation of household budget expenditure (economical improvement)

From the above-mentioned contents, implementation of this Project is assessed reasonable and effective.

CONTENTS

Union of Myanmar



LOCATION MAP

THE PREPARATORY SURVEY ON THE PROVISION OF EQUIPMENT FOR RURAL WATER SUPPLY PROJECT IN THE CENTRAL DRY ZONE

LIST OF FIGURES & TABLES

ABBREVIATIONS

Abbreviation	English
API	American Petroleum Institute
BHN	Basic Human Needs
DDA	Department of Development Affairs
DTH	Down The Hole Hammer
E/N	Exchange of Notes
G/A	Grant Agreement
IADC	International Association of Drilling Contractors
JICA	Japan International Cooperation Agency
MCDC	Mandalay City Development Committee
M/D	Minutes of Discussion
MDGs	Millennium Development Goals
SRTM	Shuttle Radar Topography Mission
TDH	Total Dynamic Head
UNICEF	United Nations Children's Fund
WHO	World Health Organization
WMC	Water Management Committee
WMO	Water Management Organizations
WRUD	Water Resource Utilization Department
VPDC	Village Tract Peace and Development Councils
VWC	Village Water Committee

Chapter 1 Background of the Project

CHAPTER 1 BACKGROUND OF THE PROJECT

1-1 Background and Outline of Grant Aid

This Grant Aid was requested in 2008 to assist the Union of Myanmar (hereinafter referred to as "Myanmar") to achieve this initial goal outlined in a "Ten-year Project for Rural Water Supply" (hereinafter referred to as "Ten-year project") (2000-2001 to 2009-2010), and the Government of Japan considered the request based on the information available at the time. Approximately two (2) years after the request, a survey team was sent to Myanmar, however, the team found the Ten-year project had already been completed in March 2010 and there were slight changes to the initial premise of the Project. In actuality, the Ten-year project improved the water supply situation in the central dry zone to some extent, but the results were limited. From this perspective, the Department of Development Affairs, Ministry of Progress of Border Areas and National Races and Development Affairs (hereinafter referred to as "DDA") recognizes the necessity and continuation of water resources development in the central dry zone. Therefore, DDA selected villages that suffer from water shortages and formulated "A Five-year Project for Rural Water Supply" (hereinafter referred to as "Five-year project") (2011-2012 to 2015-2016) to complement the previous Ten-year project. DDA has set the objectives in the Five-year project to construct 826 deep wells, and specified 110 villages in which improvement of the water supply situation is to be given top priority and immediate attention due to water shortage, poverty and so forth. However, it is almost impossible to develop the groundwater there with drilling rigs owned by DDA, because damage and deterioration over the years has significantly degraded the capacity of these machines.

The objectives of this Grant Aid Project are to procure the equipment for groundwater development for the 110 villages that have been given top priority in the Five-year project and to strengthen the water quality analysis structure in DDA. This will allow the situation stated above to be overcome and the number of villages without water resources in the central dry zone to be reduced.

1-2 Natural Condition

1-2-1 Climate

The dry season in Myanmar is between December and April, the rainy seasons are between the end of May and the beginning of June (first rainy season), and between the middle of August and the end of September (last rainy season). Ninety (90) % of the rainfall is concentrated between May and October. Average of the yearly rainfall amount from 1998 to 2010 is 575.5 mm in Nyaung Oo in the Mandalay Region. The lowest temperature is less than 15 °C between December and February; the highest temperature is more than 35 °C between March and May. Average of the yearly humidity is 63 %, the dry season (March and April) is 42 % and the rainy season (September) is 80 %.

1-2-2 Landscape

Myanmar is located between latitude 10° and 28° north, has an area of approximately 680,000 km^2 (about 1.8 times of Japan), and is characterised by a long landform sweeping north and south. It has land borders with China, Thailand, India and Bangladesh, and the total length these borders is approximately 4,600 km. It faces the Gulf of Martaban, Bay of Bengal and Indian Ocean, the total length of its coastline is approximately 2,000 km. The central dry zone in Myanmar is located in the central inland area, and has an area of 77,000 km^2 and lies across three (3) administrative areas: Mandalay, Magway and Sagaing Regions. This consists of 93 townships and 16,324 villages with a population of around 19.7 million, which accounts for 33.7 % of the total population of Myanmar. The population density there is approximately three (3) times as many as the average in the country. The average of altitude in the central dry zone is 350 to 380 m, and it slopes to the Irrawaddy River smoothly.

1-2-3 Geology and Topography

The central dry zone of Myanmar, which is a vast basin-wise plain commonly known as the Inner Burman Tertiary Basin, is located at nearly the center of the country, ranging from latitude 23° to 19° north and longitude 94° to 96.5° east. West side of the basin is bordered by the ranges of folded mountain masses, such as Arakan Yoma and Chin Hills, and the east side is bordered by the Shan Plateau which is composed of the older geological formations than those of the western mountain ranges. The Irrawaddy River flows through the central plain from north to south.

Affected largely by the Himalayan Orogeny, the geological structure of the area is characterized by the intense folds with NNW-SSE oriented folding axis on the formations older than the Miocene Stage, and by the densely developed fault system represented by predominantly E-W lineation structure. Large scale N-S oriented faults, such as the Central Volcanic Line at the center and Sagaing Fault at the east side is also outstanding in this basin.

The location of Project target villages and borderline of townships on the shaded map drawn using SRTM data are shown below. This figure clearly shows the characteristics of the area, that is a plane sandwiched by highlands in both the west and east, and that has geological structures of a south-north orientation.

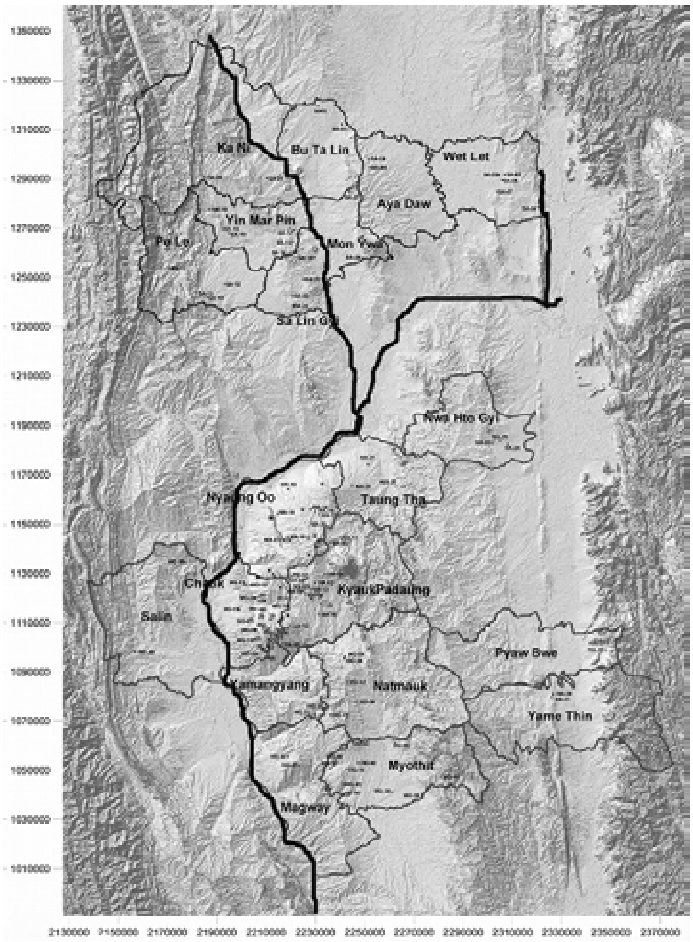


Figure 1-1: Relief Map of the Survey Area

Sedimentation of the Irrawaddy Formation began at the Upper Miocene Stage when the intense tectonic movement changed over to the gentle one, filling up the valley-wise fold syncline. In the beginning it was marine deposits, and soon changed over to continental deposits, along with the upheaval of the land and/or the regression.

The survey area is located in this basin, from latitude 22° 40’ to 20° north and from longitude 94.5°to 96° 15’ east.

The following schematic diagram shows east and west cross-section near 22° north, which roughly represents the geological structure of the Central Burman Tertiary Basin.

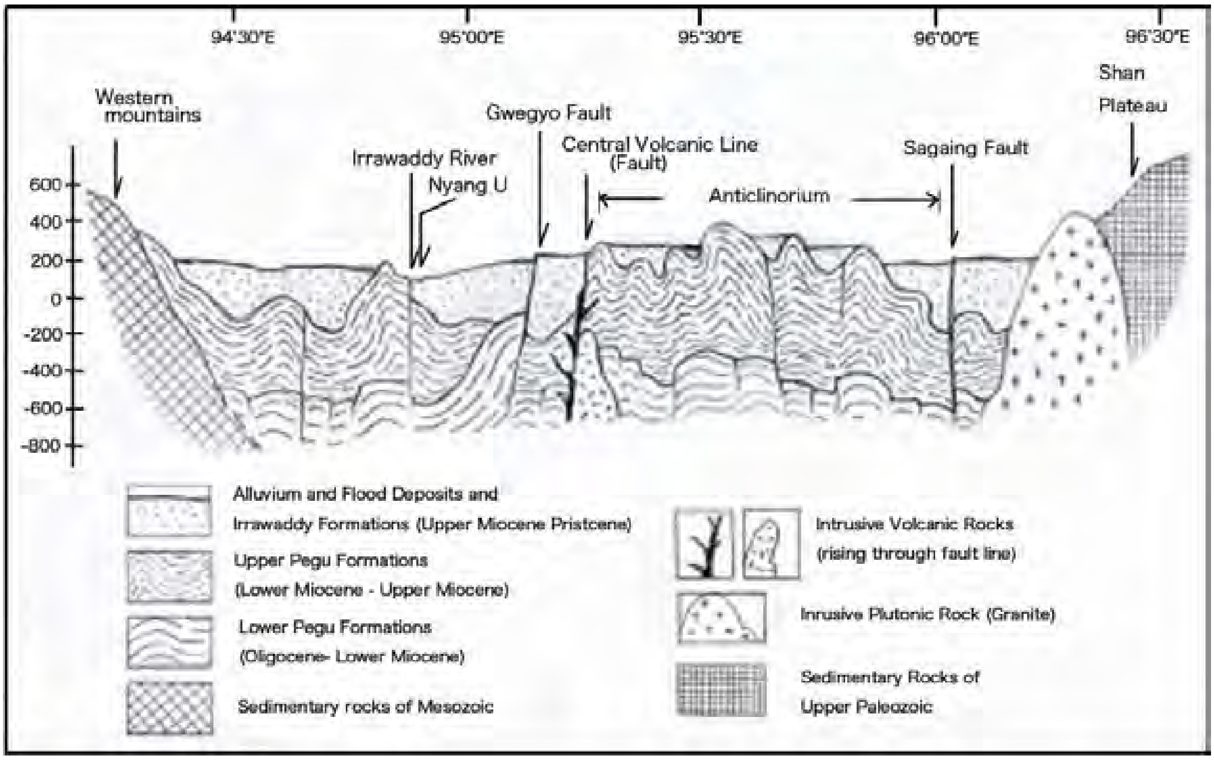


Figure 1-2: Schematic Profile in the Survey Area

Geology of the survey area is classified into the following five (5) units, so far as the range from ground surface to 700 to 800 m depth, which is a possible groundwater development depth.

A: Quaternary deposits such as flood sediments and alluvium
B: The Irrawaddy formation which was accumulated during the stages from Upper Miocene to Lower Pleistocene
C: Collectively so called Pegu Group of the Early Oligocene to the Middle Miocene: Sedimentary rock formations of intensely folded and cut by faults
D: Volcanic rocks (extrusives) being arranged along the N-S oriented straight structural line which is called the Central Volcanic Line
E: A mass of intrusive igneous rock

In these five (5) geological units, the units directly concerned with the groundwater development of construction of the deep wells are mainly B and C, and B is dominant. Distribution of Pegu group in ground surface in this area is about 30 %, but the ratio in the target area is less than 20 % with a ratio of over 70 % of B and nearly 30 % of C, where the Pegu Group's concern is not only its outcropping area but also its occurrence at shallow portion beneath the ground surface, being thinly overlain by A and/or B. With regard to the well drilling in 110 candidate villages, drilling through the Irrawaddy Formations including A is over 80 % and drilling through the Pegu Formations is less than 20 % including the areas thinly overlain by Q and Ir. F. Distribution of the units of D and E are limited to certain areas, and has no direct concern with the deep well program, even the probable influence of water quality to their adjacent areas.

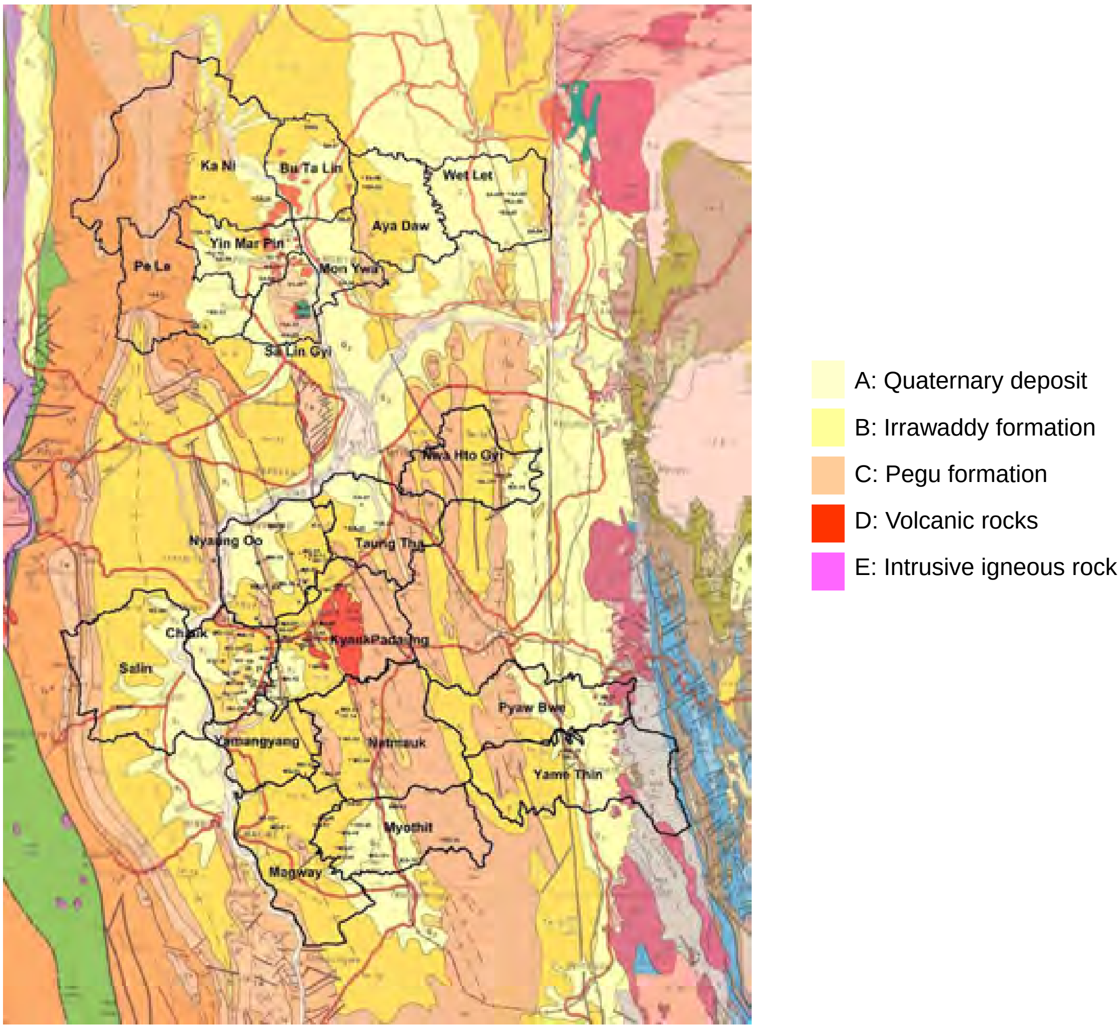


Figure 1-3: Geology of Central Dry Zone and Target Villages

1-2-4 Hydrogeology (Result of Field Survey)

(1) Purpose of Survey

The purpose of this survey (Hydrogeological and geophysical surveys) is to determine the depth of wells that would be installed by the Project, and accordingly the total number of materials, specification and models for drilling would be estimated.

(2) Survey Method

1) Pre-survey

The pre-survey had two (2) main objectives, the first was to obtain existing data that project members hadn't found out previously at the headquarters of DDA, and the second was to understand the geological conditions or water supply condition around the target villages by visiting them.

The team visited all DDA township offices in the Project target area: six (6) township offices in

Mandalay Region, and six (6) township offices in Magway Region and eight (8) township offices in Sagaing Region. The team collected the existing data and information of existing wells and results of physical survey at the DDA offices, and visited 2 to 5 villages in each township to collect information on existing wells (depth, yield, water level, water quality, etc.) in the village and/or its surroundings by interviewing villagers. The team determined the specifications of VES such as target depth, direction of traverse line, and also tried to understand the geological condition with careful observation at the site.

2) Electric Resistivity Sounding

The geophysical survey conducted in this investigation was by the vertical electric resistivity sounding method (VES), which is the most common sounding method for the purpose of the groundwater development. Of the two (2) types of electrode array, Schlumberger's Array was adopted in this survey, because it can survey deep sections easier than Wenner's Array, in consideration of the general depth of groundwater level (100 to 300 m below the ground surface) of the Central Dry Zone. In this survey, the team prepared the table of rough standards to categorize each layer.

Table 1-1: Rough Standard for Estimation of Geology by Resistivity

Geological Units	Resistivity Value (Ω-m)	Aquifer Evaluation
Unconsolidated Materials: Resistivity value nearly corresponds with grain size of materials --- Larger the resistivity, the higher the potential of aquifer		
Clay	1 to 5	Aquitard (Impermeable bed)
Silty material	5 to 15	Aquiclude (Semi-permeable)
Fine sand	15 to 30	Potential aquifer (Permeable bed)
Medium to coarse sand	30 to 90	High aquifer potential (highly permeable)
Gravel	80 to 200	Very high aquifer potential (same as above)
Rocks: Resistivity value varies with age of sedimentary rocks (Younger has lower value), and with fissure abundance (thicker fissure portion has lower value) in volcanic or metamorphic rocks, therefore relation between rock type and resistivity value is rather complicated when compared with sedimentary unconsolidated materials.		
Mudstone or shale	10 to 50	Commonly classified as aquitard
Sandstone or limestone	100 to 200	Generally regarded as potential aquifer
Volcanic rocks	150 to 400	Potential aquifer, partially
Metamorphic rocks	500 to over 2,000	Mostly regarded as aquiclude

The number of villages where the VES survey was conducted was 101 out of 110 candidate villages. The reason is that the existing VES data useful enough for analysis on the seven (7) villages were obtained during the Pre-survey stage. The other two (2) villages were excluded from the list of villages for VES because it was judged, at the Pre-survey stage, that water production from a deep well would be almost impossible, and in addition, it was found that the shallow well was available in the vicinity of the village cluster. The two (2) villages have been put into the lowest categorization without conducting the geophysical survey. Accordingly, VES survey assessment and comprehensive analysis was conducted for the 108 villages.

3) Analysis of VES Measurement and Total Hydrogeologic Evaluation

The depth of well is not determined by only the information of VES, which can classify the layers by resistivity with the depth. It should be evaluated with the combination of other information such as the result of field observation, existing geological and hydrogeological information. Such information helps to identify the geology of classified layers and find possible aquifers. However, when this layer exists higher than the natural groundwater level, it cannot give any water. The next step is to examine whether the layer exists under the water table or not. The data collected in pre-survey assisted the estimation of the ground water level around the site. The map made by SRTM elevation data distributed by NASA and existing topographical map were utilized for the estimation of groundwater level. There are some areas which have saline groundwater, which affects the result of resistivity measurements and show relatively lower resistivity than as usual. The expert carefully treats the data in the area possibly affected by a saline layer, especially the Pegu formation.

(3) Survey Result

The results of the comprehensive analysis, including the determined well depths and the thickness of materials to be drilled through are tabulated in "Appendix 7. References". These tables have been prepared based on the VES analysis being combined with such information as:

* Estimated water level of each candidate village, which is derived from existing wells inside and/or within the vicinity of concerned village throughout the pre-survey period and being informed by the DDA Township offices thereafter.
* Topographic and geological features observed during the pre-survey
* Reference data and books collected, and their analysis results

The goal of this survey was to determine the specification and amount of equipment and material required for the well drilling at the target villages. For that purpose, it is necessary to understand the following natural conditions.

1) Well depth
2) Geological condition of drilling site
3) Groundwater level of drilling site

This information will be utilized for installing wells appropriately on the basis of estimation of production rate, water quality and aquifer depth and thickness. Methods of analysis and results are explained below for all items listed in "Appendix 7. References".

1) Well Depth

The well depth determination was made through several procedures in addition to the VES, such as by referring to information on the natural groundwater level of existing well locations (together with the static water level in the well), information of groundwater quality obtained throughout the pre-survey stage, by taking inspected topography/geology into consideration and by referring to the geological map and existing literatures on geology/hydrogeology. Above all, the thesis on hydrogeology of the Central Dry Zone published by Dr. L. W. Drury (1986) was especially helpful for us to understand the hydrogeological characteristics of the survey area in the short survey period.

The groundwater development at the 110 candidate villages in the Central Dry Zone is to be conducted mostly (84 %) in the areas of the Irrawaddy formations of the unconsolidated to semi-consolidated sedimentary beds, and partially (16 %) in the Pegu Formations of the sedimentary rocks. The classified apparent resistivity was interpreted hydrogeologically in a different way in each of the unconsolidated formations and rocky formations.

Decision of Well Depths in the Unconsolidated Formations

Based on the theory of ''the higher the resistivity, the higher potential of aquifer", the comparatively higher resistivity layer beneath the natural groundwater level was targeted. Well depths are 20 to 30 m below the deepest part of this high resistivity layer, in case of resistivity values over 30 Ω-m (mostly sandy bed). Here, 20 to 30 m includes a 5 to 15 m drawdown, length of the screen casing (3 to 6 m), length of the sand trap (4 to 5.5 m) and thickness of drill cuttings deposited at the drilled borehole (1 to 3 m).

In case that the targeted aquifer is a poor aquifer with lower resistivity than 15 Ω-m (mostly silty materials involving intercalated thin sandy beds), the additional drilling length to the top depth of the aquifer increases to the range of 80 to 100 m, considering the larger drawdown of over 20 m, and also considering that the larger number of screen casings must be discontinuously installed corresponding to the intercalated thin sandy beds.

Decision of Well Depths in the Rocky Formations

It is usually essential to target the "fissure water" in rocky formations (Pegu Formations). However, since the VES hardly detects the irregular and non-bedded fissure-rich portion of the rocks, differentiation of aquifer/aquitard needed to pay attention to another type of classification, namely, difference of rock type. The Pegu Formations consist mostly of alternation of sandstone and shale, therefore, the sandstone with higher permeability (higher resistivity) was regarded as the potential aquifer. The well depths were thus determined targeting the sandstone predominant portion beneath the natural groundwater level.

However, the accuracy of depth determination in the rocky formation is very poor, especially in the Pegu Formations. Because, the formations contain saline groundwater here and there resulting in much lower resistivity results than that of the primary resistivity value of the rocks. The apparent resistivity of the rocks is so small, meaning it would be difficult to distinguish between clay and silt.

Accordingly, differentiation of sandstone and shale was made in view of comparatively higher or lower resistivity. Whereas more or less 5 % error is common in depth determination by the VES, the well depths in the Pegu Formation were determined by adding 50 m to the depths of vague border of sandstone and shale, in addition to 20 m of drawdown and others. Expectation of encountering the fissure rich portion is also included in this additional 50 m.

The low apparent resistivity on the whole in the Pegu Formation does not always designate an entirely poor groundwater quality in the Pegu Formations. The wells possibly hit the fresh fissure water at some depths, occasionally. The low apparent resistivity at the deeper portion is probably caused by such characteristics of the electric current possibly flowing more in the very low resistivity zone than the ordinary resistivity zone. Due to this effect, underlying high resistivity materials sometimes show low resistivity. The very low resistivity zone at the shallow portion often affects the resistivity of deeper potion and the result of VES cannot distinguish good/poor water quality at depth, therefore, quality of groundwater is unknown before the drilling.

With regard to quantity of groundwater in rocky formations, high production is not usually expected, except when excellent fissure water is encountered. Drawdown in the well is thought to be large in rocky formations, therefore well depths were determined by adding 70 m to the top of potential aquifers. In cases where the aquifer thickness is less than 70 m, the well depth was determined as the bottom of the expected aquifer layer.

The total drilling length of all wells was calculated as 25,390 m, of them, the total number of deep wells (more than 300 m) was 23. The estimated number and depth of wells is shown in the following table.

Table 1-2: Estimated Number of Wells with Depth Rank (108 Wells)

Depth (m)	Mandalay	Magway	Sagain	Total
400	0	2	0	2
350 to 399	1	4	1	6
300 to 349	2	9	4	15
250 to 299	7	14	5	26
200 to 249	11	13	5	29
150 to 199	9	6	8	23
100 to 149	1	4	2	7
Total	31	52	25	108

As for the location of wells 300 m or deeper, most, 15 of 23, are located in Magway Region. Moreover, 13 of these are concentrated in Chauk Township. It obviously means the groundwater development in this area is very hard.

2) Geological Condition of Drilling Site

Lithology was estimated by the category of electric resistivity in the case of unconsolidated layer. On the other hand, the composition ratio was generally found to be 30 % soft rock and 70 % medium-hard rock. Tertiary deposits are usually categorized as medium-hard rocks, however, there are unconsolidated upper layers and folded fractured layers so that part of these deposits should be soft rock. The total drilling length is categorized by the type of soil and shown in the table below. The drilling length of unconsolidated layer is 21,415 m, and rock layer is 3,975 m.

Table 1-3: Drilling Length by Lithology

Lithology		Ratio (%)		Length of drilling (m)	
Unconsolidated Materials	Clayey/Silty	30.9	84.3	7,845	21,415
	Sandy	53.4		13,570	
Rocky Formation	Soft rock	4.7	15.7	1,190	3,975
	Medium-hard rock	11.0		2,785	
Total			100.0		25,390

3) Groundwater Level of Drilling Site

The natural groundwater level is almost impossible to be detected by the VES in both unconsolidated and rocky formations, therefore, the water level used to determine the well depths are estimated by referring to known water levels of existing wells collected during and after the pre-survey. If the existing wells are not near enough to the concerned village, the cross-section including the concerned village and one (1) or two (2) known well points is to be drawn to get the approximate water level of the concerned village, provided that the villages are located on the same geological formations of similar sedimentary environment. Some sample cross-sections are given below.

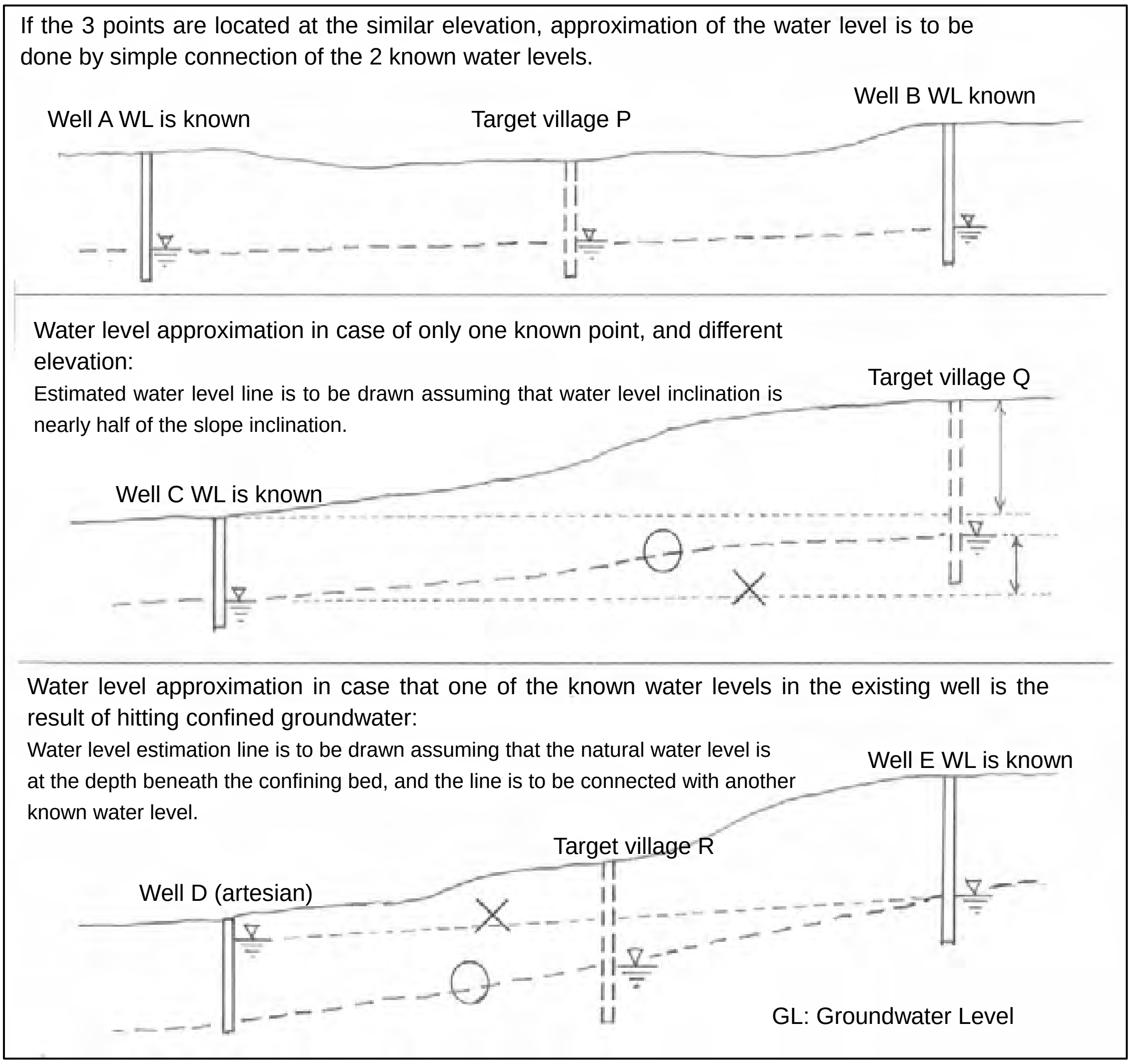


Figure 1-4: Groundwater Level Estimation Method in Cross-section

In areas where groundwater level is deep enough (over 200 m), water level is nearly the same even if the two points are a few kilometers apart, because, as a marine deposit, it has high continuity. On the contrary, if the water level is shallower than 100 m, accuracy of the water level approximation may be low, because the bed continuity is poor due to continental deposits. In case that the well to be used for estimation is located in a confined aquifer, as shown in one of the above drawings, the static water level in the well is not relevant in determining drilling depth. The natural water level of that point lies just beneath the confining bed, which must be 7 to 8 m above the bottom of the drilled borehole.

In the case of an artesian well, the groundwater level that appears after drilling must be higher than that of before drilling because of the pressure release. It is impossible to estimate the water level of artesian wells by physical survey.

The figure below gives a visual representation of static water level in a part of Chauk Township where the availability of well data is relatively high.

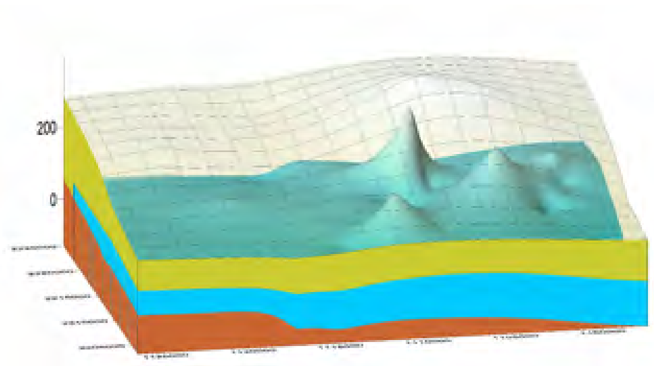


Figure 1-5: Static Water Level Described by Existing Well

The top surface with mesh shows the topography of the ground, and blue colored surface shows the static water level. The surface of static water level is not continuous and changes suddenly, so the water level cannot be estimated by interpolation or extrapolation method. For this reason, the water level estimated in this survey is not an artesian head even if the well could be artesian. However, the water level information of the well in same villages was put into the remarks of summary table as a reference.

4) Water Quality with Geology

As described above, Pegu Formation is known to contain groundwater with high salinity. The place where the Pegu Formation appears in the surface or exists beneath has high salinity, and sometimes chloride concentrations exceed 1,000 mg/L. Water containing 200 to 300 mg/L of chloride ions are considered to have a recognizable salty taste. While the groundwater in Pegu area is not suitable for drinking purposes according to the drinking water standard in Myanmar of 400 mg/L.

On the other hand, villagers sometimes report that the groundwater in Irrawaddy Formation is also “salty”. The survey team considered this a matter of importance because wells producing salty water are sometimes abandoned, therefore they investigated the groundwater quality in order to find a relationship between water quality and geology. The hydrogeologist of the survey team collected a total of 35 samples during the site survey. The analysis of these samples and those collected by the social survey team were outsourced. At the same time, the social survey team collected 73 samples for their purpose of water resource survey. In total, water quality data of 108 samples were obtained.

To overview the analysis results, the “salty” water did not necessarily have high chloride concentrations. The villagers are used to describing water with high concentrations of dissolved matter—which does have some taste—as “salty”.

Groundwater in very deep strata is generally considered to take a long time to be replenished, and tends to have high concentrations of dissolved ions. As for electric conductivity (EC)—an indicator of total dissolved materials—89 samples (82 %) are 500 µS/cm or higher, and 48 samples exceed 1,000 µS/cm. It seems very high considering usual tap water in Japan is soft water and only has an EC of 100 to 300 µS/cm. There are so many ‘very concentrated’ samples, however, only 11 of 108 samples have high concentrations of chloride exceeding the value of water quality standard such as 400 mg/L.

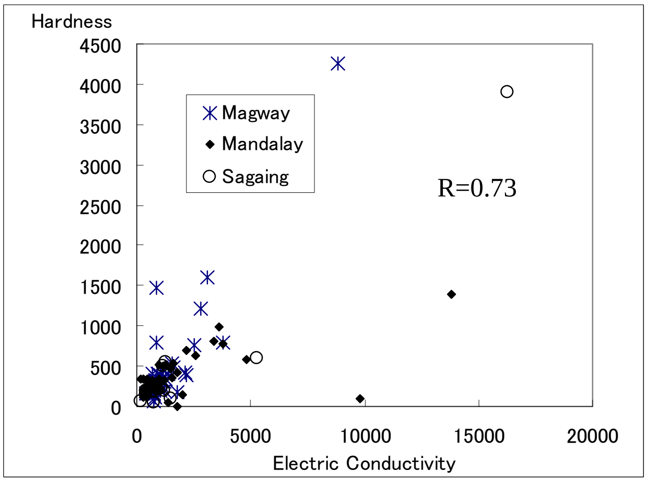


Figure 1-6: Relation between EC and Hardness

Table 1-4: Frequency Distribution of EC

Electric Conductivity	No. of Villages
<500	19
500 to 1,000	41
1000 to 5,000	43
5,000<	5
Total	108

The major components of groundwater are hardness, chloride ion, sulfate ion, etc. and the composition of dissolved ions varies with geological condition. The hardness and EC have a good correlation (correlation factor R=0.73), and the groundwater in this area has a relatively high concentration of hardness. Hardness is considered to have a noticeable taste if it is in the range of 100 to 300 mg/L. In the survey area, 53 samples (49 %) are 300 mg/L or more. Myanmar villagers are used to drinking rain water which contains only few dissolved materials, therefore, it is assumed they are sensitive to the taste of hard water. Hardness is a mixture of calcium salt and magnesium salt, and magnesium salt has a bitter taste at lower concentrations than calcium salt. There is a higher concentration of magnesium than calcium groundwater in the survey area. Such high concentrations of hardness are thought to be caused partly by Dolomite or other calcareous sediments in the Irrawaddy Formation, and the longer contact time of groundwater with sediments is expected to make denser dissolved materials.

High concentration of hardness affects not only the taste but also changes the color of boiled rice yellowish, forms deposits, commonly known as “scale”, and prevents foaming of soap. This survey also confirmed that salinity in the Pegu Formation is not the only problem facing groundwater development in the central dry zone.

The spatial distribution of water quality has not yet been clarified by this limited survey. Sometimes two very close water resources have vastly different water qualities. This may be caused by the difference of aquifer, but it cannot be confirmed because of poor existing information of developed aquifer for each well. It is recommended that DDA should collect information on the water quality of developed aquifers when DDA organizes a well inventory. The groundwater development will shift from quantity to quality in future, at that time, these inventory data of water quality will be very helpful when estimating the water quality for new well development. Besides, the information of water level change in the borehole during drilling is important, so daily drilling reports should be kept. In this survey, the explanations of the history of existing wells that the villagers provided were sometimes very useful and helpful to infer the underground conditions. Similarly, organized well inventory data will be even more helpful and important.

1-2-5 Water Quality (Result of Field Survey)

(1) Purpose of Survey

The purpose of the survey (Water quality analysis) was to determine the current water quality in the target 110 villages and simple examination and detailed water quality examination in Japan were conducted.

(2) Survey Method

At each survey village, after field observation and interview with villagers, water samples from two (2) main water sources of the village (the primary and the secondary) were systematically collected by social survey team leaders. The primary water source is more frequently used by residents rather than the secondary one.

The simple examination (pH, electrical conductivity, fluoride ion, nitrate ion, chloride ion and dissolved iron content) was conducted by the Japanese consultant. In parallel, laboratory analyses (pH, electrical conductivity, water color, turbidity, hardness, manganese, chlorine, iron, calcium and magnesium) were carried out in the Mandalay City Development Committee (MCDC) Water Quality Laboratory.

Because 29 water sources among the 110 survey villages were dried up, 190 water samples were collected finally (53 from Mandalay Region, 89 from Magway Region and 48 from Sagaing Region, respectively). Information of the water sources are summarized in “Appendix 7. References”. The water quality criterion was based on Proposed National Drinking Water Quality Standards, Myanmar 2006.

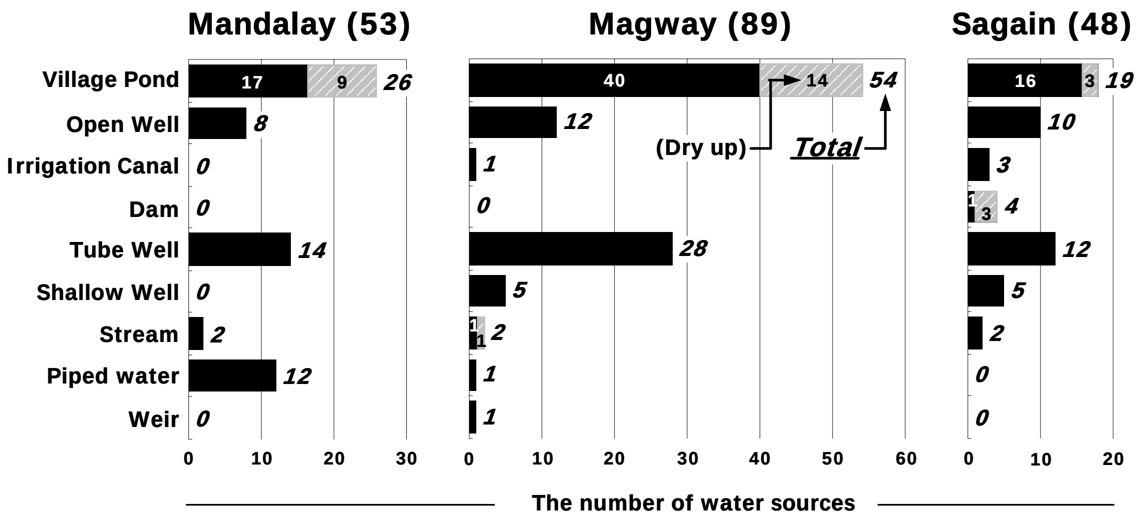


Figure 1-7: Number of Water Source Type

On the other hand, 26 water samples were transported to Japan to conduct thorough analyses. In the analyses, 18 elements (aluminum, arsenic, boron, cadmium, calcium, chromium, copper, fluoride, iron, lead, magnesium, manganese, nickel, phosphorus, potassium, selenium, sodium and zinc) and six ions (chloride, fluoride Ion, nitrite, nitrate, phosphate ion and sulfate ion) were executed.

In addition, 19 water samples among 62 deep wells which were drilled or repaired by the past technical cooperation projects were also sent to Japan to carry out the thorough analyses. These 19 wells were reported to exceed water quality criteria in the past. Sample collection method and analyses parameters were the same as mentioned above. All parameters and methods are digested in "Appendix 7. References".

(3) Survey Result

1) Propriety Decision for Potability

First, we focused three parameters, namely, turbidity, water color and electrical conductivity. In general, these parameters indicated total amount of insoluble components, dissolved organic materials and inorganic materials, respectively.

On the basis of Myanmar water quality standard 2006, only 14 water sources among the surveyed 190 sources were judged to be potable by the three parameters (Mandalay Region: 1 source, Magway Region: 8 sources, Sagaing Region: 5 sources). The 14 water sources also determined to be drinkable from the aspect of hazardous components such as arsenic and heavy metals.

Table 1-5: List of Potable Water Sources and Some Analytical Results

No.	Code	Priority	Source type	Turbidity (NTU)	Color (TCU)	EC (mS m^{-1})
	Mandalay region					
1	MA- 02	Primary	Piped water	1.07	3	39.8
	Magway region					
2	MG- 02	Secondary	Tubewell	1.11	8	19.22
3	MG- 04	Secondary	Tubewell	1.67	5	17.64
4	MG- 10	Secondary	Tubewell	4.03	10	17.59
5	MG- 17	Secondary	Tubewell	1.37	20	8.45
6	MG- 26	Secondary	Tubewell	1.31	5	22.2
7	MG- 28	Secondary	Tubewell	0.73	10	59.7
8	MG- 44	Primary	Tubewell	0.86	16	94.6
9	MG- 48	Primary	Tubewell	0.65	6	71.3
	Sagain region					
10	SA- 01	Secondary	Tubewell	2.02	7	106.8
11	SA- 02	Primary	Tubewell	1.02	20	49.5
12	SA- 07	Primary	Open well	1.34	8	92.5
13	SA- 10	Primary	Open well	1.67	3	97.8
14	SA- 11	Primary	Open well	1.83	5	112.4

2) General characteristics of water quality in the survey area

Water quality trends of non-potable sources in each region were analyzed by turbidity, water color and electric conductivity. The trends by cobweb chart are shown below.

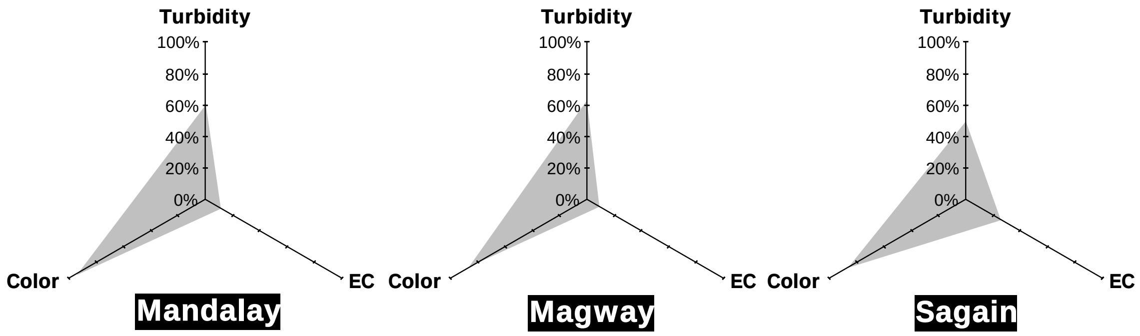


Figure 1-8: Ratio of Non-potable Water Source

As in the above figure, quite a few water sources were restricted mainly by standard values of water color. To investigate this trend further, histograms of each region are shown below.

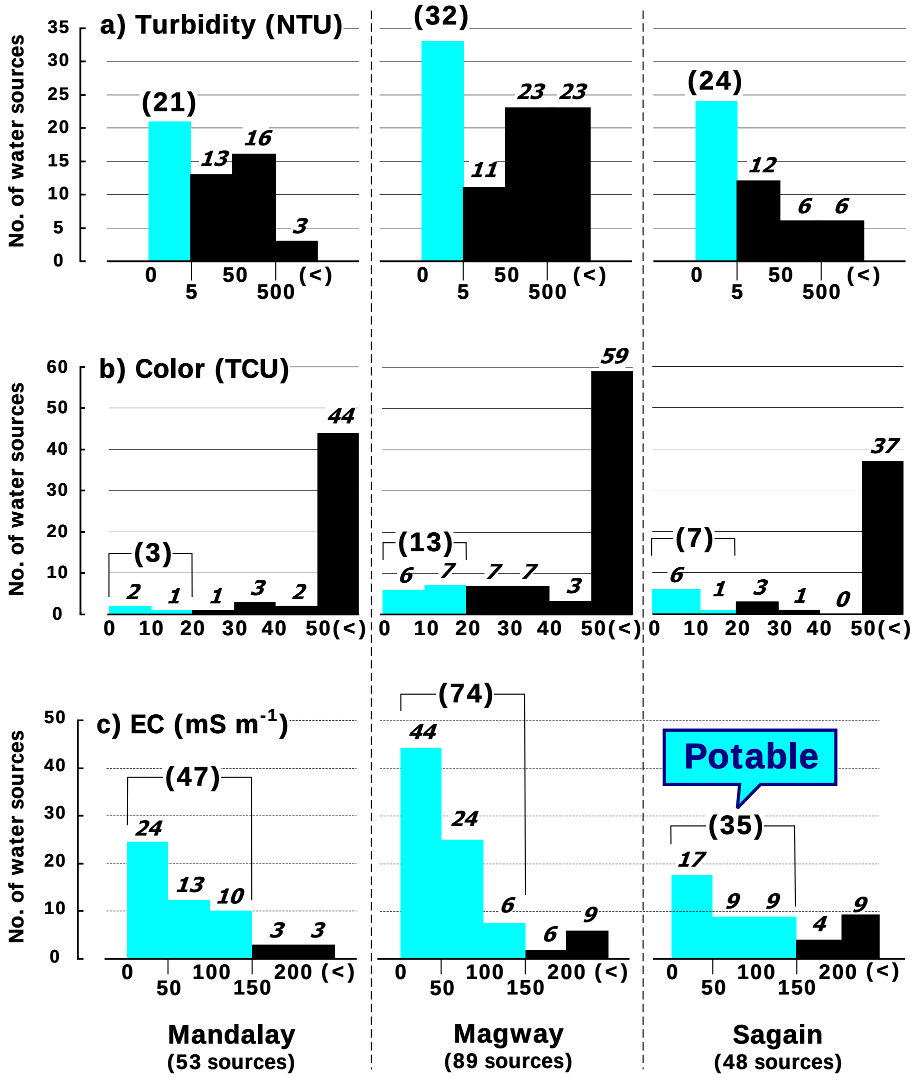


Figure 1-9: Histograms of Turbidity, Color and EC

Magway Region had more water sources which exceeded turbidity standard value (5 NTU) than other regions (a), most of them were village ponds. The results attributed that concentration of pond water was increased by the sunlight in the dry season (Cf. Photo).

a: relative clear pond, b: turbid (muddy) pond, c: dried up

Figure 1-10: Situation of Village Ponds

Meanwhile, pond water in Mandalay and Sagaing Regions were estimated to have already dried up completely at the survey period and not to reflect analytical results. Still more, water color (b) and electric conductivity (c) showed almost same trend among three (3) regions. Regarding electrical conductivity of Sagaing Region, however, about 27 % among total sources exceeded standard value (150 mS cm^{-1}). Because we could not find a clear correlation among the three (3) parameters, each parameter was considered to be independent.

As a factor affecting the increase of water color value, content of iron and aluminum are conjectured in addition to content of dissolved organic material. However, WHO Guidelines for Drinking Water Quality (3rd edition, 2004) do not mention guideline values for iron and aluminum, which means that water quality parameters of which the health effects cannot be confirmed are used to judge more than 90 % of water sources as non-potable in the survey area.

In order to effectively utilize precious drinking water resources in the central dry zone, review of the standard values and/or further spread of simple filtering system such as a pond sand filter will be necessary in near future.

3) Water Quality Examination in Japan

Twenty five (25) water samples selected from the survey villages to transport Japan to conduct thorough analyses. As a selection criterion of the test sample, we set 1) electric conductivity value exceed 150 mS cm^{-1} and 2) well water sample. Furthermore, we added an extra sample. When the social survey team visited Wet Let Township in Sagaing Region, medical doctor suggested dental fluorosis (teeth condition caused by a child receiving too much fluoride during tooth development) was apparent in the township. For that reason, we asked the survey team leader to collect a well water sample and analyzed it in Japan. Water samples to transport to Japan are summarized below.

Table 1-6: Transported Water Samples to Japan

Mandalay region (3 water sources)

Code	TownShip	Village / Town	Priority[1)]	Source[2)]	EC[3)]
MA - 27	Taung Tha	Kyaukpau	Sec.	TW	492
MA - 29	Taung Tha	Pudauksarkone	Sec.	OW	291
MA - 31	Yame Thin	Sargyin (S)	Prim.	OW	201

Magway region (14 water sources)

Code	TownShip	Village / Town	Priority	Source	EC
MG - 02	Chauk	Suetut	Sec.	TW	157
MG - 04	Chauk	Gwaypin (Ywama)	Sec.	TW	157
MG - 07	Chauk	Nayweltaw (W)	Sec.	TW	1398
MG - 14	Chauk	Sardaung (W)	Sec.	OW	1038
MG - 17	Chauk	Htansu Ywarma	Sec.	TW	159
MG - 19	Chauk	Taungthar (N)	Sec.	TW	275
MG - 20	Chauk	Thayetgone	Sec.	OW	342
MG - 24	Chauk	Konegyi	Sec.	OW	455
MG - 25	Chauk	Kaphyu	Sec.	OW	196
MG - 33	Nat Mauk	Oakpho	Prim.	OW	552
MG - 35	Nat Mauk	Kyaukpon	Sec.	TW	240
MG - 42	Myothit	Magyigon	Sec.	TW	162
MG - 46	Myothit	Bork	Sec.	TW	202
MG - 50	Sa Lin	Chaungyetet (N)	Sec.	OW	154

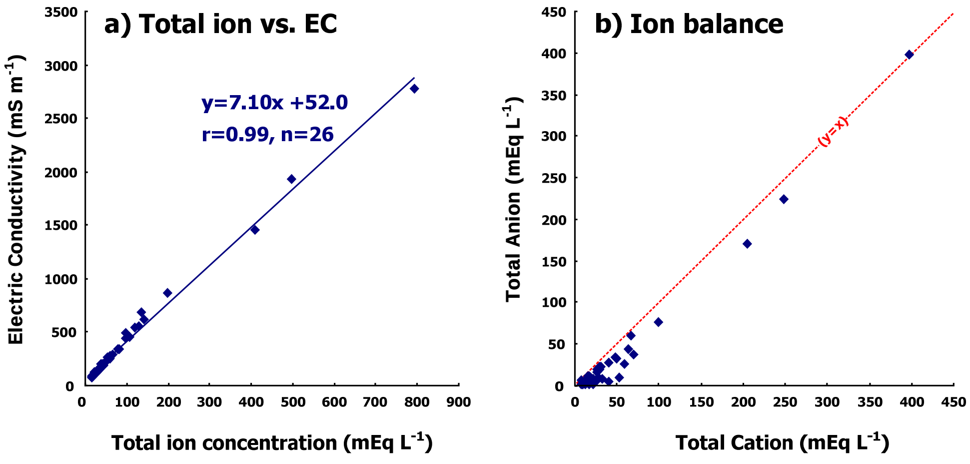
Sagain region (9 water sources)

Code	TownShip	Village / Town	Priority	Source	EC
SA - 04	Wet Let	Tamakan	Prim.	OW	268
SA - 05	Wet Let	Sahmon	Sec.	TW	753
SA - 07	Wet Let	Yonethar	Sec.	TW	205
SA - 09	Ayar Daw	Thanbayargyin	Prim.	TW	148
SA - 17	Yin Mar Pin	Myayeik	Sec.	OW	266
SA - 20	Sa Lin Gyi	Zedaw	Sec.	OW	273
SA - 21	Sa Lin Gyi	Pyawbwe	Prim.	OW	548
SA - 26	Mon Ywa	Neikbanwa	Sec.	TW	2710
(Extra[4)])	Wet Let	Wet Let	Prim.	TW	**87**

1) Prim.: Primary water source, Sec.: Secondary water source
2) TW: Tubewell (depth more than 100 feet & need mechanical/electrical power to extract water), OW: Open Well (open at the top and can get water by pulling up)
3) Electric conductivity, mS m^{-1}
4) Extra water sample collected from the village which some residents are affected fluorosis.

Analytical result: Ion balance

To understand the general trend of dissolved materials, ion balance was calculated from the analytical data set. Hydrogen ion (H^+) concentrations were derived from pH values. Concentrations of calcium ion (Ca^{2+}), magnesium ion (Mg^{2+}), potassium ion (K^+), sodium ion (Na^+) were calculated by Visual Minteq, geochemical code. Bicarbonate ion (HCO_3^-) concentrations were calculated from the alkalinity measured by MCDC, also confirmed by the calculated value from pH.



Total ion concentration: [Total cation] + [Total anion]
Total cation: [H^+] + [Ca^{2+}] + [Mg^{2+}] + [K^+] + [Na^+]
Total anion: [HCO_3^-] + [NO_3^-] + [NO_2^-] + [SO_4^{2-}] + [F^-] + [Cl^-]

Figure 1-11: Relationship between Ions and EC, Cations and Anions

It was so close relationship between the total amount of ions and electric conductivity (r=0.99), and confirmed that the conductance meter was detected by most of the dissolved components (a). The relationship between total anions and total cations (b), meanwhile, tended to be more generally cations than anions. This result suggested the presence of organic acid ions in the water and dissolved organic material contributed to high value of water color.

<u>Contents of Element and Anions</u>

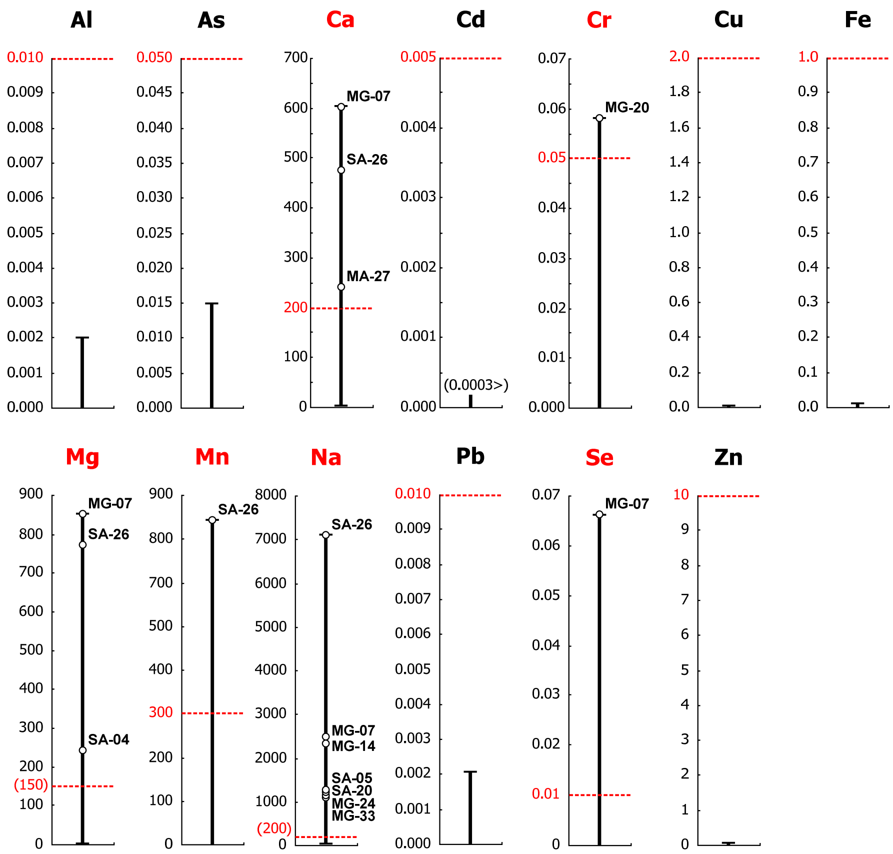
Among serious hazardous elements such as arsenic (As), cadmium (Cd), chromium (Cr), lead (Pb) and selenium (Se), Cr in Thayetgone Village (MG-20) and Se in Nayweltaw (W) Village (MG-7) exceeded the water quality criteria. Especially, Se was detected about 6.5 times as much as the criteria and it should be required to continue to monitor the water quality including the surrounding villages. In addition, element, derived from seawater in the geological age represented by sodium (Na), were detected in high concentrations in various points. These elements are supposed not to effect acute health hazard to the human body, but affect to residents lives in terms of water taste.

Some anions also exceeded the criteria values. Sulfate ion showed the most remarkable excess to the criteria, it was about 44 times in Neikbanwa Village (SA-26). This amount was far beyond sulfate ion content in standard seawater and should be considered as temporary or artificial contamination.

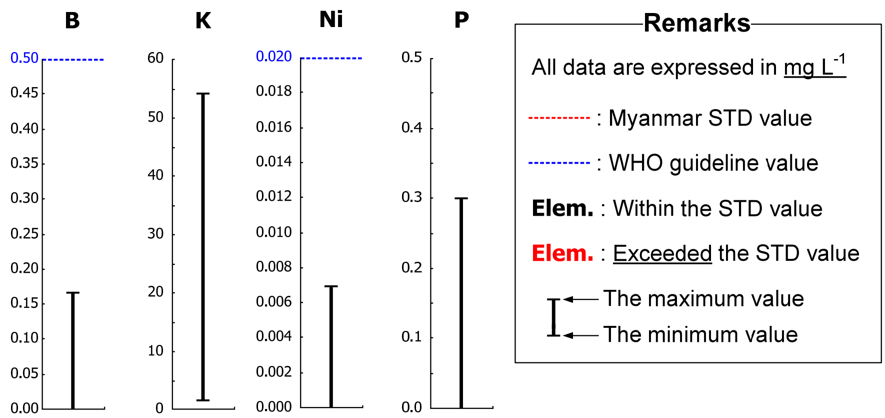
Fluoride ion (F^-) and nitrogen oxides ions (NO_2^- and NO_3^-), which were suggested groundwater contaminations in the central dry zone by the past project, also showed high concentrations sporadically this time. The maximum value of F^- was detected at Thayetgone Village (MG-20), it was about five times as much as the criterion. In addition, Wet Let Township sample which collected from the fluorosis suffering village was also detected more than four times as much as the criterion (“Extra” in the figure). It is a point to notice that the electric conductivity value was lower than other water sources (87 mS m^{-1}, the mean value among Sagaing Region sources was 177.8 mS m^{-1}). In this case, it seems difficult to point out the contamination unless fluoride analysis because other elements and anions did not exceed the criteria in this water source. Fluoride contamination in the central dry zone is highly recommended to keep watch not only from the viewpoint of natural origin but also possibility of artificial pollution. On the other hand, NO_2^- and NO_3^- exceeded the criteria at five water sources. Because there is concern that nitrogen oxides seriously affect infants, it should be kept under observation.

Chloride ion (Cl^-) was also higher than the criterion at many sources. It was considered to derive from seawater of geological age as ion-pair with Na^+.

a-1) Elements regulated by Myanmar STD



a-2) Elements data for reference purpose



b) Anion contents

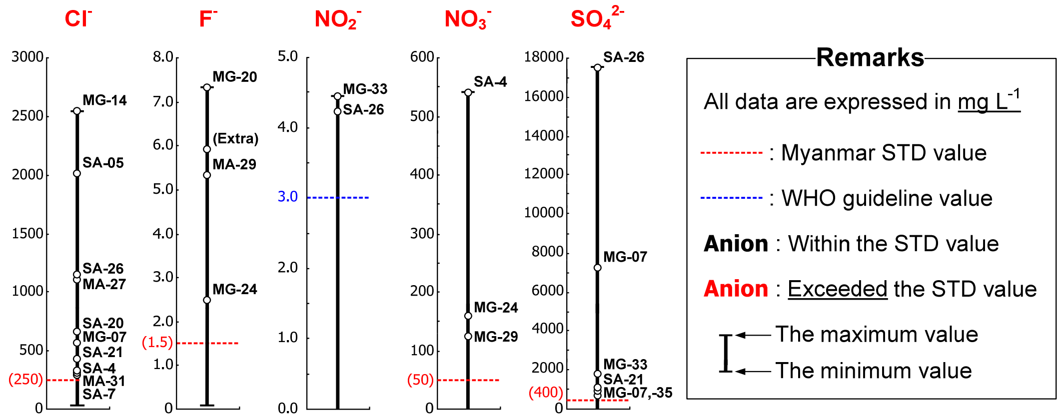


Figure 1-12: Contents of Elements and Anions in this Project

Re-examination of Well Water which was Drilled or Rehabilitated in the Past Project

Criteria-exceeded water sources which drilled or rehabilitated in the past project and analyses data at that time are shown below.

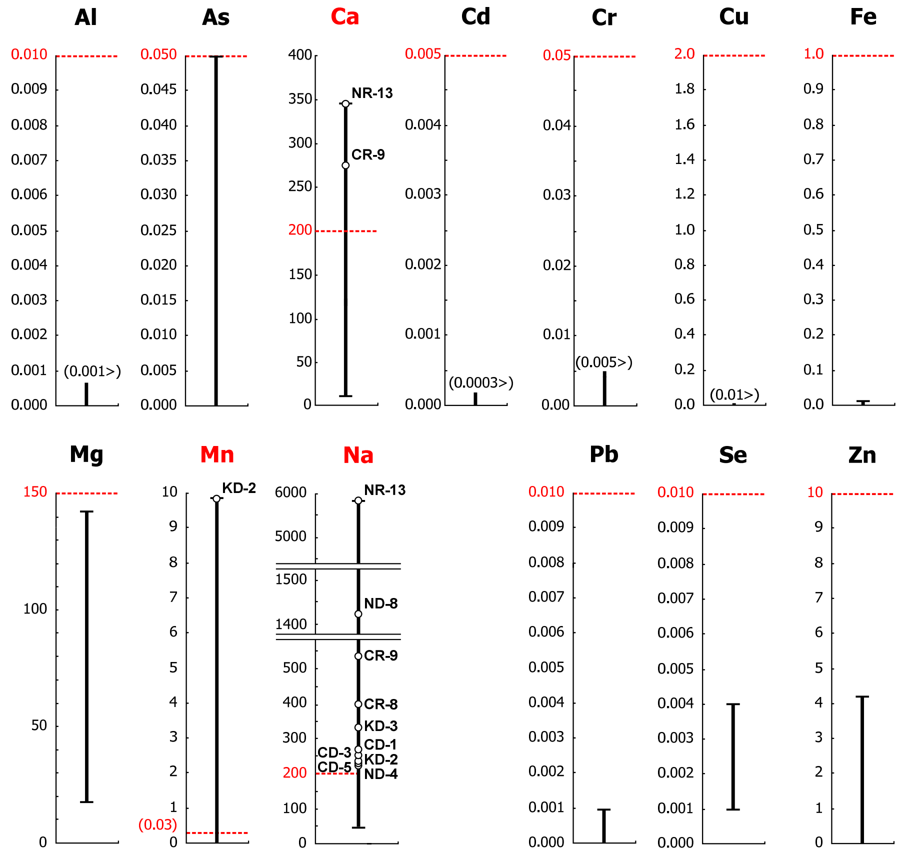
Table 1-7: Analyses Data of Well Water Quality Drilled / Rehabilitated in the Past Project

Code*	Village	pH	Hardness mg L-1	TDS mg L-1	Turbidity NTU	EC mS m-1	F (mg L-1)	NO_3 (mg L-1)	Fe (mg L-1)	As (mg L-1)	Cl (mg L-1)
ND−3	SipinThar	7.47	155	410	5	68.7	0.5	1.8	0.21	0	46
ND−4	Dann	7.54	285	560	5	94	0.81	0.9	0.59	0	35
ND−7	TheeDwin	7.57	270	700	5	117	1.13	0.11	0.16	0	145
ND−8	PhoNiKan	7.03	110	**2660**	5	445	**>1.5**	0.18	0.17	0	**310**
ND−9	Igyi	7.96	140	481	5	80.2	1.15	0.23	0.07	0	145
NR−2	SinLuAing	7.07	420	480	**150**	**480**	0	0.2	**5>**	0	21
NR−6	KvunKhainGvi	7.95	230	490	5	**490**	5	0.1	0.13	0	180
NR−8	Mvakan	8.29	130	830	5	**830**	5	0.34	0.21	0	140
NR−13	LetWe	7.09	**>500**	950	**60**	**950**	60	0.11	2.75	0	165
NR−18	Myaung	7.45	230	590	**60**	**590**	60	0.56	3.75	0	95
KD−2	Kanni(after)	7.3	**>500**	**1200**	**60**	**200**	1.17	0.3	0.39	0	71
KD−3	Ywaalu(before)	7.08	**>500**	**2190**	**200**	**365**	0	0.23	>5	0	140
KR−5	LaDaDVa(S)	8.44	340	790	10	**790**	10	0.2	0.42	0	98
CD−1	KoSu	7.52	280	**1060**	5	**178**	1	0.15	0.2	0	**295**
CD−3	SanSu(YwaMa)	7.65	225	850	10	142.8	1.11	0.5	0.07	0	**250**
CD−5	ThweNet(YwaThit)	7.7	175	747	5	124.5	1.19	0.34	0.06	0	185
CR−3	Thanbo(S)	7.69	215	530	5	**530**	5	0.4	0.02	0	**350**
CR−8	Sudaw	7.7	**>500**	**1890**	**40**	**1890**	0.36	0.04	4.5	0	**250**
CR−9	Gwaygyo	7.71	85	**1179**	**60**	**1179**	**1.5**	0.04	0.49	0	190

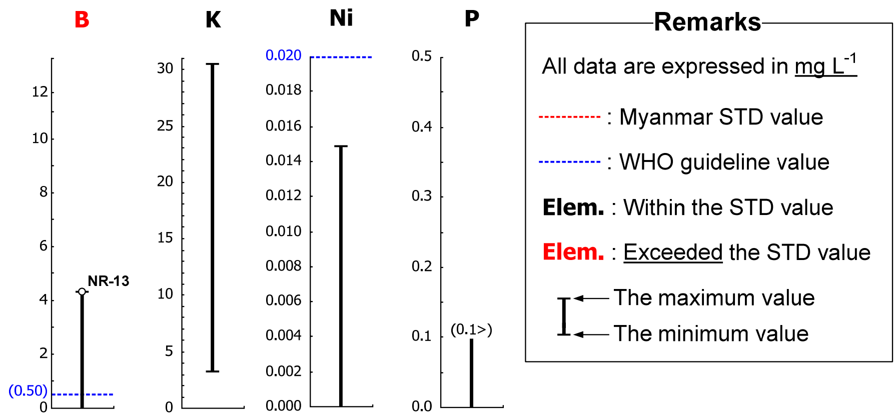
Thick figures indicate analytical values which exceed the Myanmar STD.
* ND- and NR-: Nyaung U, KD- and KR-: Kyaukpadung, CD- and CR-: Chauk

F^- was detected in high concentrations at Gwaygyo Village (CR-9) again and there was concern about its health effect on residents. Furthermore, NO_3^- was also determined high content at Sipin Thar Village (ND-3). At Let We Village (NR-13), NO_2^- concentrations exceeded the WHO guideline value for drinking water. It should be kept under observation because NO_2^- affects especially infants' health.

1) Elements regulated by Myanmar STD



2) Elements data for reference purpose



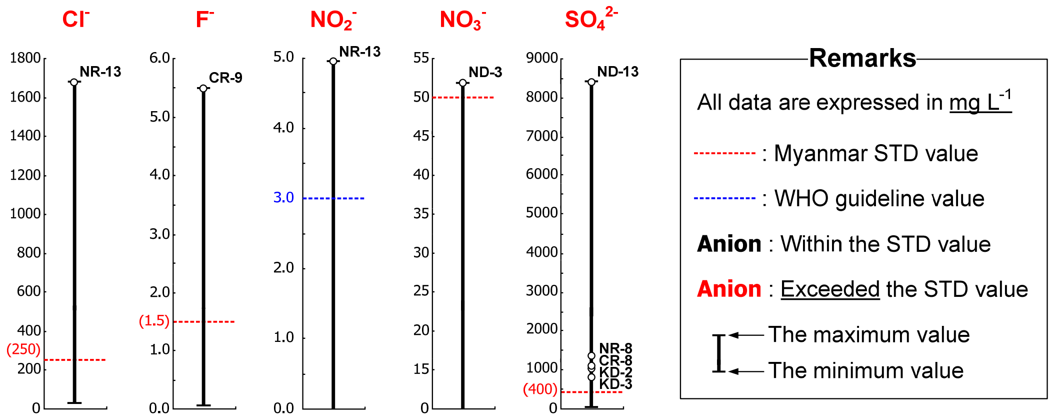


Figure 1-13: Contents of Elements and Anions in the Past Project

On the other hand, many dissolved materials were exceeded at Let We Village (NR-13). It was also estimated to derive from seawater of geological age because of high boron (B) concentration in addition to Na, Cl^- and SO_4^{2-}.

1-2-6 Social Condition (Result of Field Survey)

(1) Purpose of Survey

The purpose of the survey (Social survey) was mentioned below.

1) To obtain the basic data for the 110 selected villages, to be able to identify the characteristics of the project villages and the surrounding areas;
2) To obtain the information on socio-economic conditions in general, the current situation of water supply facilities and issues of usage/consumption/maintenance on water and other issues related to water at the village level and the household level in the selected villages, to provide the baseline data;
3) To obtain the information on the issues of water supply management (including deep tube wells, if any exist already) to identify the appropriate measures and roles of stakeholders (villagers, village water committees and DDA), so as to establish sustainable village water supply management system for long term.

(2) Survey Method

The Survey consisted of “village profile survey” and “household survey”. In addition, the village profile survey included “group interview with key informants” using pre-prepared and tested structured and “gender group interview” with semi-structured questionnaire.

1) Village Profile Survey

<u>Group Interview with Key Informants</u>

Group interview with key informants were carefully selected and invited to get quality responses for each item of the questionnaire. List of key informants and items of questionnaire targeted to each informant is described in the table below.

Table 1-8: List of Key Informants and Concerned Questionnaire Items

No.	Interviewee	Concerned questionnaire items
1	VPDC chairman (existing)	Location & Natural Environmental Conditions Basic Social and Economic Infrastructure Demographic Data
2	VPDC chairman (former)	
3	Village elders	
4	Village water committee members	Water Supply and Demand Water Supply Facilities and Management
5	Village school teacher	Education
6	Village health worker	Health & Sanitation Status
7	Village youth group members	Local organizations and Gender Issues
8	Village women group members	

<u>Gender Group Interview</u>

Gender group interview concerned with water related activities was also carried out. The key informants were divided into two (2) groups of men and women for gender analysis survey. Women groups were interviewed by a female team member and men groups were interviewed by a male team member in all the selected target villages for gender analysis.

Target villages for gender analysis were randomly selected with the basic of equal proportion from each region (eight (8) villages from each region). The main aim of the gender analysis survey is to analyze the in-depth gender perspectives on village's social and water related activities and directly utilize the results and outcomes for better gender focused project activities.

2) Household Survey

<u>Survey Items</u>

Household interviews were carried out in all 110 selected target villages of the Project. Each interviewer (survey team member) conducted a face-to-face interview with household leader or reliable person of the household at each randomly selected household of each targeted village. After the group interview, the team together with village chairman and village water committee members visited the existing village's water supply resources, such as village pond and existing tube well.

<u>Sample Size</u>

A stratified random sampling method was applied in the household survey. In each village, 15 households were targeted for the survey (a total of 1,650 households from 110 villages). As the families of different wealth classes have different situations in terms of economics and water related issues, the survey tried to get in-depth representative data from all wealth ranks of families. For that reason, within targeted 15 households, a proportionate stratification base on wealth classes (better off, middle and worse off) of village's households was also carried out as mentioned in sampling procedure.

Sampling Procedure

At each survey village, before starting the household survey, in discussion with village chairman and elders, the survey team first made a sketch map of the village showing the residential areas of different wealth classes. Then the team members randomly selected required number of households from each wealth class in accordance with prior calculation and entered for household interviews.

(3) Survey Result

1) Household Size

In all regions, the most usual household size is a medium one (having 5 to 8 family members) reaching almost 60 % of total 1,650 households surveyed. The second most common size is the small family size (with 1 to 4 members) occupying nearly 35 % of total survey households. Large families (with 9 to 12 members and more) are very rare in survey divisions resulting only less than 1 %.

2) Water Related Disease

As the survey area belongs to dry and drought environment, common water related diseases include diarrhea, dysentery, eye diseases, skin diseases, kidney diseases and intestinal diseases.

3) Existing Water Source

In the central dry zone, a variety of water supply facilities (water sources) were observed. Typical water resources in the target 110 villages are the traditional village pond, dug well, river and stream, piped water and tube well. It also reveals the seasonal change of water sources between the rainy and dry seasons in the village.

4) Average Water Consumption

There is no significant difference in seasonal changes of average water consumption by each wealth class. However, average water consumption in terms of different wealth class in all seasons is significantly different. In all survey divisions, average water consumption by “better off” and “medium” families are apparently higher than those of “worse off” families. In total of all regions, average water consumption by better off families is almost twice that of the worse off families.

5) Current Situation of Water Deficiency

In general, current water supply facilities cannot provide sufficient water both in terms of quantity and quality to the inhabitants in the all villages. The peak time of water deficiency is in the dry season, generally form March to May. The main problem is water deficiency in the dry season, meaning that the villagers cannot get enough water even though they have enough money to spend. Time for water fetching is the second most common problem as many of the surveyed households said they have to fetch water from water sources outside of their village in the dry season. Higher water cost is also a problem for those households who are in worse off class and having little income.

6) Water Related Household Expenditure

The water related household expenditure, such as buying water, renting a cart to fetch the water, or seeing doctor and buying medicine for treatment of water-related diseases, were examined in all survey villages. "Better off" households have less water related expenditure than those of "medium" and "worse off" families. On average, of all the survey villages of three divisions, "worse off" families have to spend highest portion, up to 9.4 % of their income for water and health. Also, for "worse off" families, in addition to their low income, their poor water storage facilities, poor transport options and more frequent health problems force them to spend a higher percentage of their income on water related issues.

Table 1-9: Ratio of Water Related Expenditure

Region	Better off	Medium	Worse off
Mandalay	3.5 %	8.0 %	9.2 %
Magway	5.0 %	10.3 %	10.1 %
Sagaing	2.5 %	9.6 %	9.0 %
Average	3.7 %	9.3 %	9.4 %

7) Workload for Fetching Water

<u>Mandalay Region</u>

In the rainy season, the average distance villagers need to go for fetching water is 0.6 km. The average time villagers need to spend for fetching water (for one trip including waiting time) is about 40 minutes. The most difficult village in terms of water availability is Pyinse (MA-24), where the average distance to an outside water source is 5.8 km from their homes. The village with easiest access to water source on average is Pudauksarkone (MA-29), only 0.1 km to water source and only two (2) minutes for one trip time.

On the other hand, in the dry season, most of the villages under survey have to depend on water sources outside of their village. The average distance villagers need to travel for fetching water (for one time) in the dry season is almost 1.1 km from their home. And the average time they need to spend for fetching water (for one trip including waiting time) is about 60 minutes. The village with the most hardship in terms of water availability is also Pyinse (MA-24), where the average distance to an outside water source is 8.8 km from their homes.

<u>Magway Region</u>

In the rainy season, the average distance villagers need to go for fetching water is 1.1 km. The average time villagers need to spend for fetching water (for one trip including waiting time) is about 60 minutes. The most difficult village in terms of water availability is Oakpho (MG-33), where the average distance to an outside water source is 3.2 km from their homes. The village with easiest access to water source on average Laytaisin (N) (MG-48), only 0.1 km to water source and 28 minutes for one trip time.

On the other hand, in the dry season, most of the villages under survey have to depend on water sources outside of their village. The average distance villagers need to travel for fetching water (for one time) in the dry season is almost 1.6 km from their home. And the average time they need to spend for fetching water (for one trip including waiting time) is about 90 minutes. The village with the most hardship in terms of water availability is Myaynelain (MG-08), where the average distance to an outside water source is 4.8 km from their homes.

Sagaing Region

In the rainy season, the average distance villagers need to go for fetching water is 1.2 km. The average time villagers need to spend for fetching water (for one trip including waiting time) is about 40 minutes. The most difficult village in terms of water availability is Nyaungpintar (SA-22), where the average distance to an outside water source is 8.8 km from their homes. The village with easiest access to water source on average is Sinzwel (N) (SA-19), only 0.1 km to water source and only 2 minutes for one trip time.

On the other hand, in the dry season, most of the villages under survey have to depend on water sources outside of their village. The average distance villagers need to travel for fetching water (for one time) in the dry season is almost 1.3 km from their home. And the average time they need to spend for fetching water (for one trip including waiting time) is about 50 minutes. The village with the most hardship in terms of water availability is Bawga (SA-27), where the average distance to an outside water source is 13.0 km from their homes.

8) Capability to Pay Water Fee for New Tube Well

Based on data collected from 15 randomly selected households in each survey village, the average water fee the villagers are capable and willing to pay by each wealth rank was summarized in the below table. The lowest expected water fee by the “worse off” group in total average is 23 Kyat per yoke (Approx. 46 L) and 81 Kyat per cart (Approx. 227 L). The highest one by the “better off” group in total average is 37 Kyat per yoke and 108 Kyat per cart.

Table 1-10: Water Fee Capable and Expected by Villagers to Pay from New Tube Well

Unit in Kyat

Region	Yoke			Cart		
	Better off	Medium	Worse off	Better off	Medium	Worse off
Mandalay	39	38	25	124	105	84
Magway	32	33	30	120	133	102
Sagaing	42	28	14	80	76	59
Average	37	33	23	108	104	81

9) Operation and Maintenance

Existing Village Water Management Organization

Briefly, out of 110 target villages, 52 villages have WMO or WMC. Of which 23 villages are specifically for tube well management, 20 villages are managing WSF other than tube well such as village pond, dug well, shallow well and pipe line. In the nine (9) villages, VPDC are taking control of WSF management other than tube wells in their respective villages.

Out of 31 villages with existing tube wells, 23 villages have community level tube well management organizations (17 VWC, four (4) independent cooperatives and two (2) private organizations). In the remaining eight (8) villages with existing tube wells, however, there is no definite WMO or WMC, tube wells are under management of individuals such as village leaders, village monks or individual owners.

Regular Maintenance

Almost all the village water management organizations or individuals, managing functioning tube wells are carrying out regular maintenance works with their own arrangement. The most common maintenance activity practiced was changing engine oil and the filter. However, the timing of regular maintenance differs from village to village due to different engine types, running hours, and different level of technical knowledge on regular maintenance. Other regular maintenance activities include checking water quality, water discharge rate and water depth. These regular maintenance activities are usually carried out by the member of water management organization or the assigned tube well operator. Cost for these activities, especially for engine oil and engine oil filters, are paid for by the daily water fee collected.

Water Fee Collection

Out of 31 villages with existing tube wells, 17 villages are collecting a certain amount of water fee at the time of survey to operate and maintain the wells. The lowest amount is 15 kyat for a yoke and 100 kyat for a cart. The highest amount of current water fee is 50 kyat for a yoke and 250 kyat for a cart. All the tube well management organizations set up the water fee by themselves, depending on cost calculations based on different water discharge rates, the capacity of the engine, fuel costs, remuneration for the operator and water fee collector, deposit for repairing the facility and so forth.

Experiences of Repair and Training

Major repair experiences of all villages with existing tube wells are: well repair, engine repair, pump repair, pipe drop/repair and clearing tube well for fill up with sand. As these repairs require professional know-how and access to get the necessary spare parts, village water management organizations or other groups managing the tube wells usually take assistance from outside sources for major repairs of their tube wells. Apart from local private donors and villagers themselves, the outside assistance organizations for major repairs of existing tube wells are DDA and BAJ. Out of 31 villages with existing functioning tube wells under the survey, only two (2) villages, shown in the table below, have received tube well operation and maintenance training. The organizations or government departments who have provided such training are ordinarily BAJ and DDA. In addition these trainings are relatively short-term and focused on operation and regular maintenance only.

1-3 Environmental and Social Consideration

The scope of drilling works by utilizing equipment to be procured in this Project is small work and equipment will be stored in DDA’s stockyard. Therefore, there is no environmental and social effect envisaged to the surrounding area. In addition, there is no institution of EIA (Environmental Impact Assessment) in the Union of Myanmar

Chapter 2 Contents of the Project

CHAPTER 2 CONTENTS OF THE PROJECT

2-1 Basic Concept of the Project

2-1-1 Overall Goal and Project Goal

The Government of Myanmar made improvement of the water supply situation a top priority. Subsequently, DDA formulated a Ten-year project, which aims at "developing at least one water resource in every village". Ten-year project had already been completed in March 2010, but the result is limited. From this perspective, DDA selected the villages that suffer from water shortages and formulated a Five-year project to complement the previous Ten-year project. DDA has set the objectives in the Five-year project to construct 826 deep wells. This Project is positioned as a subsidiary project for the specified 110 villages in the Five-year project in which improvement of the water supply situation is to be given top priority and immediate attention due to water shortage, poverty and so forth. This Project aims "to supply water through the entire year and elevate the living environment in the central dry zone" to achieve the DDA's overall goal at procurement of equipment and materials for groundwater development for 110 villages in the central dry zone and drilling new wells by DDA.

2-1-2 Outline of the Project

This Project aims at procurement of equipment and materials for groundwater development for 110 villages in the central dry zone, and implementation of technical assistance to develop the structure of DDA for water quality analysis to achieve the Project goal "to supply water through the entire year and elevate the living environment in the central dry zone". It is expected that the capability of deep well construction and structure of water quality analysis will be strengthened and the water supply situation in the central dry zone will be improved. Equipment and materials to be procured in this project consist of equipment for well drilling, equipment and materials for well construction, and equipment for water quality analysis.

2-2 Outline Design of the Japanese Assistance

2-2-1 Design Policy

2-2-1-1 Basic Policy

The basic policy items of the outline design of this Project are given below. Consideration was given to cost reduction when setting the scale and specifications of the equipment procurement project as appropriate to DDA.

(1) Of the equipment for well drilling and the equipment and the materials for well construction requested by the Government of Myanmar, the equipment which has been deemed appropriate

will be procured.

(2) Equipment will be procured for water quality analysis which is integral for DDA to move ahead with rural water supply planning.

(3) The technical assistance (soft component) will be implemented in order to strengthen the capability of operation and maintenance for the planned equipment procurement.

2-2-1-2 Policy on Natural Conditions

There are many unpaved roads in Myanmar, especially in the rural areas. The condition of those roads is worsened after rains, so the driving system is planned to be all-wheel-drive or four-wheel-drive. The central dry zone, which is the target area of the Project, is less than 1,000 m in altitude, therefore high altitude specifications shall not be applied for the equipment.

2-2-1-3 Policy on Socio-economic Conditions

In this Project, equipment procurement will be for well drilling and water quality analysis, and also well construction including submersible motor pumps and generators. After DDA drills wells and the water supply facilities are handed over to the villagers, the villagers shall operate and maintain them by themselves. Therefore, rigorous assessment was carried out of the villagers' capability to operate and maintain the facilities, and cover costs for payment. Based on this, the planned equipment and materials for the well construction are those which can be operated and maintained by the villagers without any difficulties.

2-2-1-4 Policy on Equipment Procurement

(1) Equipment Selection with a Well-organized Spare Parts Supply Structure

Equipment was selected by first confirming the existence of a structure for spare parts supply and choosing equipment that will be easy to maintain. In addition, a premise was established that after-sale service shall be available for the equipment through a local agent in Myanmar. Therefore, the manufacturers of the equipment in this project shall have local branches or local distribution agents, or have a local agent agreement in Myanmar.

(2) Policy on Country of Origin and Procurement Country

This Project is a grant aid project. Thus, in principal, the country in which the equipment will be procured shall be Japan or Myanmar. However, procurement in a third country was also examined to reduce project costs as well as in consideration of DDA's past record, the results of market research in Myanmar and the necessity of equipment specifications for precision.

(3) Policy on Lot Division

The equipment to be procured in this Project consists of a wide range of categories, from large drilling rigs, to construction materials such as casings and submersible motor pumps, which will require differing sources for procurement. Therefore, consideration was given to divide the equipment procurement into several lots.

2-2-1-5 Policy on Operation and Maintenance

The equipment to be procured in this Project shall be properly and sustainably operated and maintained by DDA. Therefore, equipment supported by local agents in Myanmar was selected so that the spare parts and after-sale service will be readily available. In addition, taking into consideration the sustainable operation and maintenance by the villagers, the equipment and materials for well construction which is supported by local agents in Myanmar were selected to ensure that spare parts supply and after-sale service are available as needed.

2-2-1-6 Policy on Equipment Grade

DDA has extensive experience using the type of equipment that will be procured in this Project. It was confirmed through a field survey that DDA staff has sufficient capability to operate and maintain the new equipment, and they were skilled in the field. However, it may be difficult for DDA staff to operate and maintain the equipment on their own if it is unnecessarily technologically advanced or requires too many electrical devices. Importantly, the equipment to be procured in this project shall be utilized throughout the country in the future, and at a high rate of frequency. Therefore, the specifications of the equipment were designed to be as simple as possible with the minimum use of highly technical, electric devices. In addition, taking into consideration the necessity for villagers to continue operation and maintenance, the equipment and materials for well construction, such as submersible motor pumps and generators, were designed to be as simple as possible with the minimum use of highly technical, electric devices.

2-2-1-7 Policy on Procurement Methods and Implementation Term

The new equipment in this Project shall be procured on the premise that Japanese companies will be selected through general competitive bidding based on the policy of Japanese Grant Aid. Regarding the schedule of the Project, the term of work was formulated considering the period of equipment manufacturing, transportation, training, equipment inspection and other procedures.

2-2-2 Basic Plan (Equipment Plan)

2-2-2-1 Overall Plan

(1) Request from the Government of Myanmar

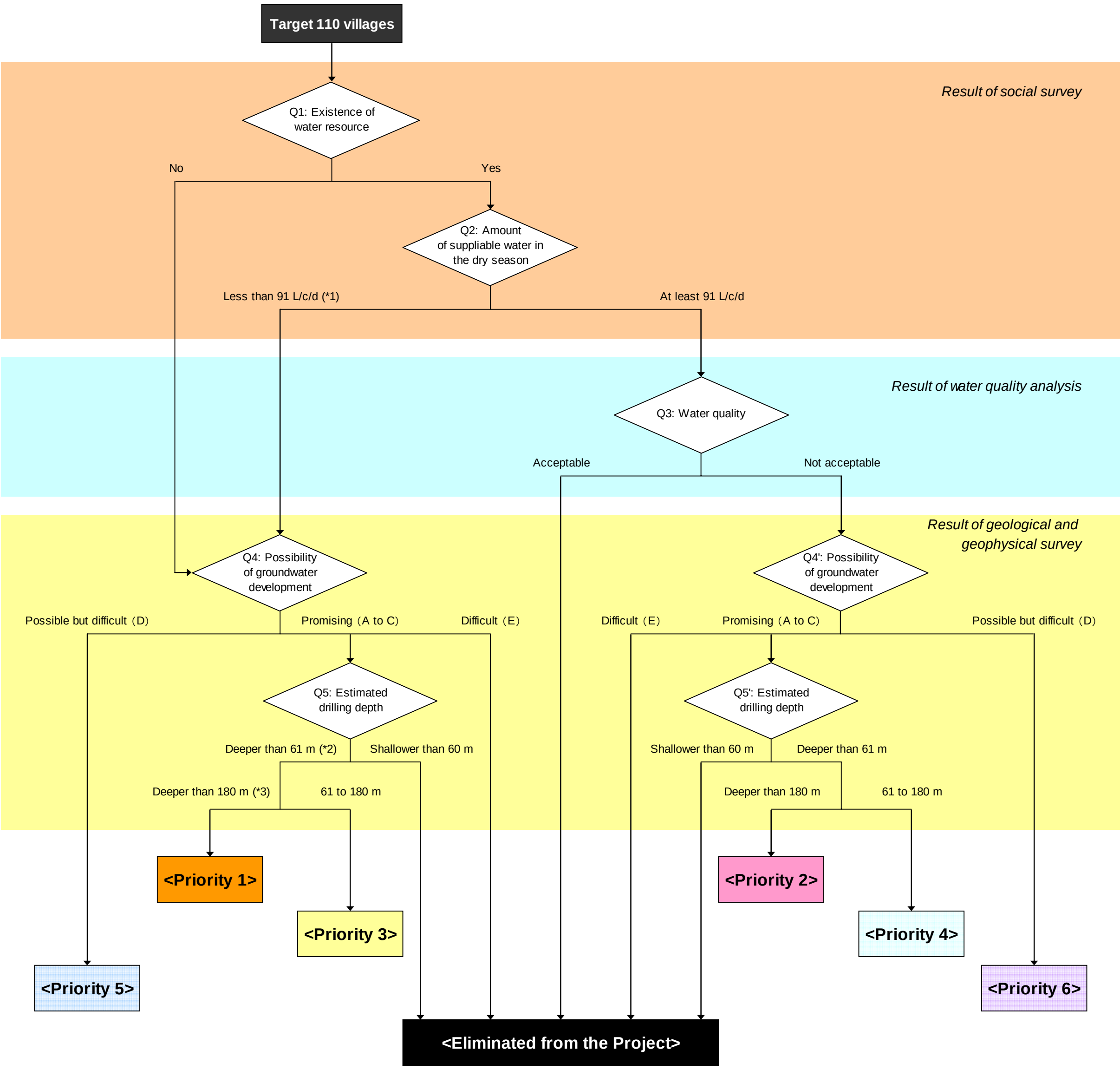
As stated in the previous chapter, this Project was implemented some time after the request from the Government of Myanmar. Therefore, the principal conditions had changed from the initial phase. Thus, it was investigated whether the equipment and target of 110 villages requested from DDA were appropriate for the Project.

Table 2-1: Equipment Requested from Myanmar at the Initial Phase

No.	Item	Q'ty
1	Drilling rig mounted on truck (for 500 m depth) and accessories	2 sets
2	Cargo truck with crane	2 units
3	Air compressor	1 unit
4	Pickup truck	2 units
5	Consumable goods for water well drilling	1 set
6	Casing and screen	for 110 villages
7	Submersible pump with generator and accessories	110 sets

(2) Inspection of the Target Villages

The objective of the Project is to procure the deep well drilling-related equipment for the 110 high-priority villages in the Five-year project. However, in the years since the request was made, the conditions of these 110 villages had changed. The Five-year project sets forth objectives for "at least one water resource in one village", "stable amount of water supply" and to "secure safe water quality". Therefore, the villages which have already satisfied the objectives of the Five-year project shall not be targeted in this Grant Aid Project. On the other hand, even though some villages were included in the 5 year project, it is likely that the water is still insufficient, with unsafe quality, and insufficient pumping capacity due to low water level and so on. DDA is unable to develop the groundwater in these villages where the natural conditions are prohibitive, and it is impossible to operate and maintain the water supply facilities sustainably. Therefore, the target villages in this Project were selected based on a comprehensive evaluation of both social and geophysical survey results to ensure project success. In addition, the main purpose is to select appropriate villages for the Project among the 110 villages based the evaluation results. In addition, DDA can also formulate an appropriate well drilling schedule by utilizing the results of this village evaluation. The following figure is a flowchart to evaluate the villages. The villages are evaluated according to the flowchart, and the results of the social and geophysical surveys.



*Note : *1 DDA recommends more than 91 L/c/d (20 gal/c/d) of water in rural area.*
**2 Deep well is defined as the well deeper than 61 m (200 feet).*
**3 The rigs DDA owns have capacity to drill down to 180 m, estimated from the study team.*

Figure 2-1: Flowchart to Determine the Priority of Target Villages

Q1: Existence of Water Resource in the Village (Result of Social Survey)

The results of the social survey revealed that each of the requested 110 villages has its own water resource. However, the Five-year project is not merely to provide "at least one water resource" in each village, it also includes objectives for a "stable amount of water supply" and to "secure safe water quality". Therefore, the second evaluation parameter concerning "the amount of supplied water in the dry season" was also confirmed in all villages since the water resources in the villages varied greatly, such as a deep well, shallow well, small reservoir and so on.

Table 2-2: Evaluation of Water Resource Existence in the Village

With water resource	Without water resource	Total
110 villages	None	110 villages
To evaluation Q2		***

Q2: Amount of Supplied Water in the Dry Season (Result of Social Survey)

The DDA recommendation for the amount of water to be supplied through an entire year in a rural area is 91 liters (or 20 imperial gallons) per capita per day (L/c/d). Therefore, the villages were evaluated based on whether the amount of water supplied is above the figure DDA recommends in the dry season when water shortages are most likely. The social survey found that 4 villages already have more than 91 L/c/d of water, and therefore, proceeded to the third step in the evaluation concerning "water quality". However, the other 106 villages which do not have enough water to meet the recommended figure were deemed viable for deep well drilling. Therefore, those 106 villages went to the fourth step and were inspected on the "possibility of groundwater development".

Table 2-3: Evaluation of the Amount of Supplied Water in the Dry Season

Less than 91 L/c/d	At least 91 L/c/d	Total
106 villages	4 villages	110 villages
To evaluation Q4	To evaluation Q3	***

Q3: Water Quality (Result of Water Quality Analysis)

None of the four (4) villages evaluated for sufficient "amount of supplied water in the dry season" met the criteria according to life affecting parameters; color, turbidity and electrical conductivity. Therefore, no villages were eliminated in this evaluation, and these 4 villages were inspected in the fourth evaluation concerning the "possibility of groundwater development". Furthermore, 190 samples were taken from the first and/or second water source in the 110 villages, but 176 (92.6 %) did not meet the water quality standard. 14 samples taken from the villages which have less than 91 L/c/d of water supply satisfied the water quality standard.

Table 2-4: Evaluation of Water Quality

Passed	Failed	Total
None	4 villages	4 villages
Eliminated from the Project	To evaluation Q4	***

Q4 and Q4': Possibility of Groundwater Development (Result of Hydrogeological and Geophysical Survey)

The 110 villages in this stage shall be categorized according to the following standards based on specific resistance from the results of geophysical survey, water level and the results of water quality analysis from available documents.

<u>Evaluation of the aquifer</u>

A (Excellent): The village has a potential aquifer of unconsolidated layer and high permeability (50 Ωm<).

B (Good): The village has an aquifer of unconsolidated layer and comparatively high permeability (50 Ωm>, >30), or
The village has an aquifer of more than 50 Ωm specific resistance, but is likely affected by rock.

C (Possible): The village may have bedrock fissure water.
The village has an aquifer of unconsolidated layer and comparatively low permeability (30 Ωm>, >10).

D (Difficult): The village has an aquifer of unconsolidated layer and low permeability (10 Ωm>).

E (Eliminated): The village with difficulties to develop groundwater based on past results, where a shallow well may be applicable.

<u>Evaluation of the groundwater level</u>

D (Difficult): The village's aquifer was categorized A, B or C (see above), but it is deemed difficult to develop the groundwater due to a water level deeper than 300 m.

<u>Evaluation of water quality</u>

D (Difficult): The village aquifer was categorized A, B or C (see above), but the water quality may be poor, especially concentration of salt.

The following table shows the evaluation results of the 110 villages. There were two (2) villages in which it may be almost impossible to develop the groundwater, so they were eliminated from the target villages in the Project. In addition, these two (2) villages were already evaluated in the stage of the field survey, and DDA has given its approval.

Table 2-5: Evaluation of the Possibility of Groundwater Development

Q4: Possibility of groundwater development (Villages with less than 91 L/c/d of supplied water)					
A	B	C	D	E	Total
29 villages	22 villages	34 villages	19 villages	2 villages	106 villages
To evaluation Q5				Eliminated	***

Q4': Possibility of groundwater development (Villages with more than 91 L/c/d of supplied water)					
A	B	C	D	E	Total
1 village	1 village	None	2 villages	None	4 villages
To evaluation Q5				Eliminated	***

Q5 and Q5': Drilling Depth (Results of Hydrogeological and Geophysical Survey)

This aim of this Project is to procure equipment for deep well construction. Since DDA defines deep wells as those at least 61 m deep, villages which require wells that are shallower than 61 m will not necessarily be included in the Project. On the other hand, as mentioned above, DDA drilling rigs are capable of drilling up to 180 m deep, and thus, villages which require wells drilled deeper than 180 m shall be given high priority in the Project. Based on these figures, each village was evaluated and its priority in this Project was examined.

Table 2-6: Estimation of the Drilling Depth

	Q5: Estimated drilling depth (Villages with less than 91 L/c/d of supplied water)				Evaluation
	A	B	C	Total	
Deeper than 180 m	1 village	None	None	1 village	Priority 2
61 to 180 m	None	1 village	None	1 village	Priority 4
Shallower than 61 m	None	None	None	None	Eliminated
Total	1 village	1 village	None	2 villages	***

	Q5: Estimated drilling depth		Evaluation
	D	Total	
Deeper than 180 m	15 villages	15 villages	Priority 5
61 to 180 m	4 villages	4 villages	
Shallower than 61 m	None	None	Eliminated
Total	19 villages	19 villages	***

	Q5': Estimated drilling depth (villages with at least 91 L/c/d of supplied water)				Evaluation
	A	B	C	Total	
Deeper than 180 m	21 villages	17 villages	27 villages	65 villages	Priority 1
61 to 180 m	8 villages	5 villages	7 villages	20 villages	Priority 3
Shallower than 61 m	None	None	None	None	Eliminated
Total	29 villages	22 villages	34 villages	85 villages	***

	Q5': Estimated drilling depth		Evaluation
	D	Total	
Deeper than 180 m	1 village	1 village	Priority 6
61 to 180 m	1 village	1 village	
Shallower than 61 m	None	None	Eliminated
Total	2 villages	2 villages	***

The following table shows the result of the final evaluation of the target 110 villages.

Table 2-7: Final Evaluation of the Target 110 Villages

Priority	No. of village	Estimated drilling depth
Priority 1	65 villages	Deeper than 180 m
Priority 2	1 village	Deeper than 180 m
Priority 3	20 villages	61 to 180 m
Priority 4	1 village	61 to 180 m
Priority 5	19 villages	Deeper than 180 m
Priority 6	2 villages	61 to 180 m
Eliminated	2 villages	***
Total	110 villages	***

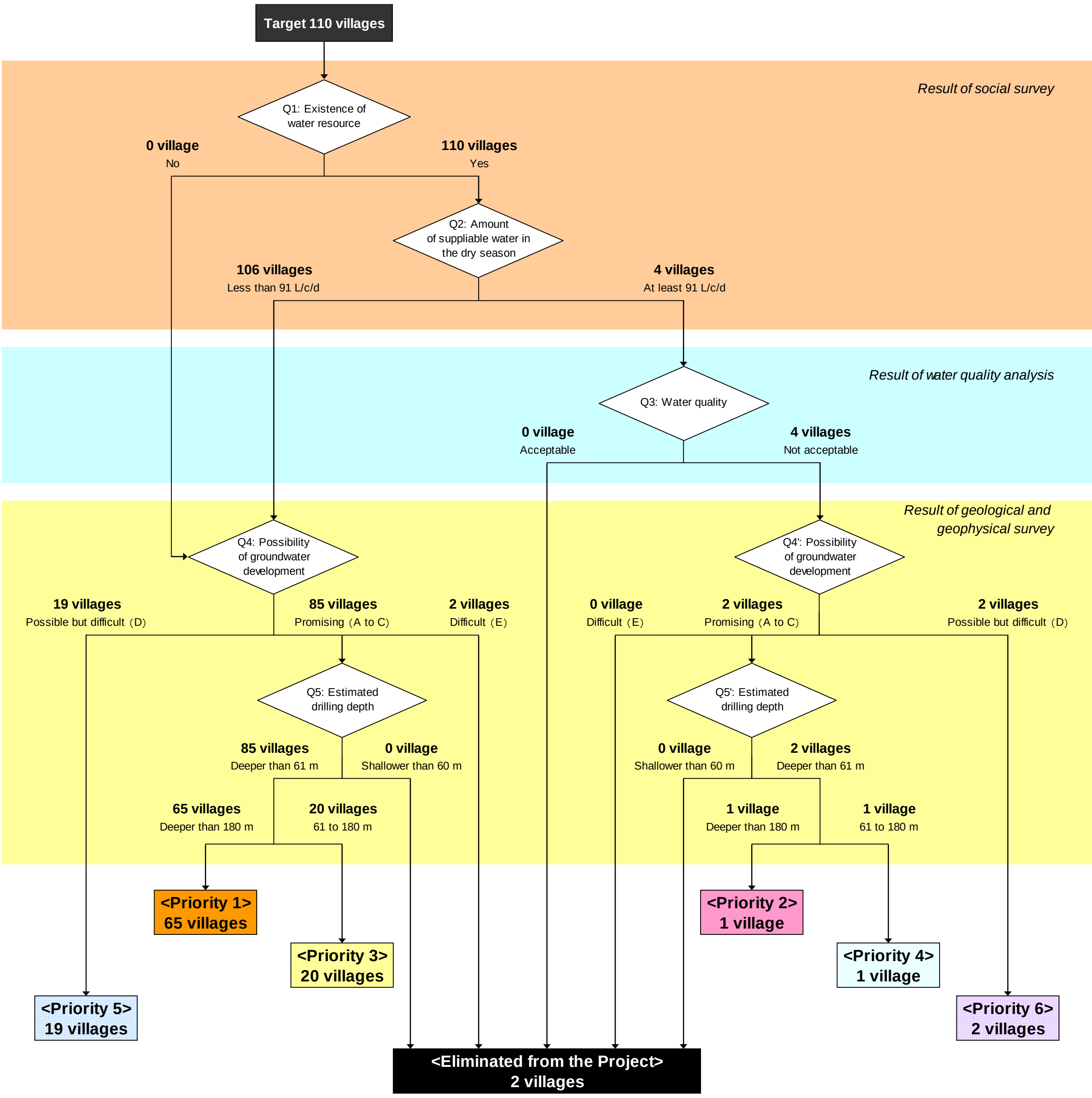


Figure 2-2: Final Evaluation of the Target 110 Villages

Q6: Final Evaluation (Selection of the Target Villages)

Up to the final evaluation, there were 21 villages categorized as Priority 5 and 6, where the possibility to develop the groundwater may be quite low due to the small amount of intake from a thin aquifer, the possibility of poor water quality (high saline content), and low effectiveness for a water supply facility because of a low water level. In these cases, it is preferable and effective from both economic and technical perspectives to depend on hand-made shallow wells or surface water. Under those circumstances, it is impossible to guarantee that DDA would definitely drill the wells in these 21 villages, or that the facilities would be correctly and sustainably utilized by the villagers. Thus, only those villages in which it can be guaranteed that well drilling will be implemented by DDA and the facilities will be utilized sustainably are targeted in this Project; that is, the 87 villages categorized as Priority 1, 2, 3 and 4.

Table 2-8: Target Villages in the Project

Priority	No. of target village	Estimated drilling depth
Priority 1	65 villages	Deeper than 181 m
Priority 2	1 village	Deeper than 181 m
Priority 3	20 villages	61 to 180 m
Priority 4	1 village	61 to 180 m
Total	87 villages	***

(3) Necessity of Pick-up Truck Procurement

The Government of Myanmar requested pick-up trucks be procured for the Project for the purpose of operation, maintenance and monitoring which requires travel. However, two (2) pick-up trucks were procured for DDA during a technical cooperation project implemented in 2009 and those vehicles can be used for this purpose, so there is little need to procure vehicles in this Project. Therefore, the pick-up trucks will not be procured in this Project.

(4) Procurement of Equipment for Water Quality Analysis

The field survey revealed that the structure for water quality analysis in DDA was fragile and the condition of the equipment had deteriorated. It is essential for the project to strengthen the structure of water quality analysis in DDA. In addition, it is necessary to procure equipment for water quality analysis to contribute toward the supply of “safe drinking water” as outlined in the Millennium Development Goals (hereinafter referred to as “MDGs”).

(5) Contents of the Project

The Project targets 87 villages and will procure the following equipment which was judged as necessary.

Table 2-9: Equipment List

Category	No.	Item	Q'ty
A. Equipment for Well Drilling	A-1	Drilling rig mounted on truck	
	A-1-1	400 m deep drilling	1 unit
	A-1-2	300 m deep drilling	1 unit
	A-2	Drilling agent (Bentonite and CMC)	1 set
	A-3	Equipment for air lift pumping and pumping test	1 set
	A-4	Air compressor	1 unit
	A-5	Cargo truck with crane	2 units
B. Equipment and Materials for Well Construction	B-1	Casing pipe for deep well (for 87 wells)	
	B-1-1	4 inch	3,250 units
	B-1-2	10 inch	350 units
	B-2	Screen pipe and bottom plug (for 87 wells)	
	B-2-1	Screen pipe	170 units
	B-2-2	Bottom plug	95 units
	B-3	Submersible motor pump and diesel engine generator (for 87 villages)	
	B-3-1	TDH 300 m	9 sets
	B-3-2	TDH 250 m	18 sets
	B-3-3	TDH 200 m	22 sets
	B-3-4	TDH 150 m	31 sets
	B-3-5	TDH 100 m	7 sets
C. Equipment for Water Quality Analysis	C-1	Spectrophotometer	1 unit
	C-2	Water still	1 unit

2-2-2-2 Equipment Plan

A. Equipment for Well Drilling

A-1: Drilling Rig Mounted on Truck

(1) Necessity of Procurement

DDA has nine (9) truck-mounted drilling rigs procured in previous Japanese projects. They have drilled 414 deep wells since the drilling performance records were first kept in 2002.

Table 2-10: Drilling Rigs Owned by DDA

No.	Model number
001	TOP-300 (Repaired TRD-300 by JICA technical cooperation project)
002	TOP-300 (Repaired TRD-300 by JICA development study project)
003	TOP-300 (Repaired TRD-300 by JICA development study project)
004	TOP-300 (Repaired TRD-300 by JICA development study project)
005	TOP-300 (Repaired TRD-300 by JICA technical cooperation project)
006	TRD-300
007	TOP-300
008	TOP-300
009	TOP-500 (Under repair)

Table 2-11: Actual Number of Deep Wells Drilled by DDA

No.	Number of wells drilled per fiscal year by each drilling rig								
	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	Total
001					7	7	6	6	26
002	7	6	8	7	6	6	7	5	52
003	9	8	7	7	9	8	10	6	64
004	9	7	8	7	8				39
005					8	5	6	6	25
006	4	5	5	6	6	7	6	5	44
007	10	12	l2	10	12	10	11	6	83
008	10	12	l2	10	12	10	10	5	81
009	n.a.								***
Total	49	50	52	47	68	53	56	39	414

Nevertheless, some of these drilling rigs have been in use for more than 20 years, and the engines (the heart of a drilling rig) and hydraulic systems have lost significant capacity due to wear over time, regardless of repairs. Therefore, it is estimated that even heavy-duty drilling rigs with a drilling capacity of 250 to 300 m are currently able to drill only around 180 m in depth. However, 66 of the 87 target villages require wells to be drilled at a depth deeper than 180 m, so it would not be feasible to develop the groundwater in those villages with the existing drilling rigs.

Meanwhile, DDA is capable of developing groundwater on their own, having organized a drilling team of 5 to 8 members so far. In addition, DDA will form two more drilling teams with eight (8) members each for this Project. Most of them participated in the Japanese technical cooperation project implemented in 2009 and have technical capabilities and experience in groundwater development.

Table 2-12: Members of DDA's New Drilling Teams

New drilling team 1			New drilling team 2		
No.	Title	Experience of TC*	No.	Title	Experience of TC
1	Engineer (Magway Region)	3 years	1	Engineer (Headquarters)	3 years
2	Associate engineer	3 years	2	Associate engineer	3 years
3	Associate engineer	3 years	3	Chief driller	None
4	Associate engineer	3 years	4	Junior engineer	3 years
5	Driller	3 years	5	Driller	3 years
6	Driller	3 years	6	Driller	3 years
7	Driller	3 years	7	Driller	3 years
8	Driller	None	8	Driller	None

*TC: Technical Cooperation implemented by JICA

At present, it would be difficult to complete the Five-year project given the condition of the current equipment, but the number of personnel required to achieve the goal has been met. Therefore, with the apparent need to procure new water well drilling rigs, the request is seen to be highly valid.

(2) Quantity of Equipment to be Procured

Based on the past drilling performance of DDA, the number of wells drilled annually is around 8 to 10. Therefore, even if only one drilling rig is procured, it would allow only 50 wells to be drilled (10 wells/year × 5 years) and the Five-year project could not be completed. Thus, two (2) drilling rigs for deep groundwater development with the capacity of 181 to 400 m will be required.

(3) Drilling Depth and Applied Method

In this Project, two (2) geological formations have been identified from the results of geophysical survey and existing documents study, classified as an unconsolidated/partially consolidated Ayeyarwaddy layer (87.5 %), and a Pegu layer (12.5 %) of rock. The following table shows the length to be drilled for each.

Table 2-13: Geological Formation Ratio and Length to be Drilled

Classification		Ratio (%)		Length to be drilled (m)	
Ayeyarwaddy layer	Clay/Silt soil	28.8	87.5	5,665	17,225
	Sandy soil	58.7		11,560	
Pegu layer	Soft rock	4.2	12.5	830	2.455
	Medium/Hard rock	8.3		1,625	
Total		***	100.0	***	19,680

Also, the maximum depth of the well to be drilled is 350 m (4 wells), with an average well depth estimated at 226 m.

Table 2-14: Prediction of the Drilling Depth

Depth to be drilled (m)	Q'ty
400	0
350 to 399	4
300 to 349	10
250 to 299	21
200 to 249	27
150 to 199	18
100 to 149	7
Total	87

DDA employs the Down The Hole hammer drilling method (hereinafter referred to as "DTH") in some parts of the mountainous area in Shan State, but most of the other areas have been developed using the Mud Rotary drilling method. In this Project, Mud Rotary will be employed since the survey results show that the target area consists mostly of an unconsolidated layer where super-hard rock is not expected, and in consideration for DDA staff's desire to learn drilling methods. Using this method, a well is drilled by applying rotational force and pressure to the edge of the bit through the drill strings, and circulating fluid (water or mud) is carried by the water pump to cool the bit and remove the drilling sludge. Therefore, for this method, a rotation device, pressurization device, hoisting device and water pump are required. The method is generally used in well drilling since it can be applied in a wide range of geological circumstances. However, this method is not ideal when drilling through layers where it is difficult to circulate water or with high swelling properties because the mud shall be carefully controlled depending on the geological layer.

(4) Specifications

1) Drilling Rig

Priority will be given to the maximum weight of the drill strings and casing pipes and the capacity of drilling fluid, which are technical components used to select the specifications of the drilling rig.

The weight of drill strings and casing pipes is related to the capacity of pull-down and draw-works of the drilling rig, and the capacity of drilling fluid is related to the discharge volume and pressure for column pore pressure of the mud pump to discharge slime (drilling slurry). These are estimated from the casing program and drilling schedule, formulated from the prediction of hydrogeology which is based on the result of the geological survey. The following figure shows the casing program and drilling schedule planned for this Project.

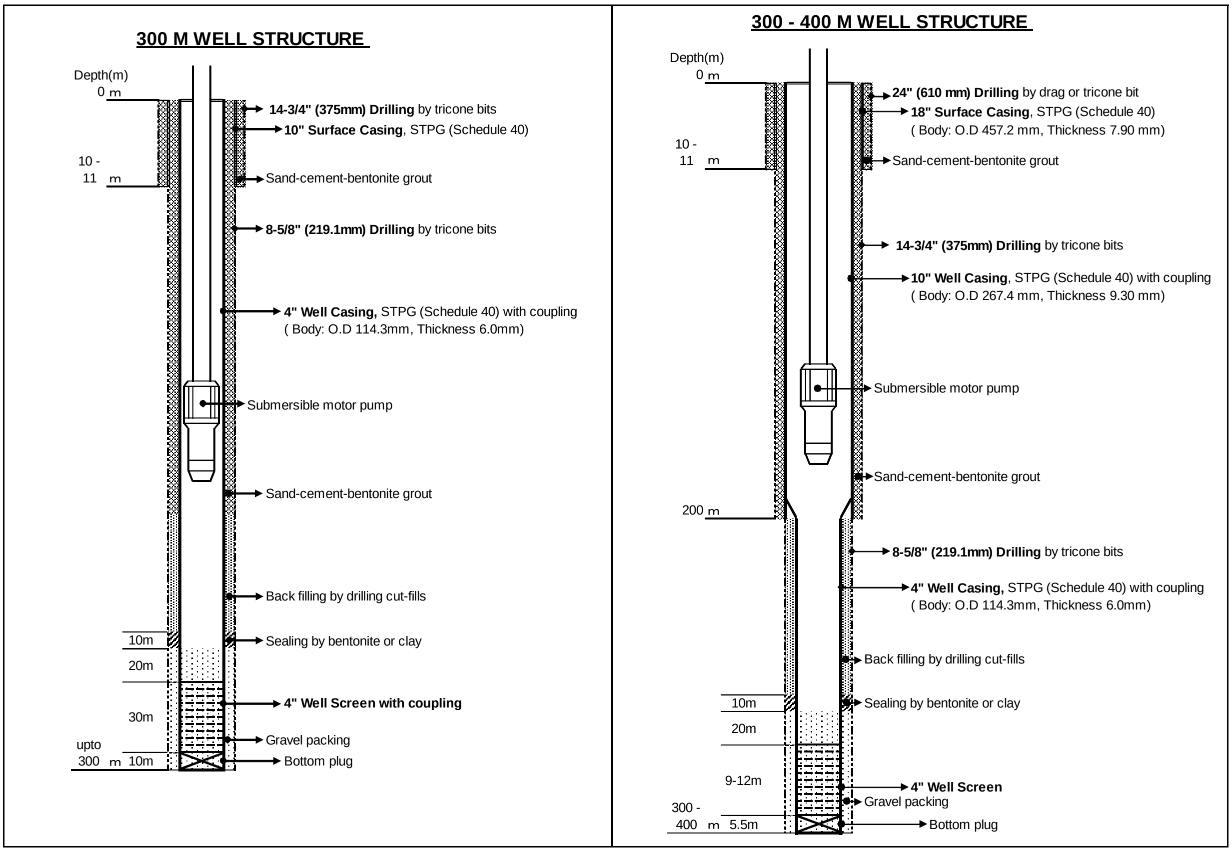


Figure 2-3: Casing Program and Drilling Schedule

The maximum weight of drill strings for a 400 m deep borehole is estimated to be approximately 14,000 to 16,000 kg. The 10 inch casing pipes weigh around 12,000 kg at 200 m, and the 4 inch casing pipes are around 6,500 kg at 400 m, so the maximum weight is estimated to be around 16,000 kg to drill 400 m deep. Similarly, the maximum weight to drill 300 m deep is estimated around 9,000 kg. Also, the capacity of drilling fluid required was estimated from the minimum ascending speed necessary to discharge the slime with 8 % bentonite. It is estimated that the minimum ascending speed is 20 cm/s if the slime has a particle diameter of 5 m/m, and 25 cm/s if the slime is 10 m/m. In addition, the minimum flow rate of the fluid shall be around 1,200 to 1,500 L/min with 4-1/2 inch drill pipes if the maximum pore diameter drilled is 14-3/4 inch.

From this, when selecting the drilling rigs, the border depth should be 300 m and the flow rate should be 1,200 L/min. Based on these figures, two (2) types of drilling rigs will be selected with a drilling capacity of 300 m and 400 m, respectively, and each depth shall be drilled with 4-1/2 inch drill pipe. Both drilling rigs will have expansive work areas and, therefore, shall be truck mounted rigs

(6×6 or 6×4). Also, it is not necessary to specify altitude restrictions since the target area in this Project is less than 1,000 m. The following tables show the outline specifications of two (2) types of drilling rigs with capacity of 400 m and 300 m deep, respectively.

Table 2-15: Outline Specifications of Drilling Rig for 400 m deep

Item	Specifications
Drilling capacity	The rig shall be capable to drill down to 400 m depth with minimum 4-1/2” outer diameter drill pipes (the borehole diameter is 14-3/4”).
Hold-back	At least 25,000 kg
Draw-works	At least 8,000 kg with single line
Mud pump	At least 1,500 L/min discharging rate
Truck	6×4 or 6×6, left-hand drive

Table 2-16: Outline Specifications of Drilling Rig for 300 m deep

Item	Specifications
Drilling capacity	The rig shall be capable to drill down to 300 m depth with minimum 4-1/2” outer diameter drill pipes (the borehole diameter is 10-5/8”).
Hold-back	At least 14,000 kg
Draw-works	At least 6,000 kg with single line
Mud pump	At least 1,200 L/min discharging rate
Truck	6×4 or 6×6, left-hand drive

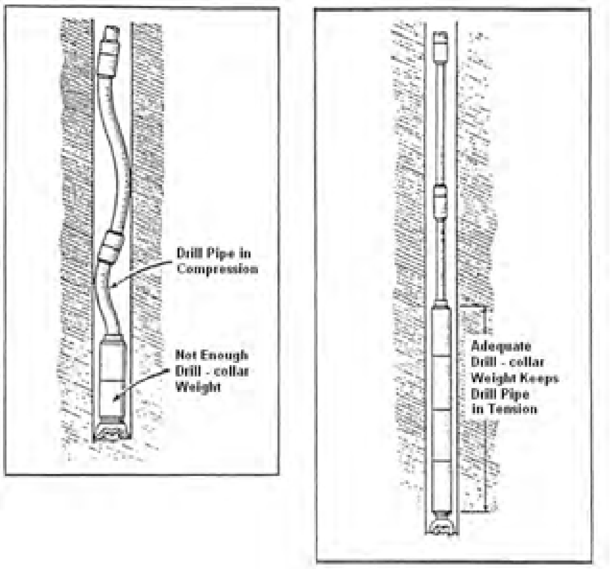
2) Drill strings

<u>Drill Pipes</u>

Well drilling generally uses 2-7/8, 3-1/2 and 4-1/2 inch outer diameter drill pipes. In this Project, considering the relation between the annular velocity for slime removal and the mountable mud pump on the truck, the drill pipes shall be at least 4-1/2 inch outer diameter, and for drilling efficiency, the length shall be 6 m.

<u>Drill Collar</u>

A drill pipe is structurally sound to withstand tension, but it is considerably vulnerable to compression and impact. Therefore, a drill collar shall be procured to keep the drill pipes in tension (hoisted by the rig) and to maintain safe conditions, avoiding drill pipe compression.



Source: Instruction book of well drilling techniques, Department of Well Drilling, Japan Petroleum Exploration Co., Ltd.

Figure 2-4: Drill Pipe and Drill Collar

In turn, the load of the rock bit (hereinafter referred to as "tricone bit") depends on the type of bit; insert bits should be 1,800 to 2,700 kg, and tooth bits should be 1,800 to 4,000 kg. Thus, the total weight of the drill collar requires 1,800 to 4,000 kg. Both insert and tooth-type tricone bits are selected in this Project, as stated below, so the weight of the drill collar was selected to be capable for the size and weight of both tricone bit types.

Table 2-17: Outline Specification of Drill Collar

Item	Specifications
Weight of drill collar	Around 160 kg/m
Size	6-3/4 inch
Unit length	6 m

<u>Tricone Bit</u>

Based on the geological formation survey results, the total length of drilling in the 87 villages is estimated to be 19,680 m. Given the past drilling performance of DDA, the estimated consumption rate of tricone bits for medium-hard to hard rock is around 150 m per unit, which results in an outstanding number of 130 tricone bits. In comparison, according to the "Reference book for standard unit requirement on well construction and workover (pp. 85)", the consumption rate for medium-hard rock formations with 10-5/8 inch is 0.043 unit per meter, which comes to the huge number of 850 bits. As this shows, the lifespan of tricone bits depends on the geological formation, rock phase and conditions of use (bit load, number of rotations and amount of mud circulated), but generally the duration of tooth and bearing is short in hard geological formations and long in soft geological formations. From a technical point of view on boring techniques, the lifespan of an insert-type bit with a super hard chip installed is around 4 to 15 times more than a steel tooth bit. Also, the sealed bearing used in an insert bit can generally be used longer than that of an open roller bearing used in a steel tooth bit. Finally, considering the technical points stated above, it was judged that the bit type should be selected with a focus on insert-type bits with tooth application for soft to hard geological formations using sealed bearing or sealed journal bearing. The tooth-type insert bit was selected based on the code of International Association of Drilling Contractors (hereinafter referred to as "IADC") for sandy soil, unconsolidated layer, soft rock and medium-hard rock. Also, the sealed journal bearing was adopted. Finally, the consumption rate was set at 450 m per unit, that is, three times DDA's past performance of 150 m. The steel tooth type of tricone bit was adopted for clay and silt layer, and its tooth type was selected from IADC code for soft-medium geological formation. The bearing will be an open roller bearing, and to calculate the quantity, the consumption rate was set at 150 m per unit. Also, a drag bit with tungsten carbide metal chip was adopted for drilling the surface soil layer, and its consumption rate was set at 150 m, the same as the steel tooth type.

The following tables show the number of tricone bits calculated from the predicted geological survey and casing program. The total number of bits is 63 for the total drilling length of 19,680 m in the 87 villages.

Table 2-18: Number of Bits for Drilling Down to 300 m

Geological layer / Rock phase							
Surface soil		Clay / Silt		Sand		Soft / Medium hard rock	
Bit type / Size							
14-3/4 inch		8-5/8 inch					
Drag bit		IADC211		IADC537		IADC617	
Drilling length (m)	Bit Q'ty (unit)	Drilling length (m)	Bit Q'ty (unit)	Drilling length (m)	Bit Q'ty (unit)	Drilling length (m)	Bit Q'ty (unit)
780	6	4,385	30	9,940	14	1,595	3

Table 2-19: Number of Bits for Drilling Down to 400 m

Geological layer / Rock phase							
Surface soil		Clay / Silt		Sand		Soft / Medium hard rock	
Bit type / Size							
24 inch		14-3/4 inch					
Drag bit		IADC211		IADC537		IADC617	
Drilling length (m)	Bit Q'ty (unit)	Drilling length (m)	Bit Q'ty (unit)	Drilling length (m)	Bit Q'ty (unit)	Drilling length (m)	Bit Q'ty (unit)
90	1	430	3	870	2	410	1
		8-5/8 inch					
		IADC211		IADC537		IADC617	
		Drilling length (m)	Bit Q'ty (unit)	Drilling length (m)	Bit Q'ty (unit)	Drilling length (m)	Bit Q'ty (unit)
		100	1	650	1	430	1

<u>Bit Stabilizer</u>

Due to the drill collar diameter being smaller than the bit diameter, if too much overload is applied, the drill pipes buckle and the borehole will inevitably become inflected. An inflected borehole will not only affect progress of the drilling schedule, but could cause accidents such as collapse of the borehole wall in some cases. Therefore, it is important to install a wing bit stabilizer that corresponds with the bit diameter between drill collars so that the drill strings are set at the center of the borehole. Bit stabilizers sized 8-5/8 and 14-3/4 inches placed at every 100 m pitch are planned.

Sub Adapters

The screws for the drill pipe, drill collar, stabilizers and bits are based on American Petroleum Institute (hereinafter referred to as "API") standards, varying in type and size. Therefore, sub connectors are required to connect these drill strings and for protection and attrition of the screws of drill strings. A bit sub to connect the bit and the drill collar, and a crossover sub to connect the drill collar and drill pipe or bit stabilizer will be selected.

A-2: Drilling Agent (Bentonite and CMC)

(1) Necessity of Procurement

"Mud" is synonymous with drilling fluid used in the mud circulation method. The main function and requirements of the mud are outlined below.

Main Function of the Mud

i. To wash the drill bit and remove cuttings from the bottom of the hole
ii. To deliver the cuttings to the surface, and keep cuttings suspended in the mud so it doesn't settle if circulation stops
iii. To control the pressure of gas, oil, water and underground fluids, and avoid blowouts
iv. To stabilize the borehole by making thin, strong and impervious mud walls
v. To cool down and lubricate the bit and drill strings
vi. To transmit information about the inside of the borehole to the surface, which is used to evaluate the geological layer

Main Requirements of the Mud

i. A good balance is maintained between the specific weight of the mud and pressure of the geological layer
ii. Rheologic conditions (fluidity) shall be good
iii. Excellent in preventing sludge and corruption of the geological layer
iv. High resistance to contamination from salt, cement and so on
v. Easily separate cuttings and gravel on the surface
vi. Low cost for making and conditioning the mud
vii. Biodegradable and nontoxic

For drilling mud, DDA has used mountain clay produced locally. The physical and chemical properties of the mountain clay have not been analyzed; however, it is unlikely that the clay is effective as drilling fluid. The reason for this presumption is that, looking at DDA's past performance, a great deal of circulation has been lost due to corruption of the borehole wall, especially when drilling deeper than 200 m. Based on that situation, it is likely that the specific weight of the mud using mountain clay is not balanced with the pressure of the geological layer, which results in poor protection of the geological layer and formation of a borehole wall. It takes at least a couple of weeks or, in some cases, several months to recover from lost circulation, and can therefore cause serious delay in the drilling schedule. If the borehole can not be recovered and the drill strings must be abandoned underground, then it is not only a serious delay of the drilling schedule, but DDA also suffers from the loss of valuable materials. For these reasons, technical requirements call for the procurement of appropriate material for mud.

(2) Quantity of Equipment to be Procured and Specifications

In order to supply stable mud, it is important to limit the use of quality bentonite as much as possible so the mud maintains all of its functions. If a large amount of bentonite is added, it would worsen the drilling rate and be difficult to control the rheology since it increases gelation due to the viscosity from salts and high temperatures. In principle, a small amount of good quality bentonite is used. Also, both bentonite and CMC have no environmental impact at all. The mud in this Project shall have an 8 % water-bentonite ratio, generally used for drilling in alluvial formation, and 0.1 % CMC mixed in, which controls fluid loss. The quantity was decided from the aggregate drilling diameter and length.

Table 2-20: Quantity of Mud Consumed in Wells Deeper than 300 m (for 400 m Drilling)

9 wells	Total length of drilling: 2,980 m			
Contents	Drilling depth	Drilling length (m)	Q'ty of mud (m^3/m)	Sub total of mud (m^3)
24 inch drilling	0 to 10 m	90	0.778	70.02
14-3/4 inch drilling	10 to 200 m	1,710	0.111	189.81
8-5/8 inch drilling	200 m to bottom	1,180	0.038	44.84
Total quantity of mud (m^3)				304.67
8 % bentonite mud	Bentonite	8 %	24,373.6	30 ton
	CMC	0.10 %	304.67	350 kg

Table 2-21: Quantity of Mud Consumed in Wells Deeper than 300 m (for 300 m Drilling)

78 wells	Total length of drilling: 16,700 m			
Contents	Drilling depth	Drilling length (m)	Q'ty of mud (m^3/m)	Sub total of mud (m^3)
24 inch drilling	***	***	0.778	***
14-3/4 inch drilling	0 to 10 m	780	0.111	86.58
8-5/8" inch drilling	10 m to bottom	15,920	0.038	604.96
Total quantity of mud (m^3)				691.54
8 % bentonite mud	Bentonite	8 %	5,532.3	60 ton
	CMC	0.10 %	691.54	750 kg

A-3: Equipment for Air Lift Pumping and Pumping Test

(1) Necessity of Procurement

This equipment is used to implement the pumping test and borehole washing after well drilling, and the installation of casing pipes and screen pipes. After well washing is completed by air lift pumping, a pumping test which consists of a step drawdown test, a constant discharge test, and a recovery test—is implemented using a submersible motor pump with a capacity of 1.2 to 1.5 times the likely permanently-installed pump. Then, the permanently-installed pump will be decided based on the result of the test. However, the amount of water to be pumped is already set based on the recommended water quantity in rural areas (100 to 120 L/min) by DDA, and the pumping head is also set beforehand based on the water level prediction from the geophysical survey in this Project. Therefore, it is not necessary to implement the pumping test to inspect the capacity of the aquifer and select the pump that will be permanently installed, and thus equipment for the pumping test, such as submersible motor pump and generator, are not required in this Project.

On the other hand, the current pumping test implemented by DDA is subject to the following procedure:

a) Drilling waste (slime) at the bottom of the well is cleaned up by a bailer after the casing pipes and screen pipes are installed and gravel is filled in.
b) When drawing up the bailer, surging will occur around the screen pipes to allow the gravel to be screened (alignment will depend on the size) so that the groundwater can easily enter into the well.
c) By repeating the procedures above, clean water is sent and circulated with the pump on the rig after cleaning the bottom, and then well washing is continued.
d) After this procedure, watching the water level on the ground level, an air pipe is inserted into the well and air lift is implemented. The amount of water pumped by air lift in this procedure is decided in relation to the amount of air delivered.
e) In air lifting, even if pumping discharge is more than 200 L/min, if the hydraulic water level descends and it is no longer possible to air lift, the amount of air delivered will be decreased to lower the amount of pumping discharge.
f) The target value of pumping discharge is around 100 to 120 L/min. If the hydraulic water level stabilizes at this value, the permanent pump should be installed. On the other hand, if the pumping discharge gradually drops below the target value, a low-capacity pump should be installed instead or the well declared a failure, depending on the needs of the village.

It is possible to implement the pumping test above and DDA is experienced doing so, although a simpler method is currently employed. Therefore, it is reasonable to wash the borehole and implement the simple pumping test with the equipment for air lift pumping.

(2) Number of Equipment to be Procured and Specifications

In relation to 0.7 MPa of air pressure of the air compressor described in the next item (A-4), one 70 m long set of tools shall be required. The air pipes to deliver compressed air shall be BQ rod (outer diameter = 59.56 m, inner diameter = 36.40 mm) of Diamond Core Drill Manufacturers Association (hereinafter referred to as "DCDMA") Standard, which is used for boring of geological survey, to prevent accidents caused by spent screws when air lifting. Also, only BQ rod is used to finalize the 4 inch well (4 inch casing pipe is used as riser pipe), and 4 inch riser pipe is used to finalize the 6 inch well. A tri-angle notch is also procured to measure the amount of pumping discharge in the field.

A-4: Air Compressor

(1) Necessity of Procurement

An air compressor is used for air lift pumping as described in the previous item. In the procedure of air lift pumping, the appropriate length of riser pipes is inserted into the well and then air pipes are inserted in the riser pipes. The compressed air is delivered through this air pipe and the mixed fluid of mud and air bubbles is made. This mixed fluid of air-liquid has less specific weight and density than drilling fluid mud out of the riser pipe, therefore it can be pumped up to a higher level than the water level outside of the riser pipe. As this work is operated for a while, groundwater from the aquifer enters and washes the well, and mud is gradually replaced by groundwater and the well is finalized. The air compressor used in this operation is the compressor for well finalization. It is quite necessary since one compressor is required for one set of equipment for air lift pumping.

(2) Number of Equipment to be Procured and Specifications

The following two points, which have a significant affect on the effectiveness of air lift pumping are in relation to the hydraulic water level (H) and submergence depth (Hs), which affect the efficiency of the pump (Reference: Soki YAMAMOTO, *Pumping test and well control*).

i. The length between hydraulic water level and a part of the riser pipe on the ground (pump head H), and the length between hydraulic water level and the bottom of the air pipe (submergence depth Hs)
ii. Submergence

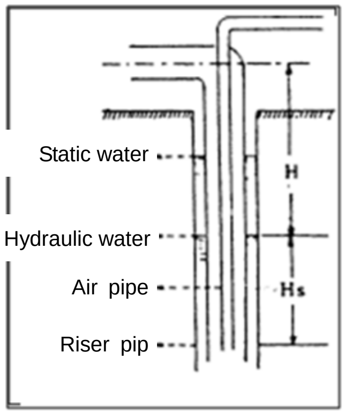


Figure 2-5: Concept of Air Lift Pumping

Table 2-22: Relation between Hydraulic Water Level (H) and Submergence Depth (Hs)

H (m)	Hs (m)	H (m)	Hs (m)
to 15	(2.3 to 1.9) H	60 to 90	(1.0 to 0.75) H
15 to 30	(1.9 to 1.2) H	90 to 120	(0.75 to 0.67) H
30 to 60	(1.2 to 1.0) H	120 to 150	(0.67 to 0.49) H

The following table shows submergence, which influences the effectiveness of air lift pumping. Around 70 % of submergence is said to ensure the best performance of air lift pumping, but it is not necessarily the case that this 70 % can be achieved because of the relation between hydraulic water level (H) and submergence depth (Hs). The constant (C) is an experimental value related to arrangement of air pipe and submergence.

Table 2-23: Submergence

Necessary air delivery V for pumping 1 gallon of water

$$V\ (ft^3/min.) = \frac{H}{C\log\frac{Hs + 34}{34}} \qquad \text{Submergence (\%)} : \frac{Hs}{H + Hs} \times 100$$

H : Pump head (ft)
Hs: Submergence depth (ft)
C: Constant (Different according to submergence)

Submergence (%)	70	65	60	55	50
Constant	322	306	285	262	238

The important component for air lift pumping is the maximum discharge amount in contrast with the amount of planned discharge. As can be seen in the table above, the greatest influence is the amount of compressed air delivered. Also, the amount of air delivered is related to the sum of the hydraulic water level (H) and submergence depth (Hs) to determine the constant (C), i.e., the air pressure. The amount of compressed air required is estimated to be sufficient at 2 to 6 m^3/min when submergence is 50 to 70 % to 100 to 120 L/min of planned discharge. On the other hand, more than 2

MPa of water is pressurized to the deepest part of the air pipe during air lift pumping since the results of the prediction from the geological survey show there are wells where the sum of hydraulic water level and submergence exceed 200 m. In other words, it would be impossible to implement air lift pumping if more than 2 to 3 MPa of compressed air were required to deliver the air out of the air pipe.

Concerning the equipment specifications selection, it is not necessary to procure a heavy-duty compressor that can deliver 2 MPa of high-pressure air. In addition, an additional booster compressor (to increase pressure) is required to deliver more than 2 MPa of compressed air, and this is unrealistic for equipment intended for construction of village water supply facilities.

Therefore, it is advisable to select a compressor which can effectively implement air lift pumping down to a submergence depth of 100 m, which DDA can realistically implement. The following table shows the specifications of the equipment. Also, the compressor shall not be the trailer type, but skid base considering access to the site and transportation by truck.

Table 2-24: Outline Specifications of Air Compressor

Item	Specifications
Air delivery	At least 8.5 m^3/min
Air pressure	At least 0.7 MPa
Type	Skid base

A-5: Cargo Truck with Crane

(1) Necessity of Procurement

This vehicle is used to transport the materials and equipment to the site so that the drilling team can continue work without unnecessary interruption. The vehicle transports a variety of materials and equipment for deep well construction such as drill strings for well drilling (drill pipes and drill collars), the air compressor for air lifting, as well as riser pipes, casing pipes and screen pipes. The vehicle may also be used to install and pull up the pumps.

Currently, to service 8 drilling rigs, DDA owns two (2) of these vehicles with 3 ton cranes, and three (3) with 6 ton cranes, for a total of five (5) equipment transportation vehicles. However, these transportation vehicles are used frequently since the drilling sites are scattered around the area. If an additional two drilling rigs are procured, there will be 10 drilling rigs in total. This exceeds the capacity to transport materials and equipment, which would highly affect the schedule if even one vehicle were to require repairs. Taking this into consideration, it is necessary to procure one cargo truck with a crane.

(2) Number of Equipment to be Procured and Specifications

To operate the Project smoothly and supplement the current capacity for transportation of materials and equipment for well drilling, two (2) cargo trucks with cranes are procured, one for each new drilling rig.

The materials and equipment which are transported by the cargo truck with crane vary greatly, including drill strings (drill pipes, drill collars and so on), drilling agent (bentonite and CMC), equipment for air lift pumping (compressor, air pipes, water pipes and so on), permanently-installed pumps, generators, casing pipe and screen pipes. The following table shows the materials and equipment to be transported by truck for one well.

Table 2-25: Materials and Equipment Transported by Truck

Name	Specifications	Q'ty	Unit mass (kg)	Total mass (kg)
Drill pipes	4-1/2" OD, L = 6 m	70 units	Around 26 kg/m	Around 1,820 kg
Drill collars	6-3/4" OD, L = 6 m	6 units	Around 160 kg/m	Around 5,760 kg
Drill bits, subs etc.	14-3/4"	1 set	Around 1,500 kg	Around 1,500 kg
Casing pipes	4" OD, L = 5.5 m	70 units	Around 16 kg/m	Around 6,160 kg
Bentonite		110 bags	Around 25 kg	Around 2,750 kg
Compressor	1 MPa, 8.5 m^3/min	1 unit	Around 1,750 kg	Around 1,750 kg
Air pipes	55 mm OD, L = 6 m	400 m	Around 6 kg/m	Around 2,400 kg

These materials and equipment are not transported at the same time, but it is effective to transport at least the drill strings (drill pipes and drill collars), casing pipes and accessories at one time. The total weight of the drill pipes and drill collars, which are the longest of all equipment, is around 9 tons. Also, the crane capacity shall be 5.5 tons considering the 4,500 kg compressor (Ingersol-Rand, USA) which is the heaviest item at DDA. The cargo length shall be more than 6 m, taking long-pipe transportation into account. In addition, the driving system shall be 6×6 or 6×4, considering the road conditions and traveling between sites. The following table shows the main specifications of the cargo truck with crane.

Table 2-26: Outline Specifications of Cargo Truck with Crane

Item	Specifications
Payload	At least 10 tons
Crane capacity	At least 5.5 tons
Cargo length	At least 6 m
Driving system	6×6, left-hand drive

B. Equipment and Materials for Well Construction

The target 87 villages in this Project are given the top priority in the Five-year project, and it is highly necessary and appropriate to construct those water supply facilities. The equipment to be procured in this Project shall be of the appropriate quantity, quality and specifications for the deep well drilling in at least these 87 villages. At present, it is rather difficult financially for DDA to purchase the equipment and materials, such as casing pipes, screen pipes and pumps for wells. If the procurement of the equipment and materials for well construction were to be delayed, it would not only prevent the other equipment for well drilling from being used effectively, but it would be impossible to complete the groundwater development in the 87 villages in time. Therefore, it is highly required to procure the equipment and materials for well construction for all target 87 villages. Regarding casing pipes, screen pipes and bottom plugs, an additional 5 % of the required quantity is procured in consideration of potential well failure.

B-1: Casing Pipe (for 87 Wells)

Based on the casing program (see the previous chapter) and the result of the prediction from the geological survey in the 87 villages in this Project, the 87 villages were classified into those that require wells drilled shallower than 300 m, and those deeper than 300 m. The wells shallower than 300 m are finalized with 4 inch based on the specifications DDA currently applies. The wells deeper than 300 m are finalized with 10 inch up to 200 m in depth, and 4 inch from 200 m to the bottom to prevent well collapse when drilling and strength of casing pipes.

The material of the casing pipe itself shall be seamless steel pipe for high pressure piping works, equivalent to JIS G3454 STPG Sch40 JIS G3454, which was used in past Japanese Grant Aid and technical cooperation projects, and which DDA continues to employ. The joint of the casing pipes shall be coupling. The following table shows the specifications and quantity of the casing pipes.

Table 2-27: Outline Specifications of Casing Pipe

Code	Nominal size	Specifications	Q'ty
Seamless steel pipe for high pressure piping works, equivalent to JIS G3454 STPG Sch40, with coupling joint	4 inch	Outer diameter: 114.3 mm, thickness: 6 mm, length 5.5 m/unit	3,250 units
	10 inch	Outer diameter: 267.4 mm, thickness: 9.3 mm, length 5.5 m/unit	350 units

B-2: Screen Pipe and Bottom Plug (for 87 Wells)

Screen pipes are installed into the unconsolidated fine sand and gravel layer, except for some parts in the target area. Therefore, the screen slit shall be 0.5 mm to prevent fine sand from entering into the well considering the lifespan of the well and effect on the pump. Also, the material of the screen shall be galvanized iron to prevent corrosion due to the water quality. It shall be 4 inch and can be connected to casing pipes with coupling. The quantity was determined by the estimation of the aquifer from the result of the geophysical survey. To prevent sand entering into the well over time, bottom plugs which store the sediment are procured for all the target wells.

Table 2-28: Outline Specifications of Screen Pipe and Bottom Plug

Nominal size	Specifications	Q'ty
4 inch screen pipe	Type: Johnson type, material: Galvanized Iron, slot size: 0.5 mm, opening ratio: 10 %, effective unit length: 3 m/unit, connection: same type and size as 4 inch casing pipes, and also with coupling same size as 4 inch casing pipes	170 units
4 inch bottom plug	For sand sedimentation	95 units

B-3: Submersible Motor Pump and Diesel Engine Generator (for 87 Villages)

DDA has installed two (2) types of pumps, the Mono pump, which is a single axis lineshaft screw pump, and the submersible motor pump as the power pump for wells. As a result of comparison between both pumps from a variety of aspects, the submersible pump is valid for the Project. The following table shows the result of this comparison.

Table 2-29: Validity of Procurement of Submersible Motor Pump

Item	Single axis lineshaft screw pump	Submersible motor pump	Determination
Current distribution in the central dry zone in Myanmar	The "Mono pump" for deep wells used to be made by an Australian company, "Mono Pumps Pty. Ltd.", but now an American company has taken it over. Because of the pump's structure, it is quite expensive. Spare parts cannot be procured individually, only as a unit sale. Therefore, it is expensive and takes time to procure them.	Recently, submersible motor pumps made in China, India and EU countries are sold in Myanmar. This is not limited to Yangon, but distributors/agents have also opened gradually in Mandalay, which is the main business district in the central dry zone. It is getting much easier than before to procure the pump. There are abundant spare parts in terms of both type and quantity, and they are easily procured.	Recently, submersible motor pumps are in higher circulation than Mono pumps in Myanmar. The submersible motor pump is versatile in Mandalay in the central dry zone, too. Good: Submer. motor P Fair: Mono P
Performance and experience of DDA	Commencing with JICA technical cooperation project, DDA has performance and experience to install Mono pumps for rural water supply.	In the JICA technical cooperation project, DDA has installed submersible motor pumps in 4 villages. Also, Kaung Pin and other villages in Nyaung U have experience using submersible motor pumps.	DDA has installed and repaired both submersible motor pumps and Mono pumps. Good: Submer. motor P Good: Mono P
Technical skill for operation and maintenance of DDA and the structure of after sales service	By the training in JICA technical cooperation project, they have already learned the series of techniques for operation and maintenance, from installation to failure, diagnosis and repair of Mono pumps. However, the driving part of the pump is a specially made product, thus it is impossible to repair. There is no after-sale service structure.	By the training in JICA technical cooperation project, they have learned the techniques on installation and failure diagnosis for the submersible motor pump. DDA has experience to cooperate with the companies nearby (Mandalay) and repair the pump after failure diagnosis.	It is difficult for DDA to repair submersible motors since it is constructed as a unit. However, DDA would give a repair diagnosis and then the actual repair is done by the agents of the pump. Good: Submer. motor P Poor: Mono P
Request from DDA	DDA feels it is difficult to operate and maintain it in keeping with the situation of spare parts	DDA thinks submersible motor pumps will be the main equipment for groundwater	None

Item	Single axis lineshaft screw pump	Submersible motor pump	Determination
	procurement in the country.	pumping because they are easy to operate and maintain, as well as to procure spare parts.	
Required technical level	Because of the effectiveness caused by the pump structure, a lot of shaft horsepower is lost. That is, the structure of the whole pump is complicated.	Since the pump is driven by a submersible motor installed on the pump, the loss of shaft horsepower is low. That is, the structure of the whole pump is simple.	When comparing them on amount of water discharge and pump head, the submersible motor pump requires less output than the Mono pump. The submersible motor pump is superior to the Mono pump from the economical aspect, too. Also, the submersible motor pump is preferable from the aspect on CO_2 emission. Good: Submer. motor P Poor: Mono P
Synthetic determination	As stated above, the submersible motor pump is appropriate in this project from the current situation of its procurement, experience and technical level of DDA and so on. Also, DDA will install the equipment for groundwater pumping with a focus on submersible motor pumps after drilling in the 87 villages is completed. Staff in DDA Nyaung Oo workshop have learned techniques on operation and maintenance of the Mono pump and submersible motor pump. If DDA improves the skill of operation and maintenance for submersible motor pump through this project, they would become more familiar with both type of pumps, and finally contribute to operation and maintenance of water supply facilities very much in the future.		

The capacity of submersible motor pumps shall be 100 to 120 L/min for village water supply wells according to DDA, and pump head (Total Dynamic Head, hereinafter referred to as the “TDH”) was classified into five (5) types based on the prediction of hydraulic water level from the result of the geophysical survey. However, in the case of 300 m pumping head for a 4 inch well, the maximum capacity of the submersible motor pump is around 70 L/min due to the output limit of the submersible motor. Power supply from a generator is appropriate to activate the pump, so one is procured for each pump. Also, to prevent the motor from burnout when idle in case of low water level, a water level relay is planned so that the motor will stop automatically at such times. The following table shows the outline specifications and quantity of the submersible motor pump and the generator.

Table 2-30: Outline Specifications of Submersible Motor Pump and Diesel Engine Generator

Submersible motor pump	Generator	Quantity
Submersible motor pump for 4 inch well, 3 phase, 380 to 400 V, 50 Hz, riser pipes, water level relay with cable, check valve, control panel, 10 m of cabtire cable	Water-cooled, diesel engine generator	Total 87 sets
TDH 100 m, Discharge rate 100 L/min	*20 KVA	9 sets
TDH 150 m, Discharge rate 100 L/min	*25 KVA	18 sets
TDH 200 m, Discharge rate 100 L/min	*25 KVA	22 sets
TDH 250 m, Discharge rate 100 L/min	*25 KVA	31 sets
TDH 300 m, Discharge rate 70 L/min	*25 KVA	7 sets

* The output of the generator doesn’t necessarily have to be this value if the pump can be activated

C. Equipment for Water Quality Analysis

This category of equipment was not initially requested by the Myanmar side. However, as a result of the field survey, it is essential to strengthen the current structure of water quality analysis of DDA. Also, analysis contributes to Myanmar achieving its upper goal which includes “supply safe drinking water”, and therefore the related equipment is procured in this Project.

C-1: Spectrophotometer

(1) Necessity of Procurement

This equipment is mainly used to measure the amount of various dissolved elements in the water. A spectrophotometer is a highly versatile, analytical piece of equipment and is relatively easy to maintain. Currently, DDA owns spectrophotometers provided by WHO and UNICEF in the laboratory, but over time the optical system units on both have degraded, so they have become unreliable on a constant basis. Therefore, procurement of this equipment is planned in this Project to secure the accuracy of analytical value. By procuring this equipment, it becomes possible to measure 12 of 19 elements that are described in the DDA water quality standard (with the exception of mercury and lead).

(2) Number of Equipment to be Procured and Specifications

In consideration of the current laboratory conditions, one (1) spectrophotometer will be procured with standard specifications. Along with this equipment, a set of reagent to test for chrome, copper, manganese, aluminum, sulphate, zinc, calcium and magnesium, which are described in the water quality standard, will be procured at the same time. The amount of reagent is for 250 tests, which accounts for 174 tests in the 87 villages (2 tests × 87 villages) and 76 spare tests (approximately half of the 174 samples).

Table 2-31: Outline Specifications of Spectrophotometer

Item	Specifications
Wavelength range	Around 190 to 1,100 nm
Spectrum bandwidth	Less than 5 nm
Reagent	for 250 tests of Chromium, Copper, Manganese, Aluminum, Sulphate, Zinc, Calcium, Magnesium

C-2: Water Still

(1) Necessity of Procurement

This equipment is used for reagent preparation, control test measurement (for zero concentration) and final wash of the test tools. As is commonly known, this is an essential piece of equipment for all water quality laboratories. Currently at the DDA laboratories, distilled water is used for the above operation, however, it is purchased. Tap water in Myanmar contains many impurities and dissolved substances, and it is therefore impossible to implement highly accurate water quality tests. Given this situation, it is planned to procure this equipment.

(2) Number of Equipment to be Procured and Specifications

In order to analyze one (1) sample, approximately 4 to 5 L of distilled water is needed. According to the performance of the water quality tests by DDA in 2009, 268 samples were analyzed, therefore, the average number of tests in a day is one (1). One (1) water still specified below will be sufficient if it is operated six (6) hours per day.

Table 2-32: Outline Specifications of Water Still

Item	Specifications
Water quality	Purified water quality (Less than 1.0 mS/m)
Distiling capacity	At least 1.6 L/hour

2-2-3 Implementation Plan

2-2-3-1 Implementation Policy

(1) Basic Policy

This Project shall be implemented in accordance with the scheme of Japan's Grant Aid for a single-year. The Grand Aid shall be offered based on the Exchange of Notes (hereinafter referred to as the "E/N") in which the Project purpose, implementing organizations and the conditions of the Grant Aid confirmed between the Government of Japan and the Government of Myanmar shall be approved. Following the E/N, the Grant Agreement (hereinafter referred to as the "G/A") of the Project shall be concluded between the Government of Myanmar and JICA to define the payment conditions, items to be borne by the Myanmar side and procurement conditions of the Project. In terms of detailed procedures concerned with procurement under the Grant Aid, they shall be agreed upon between the Government of Myanmar and JICA at the times of signing the E/N and the G/A.

(2) Procurement Method

Essentially, the budget of the Grant Aid shall be used to purchase the products made in Japan and Myanmar, and the services are supplied by Japanese and Myanmar nationals. It is also possible to use the budget of the Grant Aid to purchase products and services from third countries (i.e. those other than Japan and Myanmar) when the necessity is approved by JICA and the Government of Myanmar (or the authorities designated by the government). However, the prime contractor to implement the grant aid, that is, the consultant and the procurement companies, shall be Japanese nationals.

The procurement company shall be selected, in principal, by competitive tender so that fair competition is ensured among the tenderers to procure the products or services. The tender documents shall be made by the consultant upon discussion with the Government of Myanmar.

(3) Lot Division for Equipment Procurement

The equipment planned in this Project can be classified as: "A. Equipment for Well Drilling", "B. Equipment and Materials for Well Construction", and "C. Equipment for Water Quality Analysis". Of the equipment in this Project, the equipment for well drilling contains relatively expensive items, and therefore shall be kept as a single lot to maintain fairness of the tender. Thus, the equipment in this Project shall be procured with two (2) lots. The following table shows the contents of each lot.

Table 2-33: Lot Division of the Procurement

Lot	No.	Name	Q'ty	Probable country of origin	Procurement country
Lot 1	A-1	Drilling rig mounted on truck			
	A-1-1	400 m deep drilling	1 unit	Japan	Japan
	A-1-2	300 m deep drilling	1 unit	Japan	Japan
	A-2	Drilling agent (Bentonite and CMC)	1 set	Japan, Thailand, Italy	Thailand
	A-3	Equipment for air lift pumping and pumping test	1 set	Japan	Japan
	A-4	Air compressor	1 unit	Japan	Japan
	A-5	Cargo truck with crane	2 units	Japan	Japan
	C-1	Spectrophotometer	1 set	Japan, Singapore, USA	Japan
	C-2	Water still	1 unit	Japan	Japan
Lot 2	B-1	Casing pipe (for 87 wells)			
	B-1-1	4 inch	3,250 units	Japan, Thailand, China	Myanmar
	B-1-2	10 inch	350 units	Japan, Thailand, China	Myanmar
	B-2	Screen pipe and bottom plug (for 87 wells)			
	B-2-1	Screen pipe	170 units	Japan, Thailand, Australia	Myanmar
	B-2-2	Bottom plug	95 units	Japan, Thailand	Japan
	B-3	Submersible motor pump and diesel engine generator (for 87 villages)			
	B-3-1	TDH 300 m	9 sets	Pump: Japan, Germany, Italy Generator: Japan, Germany, Italy, Indonesia, China	Myanmar
	B-3-2	TDH 250 m	18 sets		Myanmar
	B-3-3	TDH 200 m	22 sets		Myanmar
	B-3-4	TDH 150 m	31 sets		Myanmar
	B-3-5	TDH 100 m	7 sets		Myanmar

(4) Consultant

The Consultant of the Project shall conclude a contract regarding services for tendering and procurement supervising works. The services contained in each step shall be as follows:

1) Service before the Tender Stage

The Consultant shall review the field survey results produced by the Preparatory Survey (Basic Design) of the Project. After review, the Consultant will prepare tender documents and shall indemnify against the consistency in the services with the approval from the Government of Myanmar.

2) Services in the Tender Stage

The Consultant shall execute the following services in the tender stage:

a) Compiling the tender documents
b) Holding the tender
c) Preparation of questions/answers and amendment drafts regarding tender
d) Production of the implementation and evaluation tables for the technical evaluation and evaluation report
e) Assist the contract negotiations of the Project

3) Service in the Procurement Supervising Work Stage

The consultant shall check whether the equipment based on the required quantity and specification arrives at the site from the manufacturers in the supervising work stage. Also, the consultant shall oversee any training, if necessary, and supervise it.

(5) Implementing Organizations of the Myanmar Side

The responsible organization of the Myanmar side for the Project is the Ministry of Progress of Border Areas and National Races and Development Affairs, and the implementing organization is DDA. For the smooth progress of the project, it shall be necessary for the Consultant, the Contractor(s) and the concerned organizations of the Myanmar side to be in close contact and consult with one another. Accordingly, the Myanmar side shall assign responsible persons that will be in charge of the Project.

2-2-3-2 Implementation Conditions

(1) Securement of Space for New Equipment

It is necessary for the Myanmar side to clean and organize space to store and place the equipment prior to delivery to encourage smooth commencement of operation.

(2) Lot Division for Equipment Procurement

The equipment procurement is divided into two (2) lots, as mentioned above. Therefore, the operations are sure to be finished on time, and it is necessary to manage the schedule carefully.

2-2-3-3 Scope of Works

(1) Equipment Delivery to the Destination

All of the equipment to be procured in the project shall be delivered to DDA’s stockyard at Yangon by the Japanese side. The delivery between the stockyard and the site is implemented by the Myanmar side.

(2) Equipment Installation

“Test and adjustment work” and “Initial operation training” of the equipment are implemented by the Japanese side as described herein below.

(3) Scope of Works

Scope of works of the Project is shown below.

Table 2-34: Scope of Works

Work	Japanese side	Myanmar side
1. Equipment	–	–
■ Equipment procurement	✓	
■ Securement of power supply for equipment operation		✓
2. Securement of space for equipment		✓
3. Delivery of equipment	–	–
■ Delivery to the destination	✓	
■ Prompt processing of customs clearance and other procedures		✓
■ Tax exemption		✓
■ Acquisition of permission to import equipment		✓
4. Banking and issue of A/P		✓
■ Implementation of banking		✓
■ Issue of A/P		✓
■ Expense for procedure above		✓
5. Expense and procedure for the related people of the Project to enter, exit and stay in the country		✓
6. Other necessary procedure for the Project		✓
7. Other necessary expenses for the Project and its related works		✓
8. Tendering	–	–
■ Producing the tender documents	✓	
■ Consulting works for tendering and procurement supervision	✓	
9. Implementation of receiving inspection of equipment	–	–
■ Implementation of equipment inspection	✓	
■ Present during equipment inspection	✓	✓
■ Implementation of operational guidance	✓	
10. Implementation of technical assistance (Soft component)	✓	

2-2-3-4 Consultant Supervision

(1) Basic Concept

The consultant shall supervise the contractor in order to execute project contracts adequately and without complication. The consultant supervision works shall aim to supervise whether or not the procurement is to be implemented correctly, while ensuring prescribed qualities in accordance with documents such as specifications stipulated in the contracts of the Project. It shall also supervise whether or not the contractor is to control and store documents adequately concerning its working records such as quality control data, photos and equipment procurement.

(2) Installations of Equipment and Operation Trainings

None of the equipment in this Project requires installation. Also, DDA has long used the equipment to be procured in this Project so far, and thus no training is necessary. However, operation varies among manufacturers, and accidents may happen due to operation mistakes. Furthermore, the drilling rig in this Project is bigger than that which DDA has used so far, and some tools are new for DDA. Therefore, “Test and adjustment work” and “Initial operation training” will be implemented for “A-1 Drilling Rig Mounted on Truck” and “B-3 Submersible Motor Pump and Diesel Engine Generator” at the time of delivery.

(3) Dispatching of the Consultant

The contractor shall be responsible for procurement of the equipment and the consultant shall supervise it together with the contractor. The consultant shall assign and dispatch the personnel described in the table below.

Table 2-35: Dispatching of the Consultant

Personnel	Category	Term
Inspector	Equipment inspection	Spot
Procurement supervisor	Procurement supervision, equipment supervision	Spot

2-2-3-5 Procurement Plan

(1) Procurement Method

In this Project, it is likely that the equipment to be procured in Lot 1 (the equipment for well drilling and the equipment for water quality analysis) may be procured in Japan and Lot 2 (the equipment and materials for well construction) may be procured in Myanmar. Especially, submersible motor pumps and generators shall be selected as those which are widely available in the country since they will be operated and maintained by the villagers after installation. Also, the equipment will be procured from local distributing agents or a company which makes a contract with a local agent to guarantee after-service.

(2) Spare Parts and Consumable Goods for the Equipment

Spare parts and consumable goods for equipment to be procured will not be procured in the Project because these are able to be procured at the local agents.

2-2-3-6 Operational Guidance Plan

(1) Test and Adjustment Work

In this Project, test and adjustment work is implemented for “A-1 Drilling rig mounted on truck” and “B-3 Submersible motor pump set and diesel generator set”. This work takes several hours or up to half a day. Also, this work is implemented together with “Initial operation training” for the equipment, and therefore, the time required for this wok is included in “Initial operation training”.

(2) Initial Operation Training

In this training, an engineer from the manufacturer is dispatched for the training of the drilling rig, and a local engineer is in charge of the submersible motor pumps. The training for each of these requires 10 days and 2 days, respectively.

Table 2-36: Term of Dispatching Personnel for Initial Operation Training

Lot	Personnel	Name of equipment	Duration	Place
1	Engineer from manufacturer (Japanese)	A-1-1 Drilling rig for 400 m A-1-2 Drilling rig for 300 m	10 days	DDA stockyard in Yangon
2	Mechanical Engineer (Local)	B-3 Submersible motor pump and diesel engine generator	2 days	
Total			12 days	***

(3) Operation and Maintenance Training

In this Project, operation and maintenance training is not required.

2-2-3-7 Soft Component Plan

(1) Background

The groundwater quality in the central dry zone is strongly affected by the geological environment from a Pegu layer of marine stratum, so the groundwater in many areas indicates significantly high salt concentration. Also, blackish-brown sedimentation frequently occurs since iron and manganese dissolved into the groundwater are aerated and then oxidized.

Currently in DDA, the water from newly drilled and renovated wells is sent to the laboratory and the water quality is tested there. Then, if it is judged that the well has problems with water quality, DDA takes measures, which may include banning use of the well. In other words, test data indicated by the laboratories has significant authority and responsibility, and therefore it is the duty of DDA to garner accurate test results.

Nevertheless, there are some concerns on the structure of operation and maintenance, and the method of water quality testing in the laboratories which are in charge of safety for the water supplied by newly drilled wells. The relationship between the new construction of water resources and water quality testing is inextricably linked, so that without strengthening the structure of water quality testing it is not possible to contribute to MDGs in Myanmar, which aims to supply safe drinking water, without strengthening the structure of water quality testing. In addition, regarding the equipment procured by WHO and UNICEF etc., they are not operated and maintained properly. Therefore, there is a concern that the same mistakes may be duplicated in this project unless the structure and techniques to implement appropriate maintenance are well organized. Given this background, to ensure the smooth commencement of the project and sustain the effect of cooperation, there is a plan for a soft component to be implemented for technical assistance on water quality analysis.

(2) Objective

In this Project, the soft component aims at "strengthening the structure and improving accuracy of water quality analysis", and the activities will begin with three (3) points described below, which are the outputs to achieve the objective of the soft component.

(3) Achievement

The three (3) results to be achieved as results of this soft component are:

Result 1: Acquirement of techniques for water quality analysis (18 parameters)
Result 2: Master operation procedure, maintenance and management of the equipment
Result 3: Improvement of ledgers and manuals

(4) Report

The following reports will be submitted as appropriate to JICA (in Japanese) and the implementing organization in Myanmar, DDA (in English).

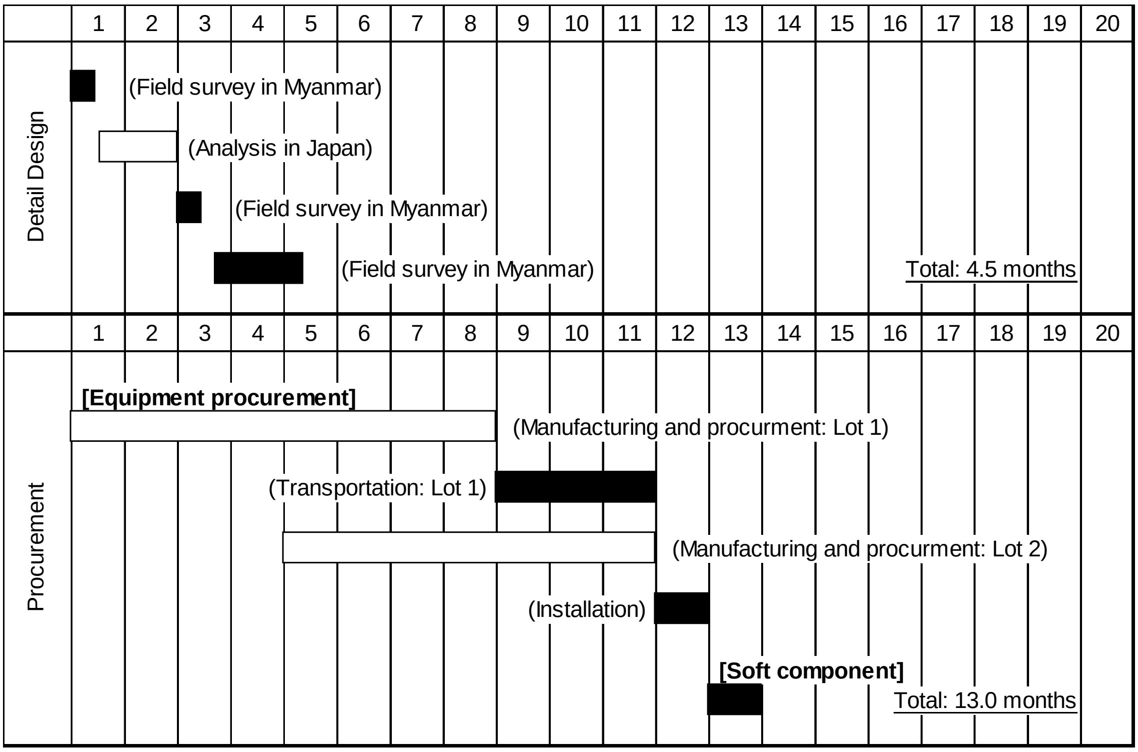
a) Activity plan (JICA Myanmar office: arrival at Myanmar, DDA: arrival at Nay Phy Taw)
b) Activity report (weekly, DDA: on completion of each term)
c) Manual for water quality analysis (English, JICA Myanmar office: on completion of the 4th term, DDA: on completion of the 4th term)
d) Manual for maintenance of the equipment for water quality analysis (English, JICA Myanmar office: before leaving, DDA: on completion of the 4th term)
e) Completion report (JICA head office: after arrival at Japan)

The soft component plan in this Project is attached at the end of the report as an appendix.

2-2-3-8 Implementation Schedule

The following shows the implementation schedule of this Project.

Table 2-37: Implementation Schedule of the Project



2-3 Obligations of the Recipient Country

2-3-1 Specific Items for this Project

The following special items are required to be undertaken by Myanmar side when carrying out the Project.

1) To secure salary for personnel who will be assigned to the Project
2) To attend inspection for equipment
3) To ensure the space for newly procured equipment
4) To strengthen the monitoring system for operation and maintenance for newly procured equipment
5) To secure and dispatch the personnel for the operation training for newly procured equipment
6) To secure and dispatch the personnel for the technical assistance (soft component)
7) To proceed and pay the necessary banking fees of the Project
8) To transport procured equipment to the site
9) To drill, utilizing equipment to be procured
10) To construct water tanks and pump houses
11) To operate and maintain the procured equipment
12) To report on the usage of the procured equipment and progress of drilling plan semiannually to JICA office

2-3-2 General Item

In the implementation of Japanese Grant Aid Scheme, the recipient country is required to undertake certain measures as follows:

1) To ensure prompt execution for unloading, customs clearance at the port of disembarkation and internal transportation of the products purchased under the Grant Aid.
2) To exempt from custom duties, internal taxes and other fiscal levies, this will be imposed in the recipient country with respect to the supply of the products and services under the verified contracts.
3) To accord the agent whose services may be required in connection with the supply of the products and services under the verified contracts, such facilities that may be necessary for their entry into the recipient country and stay therein for the performance of the work.
4) The recipient country is required to operate and maintain the facilities constructed and equipment purchased under the Grant Aid property and effectively and to assign staff necessary for this operation and maintenance as well as to bear all the expenses other than those converted by the Grant Aid.
5) The products purchased under the Grant Aid should not be re-exported from the recipient country.

2-4 Project Operation Plan

2-4-1 Basic Policy

Operation and maintenance fee for equipment to be procured for this Project will be covered by DDA's budget.

2-4-2 Operation and Maintenance Structure

An estimate of new operation and maintenance cost for equipment to be procured by this Project is detailed in "2-5-2 Operation and Maintenance Cost". It is thought that no further operation and maintenance cost will be incurred, because the project cost is small, DDA has experience using the main equipment, and specification of the equipment is common and technically straightforward.

2-5 Project Cost Estimation

2-5-1 Initial Cost Estimation

This cost estimation is provisional and would be further examined by the Government of Japan for the approval of the Grant. A breakdown of cost based on the aforementioned obligations of each country is estimated as follows:

2-5-1-1 Obligations of Myanmar Side

Obligation of Myanmar side: 50,798,500 Kyat

Obligation	Cost (Kyat)
Inland transportation for drilling rigs and tracks with crane (Fuel, Yangon to Nyang Oo)	456,000
Inland transportation for other equipment (Yangon to Nyang Oo)	45,772,500
Daily allowance and accommodation fee for DDA staff	1,320,000
Commission for Banking Arrangement (B/A)	3,250,000
Total	50,798,500

2-5-1-2 Condition of Cost Estimation

(1) Time of Cost Estimation

The Project cost was estimated in July 2010.

(2) Exchange Rate

The Project cost was calculated using the following average exchange rate in six (6) months from January 1st to June 30, 2010.

1 USD = 92.35 JPY

(3) Schedule for Equipment Procurement

The schedule is shown in "2-2-3-8 Implementation Schedule".

(4) Others

The Project cost was estimated according to the Guideline of Japanese Grant Aid.

2-5-2 Operation and Maintenance Cost

From past performance by DDA, the necessary cost for deep well construction is estimated at 12 million Kyat for one (1) well construction, 12 million Kyat for the year for maintenance of drilling equipment. In addition, the construction cost for a pump house and water tank is basically covered by each village. However, DDA may cover the construction cost for economically impoverished villages. Therefore, these costs are estimated as the obligation of DDA.

Table 2-38: Operation and Maintenance Cost

Unit in Kyat

No.	Cost for water supply facility construction		Maintenance cost		
	Item	Per one well	Item	Per one unit	Annually (2 units)
1	Geophysical survey	174,200	Well drilling rig	1,500,000	3,000,000
2	Transportation of equipment and materials (Yangon-sites)	1,300,000	Cargo truck with crane	4,400,000	8,800,000
3	Preparation work	814,300	Air compressor (1 unit)	500,000	500,000
4	Drilling work	6,190,800			
5	Well logging and casing installation	213,300			
6	Well washing and pumping test	771,615			
7	Installation of submersible motor pump	203,408			
8	Removal work	694,500			
9	Construction of cabin for pump	690,000			
10	Construction of water supply tank	1,650,000			
	Total	12,702,123	Total	6,400,000	12,300,000

*Note: The number of compressor is one

Operation and maintenance cost in the Five-year project is shown in the following table. It is assumed that seven (7) wells will be constructed in the 1st year by drilling equipment to be procured, and 20 wells will be constructed in the 2nd to 5th years, respectively. In this case, the cost ratio covering the budget of the Five-year project is 5.5 to 12.6 % for the year, and therefore, DDA will be able to carry out operation and management within the budget.

Table 2-39: Ratio of Operation and Maintenance Cost in the Budget of Five-year Project

Unit in Million Kyat

Year	Cost for water supply facility construction			Maintenance of equipment (2)	Operation and maintenance (1)＋(2)	Budget for the Five-year project	Ratio to the budget
	Per one well	The number of well to be drilled	Sub total (1)				
2011-2012	12.70	7	88.91	12.30	101.21	1,917.80	5.3%
2012-2013	12.70	20	254.04	12.30	266.34	2,109.58	12.6%
2013-2014	12.70	20	254.04	12.30	266.34	2,320.54	11.5%
2014-2015	12.70	20	254.04	12.30	266.34	2,552.60	10.4%
2015-2016	12.70	20	254.04	12.30	266.34	2,807.85	9.5%
Total	***	87	1,105.08	***	1,166.58	11,708.37	10.0%

On the other hand, the procurement cost for equipment and test reagent by UNICEF at the moment is calculated to be about 19 million Kyat. The cost ratio covering the budget of the Five-year project is a relatively small sum of 0.8 % (average), DDA can set them in the budget. Therefore, DDA will surely be able to carry out Project operation and maintenance for the Grant Aid Project by the Japanese Government.

2-6 Other Relevant Issue

2-6-1 Access to Target Villages

The many access roads to the target villages are unpaved, the condition of those roads is worsened after rains mentioned above. In case of designing of construction plan, therefore, DDA have to consider seasonal order to construct wells in great detail.

2-6-2 Provision of Spare Parts

Equipment and materials to be procured in this Project are able to purchase their spare parts in the central dry zone, therefore, the villagers can purchase from the distributing agent by themselves. However, the quality and procurement period of their spare parts has an effect on the villagers' usage of water supply facilities. Therefore DDA has to understand the procurement situation of spare parts and needs to participate positively.

Chapter 3 Project Evaluation

CHAPTER 3 PROJECT EVALUATION

3-1 Recomendations

3-1-1 Prerequisite for Project Implementation

(1) To Secure the Budget and Personnel Steadily

It is required to take appropriate measures to secure the budget and personnel of DDA with respect to the project implementation and the soft component activities.

(2) To Use the Experience of the Participation to the Technical Cooperation Project

It is requested to put the DDA staff members, who joined the past JICA technical cooperation project "The Project on Rural Water Supply Technology in the Central Dry Zone in the Union of Myanmar", in this Project so that they can make use of their technical knowledge and know-how actively for this Project.

3-1-2 Outside Conditions for the Achievement of the Entire Project Plan

(1) Dealing with the 23 Villages Eliminated from the Project

Twenty three (23) villages were eliminated from the target villages in this Project since they were found to be difficult to develop groundwater in deeper layer. However, these villages are also suffering from water shortages due to depletion. Therefore, DDA is requested to formulate the groundwater development plan for these 23 villages as soon as possible, using the experience of the past project of surface water conservation and piped water supply from nearby villages etc.

(2) Commoditizing the Data

It is found that the central and local offices do not share the well drilling data implemented in the past, result of the water quality analysis and needs from the residents on water supply facilities accurately. Also, local offices cannot use the valuable data thoroughly even if they have such data in their offices. Therefore, the data of 87 villages which will be obtained through the Project implementation shall be shared by the central and local offices properly, and used to achieve the goal of the Five-year project.

(3) Monitoring by DDA

The villagers will establish a water management committee and a system to control the water supply facilities will be organized in each village after the construction of water supply facilities. DDA is requested not only to support the establishment of the water management committee, but also to cooperate with the committee tightly to grasp the availability of water supply facilities so that DDA makes a proposal technically and assists repairment of the equipment. For a long term usage of water supply facilities, it is important to secure stated water quantity, grasp the water quantity fluctuation with seasons and worsening of water quality. Therefore, DDA is requested to implement periodical monitoring.

(4) Cooperation with Other Donors

Currently, the DDA laboratory has some supports from WHO and UNICEF on equipment procurement such as analysis instruments and reagents. However, their type and quantity are not appropriate since inventory control is not well organized and examination plan is not formulated properly. The structure of water quality analysis shall be well established through this Project to make cooperation from other donors more efficient.

3-2 Project Evaluation

3-2-1 Relevancy

The Project implementation by Grant Aid is evaluated to be reasonable based on the result of this survey for the following reasons.

1) Target of this Project is 98,058 peoples of 87 villages in the central dry zone, a considerable number of whom are in the “worse off” category.
2) The villagers in the target villages use poor water sources (water quality and quantity). The implementation of this Project will enable the distribution safe and sustainable water to the villagers and contribute to improving their lives.
3) DDA, as an implementing agency, has enough capability and experience in well drilling, rehabilitation, operation and maintenance, and takes enough budgetary steps. In addition, water supply facilities to be constructed by DDA in this Project are of a common level in Myanmar, and special techniques are not needed.
4) DDA aims at “developing at least one (1) water resource in every village” as part of the Five-year project, implementation of this Project aims to archive this objective.
5) This Project is not a profit-earning project.
6) Negative impact on the environment is not generated by the Project implementation according to the Environment Impact Assessment (EIA).
7) The Project implementation by Japanese Grant Aid scheme is not particularly difficult.

3-2-2 Effectivity

(1) Quantitative Impact

Quantitative impact to be expected by implementation of this Project is mentioned below.

Table 3-1: Quantitative Impact after Implementation of this Project

Indicator	Baseline (2010)	Target value (2016)
The village has the water source to be able to fetch sanitary and sustainable water in the target 87 villages	0 village (0 people)	87 villages (98,058 peoples)
Water quality parameters able to be analized at the DDA laboratory	10 parameters (not high accuracy)	18 parameters

(2) Qualitative Impact

Quantitative impact to be expected by implementation of this Project is mentioned below.

1) Mitigation of workload (time) for fetching water
2) Mitigation of water related diseases
3) Improvement of enrollment ratio of children
4) Mitigation of household budget expenditure (economical improvement)

From the above-mentioned contents, implementation of this Project is assessed reasonable and effective.

[Appendices]

1. Member List of the Survey Team
2. Survey Schedule
3. List of Parties Concerned in the Recipient Country
4. Minutes of Discussions
5. Soft Component Plan
6. Other Relevant Data
7. References

Appendix 1

Member List of the Survey Team

APPENDIX 1 MEMBER LIST OF THE SURVEY TEAM

(1) Preparatory Survey

Officilas

Mr. Fumihiko Okiura	Team Leader	Japan International Cooperation Agency (JICA)
Dr. Katsuhiko Yoshida	Groundwater Development / Operation and Maintenance	Japan International Cooperation Agency (JICA)
Mr. Akio Endo	Planning Management	Japan International Cooperation Agency (JICA)

Consultants

Mr. Takeshi Nakano	Chif Consultant / Groundwater Development Planning	Kokusai Kogyo Co., Ltd.
Mr. Kunio Fujiwara	Hydrogeology 1 / Geophysical Survey 1	Dairyu Counsulting Engineer Co., Ltd.
Ms. Yasuko Kamegai	Hydrogeology 2	Kokusai Kogyo Co., Ltd.
Mr. Noboru Matsumoto	Geophysical Survey 2	Mitsui Mineral Development Engineering Co., Ltd.
Dr. Hirokatsu Utagawa	Water Quality	Kokusai Kogyo Co., Ltd.
Mr. Hideto Yamazaki	Operation and Maintenance Management / Environmental and Social Consideration	Kokusai Kogyo Co., Ltd.
Mr. Hidekuni Usami	Equipment Planning	Inter Techno Consultant Co., Ltd.
Mr. Shiro Mitsuno	Procurement Planning / Cost Estimation	Kokusai Kogyo Co., Ltd.
Mr. Ryohei Matsumoto	Project Coodinator	Kokusai Kogyo Co., Ltd.

(2) Explanation on Draft Final Report

Officials

Mr. Fumihiko Okiura	Team Leader	Japan International Cooperation Agency (JICA)
Mr. Ryuji Ogata	Survey Planning	Japan International Cooperation Agency (JICA)

Consultants

Mr. Takeshi Nakano	Chif Consultant / Groundwater Development Planning	Kokusai Kogyo Co., Ltd.
Mr. Kunio Fujiwara	Hydrogeology 1 / Geophysical Survey 1	Dairyu Counsulting Engineer Co., Ltd.
Mr. Hidekuni Usami	Equipment Planning	Inter Techno Consultant Co., Ltd.

Appendix 2

Study Schedule

APPENDIX 2 SURVEY SCHEDULE

(1) Preparatory Survey

		Officials			Consultants								
		Team Leader	Groundwater Development / Operation and Maintenance	Planning Management	Chif Consultant / Groundwater Development Planning	Hydrogeology 1 / Geophysical Survey 1	Hydrogeology 2	Geophysical Survey 2	Water Quality	Operation and Maintenance Management / Environmental and Social Consideration	Equipment Planning	Procurement Planning / Cost Estimation	Project Coodinator
		Mr. Okiura	Dr. Yoshida	Mr. Endo	Mr. Nakano	Mr. Fujiwara	Ms. Kamegai	Mr. Matsumoto	Dr. Utagawa	Mr. Yamazaki	Mr. Usami	Mr. Mitsuno	Mr. Matsumoto
May. 16	Sun				Arrive at YGN		Arrive at YGN						
May. 17	Mon				Coutesy to JICA		Coutesy to JICA						
May. 18	Tue				Preparation		Preparation						
May. 19	Wed				Meeting		Meeting						
May. 20	Thu				Meeting		Meeting						
May. 21	Fri				Meeting		Meeting						
May. 22	Sat	Arrive at YGN			Data collection		Data collection						
May. 23	Sun	Team meeting			Data collection	Arrive at YGN	Data collection	Arrive at YGN					
May. 24	Mon	Courtesy call to JICA and EOJ			Coutesy call	Coutesy call to JICA							
May. 25	Tue	Explanation of M/D			Explanation M/D	Data collection	Explanation M/D	Data collection			YGN market reserch		
May. 26	Wed	Singing of M/D			Signing of M/D	Data collection	Signing of M/D	Data collection			YGN market reserch		
May. 27	Thu	Leave for YGN			Leave for YGN	Data collection	Leave for YGN	Data collection			YGN market reserch		Arrive at YGN
May. 28	Fri	Report to JICA and EOJ, Leave for BKK			Report to JICA	Data collection					YGN market reserch		Data collection
May. 29	Sat	Arrive at NRT			Leave for NYU						Data collection		Leave for NYU
May. 30	Sun				Team meeting						Leave for NPT		Team meeting
May. 31	Mon				DDA G/P meeting				Meeting W/Q	Survey meeting	Leave for NYU		Meeting
Jun. 1	Tue				Test G/P				Meeting W/Q	Survey meeting	Visit NYU workshop		Meeting
Jun. 2	Wed				Pre-survey				W/Q analysis	Social survey	Visit NYU workshop		Social survey
Jun. 3	Thu				Pre-survey				W/Q analysis	Social survey	Visit NYU workshop		Social survey
Jun. 4	Fri				Pre-survey				W/Q analysis	Social survey	Leave for MDL		Social survey
Jun. 5	Sat				Pre-survey				W/Q analysis	Social survey	MDL market reserch		Social survey
Jun. 6	Sun				Pre-survey				W/Q analysis	Social survey	Leave for NPT		Social survey
Jun. 7	Mon				Pre-survey				W/Q analysis	Social survey	Visit NPT workshop		Social survey
Jun. 8	Tue				Pre-survey				W/Q analysis	Social survey	DDA meeting		Social survey
Jun. 9	Wed				Pre-survey				Visit MCDC	Social survey	Leave for YGN		Visit MCDC
Jun. 10	Thu				Data collection	Pre-survey			Visit MCDC	Social survey	Data collection	Meeting	Visit MCDC
Jun. 11	Fri				Data collection	Pre-survey			Leave for NYU		YGN market reserch		Leave for NYU
Jun. 12	Sat				Data collection	Pre-survey			Data collection	Social survey	YGN market reserch		Social survey
Jun. 13	Sun				Team meeting						Data collection		Team meeting
Jun. 14	Mon				DDA Meeting	G/P data analysis			DDA meeting		Data collection		Social survey
Jun. 15	Tue				DDA Meeting	G/P data analysis			DDA meeting		Visit YGN workshop		Social survey
Jun. 16	Wed				Leave for YGN	G/P data analysis			Leave for YGN		YGN market reserch		Social survey
Jun. 17	Thu				Data collection	G/P data analysis			Data collection		YGN market reserch		Social survey
Jun. 18	Fri				Report to JICA	G/P data analysis			Leave for NYU	Report to JICA			Social survey
Jun. 19	Sat				Data collection	G/P data analysis			W/Q analysis	Data collection			Social survey
Jun. 20	Sun				Leave for BKK	G/P data analysis			W/Q analysis	Leave for BKK			Social survey
Jun. 21	Mon				Arrive at NRT	G/P data analysis			W/Q analysis	Arrive at NRT			Social survey
Jun. 22	Tue					G/P data analysis			W/Q analysis				Social survey
Jun. 23	Wed					G/P data analysis			W/Q analysis				Social survey
Jun. 24	Thu					G/P data analysis			W/Q analysis				Social survey
Jun. 25	Fri					G/P data analysis			W/Q analysis				Social survey
Jun. 26	Sat					G/P data analysis			W/Q analysis				Social survey
Jun. 27	Sun					Leave for MNW	Data analysis	Leave for MNW	W/Q analysis				Social survey
Jun. 28	Mon					G/P survey	Data analysis	G/P survey	W/Q analysis				Social survey
Jun. 29	Tue					Leave for NYU	Data analysis	Leave for NYU	W/Q analysis				Social survey
Jun. 30	Wed					G/P data analysis			W/Q analysis				Social survey
Jul. 1	Thu					G/P data analysis			W/Q analysis				Social survey
Jul. 2	Fri					G/P data analysis			W/Q analysis				Social survey
Jul. 3	Sat					G/P data analysis			W/Q analysis				Social survey
Jul. 4	Sun					G/P data analysis	Leave for YGN	G/P data analysis	W/Q analysis				Social survey
Jul. 5	Mon					G/P data analysis	Report to JICA	G/P data analysis	W/Q analysis				Social survey
Jul. 6	Tue					G/P data analysis	Leave for BKK	G/P data analysis	W/Q analysis				Social survey
Jul. 7	Wed				Arrive at YGN	G/P data analysis	Arrive at NRT	G/P data analysis	W/Q analysis				Social survey
Jul. 8	Thu				Courtesy JICA	G/P data analysis		G/P data analysis	W/Q analysis				Social survey
Jul. 9	Fri				DDA meeting	G/P data analysis		G/P data analysis	DDA meeting				DDA meeting
Jul. 10	Sat				Leave for NYU	G/P data analysis		G/P data analysis	Leave for NYU				Leave for NYU
Jul. 11	Sun				Data collection	G/P data analysis		G/P data analysis	W/Q analysis				Data collection
Jul. 12	Mon				Data collection	G/P data analysis		G/P data analysis	W/Q analysis				Data collection
Jul. 13	Tue				Data collection	G/P data analysis		G/P data analysis	W/Q analysis				Data collection
Jul. 14	Wed				Data collection	G/P data analysis		G/P data analysis	W/Q analysis				Data collection
Jul. 15	Thu				Data collection	G/P data analysis		G/P data analysis	W/Q analysis				Data collection
Jul. 16	Fri				Data collection	G/P data analysis		G/P data analysis	W/Q analysis				Data collection
Jul. 17	Sat				Data collection	G/P data analysis		G/P data analysis	W/Q analysis				Data collection
Jul. 18	Sun				Data collection	G/P data analysis		G/P data analysis	W/Q analysis				Data collection
Jul. 19	Mon				Leave for NPT			Leave for NPT					Leave for NPT
Jul. 20	Tue				Signing of technical note			Signing of technical note					Signing of TN
Jul. 21	Wed				Data collection			Data collection					Data collection
Jul. 22	Thu				Report to JICA			Report to JICA					Report to JICA
Jul. 23	Fri				Leave for BKK			Leave for BKK					Leave for BKK
Jul. 24	Sat				Arrive at NRT			Arrive at NRT					Arrive at NRT

NRT: Narita (Tokyo), BKK: Bangkok, YGN: Yangon, NPT: Nay Pyi Taw, NYU: Nyaung Oo, MDL: Mandalay, MNW: Moniwa

(2) Explanation on Draft Final Report

		Officials		Consultants		
		Team Leader	Survey Planning	Chif Consultant / Groundwater Development Planning	Hydrogeology 1 / Geophysical Survey 1	Equipment Planning
		Mr. Okiura	Mr. Ogata	Mr. Nakano	Mr. Fujiwara	Mr. Usami
Dec. 8	Wed			Arrive at YGN		
Dec. 9	Thu		Arrive at YGN	Courtesy call to JICA, Leave for NPT		
Dec. 10	Fri		Meeting	Explanation of DBD, Leave for YGN		
Dec. 11	Sat		Leave for NYU, Site visit	Leave for NYU, Site visit		Market reserch
Dec. 12	Sun	Arrive at YGN	Site vist, Leave for YGN	Site visit, Leave for YGN		Data collection
Dec. 13	Mon	Courtesy call to JICA, Leave for NPT		Courtesy call to JICA, Leave for NPT		
Dec. 14	Tue	Explanation and signing of M/D		Explanation and signing of M/D		
Dec. 15	Wed	Leave for YGN, Report to JICA		Leave for YGN, Report to JICA		
Dec. 16	Thu	Leave for BKK		Data collection, Leave for BKK		
Dec. 17	Fri	Arrive at VTN	Arrive at NRT	Arrive at NRT		

NRT: Narita (Tokyo), BKK: Bangkok, YGN: Yangon, NPT: Nay Pyi Taw, NYU: Nyaung Oo

Appendix 3

List of Parties Concerned in the Recipient Country

APPENDIX 3 LIST OF PARTIES CONCERNED IN THE RECIPIENT COUNTRY

Department of Development Affair (DDA)

U Myo Myint	Director General (Preparatory Survey)
U Soe Ko Ko	Director General (Explanation on Draft Final Report)
U Than Kyaw Htoo	Deputy Director General
U Myint Oo	Deputy Director General (Engineer)
U Hla Thein Aung	Deputy Chief Engineer
U Khant Zaw	Engineering Director (Admin)
U Htay Nyunt	Engineering Director (Water supply)
Daw Kyu Kyu Khin	Engineering Director (Water supply)
Dr. Tun Lwin	Deputy Director
U Kyaw Swe	Deputy Director (Engineer)
U Kyaw San Htun	Deputy Director (Central Vehicle and Store Section)
U Ye Khaung	Assistant Director (International Relation Section)
Dr. Zarni Minn	Assistant Director (International Relation Section)
U Soe Naing	Assistant Director (Yangon)
U Myo Aung	Executive Officer (Nyaung Oo)
U Ye Zarni Aung	Assistant Engineer (Nyaung Oo)
Daw Wint War Phyu	Assistant Engineer (Mandalay)

Mandalay City Development Committee (MCDC)

U Tun Kyi	Head of Water and Sanitation Department
U Tint Lwin	Assistant Director
U Khin Mg. Thin	Assistant Engineer
Daw Khin Thida Aung	Junior Engineer
Daw Tin Tin Hla	Assistant

UNICEF

U Khin Aung Thein	Project Officer (Water Quality)
U Terence Kadoe	WASH Officer

Embassy of Japan

Mr. Mitsuji Suzuka	Counselor
Mr. Tatsuya Mishiuma	Second Secretary

JICA Myanmar Office

Mr. Hideo Miyamoto	Chief Representative
Mr. Katsuyosi Saito	Senior Representative

Mr. Junichi Hirano	Assistant Resident Representative
Mr. Yasuyuki Sato	Representative
Dr. Minoru Yoshida	Project Formulation Adviser
U Mg. Mg. Than	Program Officer

Bridge Asia Japan (BAJ)

Dr. Yasufumi Tsukamura	Country Representative Myanmar
Ms. Masako Mori	Program Manager
U Mg. Mg. Lay	Administrator
U Win Htike	Hydrogeologist

Appendix 4

Minutes of Discussions

APPENDIX 4 MINUTES OF DISCUSSIONS

(1) Minutes of Discussions (May 26, 2010)

MINUTES OF DISCUSSIONS
ON THE PREPARATORY SURVEY (BASIC DESIGN)
ON THE PROVISION OF EQUIPMENT FOR RURAL WATER SUPPLY PROJECT
IN THE CENTRAL DRY ZONE
IN THE UNION OF MYANMAR

In response to the request from the Government of the Union of Myanmar (hereinafter referred to as "Myanmar", the Government of Japan decided to conduct a Preparatory Survey on the Provision of Equipment for Rural Water Supply Project in the Central Dry Zone (hereinafter referred to as "the Project") and entrusted the survey to the Japan International Cooperation Agency (hereinafter referred to as "JICA") .

JICA sent to Myanmar the Preparatory Survey Team (hereinafter referred to as "the Team"), which is headed by Mr. Fumihiko Okiura, Director, Water Resources Management Division 1, Water Resources and Disaster Management Group, Global Environment Department, JICA, and is scheduled to stay in the country from May 23 to May 28, 2010.

The Team held discussions with the officials concerned of the Government of Myanmar and conducted a field survey at the target area.

In the course of discussions and field survey, both parties confirmed the main items described in the attached sheets. The Team will proceed to further works and prepare the Preparatory Survey Report.

Nay Pyi Taw, May 26, 2010

Fumihiko Okiura
Leader
Preparatory Survey Team
Japan International Cooperation Agency
Japan

U Myo Myint
Director General
Department of Development Affairs
Ministry for Progress of Border Areas and National Races and Development Affairs
The Union of Myanmar

ATTACHMENT

1. Objective of the Project

The objective of the Project is to develop water resources by drilling deep tube wells in the Central Dry Zone.

2. Project Site

The Project sites requested by the Myanmar side are located at three Divisions (Mandalay, Magway, Sagaing) in the Central Dry Zone as in **Annex-1**.

3. Responsible and Implementing Agency

3-1 The Responsible Agency is Ministry for Progress of Border Areas and National Races and Development Affairs.

3-2 The Implementing Agency is Department of Development Affairs (hereinafter referred to as "DDA"). The organization chart of DDA is shown in **Annex-2.**

4. Items requested by the Government of Myanmar

After discussions between the Myanmar side and the Team (hereinafter referred to as "the both sides"), the items described in **Annex-3** were finally requested by the Myanmar side.

The both sides confirmed that the appropriateness of the request would be examined in accordance with the further studies and analysis, and the final components of the Project would be decided by the Japanese side.

5. Japan's Grant Aid Scheme

5-1 The Myanmar side understands the Japan's Grant Aid Scheme explained by the Team, as described in **Annex-4**.

5-2 The Myanmar side will take necessary measures, as described in **Annex-5**, for smooth implementation of the Project, as a condition for the Japan's Grant Aid to be implemented.

6. Schedule of the Survey

6-1 The consultant members of the Team will proceed to further studies in Myanmar until July 23, 2010.

6-2 JICA will prepare the survey report in English and dispatch a mission in order to explain its contents to the Myanmar side around November 2010.

6-3 In case that the contents of the report are accepted in principle by the Myanmar side, JICA will finalize the report and send it to the Myanmar side around February 2011.

6-4 The Myanmar side understands that execution of the Preparatory Survey (hereinafter referred to as "the Survey") does not necessarily imply the Japanese Government's commitment of the Project implementation.

7. Background of Request by the Myanmar Side

(1) New Action Plan for Rural Water Supply of DDA

DDA explained to the Team that "A Ten Year Project for Rural Water Supply by Development Committees of Sagaing, Magway and Mandalay Divisions (From 2000-2001 to 2009-2010)" (hereinafter referred to as "the Ten Year Project") was implemented, however, the needs to develop new water resources are still high in the Central Dry Zone because there are still serious problems of drinking water quantity and quality. To tackle with these problems, DDA prepared the following plan as shown in **Annex-6** to develop water resources continuously in the Central Dry Zone, and it was already approved by Ministry for Progress of Border Areas and National Races and Development Affairs.

Title: Plan on adequate provision of rural water supply in the Central Dry Zone (hereinafter referred to as "the New Action Plan")

Objective: To develop new water resources in 1,077 target villages

Target Year: From 2010-2011 to 2014-2015

Number of target villages to develop deep tube wells: 826 villages

(2) Request for Japan's Grant Aid Project

DDA explained to the Team that 110 villages in the New Action Plan are selected among 826 villages as the target of Japan's Grant Aid Project shown in **Annex-7,** from the point of view of well depth, water quantity and quality.

8. Major undertakings by the Myanmar Side

In case the request shall be approved by Japanese government, the Myanmar side agreed to undertake following issues.

(1) Implementation structure of deep tube well construction by the Myanmar side

The both sides confirmed that the construction works of the deep tube wells in the Project shall be executed by the Myanmar side with its full responsibility:

1) DDA will assign appropriate number of staff who have experience and skill of drilling deep tube wells. The staff allocation plan is shown in **Annex-8**. The plan to drill deep tube wells by utilizing procured drilling rig(s) and existing drilling rigs are shown in **Annex-9**.

2) DDA will secure the necessary budget timely.

(2) Operation and Maintenance of Facilities, Equipment and Materials

The water supply facilities constructed by the Myanmar side shall be properly operated and maintained by the target villages with support by DDA. The equipment and materials procured through the Project shall be properly operated and maintained by DDA.

(3) Semiannual Report

Semiannual report of progress of the deep tube well construction work will be submitted by DDA to JICA Myanmar Office. Following items should be included in the report and those items will be finalized during the Survey.

- Progress of the well construction
- Stock of procured well construction materials
- Utilization record of procured equipment
- Others (water quality issues, etc)

9. Water Quality

The Team mentioned the concentration of Fluoride and Nitrate-Nitrogen exceed Myanmar national proposed water quality standard in some deep tube well water in target area, and it might be the cause of negative impact to villagers' health. DDA explained that they will take appropriate countermeasures for those deep tube wells based on the result of the Survey and recommendations which will be made by the Team.

10. Other Relevant Issues

(1) Inception Report

The content of Inception report, which the Team explained to the Myanmar side, was understood and accepted in principle by the Myanmar side.

(2) Arrangements for the Survey by the Myanmar side

As a response to the request by the Team, the Myanmar side agreed to arrange necessary number of counterpart personnel such as staff of geophysical survey and equipment such as Syscal R1 and R2 for the Survey and provide appropriate data and information relevant to the Project for the smooth implementation of the Survey. Following issues are agreed to be taken by the Myanmar side for the efficient implementation of the Survey.

1) To ensure the safety and security of the Team members
2) To exempt taxes and other charges, including customs clearance fees, on the equipment and materials brought into Myanmar for implementation of the Survey
3) To exempt taxes on the wages and allowances paid to the Team members for conducting the Survey
4) To facilitate the transfer of funds necessary for the Survey to Myanmar and use of the funds
5) To ensure permission to enter private properties or restricted areas as necessary for the implementation of the Survey, except when entry is prohibited by law
6) To permit taking all the collected materials concerning the Survey back to Japan
7) To make referrals to medical institutions, if necessary. The cost of medical treatment shall be borne by the Team member

8) To coordinate the operations and communications between the relevant government agencies and the Team
9) To provide with materials and information concerning the Survey
10) To cooperate with other survey(s) as necessary
11) Provision of counterpart personnel (staff of geophysical survey)
12) Provision of two (2) sets of the equipment of geophysical survey (Syscal R1 and R2) and its accessories
13) Besides the above, any other cooperation necessary to conduct the Survey shall be given

(3) Eligible Country for Procurement

The Myanmar side requested that the eligible country for procurement of drilling rig(s) shall be Japan in the reason that DDA staffs are accustomed to operate and maintain Japanese rigs which can be used for long time due to its quality. The eligible country for equipment and materials will be considered during the survey from the point of view of cost, specification, quality and availability.

(4) Technical Assistance

The consultant services for the water quality examination and/or other fields shall be considered through the Survey.

(5) Tax Exemption

The tax exemption, custom duty, and any other taxes and fiscal levies in Myanmar which is to be arisen from the Project activities will be ensured by DDA. DDA will take any procedures necessary for tax exemption.

(6) Overlapping with Other Projects

The Myanmar side explained that the Project would not be overlapped with any other projects supported by other donor agencies, NGOs, and Myanmar official organizations.

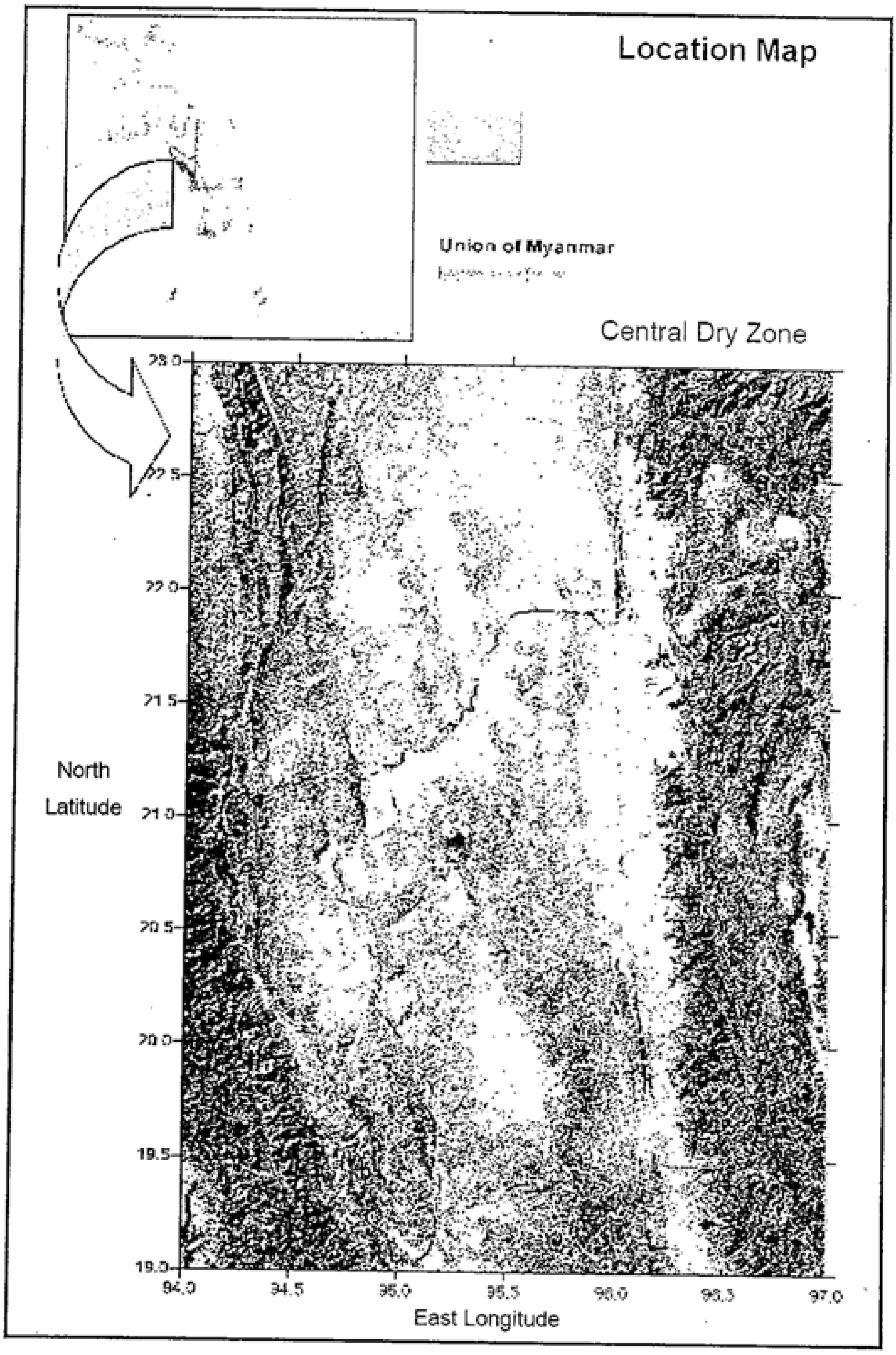
(7) Visibility of the Project

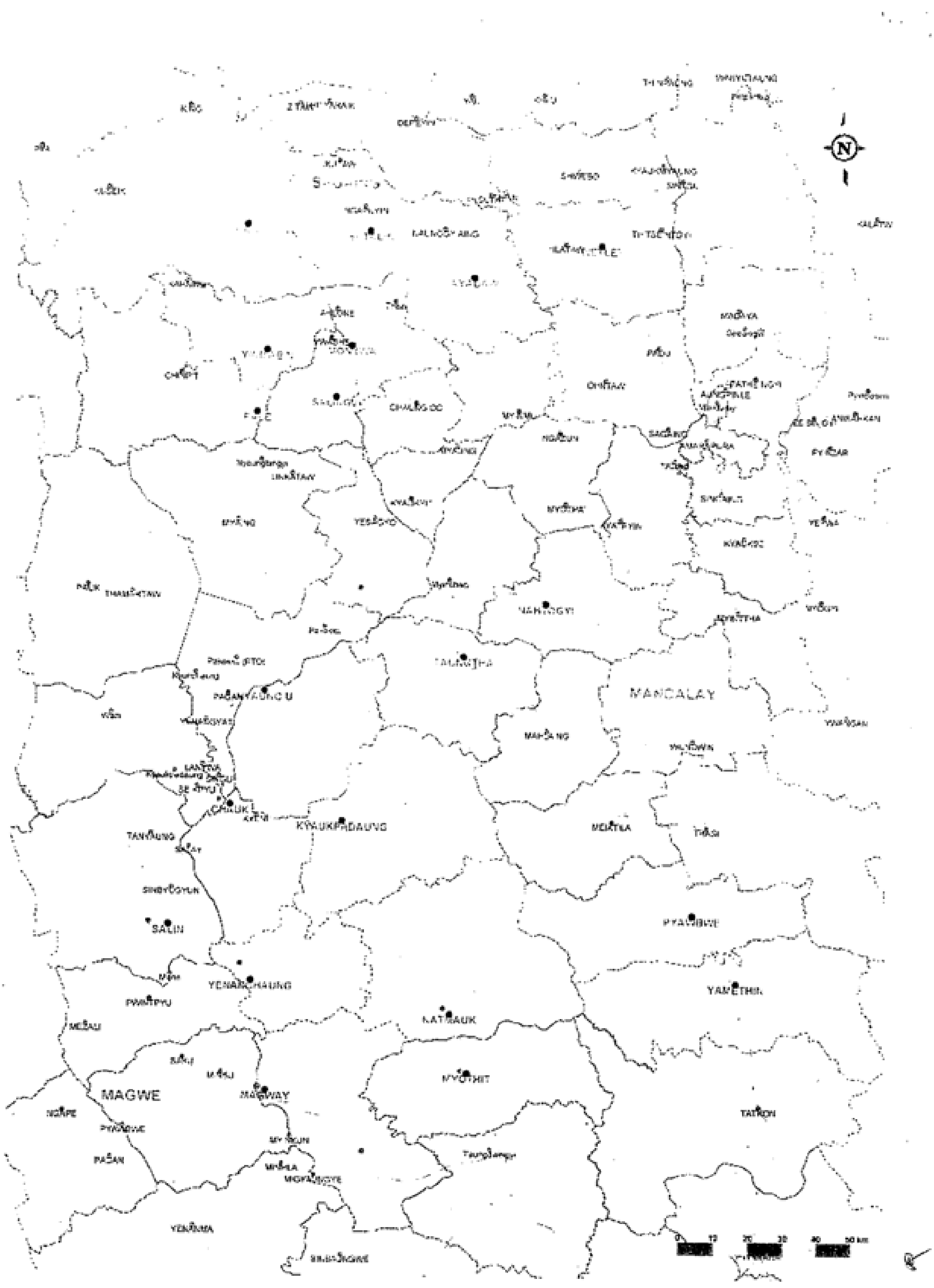
The Team explained that the visibility of the Project should be ensured as a token of cooperation from the Japanese people if the Project would be realized. The Myanmar side explained the following ideas to enhance publicity of the Project:

(a) To prepare brochures
(b) To publicize the Project in the mass media, and
(c) Commemoration panels.

Annex-1	Project Sites Map
Annex-2	Organization Chart of DDA
Annex-3	Items Requested by the Myanmar Side
Annex-4	Japan's Grant Aid Scheme
Annex-5	Major Undertakings to be taken by Each Government
Annex-6	Plan on Adequate Provision of Rural Water Supply in the Central Dry Zone
Annex-7	List of Target Villages
Annex-8	Allocation Plan of DDA Staffs
Annex-9	Utilization Plan of Procured Drilling Rig(s)

Annex-1: Project Sites Map




N
MANDALAY
MAGWE
KYAUKPADAUNG
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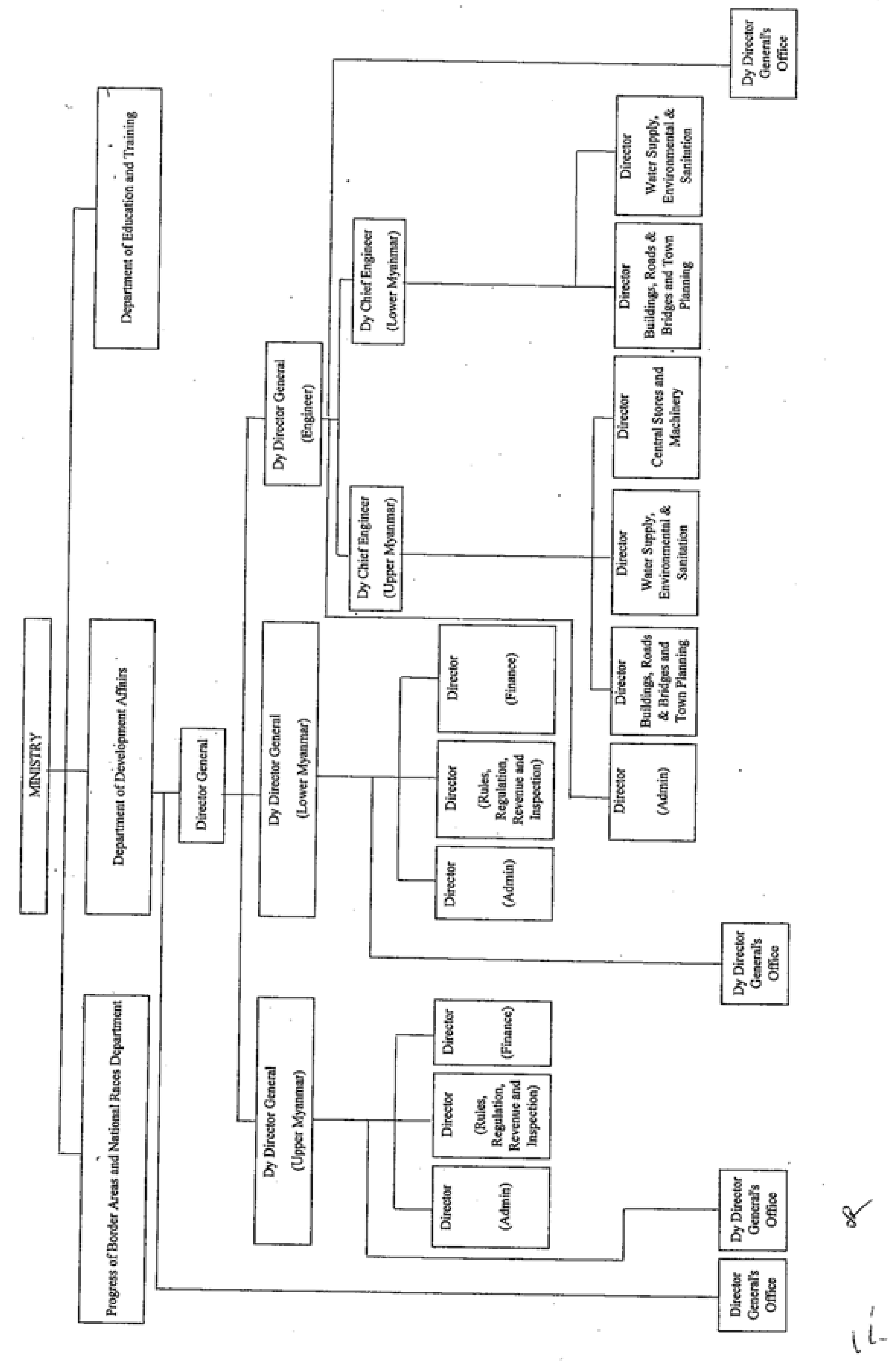
NATMAUK
MYOTHIT
MEIKTILA
PYAWBWE
YAMETHIN
TATKON

Annex-2 Organization Chart of DDA



Annex-3: Items Requested by the Myanmar Side

Items	unit
Drilling Rig mounted on truck (for 500m depth) and accessories	2 sets
Cargo truck with crane	2 units
Air compressor	1 unit
Pick up truck	2 units
Consumable goods for water well drilling	1 set
Casing and screen	110 villages
Submersible Pump with generator and accessories	110 sets