8. INITIAL ENVIRONMENTAL EXAMINATION (IEE)

8.1 Background

(1) Existing Environmental Situation

1) The Union of Myanmar is a land endowed with mostly semi-arid monsoon forests and monsoon rainfall. However due to the cutting of trees for firewood, land development for agriculture, forest fire, etc., the forest land-area which was originally two third of the total territory was considerably reduced. What has ever worsened the situation is that the insurgents recklessly cut the teak trees for money while the poor people enlarge the agricultural land for poppy growing. Moreover the reduction of forest area has led to soil erosion which in turn results in the reduction of natural recovery of soil fertility.

2) The wide variety of forest types including mangrove provide for a rich diversity of flora and fauna. As a result of its unusual ecological diversity, Myanmar is home to more than 300 known mammal species, 400 reptile species and 1000 bird species and a haven for about 7000 species of plants. It is however noticeable that the biological resources have deteriorated over the decades due to disturbances caused by humans and fragmentation of habitats.

3) Large number of wild elephants are captured annually under a Control Scheme administered under the Forest Department to replenish herds working in Timber industry. Despite protection measures by the Forest Department, elephant population are subject to illegal poaching for tusks in a number of areas.

4) The development works on water resources have been conducted by various departments of the Government of Union of Myanmar, but mostly without any environmental impact consideration. Most of the dams constructed so far have not had the reserved volume of storage water for the drinking water component. Moreover, also the laws and regulations on the environmental impact studies have not been enacted. Overall judgment based on the existing condition reveals that there should be an authority or a coordinating committee that will regulate, monitor and coordinate the water resources development activities of the various Ministries, such as the Ministry of Progress of Border Areas and National Races and Development Affairs, Ministry of Agriculture and Irrigation, Ministry of Construction and Ministry of Energy, etc.

(2) Environmental Management Activities in the Union of Myanmar

Previously before 1992, environmental management pattern was directly carried out administered by the respective ministries without a central coordinating environmental institution in Myanmar. But in 1992, an institution called the National Commission for Environmental Affairs (NCEA) was established under the Ministry of Foreign Affairs to manage and coordinate the environmental affairs of the Union of Myanmar as a separate entity. The NCEA has also been making sustained effort for enhancing public awareness and participation in environmental protection activities. Workshops, seminars and training courses have also been held with the aim of disseminating education and disseminating knowledge on environmental protection among the departments and the public.

The NCEA serves as the main contact point for external and internal environmental affairs. At present the Commission is preparing the Environmental Law and the Environmental Impact Assessment Law, it is learnt, the draft of which shall be thoroughly reviewed and finalized later.

With respect to the water quality standard, the WHO standard is used as a national standard with some adjustment for applicable use in each sector related with water supply.

NCEA has also formulated Myanmar Agenda 21 as an expression of the political commitment of the Government to sustainable development in line with the Historic Earth Summit in 1992.

These efforts and policies by NCEA are quite praise worthy, but it is to be pointed out here that actual practices are necessary as far as environmental affairs are concerned, such as monitoring the environmental condition of big cities, rural areas, industries, rivers, lakes, forests and so on. Monitoring may require sophisticated instruments, but monitoring by eye, ear or nose is still sufficient for some cases in question.

The following materials were collected from the National Commission for Environmental Affairs on 10th September 2001.

1) National environment policy of Myanmar
2) Water and Air Pollution Control Plan (Standing Order No.3/95) Ministry of Industry (1)
3) Myanmar Laws Relating to Environment
4) Brief Environmental Situation in Myanmar
5) International Environmental Conventions / Protocols Signed/ Ratified by Myanmar

Myanmar has the following environmental laws.

- ✧ The Protection of Wild Life and Wild Plants and Conservation of Natural Areas Law, 1994
- ✧ The Forest Law, 1992

The environmental conservation is controlled on the basis of these laws in Myanmar. Air quality protection law is not yet enacted.

8.2 The Project

The environmental policy shall be to conduct the initial environmental examination in compliance with the environmental law and the environmental assessment law of the Union of Myanmar if they were in existence or enacted during the course of the study.

But these environmental laws were not established as yet. Since environmental guidelines were not yet established in the Union of Myanmar, the IEE shall be conducted in accordance with the environmental guidelines that are in particular formulated for water supply development projects by JICA.

JICA's guide lines are based on the principles of promoting sustainable development while improving the living standard of the residents. The guide lines aim at harmonizing the development with a desirable environment.

By the study on initial environmental examination (IEE) or "Environmental Consideration", it shall be judged whether the project will have significant impacts on the environment or not, to assess the impacts and to incorporate measures to prevent or alleviate their effects, if necessary. The IEE is a prerequisite (a standard practice) for the sustainability of the development.

8.3 Scope of the Examination

The Initial Environmental Examination (hereinafter called "IEE"), a standard practice at the stage of master plan study, is carried out here to clarify the environmental impacts that may result from the implementation of this project on the basis of the existing information and data in a short period at a low cost. The present IEE is conducted with the following two objectives.

(1) to evaluate whether Environmental Impact Assessment (hereinafter EIA) is necessary

for the project at the project implementation stage and, if so, to define its contents and

(2) to examine from an environmental point of view the measures for alleviating the effects of the project which require the environmental consideration, but not a full-scale EIA.

If IEE shows the serious impacts on the existing environment, EIA shall be conducted at the stage of Implementation Study.

8.4 Framework for Initial Environmental Examination (IEE)

The IEE shall be conducted in accordance with the process that consists of the following four activities:

(1) basics to the process,
(2) description of environmental setting,
(3) impact prediction and assessment and
(4) proposing remedial measures.

8.5 Basics to the Process

As stated above, the IEE shall be conducted in accordance with the standard of practice laid down by JICA.

8.6 Description of Environmental Setting

(1) Purpose

1) To get the basic idea on the project for assessment of environmental impacts
2) To provide sufficient information for the decision makers

(2) The description of the environmental setting includes the following.

1) Project Description

For the project description, refer to Table 8.1. It includes background, objective, location, executing agency, beneficial population, features of the project, etc.

2) Site Description

For general features of the project site, refer to Table 8.2. It includes the environmental parameters, such as socio-economic environment (inhabitants, facilities pertinent to livelihood), natural environment (topography and geology, groundwater, lakes, rivers and meteorology, indigenous rare species of flora and fauna), environmental pollution (complaints and counter-measures) and others. For more details on the description of the environmental setting, refer to Table 8.6 (1) to Table 8.6 (4) which gives further information on the project site.

8.7 Impact Prediction and Assessment

Prediction and assessment of impacts from the project on the physical, chemical, biological, cultural, and socioeconomic environment (scoping) is carried out as a part of this initial environmental examination. The results from scoping are stated in Table 8.3.

Table 8.4 shows further studies conducted on the environmental parameters that are likely to be impacts from the project. These parameters are obtained from scoping.

8.8 Impacts from the Project and Counter-measures

In table 8.5, the impacts from the projects are stated and remedial measures are proposed. However, no serious impacts are foreseen from the project. The details of the proposed remedial measures are as follows.

(1) Surface Water Intake

The existing water quantity at the minimum discharge and its corresponding water level of Ayeyarwaddy is predicted from available discharge data. Since the extraction volume is small (only 2.6 m^3/sec), no significant water level decrease from the predicted level shall occur. No adverse effect shall be there due to abstraction for city water supply.

(2) Water Treatment Plant

At present, no water treatment plant is there in Mandalay City. The new water treatment plant shall be in the Master Plan planned to construct at the west side of Mandalay Hill with a treatment capacity of 200,000 m^3/day at full scale level in 2020. The treatment method is the so called sedimentation with coagulant + rapid sand filter + disinfection. The sludge, which comes out from the treatment process, is the sediment of fine soil particles such as sand,

silt and clay. Although those substances are generally not pollutant to the environment, the sludge is planed to be settled in the sludge drying beds to be constructed in the same compound of the WTP. The dried sludge will be disposed at a designated disposal site or utilized for reclaiming low lands.

(3) Wastewater Generation

The wastewater generated from the central area and west side of the Mandalay City shall be collected by using the Shwe Ta Chaung canal (drainage channel) and it shall be treated by a new sewage treatment plant to be built upstream of the existing drainage pump-house, after which the treated water shall be pumped out into the Ayeyarwaddy River. Furthermore, the combined wastewater from east side of Mandalay shall be collected by the existing Columbo drainage canal to undergo treatment at a new (planned) sewage treatment plant that is to be constructed just upstream of Taung tha man Pond. After that the treated wastewater shall be discharged into Taung tha man Pond and from there into the Ayeyarwaddy River. Refer to Fig.2.2.3 Drainage system in Mandalay City.

8.9 Conclusion

The present IEE shows that the project has no serious impacts on the existing environment. Hence it is concluded that the Environmental Impact Assessment (EIA) is not necessary to conduct at the stage of Implementation Study.

Table 8.1 Project Description

Water supply improvement plan in Mandalay City

Item		Description
Study Name		Water Supply Improvement Plan in Mandalay City
Background		At present, a large scale restriction of water supply is not yet enforced in the originally developed city areas, but in the newly developed eastern and southern regions, water supply facilities are not yet constructed. Hence residents have to rely on MCDC's public cooperative wells or private wells as a water source. Thus the development of a new water source with a new pipe-line system is a predominant issue for Mandalay city.
Objective		The basis of a medium-term ground water monitoring system shall be established and the water balance between increased water supply resulting from the increase of population and development of industries shall be regularly examined by MCDC. And the timely and step-by-step approach of construction of a water treatment plant using a river water source shall be proposed in the long-term water supply project and a most economic and flexible plan of construction and maintenance of a water supply system shall be envisaged.
Location		Mandalay City, Union of Myanmar
Executing Agency		Mandalay City Development Committee (MCDC)
Beneficiaries		A population of 800,000 as of July 2000, Estimated population of 2020: 1,098,800
Project Components	Type of project	New facilities and extension of existing facilities
	Main features	Drinking water and City water supply
	Water source/water quality	Surface water from Ayeyarwaddy Water quality: good
	Water Conveyance facilities	Total length: 290 km, of steel pipe line
	Water Treatment Plant	Treatment method: Sedimentation with coagulant + rapid sand filter + disinfection Capacity of treatment: 200,000 m3/day
	Water distribution/ reservoir facilities	Reservoir:: 3 Nos., Total Capacity: 50,000 m3
	Appurtenant facilities	Power line and management facilities
Miscellaneous		

Table 8.2 Site Description
Water supply improvement plan in Mandalay City

Item		Description
Study Name		Water supply improvement plan in Mandalay City
Socio-economic Environment	Inhabitants: (Residents/ Indigenous/ their views on the project, etc.)	Second largest city in Myanmar. In future, the city is expected to get extended in area and in population. Residents' expectation on the project is high. They are anxious about securing good-quality drinking water for their livelihood.
	Facilities pertinent to livelihood (well, reservoirs, water supply / electricity)	Water supply facilities were constructed, but the water supply to newly developed regions of the city is not yet carried out.
	Public health and sanitation (illness, infectious diseases, hospitals, sanitary habits)	The waters from the wells are being tested regularly. Since the groundwater is used, the water is free from pathogenic bacteria.
Natural Enviroment	Topography and geology (steep slopes, soft grounds, wetlands / faults)	The city is situated in the central low land with a slight difference of ground heights.
	Ground water, lakes, rivers, meteorology (water quality, quantity, rainfall, etc.)	Although the city lies in the central dry zone, the water quantity of the perennial river contemplated for water intake (Ayeyarwaddy) is abundant.
	Indigenous rare species of flora and fauna, their habitats (Natural park, thriving / habitats of rare species, etc.)	No rare species of any kind is found in the project area.
Environmental Pollution	Complaints Pollution of the utmost concern	Drainage problem Water pollution due to discharge of dirty water from industries Air pollution due to dirty waters from industries
	Countermeasures (institutional measures / Compensation, etc.)	Measures against pollution and drainage problems are under planning stage.
Others		

For further details of the project site, refer to Table 5.10.2 (1) to Table 5.10.2 (4).

Table 8.3 Results from Scoping

Name of Project			Water Supply Improvement Plan in Mandalay City	
Environmental Item			Evaluation	Reason or Ground
Socio-economic Environment	1	Resettlement of residents	C	Land required for water supply facilities
	2	Economic activities	D	No significant effect on peoples' economic activities. Facilities shall be built on government owned land.
	3	Transportation and public facilities	D	No effect. Pipe Lines shall pass along the roads or across waste land
	4	Split of communities	D	Facilities shall be built on government owned land and pipe lines shall pass along the roads or across waste land
	5	Historical relics and cultural heritage	D	No effect on historical relics and cultural heritages
	6	Water right of users	C	Water rights are to be clarified..
	7	Public health and sanitation	D	Shall be improved
	8	Waste	D	To plot an appropriate waste disposal plan
	9	Hazards (risk)	D	No occurrence
Natural Environment	10	Topography and geology	D	No major changes of topographic condition
	11	Soil Erosion	D	No major changes of soil or topography.
	12	Groundwater	C	Possibility of ground water draw-down
	13	Lakes and river flow	C	Possibility of flow changes at and around water-intake site
	14	Coastal and coastal zone	D	No coastal area in the project
	15	Flora and fauna	D	The existence of rare species is not notified. Change of facility location is possible in case of effect on them.
	16	Meteorology	D	No facility shall change meteorological condition
	17	Aesthetic appearance	D	Small scale structures, their appearance is not a disturbance to others.
Environmental Pollution	18	Air Pollution	D	No facility to pollute air
	19	Water pollution	C	Possibility of flow changes at and around water intake site.
	20	Soil contamination	D	Drainage and treatment shall solve the problem
	21	Noise and vibration	D	Restricted to during construction
	22	Ground subsidence	C	Due to excessive withdrawal of groundwater, ground subsidence is likely to occur
	23	Offensive oder	D	No facility to make bad smell

Note;
A : Great impact
B : Some impact is expected
C : Further studies are required to clarify the impact in IEE.
D : Almost no impact, not to be included in IEE.

Table 8.4 Impacts under Analysis for Initial Environmental Examination

Water Supply Improvement Plan in Mandalay City

No.	Environmental Impacts due to the Project	Studies Conducted	Degree of Impact and counter-measures
1	Resettlement of residents	Studies on proposed facility sites reveal that resettlement of residents shall not be required.	No impact The land used for water supply facilities is owned by the government (MCDC).
2	Acquiring water rights	Study on water right and existing water users' right	Abstraction volume is small (only 2.6 m^3/sec) and the river is controlled by the government. Hence no need to acquire water right.
3	Groundwater	Study on the groundwater potential	Total potential of groundwater is 230,000 m3/day. At present 170,000 m3/day is being extracted. Groundwater recharge volume is only 100,000m3/day, but with additional recharge from Ayeyarwaddy, the groundwater balance is maintained.
4	Ground subsidence	Study on geological condition of the ground, such as the thickness of clay layer, etc.	No ground subsidence
5	Hydrological changes	Study on flow condition and water level at the intake site	No significant change of Ayeyarwaddy's flow condition and intake-site's water level since the abstracted volume is small, i.e.2.6 m^3/sec.
6	Water pollution	The extent of pollution caused by waste water including factory discharge is scrutinized. Prediction of river-water pollution due to the increased discharge as a result of the increase in water supply facilities is made.	The water quality standard of discharged water is to be specified. A waste water treatment system (a combined type) is proposed. As a counter-measure against pollution, a sewage treatment plant with additional drainage facilities is proposed.

Table 8.5 Environmental Impacts from the Proposed Project
Water Supply Improvement Plan in Mandalay City

Environmental Item	Environmental Impact		Evaluation and Counter-measures
	Existing (2002)	Future (2020)	
Surface Water Intake	1) Pump house at the existing Mandalay Groundwater pump station does not generate any noise.	The new intake at 22nd street will be a source of noise pollution although the impacts are very insignificant.	The impacts are negligible and remedial measures are not necessary.
Water treatment plant	No treatment plant at present	O/M of the new plant at the west side of Mandalay hill including sludge management is satisfactory with no significant adverse impacts on the surrounding environment.	No significant impact is antic ipated in future.
Wastewater generation	For final disposal of generated wastewater due to existing water supply, the drainage channel and drainage facilities require upgrading and rehabilitation	Increased wastewater generation due to additional flush-toilet users increases demand for sewage collection and treatment system together with additional drainage facilities	A sewerage development master plan study is recommended for addressing both existing and the anticipated future wastewater disposal problems.
Hydrological Changes at Intake Site	Flow is normal at the 22nd street intake site with a difference of the high-flood water level and the low-flow dry season water level at 10.71 m (once-in-20 year flood).	Flow at the 22nd street intake site will be reduced by 2.6 m3/sec. The change in difference of the high flood water level and the low-flow dry season water level is insignificant.	Impact to downstream water level and impact to the river flow are negligible.

Table 8.6 (1) DESCRIPTION OF ENVIRONMENTAL SETTING
Water Supply Improvement Plan in Mandalay City

Environmental Parameter	Natural Environment: Groundwater, lakes and rivers
Sites under Study	Ayeyawaddy, Dotehtawaddy, Groundwater Pump Stations, Mandalay Royal Moat

Scope of study

Mandalay city and its water resources

Other Information

Mandalay City has been built by Sinbyushin, the 3rd king of Kaungbaung dynasty in the year 1859. The palace was constructed first and the royal moat later. Water for the moat was carried over by unlined channels from the royal weir at Sedawgyi (46 km from Mandalay) on Chaungmagyi river that is flowing from Mogok high lands down to Ayeyawaddy plain. The moat water was originally used for drinking and domestic purpose for Mandalay city residents. But with the increase of population, the water demand increased and people had to rely on water from tube wells and hand-dug wells. Moreover, Ayeyawaddy river, the perennial river with an annual runoff of 262 billion cubic meters at Sagaing gauging station, is flowing on the western side of Mandalay city. On the other hand, irrigation channels are carrying water enough for domestic use. Thus the water environment of Mandalay is fairly good. However, with the ever increasing population and industries, the water demand is increasing. Extraction of groundwater more than the present extraction (170,000 m3/day) may have adverse impacts on the city. Using surface water for domestic water supply shall solve the problem.

Overall Judgment

Although sufficient water is available, good and sanitarily potable drinking water is scarce, hence it has been ever longing desire of Mandalay residents to obtain good-quality drinking water. Efforts are being stepped up supply water to newly developed areas of the city.

Photographs

(1) Ayeyawaddy at Proposed Intake 1

(2) Dotehtawaddy River at Shwesayan GS

(3) Kandawgyi Lake of Mandalay City

(4) Mandalay Royal Moat

Table 8.6 (2) DESCRIPTION OF ENVIRONMENTAL SETTING
Water Supply Improvement Plan in Mandalay City

Environmental Parameter	Socio-economic Environment: Drainage Facilities pertinent to livelihood
Sites under Study	Drainage Facilities

Scope of study

Mandalay City drainage facilities

Other Information

Waste water from Mandalay city is being discharged into Ayeyarwaddy river without proper treatment. Industrial effluents are also being discharged into natural streams without proper treatment. As the evaporation is quite high in Mandalay area, the waste water from the city is not large in quantity (total 40 m3/sec estimated). But waste water from industries is rather contaminated with bad order spreading around the streams where effluents are discharged. With the increase in water supply, the number of flush toilets shall increase. Thus waste water including sewage is expected to increase in future in Mandalay City. A drainage project is recommended to improve and step up health and social services to Mandalay City residents. At present drainage of waste water is carried out by gravity and discharged into Ayeyarwaddy during dry season, but in rainy season when the Ayeyawaddy river water rises, the outlet gate at Shwege, situated about 8 Km from Mandalay, is closed and waste water is pumped out into Ayeyawaddy with 3 pumps of 50 HP each.

Overall Judgment

Main drainage channels are working properly, but the road-side drains are considered not working properly or are not well provided for the stormwater drainage.

Photographs

(1) Mandalay drainage pump house

(2) Outlet gate to the Ayeyarwaddy River

(3) Outlet pipes of pump house

(4) Main drainage channel (Shwetachaung)

Table 8.6 (3) DESCRIPTION OF ENVIRONMENTAL SETTING
Water Supply Improvement Plan in Mandalay City

Environmental Parameter	Natural Environment: Topography and Geology
Sites under Study	Mandalay City, Mandalay hill, Outskirts of the City

Scope of study

Mandalay City and its outskirts

Other Information

The land is quite flat with a slight difference of elevation. Since the time of King Alaungphya (around AD1890), Mandalay agricultural flat land of more than 20,000 ha has been brought under irrigation with the irrigation water carried over by unlined main canal from Chaungmagyi river that originates from Mogok ranges of mountains. Mandalay royal moat is being fed by this canal. Mandalay hill is the only highland that can be seen around this area. The hill is geologically made up of sedimentary rock and limestone and the flat plain is mostly of alluvial Irrawaddy formation. As the land is flat, the drainage of the City is quite difficult. But at the low land in the south-west portion of Mandalay, a lake (Kandawgyi Lake) is naturally formed to serve as a retention pond for the flood water coming from Mandalay city. The mountains to the east of Mandalay are the limestone rich area and limestone is being extracted for cement production.

Overall Judgment

Topography of the area is quite good for irrigated agricultural activities. It is also a factor for good inland transportation, making Mandalay a very thriving city.

Photographs

(1) Royal Moat around the Palace (Mandalay)

(2) Mandalay canal

(3) Mandalay hill

(4) Limestone outcrops near Mandalay

Table 8.6 (4) DESCRIPTION OF ENVIRONMENTAL SETTING
Water Supply Improvement Plan in Mandalay City

Environmental Parameter	Environmental pollution, Complaints
Sites under Study	River pollution due to dirty waste from factories, garbage problem

Scope of study

River pollution, tube wells dug by assistance

Other Information

From the reconnaissance studies, it is learnt that waste water from factories of Mandalay Industrial Zone are being discharged into streams and drainage channels. And these channels empty into Dotehtawaddy as shown in photograph (1). These dirty water carriers emit dirty smell leading to air pollution. The smell is a nuisance to the people. Both water pollution and air pollution shall give harmful effects to the people living in the vicinity of these streams. Stringent rules on the factory effluents should be imposed and monitoring of these effluents should be carried out by the environmental authorities concerned, or else the environmental deterioration shall continue to an unbearable proportion. Such effluents from industries shall pollute groundwater and surface water and lead to horrible disease to the people surrounding the industries as a result of eating the fish in and drinking the water of the polluted tube wells or streams. Here establishment of an Environment Monitoring Committee for these and other environmental affairs is proposed for the safe environment of the Mandalay City.

Overall Judgment

The pollution of water occurs due to discharge of dirty water from factories leading to air pollution due to dirty smell from waters.
Garbage disposal is also a problem that has to be addressed in future.

Photographs

(1) Dirty water discharging into Dotehtawaddy

(2) Garbage disposal site in Mandalay

(3) Factory Effluents discharged into streams

(4) A new tube well dug by JICA assistance (150 m depth)

9. TECHNOLOGY TRANSFERRED IN THE STUDY

Through the study, some significant technology and knowledge on the methods of groundwater development have been transferred to MCDC staff. The main ones were: 1) reporting on drilling progress, well logging, pumping test, 2) groundwater monitoring, 3) formulation of well data base, and 4) operation of computer software for groundwater simulation.

(1) Preparation of Report on Drilling Work and Result of Tests

MCDC has drilled 28 of production wells in Mandalay City from 1989 to 2001 by using its own drilling rig provided by Australia. MCDC's drilling team also constructed a deep tube well as a test well proposed in this Study. The drilling team showed a high drilling performance, however, the team has no proper way of reporting about drilling process such as progress of drilling, soil condition analyzed by collecting the slime, well logging, pumping test, etc. Under instruction of experts of the Study Team, the drilling team made a report properly based on the fieldwork of drilling, well logging, pumping test, etc. The report prepared by the drilling team would be used as a text for the next occasion of well drilling. The drilling team understood that such report would be significant data for groundwater development strategy of Mandalay City.

(2) Groundwater Monitoring

Groundwater monitoring methodologies were also transferred to the officers in charge of MCDC through the actual field work such as the monthly monitoring of 15 existing tube wells for one year and the simultaneous monitoring of 100 tube wells conducted twice in the dry season with respect to water quality and groundwater level. It is strongly expected that MCDC will continue the monitoring on the same manner as conducted in the study. Data to be accumulated through the periodical monitoring will be very useful tools for the future groundwater management of Mandalay City.

(3) Formulation of Well Database

Formulation of database of the existing tube wells by computer software was also very useful in Mandalay City. MCDC earlier had no proper technology to compile data of the existing tube wells. Data so far input into the database in the study is not adequate at the moment, however with more data compiled, the database would become a more useful tool for making a strategy of groundwater management. As the database can be also used as an inventory of the private tube wells, the database will be a very useful for MCDC to manage tube wells of the whole area.

(4) Operation of Computer Software for Groundwater Simulation

Through the Study some engineers of MCDC were instructed how to operate the groundwater simulation software. They have mastered basic operations to revise the data and renew the simulation when they need in future. A brief operation manual of this software used in the training is compiled in 2-I of Vol. III Supporting Report.

10. PROJECT EVALUATION

10.1 Technical Evaluation

The proposed project for water supply system in Mandaly City consists of the following two components:

(1) Expansion of the existing water supply system (raw water source: groundwater)

(2) The water supply system newly introduced (raw water source: the Ayeyarwaddy River): The river water will be distributed after treatment at the proposed Water Treatment Plant (WTP).

The public water supply system of Mandalay City was started in 1935 by operation of four tube wells. Since 1955, new tube wells were built up to a completed total of 17 tube wells by the end of 1962. The Asian Development Bank (ADB) carried out a feasibility study for the expansion of the existing water supply system, which was called "Mandalay Water Supply Project". The construction under the project was implemented from 1982 to 1992. MCDC was involved in construction of 21 tube wells, laying of pipelines, and installation works of various other facilities. Thus MCDC has a lot of experience for groundwater supply system.

The proposed Urgent Project is also one of groundwater development. This project is intended to supply much more and safer water to the people in the present water service area by construction of five new tube wells, expansion of distribution reservoir and installation of booster pumps and a disinfection facility etc. These facilities are not new to MCDC except the disinfection facility using calcium hypochlorite. MCDC already has the capability for groundwater development and management of water supply system through its operation. Disinfection technology by calcium hypochlorite is new to MCDC. However this should not be difficult for MCDC to master because the system is simpler than the chlorination gas injection system in which MCDC has much experience. Therefore, the proposed groundwater supply system is evaluated as appropriate and reasonable from the technical point of view.

On the other hand, the project of surface water supply system is new to MCDC. At present, MCDC has no experience in proper technology for operation and maintenance of a water treatment plant (WTP). However operation of WTP is not new in Myanmar. Actually, a WTP is in operation for Paleik Textile Factory (capacity: 24,000 m^3/d) situated downstream in the Dotehtawaddy River. Necessary operation and maintenance technology could be transferred to MCDC staff through training during the design-phase and construction-phase based on the construction package contract. Also, the appropriate WTP technology could be

transferred to key staff of MCDC through training courses to be held in advanced countries. Hence, introduction of surface water supply system is also evaluated as suitable from the technical point of view.

10.2 Financial and Economic Evaluation

A tariff model was developed to simulate cash flow of the project under three options of fund sources. The tariff models were designed to follow the past growth rate of the economy, on an annual base for the entire project life. Geographical proximity of Mandalay to China is expected to contribute to robust growth of the regional economy and hence increased affordability of the prospective users to pay for the water. The tariff in the initial stage of project implementation was determined considering the current tariff, willingness to pay and affordability of the prospective users, which ranged between 0.100 and US$ 0.175 per m^3. The Financial Internal Rate of Return (FIRR) of the overall proposed project was estimated at 8.0 % when the tariff was set at US$ 0.15 per m^3 in the initial stage and thereafter raised annually by 4 %. The FIRRs of the sub-projects namely, Urgent Project, Expansion of Existing Pipe Network supplied by BPS1, and the Surface Water System Development Project, were estimated at 13.0 %, 14.3 % and 7.1 % respectively. The FIRR of the overall project declined to 6.5 %, in a sensitivity analysis assuming 10 % increase in project cost and 10 % decrease in project revenue. However, the FIRR was improved to 7.2 % in the case when the total project cost of the Urgent Project was assumed to be subsidized by foreign and/or the central government. It further improved to 9.3 % assuming that 25 % of the cost of other sub-projects also be subsidized by the central government in addition to the subsidies in the former case.

The economic rate of return (EIRR) of the overall proposed project was estimated at 8.1 %, and that of the sub-projects; Urgent Project, Expansion of Existing Pipe Network supplied by BPS1, and the Surface Water System Development Project, were 12.3 %, 13.8 %, and 7.3 % respectively.

From the points of FIRR and EIRR, the robustness of the two sub-projects Urgent Project and the Expansion of Existing Pipe Network supplied by BPS1 were judged to be high enough for implementation, but the same of the Surface Water System Development Project was comparatively weak. Therefore, for the implementation of the latter project, it is strongly recommended that MCDC should make strict management of the project cost and the water revenue with necessary monitoring of the trend of economic development in Mandalay City.

10.3 Environmental Evaluation

The study area of the Master Plan is administrative area of Mandalay City, which consists of both built up area and vacant area such as farmland and potential flood area. No indigenous rare species live in the Study Area.

Although the drawn amount of groundwater will increase with the implementation of the Urgent Project, land subsidence should not occur because the existing ground formation consists of hard clay and sand. The surplus soil generated from construction works is not harmful; however it should be properly disposed at a designated final disposal site. The sludge from WTP shall be treated at the sludge drying beds and the dried sludge shall also be disposed at a designated disposal site.

Therefore, environmental impacts from the proposed projects through the construction and operation are negligible.

10.4 Overall Evaluation

The proposed Urgent Project is expected to bring the following advantages:

- To increase 26,000m^3/day of supplied water volume, which corresponds to about 24 % of the present water supply volume to a service population of 100,000.
- To raise water pressure in the distribution pipeline to send water to the service areas where people have difficulty in receiving enough water due to being far from the booster pumping station (BPS1).
- To prevent any acute spread of water born diseases due to distribution of hygienic water.

The facilities proposed in the Urgent Project are familiar to MCDC, as such the staff of MCDC should be able to operate them without any difficulties. Besides, the project cost is not so large compared with the new water supply system using surface water.

The proposed water supply system using surface water is indispensable considering limitation of the potential of groundwater development in Mandalay City. MCDC has a big advantage in using surface water because the Ayeyarwaddy River flows along the west side of the City with abundant quantity and suitable quality for the water source. The river water will be distributed to people after conventional treatment process at the proposed WTP. By the proposed water supply system, the service area will cover the whole city area and the service ratio will reach the 90 % of the population base in 2010. Therefore, the proposed project can contribute to raise the living standard of the citizens and lead to sound economic development

of Mandalay City.

Thus the proposed water supply project as a whole is recommended from economical, technical, and environmental points of view. Hence, it is concluded that project is appropriate for economic and social development of Mandalay, which is the second largest city in Myanmar.

11. RECOMMENDATIONS

11.1 Expansion of the Existing Water Supply System

(1) Enhancement of Administrative Capability of WSD

Water supply service should be provided to the people stably and continuously. The revenue from the water supply service should be spent effectively for operation and maintenance of the system. At present, the water tariff is collected by the Revenue Department of MCDC as a levy for the services provided by WSD and is pooled in the revenue account of MCDC not WSD. Therefore, it is not easy to acquire abundant budget for investment in the water works such as expansion, rehabilitation, and full-scale overhaul etc., of the system. In considering introduction of the proposed project, proper budgetary arrangement for future activities is indispensable. The self-supporting accounting system for the water supply activities is a key point to realize sustainable operation of the water works. The introduction of the self-supporting accounting system is recommended well before repayment of a bank loan for implementation of the proposed project will start.

Moreover, in order to reduce non-revenue water of the existing water supply system, the following actions should be taken:

- To replace inaccurate and old water meters
- To install water meters for consumers
- To modify the existing legislation to collect water tariff for public facilities
- To prevent illegal connections and to punish the violators
- To deliver water bills to all consumers and collect the charges properly and impartially.
- To inspection system

(2) Introduction of Computer Oriented Engineering Works

Various calculations, analyses, and data processing were done in the study in cooperation with counterpart personnel using the computers. The administration of water supply works can be carried out effectively by good use of computers. Therefore it is recommended for MCDC to expedite switching on to computer oriented engineering works for the following fields:

- Compiling and processing of data related to operation and maintenance records of the existing water supply system.

- Preparing inventory for the facilities, equipment, and the stock of spare parts, etc.
- Planning, design and Drawing works
- Updating and effective utilization of data of the Wells Database produced in the Study for the Control of groundwater production.

(3) Establishing of Groundwater Monitoring System

A Well Database for Mandalay City was produced in the Study. Monthly monitoring of groundwater level and quality of selected 15 tube wells was also conducted for one year. Such technology was transferred to MCDC personnel during the study period.

It is highly recommended to monitor groundwater conditions constantly when drawing groundwater continuously. In case any adverse changes are observed, MCDC has to take proper actions to prevent over drawing of groundwater by private wells, which are now being unchecked.

(4) Improved Management of Water Distribution

It is less than 20 years after the existing water supply system was inaugurated. The water distribution network is still maintained in good condition. However, considering expansion of the water service area and forecast deterioration of the system in the future, it is recommended for MCDC to take the following actions for effective management of the water distribution system.

- To conduct a water leakage survey using detecting technology
- To replace deteriorated pipes when leakage is detected
- To establish "District Meter Area" (DMA) system

11.2 Introducing of New Water Supply System

(1) Acquisition of Technology on Operation of WTP

MCDC has no experience in operation and maintenance of a water treatment plant (WTP). In the inauguration stage of the new WTP, WTP operation and maintenance technology should be transferred to MCDC staff on a contract basis, such as through vendor training. There is a good example of WTP at a textile factory near Mandalay City. Although its capacity is smaller than the proposed one, the treatment process is of the same type (sedimentation with coagulation and rapid sand filter). Therefore, sending WSD's engineers to the textile factory to learn operation and maintenance of the WTP before the

commissioning of the proposed WTP is recommended. It is also recommended to let key staff participate in suitable training programs provided by advanced countries.

(2) Revision of Water Tariff

In the Study, it is assumed that the main portion of initial investment costs of the proposed projects will be covered by loans. The current water tariff should be increased in consideration of repayment of the loan and expenditure for operation and maintenance of the new facilities. It is recommended for MCDC to hold public awareness/information activities about the water tariff revisions to gain good understanding from the consumers.

(3) Reform of Water and Sanitation Department (WSD)

In accordance with introduction of the new water supply system to MCDC, modification of the organization of WSD is indispensable because new facilities such as intake facility, WTP, and reservoirs etc. will be added. Therefore MCDC has to recruit new staff and give proper training to them in order to provide a satisfactory water supply service to the consumers.

(4) Sanitation and Wastewater Management

To prevent water contamination of the proposed intake site, proper wastewater management is recommended as described below:

- To conduct education on sanitation, for example not to dispose of solid waste into water bodies.
- To introduce individual wastewater treatment facilities for households along the streams and canals within the catchment basin of the intake site.

Increase of water supply volume causes augmentation also of wastewater volume in the City. Therefore it is strongly recommended for MCDC conduct a study on wastewater and drainage management in Mandalay City.

PART III STUDY ON WATER SUPPLY IMPROVEMENT PLAN IN THE CENTRAL DRY ZONE

PART III WATER SUPPLY IMPROVEMENT PLAN IN CENTRAL DRY ZONE

1 GENERAL CONDITIONS OF THE STUDY AREA

1.1 Natural Conditions

1.1.1 Topography

The Central Dry Zone is situated in an essentially elongated sedimentological basin (Inner-Burman Tertiary Basin) between latitudes 19 ° to 23 ° north and longitudes 94 ° to 96 ° 30 ′ east. It has maximum length of 560 km, width of 270 km and a total area of 77,000 km^2. The study area, 11 Townships, belongs to Mandalay and Magway Division and has a total area of 16,400 km^2 (see opening page "The Location Map of the Study Area").

This basin is surrounded on three sides by large mountain ranges. The west and north are situated the mountains of the Indo-Burman Ranges (Western Ranges). To the south along this range the Arakan Yoma rises to elevation of 2,000 m, while further north Mt.Victoria in the Chin Hills attains a height of 3,000 m. The highlands of the Shan Plateau, which form part of the Sino- Burman Range (Eastern Highland) rise abruptly to an average height of 600 m to form eastern boundary.

A low lying range of hills known as the Pegu Yoma Anticrinorium rises in the central part of the Dry Zone near Mandalay and run southward. The Pegu Yoma and its extensions are approximately 500 km in length and 60 km wide. This anticlinorium divides the basin into two meridional valley systems (see Fig. 1.1.1.1).

The Ayeyarwaddy River flows south along a north-south fault line to Mandalay City where it turns west and then south to occupy the western valley while the Sittang River occupies the eastern drainage system. Major tributaries of the Ayeyarwaddy River include the Chindwin and the Mu Rivers.

The alluvial flats of the Ayeyarwaddy River gently slope to the south. At Mandalay City, they are about 66 m above mean sea level (AMSL) while at Magway Town the alluvial flats are about 45 m AMSL.

The overall flat morphology of the western drainage system is interrupted by a series of geotectonically induced elongated ridges. Most of these are orientated in NNW-SSE direction. They rise as much as 180 m above the surrounding plains. Mt. Popa is an extinct volcano that rises to 1,500 m AMSL to form the dominant topographic feature in the

Dry Zone.

The drainage and relief patterns within the study area are closely related with the past and present geotectonic activity and lithology.

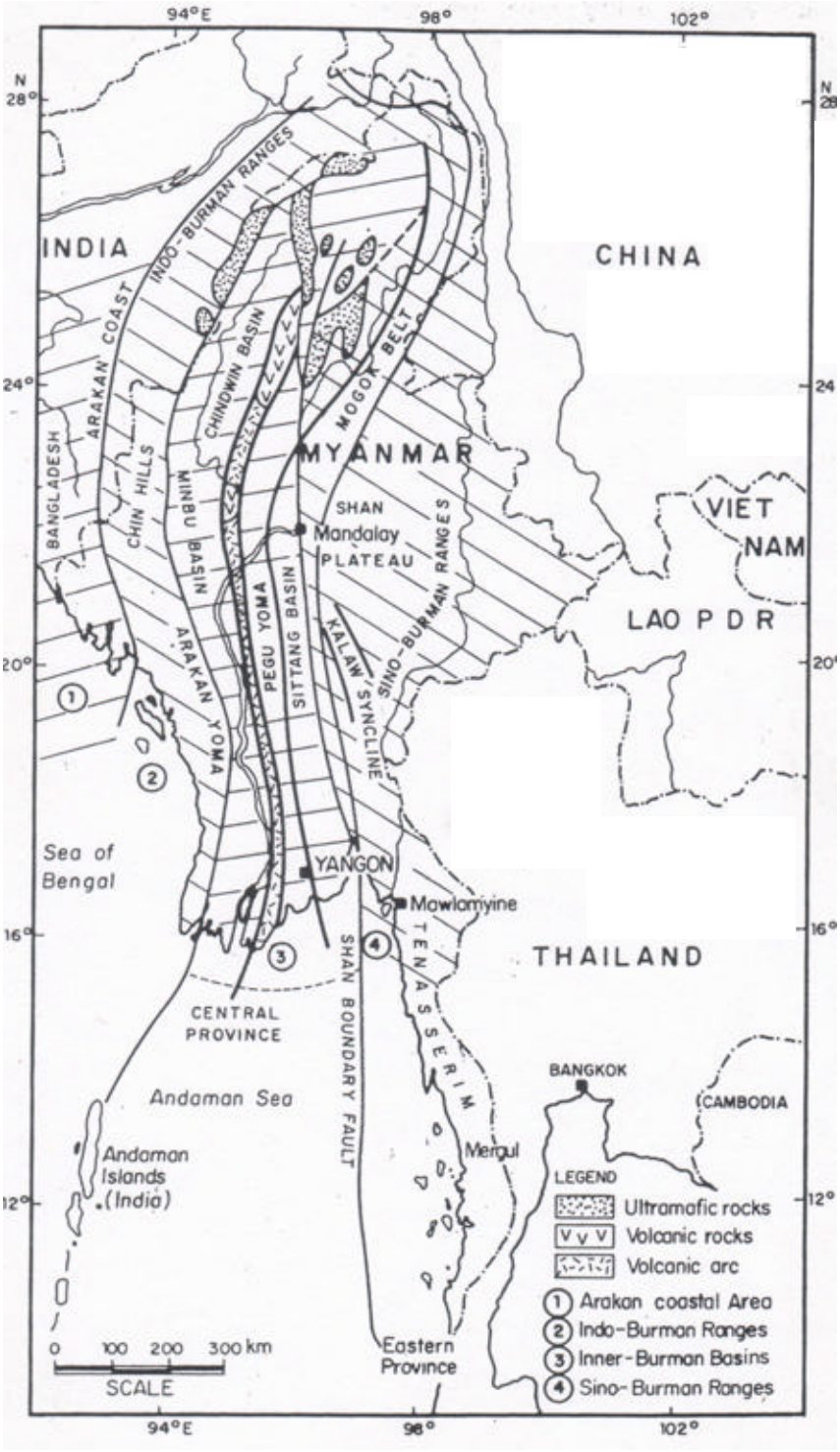

Fig. 1.1.1.1 Principal Geological Features of Myanmar

Source: "Geology and Mineral Resources of Myanmar, 1966 ESCAP"

1.1.2 Climate

The Central Dry Zone (hereinafter the zone) is situated in the central region of Myanmar. It has a hot tropical climate throughout the year with the maximum day time temperature going up to 40 ℃ in the month of April. As it lies in the central region of Myanmar, which is far away from Monsoon rainstorm coming from the Andaman Sea, the Central Dry Zone has a scanty rainfall with a long dry season from November to May of the following year. The climatological characteristics of the Central Dry Zone are as follows.

(1) Rainfall

The Central Dry Zone is hot and dry in climate with an annual rainfall ranging from 400 mm to 880 mm. The rainy season starts from the middle of May and ends around the beginning of November. The rainfall distribution pattern of a year is of an uneven and erratic nature with the water-abundant year's rainfall of 880 mm at Myothit and the drought year's rainfall of 432 mm at Yezagyo. The rainy season has 40 to 60 rainy days in a year. Other days are entirely dry without any rainfall. The rainfall intensity of the zone is estimated 40 mm/hour which is rather high. Consequently soil saturation is little with a high rate of land erosion around big rivers.

1) Comparison of Average Monthly Rainfalls in Central Dry Zone

The following table shows the average monthly rainfalls derived from the records over a period of 10 years from 1990 to 1999 at 5 meteorological stations in the Central Dry Zone.

Table 1.1.2.1 Average Monthly Rainfall at 5 Meteorological Stations (mm)

Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Magway	0	5	9	17	119	111	90	129	159	116	62	7	824
Nyaung U	0	3	9	16	76	83	67	84	137	85	44	3	607
Myingyan	0	5	1	33	53	80	50	113	180	86	27	4	632
Chauk	0	2	9	8	121	61	36	111	137	105	19	1	610
Mandalay	0	8	12	53	129	96	73	143	186	99	36	3	837

From this table it is learnt that the highest rainfall occurs in September at all stations. Negligible rainfall is recorded from December to March. The monthly rainfalls of theses stations are plotted in Fig.1.1.2.1 for comparison of rainfall patterns at these stations. From this figure it is found that the monthly rainfall pattern has two peaks in a year, one in May or June and the other in September.

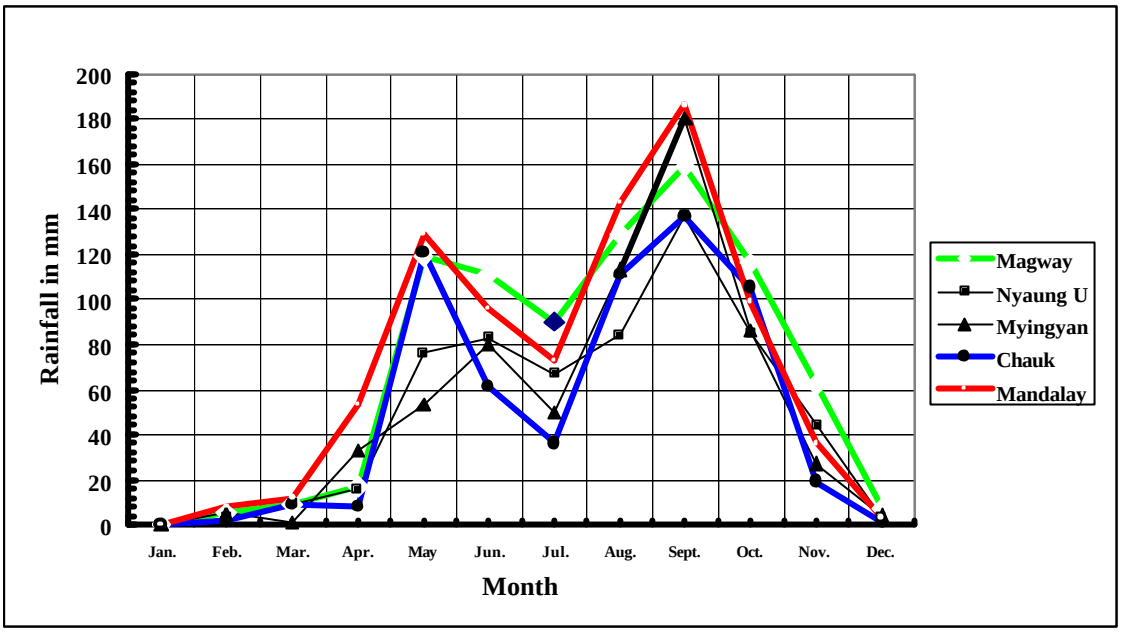

Fig.1.1.2.1 Comparison of Monthly Rainfalls at 5 Meteorological Stations

2) Monthly Rainfalls at Nyaung U Meteorological Station

The following table shows the monthly rainfalls at Nyaung U meteorological station recorded over a period of 10 years from 1991 to 2000. In order to make a year-wise comparison of the monthly rainfalls, two graphs of monthly rainfalls are plotted with one for the period from 1991 to 1995 and the other from 1996 to 2000. From these graphs it is learnt that during the period of 5 years from 1991 to 1995, the annual rainfalls in four years are lower than the 10 years' average of 555 mm except the year 1992 with 604 mm. And during the period of the later 5 years from 1996 to 2000, the annual rainfalls are higher than the 10 years' average of 555 mm in the case of three years (1996, 1999 and 2000), but two years' rainfalls (1997,1998) are lower than the 10 years' average. Refer to Fig.1.1.2.2 and Fig.1.1.2.3.

Table 1.1.2.2 Monthly Rainfalls at Nyaung U Meteorological Station (mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1991	0	0	0	34	56	50	14	78	107	106	66	6	517
1992	0	12	0	0	111	41	68	104	90	143	23	12	604
1993	0	12	0	2	105	95	4	60	159	79	0	0	516
1994	0	0	3	23	26	130	77	127	81	16	18	0	501
1995	0	0	0	0	21	14	37	113	132	93	56	0	466
1996	0	15	74	10	11	111	7	115	203	98	73	0	717
1997	0	0	5	17	46	26	68	102	77	34	27	7	409
1998	0	0	0	6	74	0	7	22	172	77	2	0	360
1999	0	0	0	1	172	99	23	45	161	227	139	0	867
2000	1	8	10	17	250	49	55	2	90	106	0	0	588
Mean	0.1	4.7	9.2	11	87.2	61.5	36	76.8	127.2	97.9	40.4	2.5	555

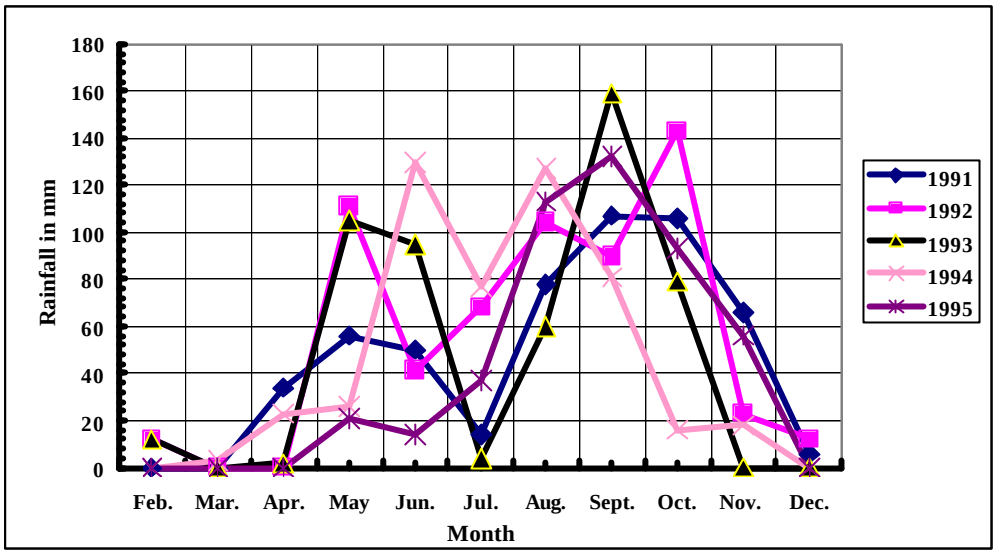

Fig.1.1.2.2 Year-wise Comparison of Monthly Rainfalls at Nyaung U (1991-1995)

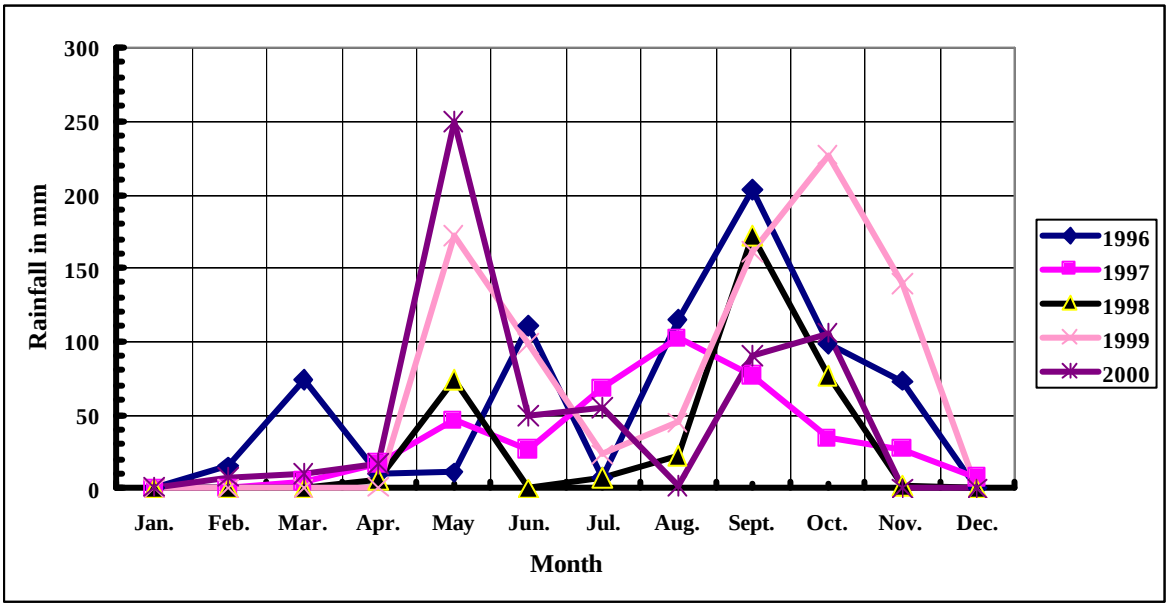

Fig.1.1.2.3 Year-wise Comparison of Monthly Rainfalls at Nyaung U (1996-2000)

From this analysis it is found that the rainfall environment in the zone has improved to the extent that the monthly rainfalls become regular; they are becoming less erratic.

3) Township-wise Comparison of Annual Rainfalls

All available annual rainfalls of 11 townships, where the target villages of the study are located, in the Central Dry Zone are collected and listed up to draw graphs to compare annual rainfalls of 11 townships as shown in Fig.1.1.2.4 and Fig.1.1.2.5. In the case of Mandalay Division, it is found that Kyaukpadaung and Pyawbwe townships both have the highest annual rainfall of around 800 mm and Taungtha and Myingyan townships have the lower-than-average annual rainfall of around

640 mm and Nyaung U has the lowest annual rainfall. Natogyi Township has the average annual rainfall of 690 mm. In the case of Magway Division, Magway and Myothit both have the highest annual rainfall around 850 mm and both Pakokku and Chauk have the average around 640 mm and Yezagyo has the lowest annual rainfall recorded around 430 mm. These facts reveal that the water environment of Taungtha, Myingyann, Nyaung U and Yezagyo townships is quite bleak. And the water supply conditions should be stepped up in those townships in order to relieve the people from extremely hot and dry climate. Refer to Fig.1.1.2.4 and Fig.1.1.2.5.

Table 1.1.2.3 Annual Rainfalls of 11 Townships of the Project Area Unit (mm)

Year		2002	2001	2000	1999	98	97	96	95	94	93	92	91
Mandalay Division	Av.												
Nyaung U	573	772	556	588	867	360	409	717	466	501	516	604	517
Taungtha	642		809	885	947	531	385	822	621	206	674	542	
Natogyi	690				738	380	536	942	552	577	1046	749	
Kyaukpadaung	809	864	976		949	623	836	995	709	763	558	814	
Myingyan	650			766	865	521	445	571		653	750	631	
Pyawbwe	742			659	929	489	747	1100	874	444	611	823	
Mandalay Division												Division Average: 684 mm	
Magway Division													
Yezagyo	432				683	326	294	382	361	323	605	480	
Pakokku	643				643								
Chauk	637	627	578	610	719	446	545	747	567	635	714	815	
Magway	842				996	444	938	1054	1200	479	709	918	
Myothit	879				958	667	610	1084	1335	850	503	1025	
Division Average:												Division Average: 687 mm	

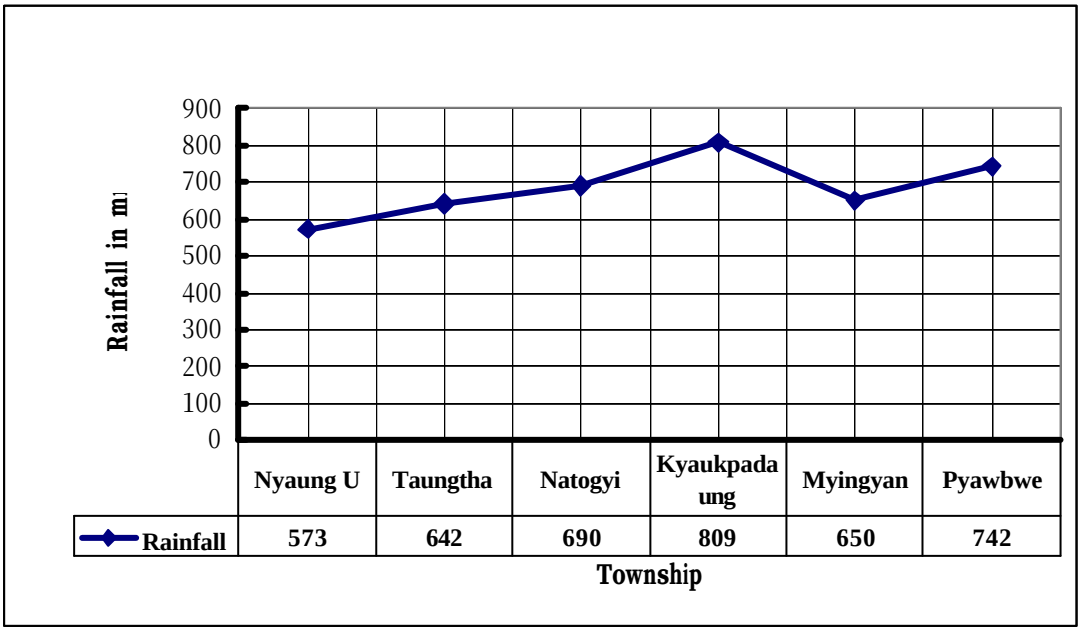

Fig.1.1.2.4 Township-wise Annual Rainfall in Mandalay Division

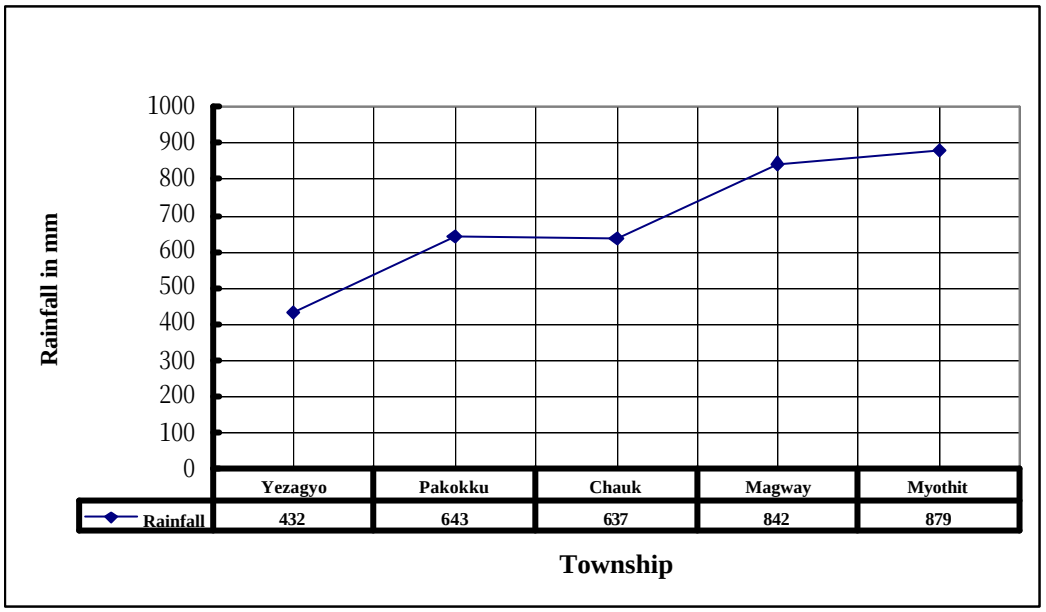

Fig.1.1.2.5 Township-wise Annual Rainfall in Magway Division

(2) Temperature

In the Central Dry Zone, the day time temperature goes up to 44℃ that is relatively high as compared to those of other regions of the country. The monthly variation of maximum temperatures and the monthly variation of minimum temperatures (2001 actual) at Kyaukpadaung, Nyaung U and Taungtha meteorological stations are shown in Fig.1.1.2.6 and Fig.1.1.2.7 respectively.

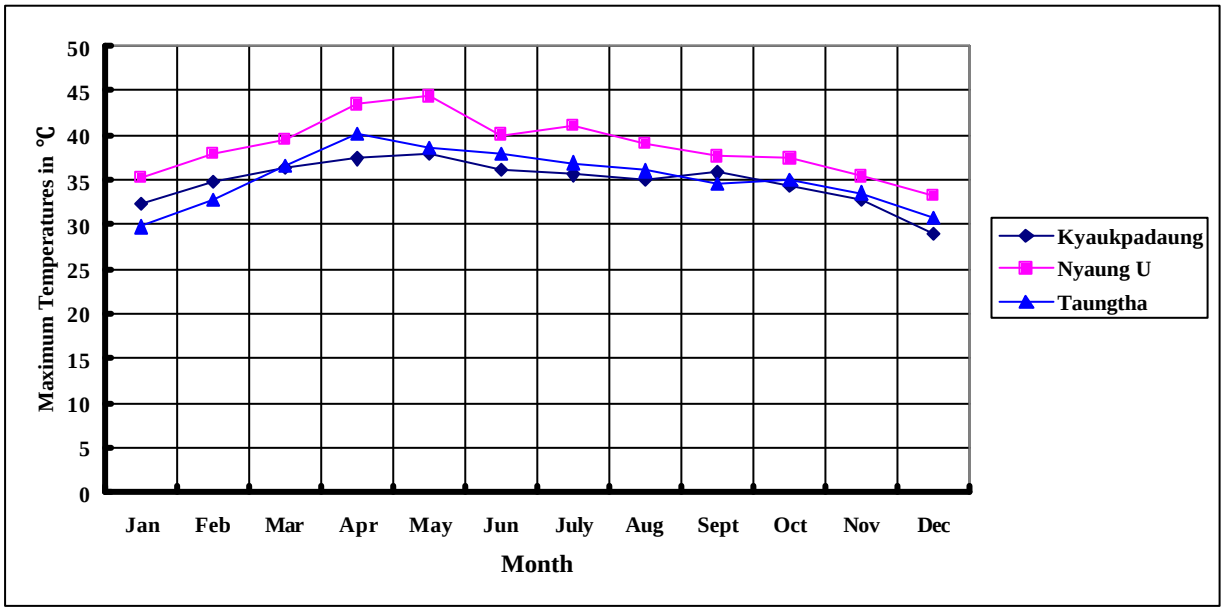

Fig.1.1.2.6 Monthly Variation of Maximum Temperatures at 3 Meteorological Stations

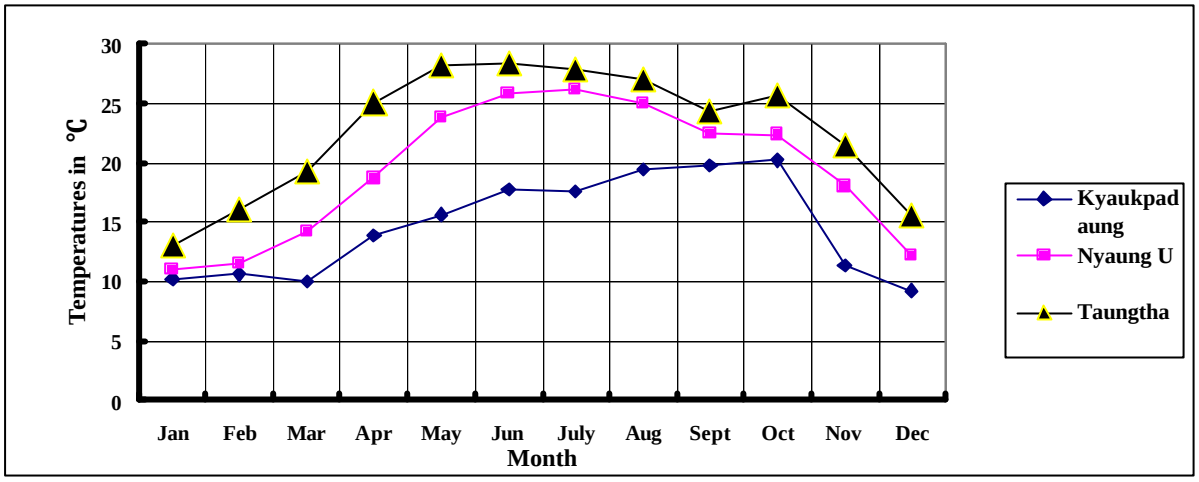

Fig.1.1.2.7 Monthly Variation of Minimum Temperatures at 3 Meteorological Stations

The highest monthly maximum temperatures are 44.3 ℃ at Nyaung U and 40.1 ℃ at Taungtha in April and 37.9℃ at Kyaukpadaung in May. As the Monsoon rain comes, the maximum day time temperature drops suddenly in June by 3 degree C to 4 degree C. The high temperature in the Central Dry Zone results in a high rate of evaporation, thus making the air so dry that the upper surface layer of the land is occasionally eroded with wind and rain. It is recognized that the annual erosion rate of the zone is around 1 to 1.5 mm per year. The coldest month in Taungtha and Nyaung U is January and that of Kyaukpadaung is February, when the minimum temperatures are around 12 degree C.

Table 1.1.2.4 Monthly Average Air Temperatures of 5 Cities (Average of 1990-1999) (℃)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov	Dec.
Yangon	24.9	26.5	28.9	30.4	29.4	27.5	26.8	26.5	27.1	27.7	27.3	25.3
Mandalay	21.8	24.5	28.5	31.5	31.5	30.7	30.6	30.1	29.5	28.7	25.7	22.1
Magway	20.6	23.3	27.7	29.9	30.6	28.6	27.7	27.5	27.6	27.3	24.4	21.2
Chauk**	21.3	23.7	27.9	31.4	33.3	31.8	32.0	30.5	30.2	29.3	25.3	22.2
Nyaung U	21.4	23.9	28.3	31.7	32.2	31	30.4	29.9	29.2	28.5	25.7	21.9
** : Average of 1996 -2000												

Ref.: Statistical Year Book

Monthly average (average of maximum and minimum) air temperatures of 5 cities: Yangon, Mandalay, Magway, Chauk and Nyaung U are compared as shown in Fig.1.1.2.8. From this table, it is revealed that Chauk is the hottest, the average monthly temperature of 33 degree C, followed by Nyaung U, Mandalay and Magway. Yangon, located in the tropical rain climate zone, shows a little similar to Magway in the changes of temperature.

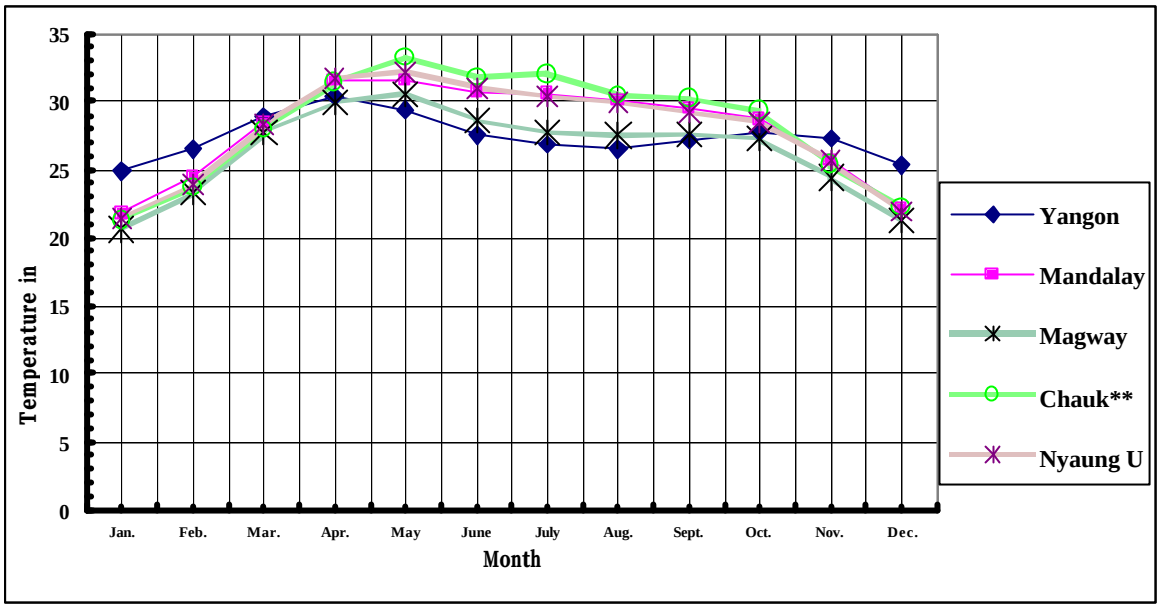

Fig.1.1.2.8 Monthly Average Daily Temperatures of 5 Cities

(3) Evaporation

The monthly evaporation rates at Nyaung U meteorological station are shown in Table 1.1.2.5 for the last 7 years from 1994 to 2000. As a result of fairly high air temperature in Nyaung U, the highest annual evaporation ranges from 1691 mm to 2264 mm. Monthly average evaporations at Nyaung U are compared with those at Mandalay as shown in Fig.1.1.2.9. The comparison of average monthly evaporation rates reveals that the annual evaporation in Nyaung U is higher than that of Mandalay; that is 2047 mm against 1897 mm.

Table 1.1.2.5 Monthly Evaporation Rates at Nyaung U Meteorological Station (mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1994	125	152	233	252	300	226	205	150	158	156	120	108	2185
1995	134	154	232	290	289	279	222	186	160	130	99	89	2264
1996	108	145	251	259	270	269	267	159	137	139	103	87	2194
1997	98	127	201	208	254	220	177	167	150	132	87	105	1926
1998	100	169	226	252	236	268	231	237	157	151	117	98	2242
1999	103	117	193	220	170	178	216	178	145	133	92	81	1826
2000	107	126	187	226	140	171	184	203	112	119	79	37	1691
Mean	111	141	218	244	237	230	215	183	146	137	100	86	2047

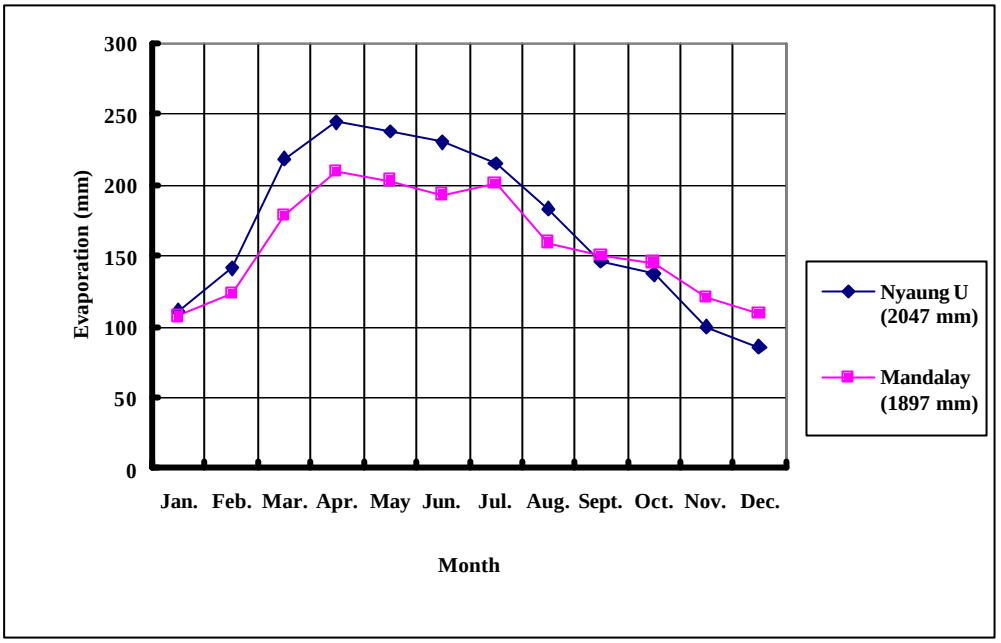

Fig. 1.1.2.9 Comparison of Monthly Evaporation Rates (Nyaung U against Mandalay)

(4) Relative Humidity

The monthly average daily relative humidity variations of 10 year's record (1991-2000) at Nyaung U and Mandalay meteorological stations are shown in Fig.1.1.2.10. Average annual relative humidity is 67% at Mandalay and 60% at Nyaung U. From this figure it is learnt that the relative humidity is lowest in March and April and increases from May to September. The average relative humidity is highest in September and October and then it decreases from December to March.

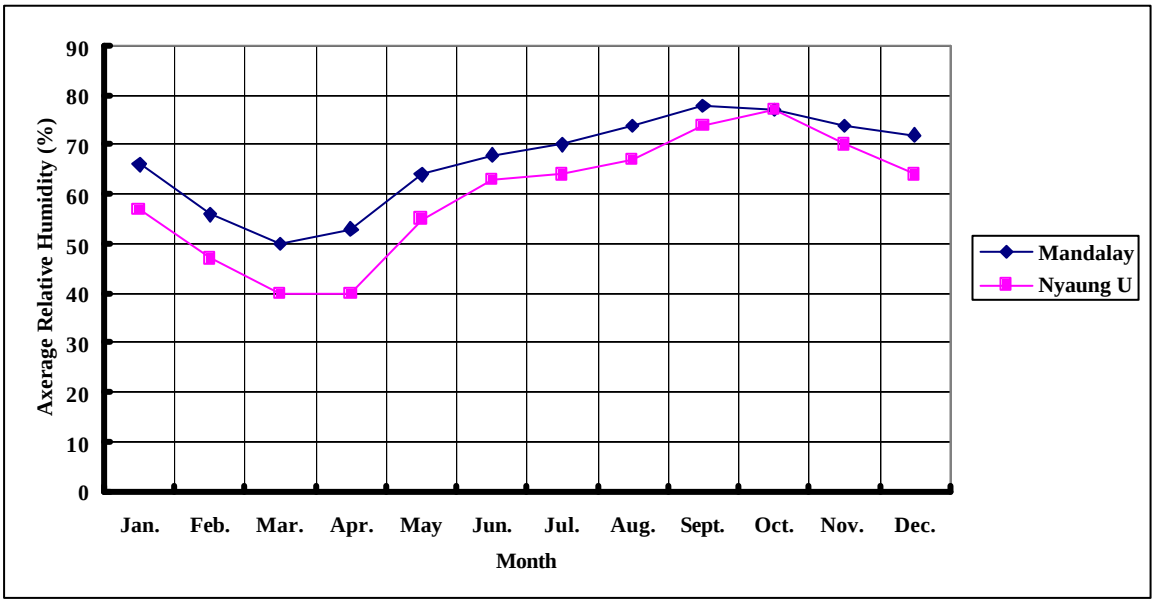

Fig.1.1.2.10 Monthly Variation of Relative Humidity at Mandalay and Nyaung U

The mean relative humidity values in 1999 at 4 meteorological stations (from 2002 Statistical Year Book): Magway, Mandalay, Nyaung U and Yangon are 70.2 %, 67.0 %, 61.3 % and 78.3% respectively. From this comparison, it is learnt that Nyaung U is the driest of them.

(5) Sunshine Hours

The data on monthly mean sunshine hours at Nyaung U meteorological station are not complete. Some data are missing. According to one year's data (1999), the average annual sunshine hour is 8 hours per day. The sunshine hour is longest in January and then decreases gradually until the end of August with the lowest sunshine hour recorded in August at 5.1 hours per day. The following Fig.1.1.2.11 shows the comparison of sunshine hours at Nyaung U and at Mandalay based on the actual data of 1999.

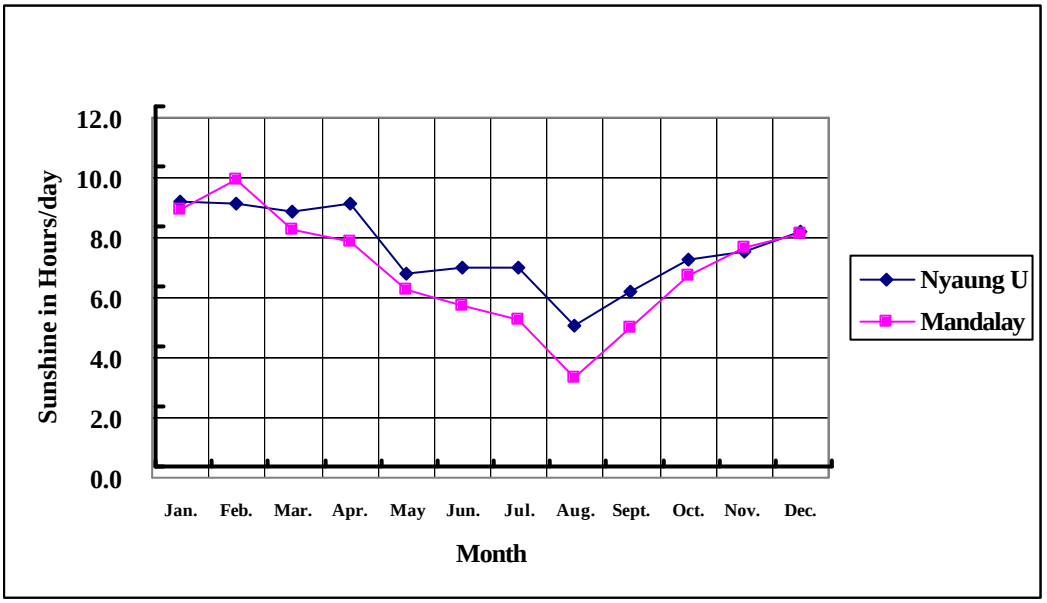

Fig.1.1.2.11 Comparison of Sunshine Hours at Mandalay and Nyaung U

(6) Conclusion

Yezagyo, Nyaung U, Taungtha, Myingyan and Chauk townships have scarce annual rainfall. And in those townships, the day time temperature is rather high going up to more than 40 degree C in the month of April and May leading to a bleak environmental climate in these townships. It is essential to step up efforts to provide these townships with plenty of potable water and water resources utilization facilities.

1.1.3 Regional Geology

Myanmar is situated in an area of complex plate tectonic setting. As a result of plate tectonic evolution, the country has been divided from west to east into four major geotectonic units, the Arakan Coastal Zone, Indo-Burman Ranges, Inner-Burman Basin and Sino-Burman Ranges, forming the north-south elongated structures. The Central Dry Zone is included in the Inner-Burman Basin (or Inner-Burman Trtiary Basin).

The Inner-Burman Tertiary Basin consists of two major north-south oriented sedimentary troughs separated by a central line of volcanic rocks. The troughs are subdivided into a number of S-N or SW-NE oriented sub-basins up to 600 km and 200 km wide. The sub-basins contain up to 10,000 m of Tertiary and Quaternary deposits.

Depending on the width of the basin, the deposits were deformed by more or less extensive compression folding which locally led to overthrusting in the range of 1,000 m. The anticlinal trends can be occasionally be traced over distance of 100 km and more; they exhibit special culminations along their longitudinal axes, they show frequently offset and they are frequently faulted. Block faulting is encountered, in particular, in the boundary zones of the sub-basins. In the uplift areas that separate the sub-basins from each other, Early Tertiary rocks, crystalline and metamorphic rocks crop out.

The sedimentary filling of the Inner-Burman Tertiary Basin consists of Miocene, Oligocene, Eocene, and to a lesser extent Paleocene sequences overlain by Middle Miocene-Quaternary clastic rocks and underlain by Cretaceous, probably also by Jurassic, Triassic and older rocks. The Tertiary rocks that are developed exclusively in marine facies in southern Myanmar indicate a continental influence, becoming increasingly intense towards the N and NE, on depositional environment. They are mostly argillaceous and fine sandy (see Table 1.1.3.1).

The Central Dry Zone is covered with Tertiary sedimentary rocks, which may be grouped under three broad unit, namely, in ascending order, the Eocene rocks, Pegu Group (Oligo-Miocene) and Irrawddy Formation (Pliocene to Pleistocene). The study area is covered, particularly, with the last two and Quaternary unconsolidated sediments (Middle Pleistocene to Holocene, Alluvium) (see Fig. 1.1.3.1).

Table 1.1.3.1 Stratigraphy and Lithological Description of Sediments in the Central Basin
Inner Burman Tertiary Basin

System	Stage		Age	Group	Formation	Lithological Description	Thickness(m)	Symbol for map	Volcanic Act.
CENOZOIC / QUATERNARY	Holocene		* 0.01		Unconsolidated Sediments	Fluviatile clay, silt, sand, gravel, wood, cobble deposited on alluvial flats ,river terraces and piedmont plains	180	Q2	Volcanics in Lower Chindwin and Mt.Popa area are included in the central volcanic line(the inner volcanic arc).(V) Mt. Popa area : Andesites,Rhyolite,Basalts (U-Mio. to Plio. & Pleist. to L-Holo.) Lower Chindwin area : Andesites,Tuff, Rhyolite ,Basalts(U-Mio. to U-Pli.)
	Pleistocene	U M L	2		Mow Gravel	Sand and gravel, minor wood, lignites, clay and silt, fluviatiles and colluvials	90	Q1	
CENOZOIC / TERTIARY	Pliocene				Upper Irrawaddy / Lower Irrawaddy (Irrawaddy Formation)	Medium to coarse grained, yellow-brown to blue gray, sand and gravel loosely cemented, current bedded, abundant fossil wood and calcareous nodules, clay beds, minor red bed, flluviatile	1860	Tm - Tp	
	Miocene	U M L	5 / 25	PEGU GROUP	Obogon Fm.	Alternating blue-gray shale, fine to medium sandstone, minor gypsum	1080	Tm	
					Kyaukkok Fm.	Sandstone,fine-medium grained, minor shale, rich molluscan fauna, marines	1200		
					Pyawbwe Fm.	Shale,bluish black/gray, minor fine to medium grained sandstone	1260		
	Oligocene	U M L	40		Okhmintaung Fm.	Sandy sequence between shale beds, lepidocyclina limestone, gypsum, marine	1950	Tf	
					Padaung Fm.	Shale, dark bluish gray, minor sandstones, coral, gypsum, foraminifera and molluscan rich, marine	1200		
					Shwezetaw Fm.	Sandstone, fine grained, sandy shale, coral gypsum, calcareous at base	1080		
	Eocene	U M L	55		Yaw Fm.	Shale, gray, minor sandstone, limestone, marine	900		
					Pondaung Fm.	Sandstone, minor conglomerate, fossil wood, marl, carbonecous shale, mollasca, marine	2250		
					Tobyin Fm.	Shale, bluish black, minor brown sandstone, limestone, lignite, coal, conglomerate, marine	3150		
					Tilin Fm.	Sandstone, fine to medium grained, blue gray, minor silicified wood, red bed, gravel, marine	3000		
					Loungshe Fm.	Shale, bluish black, minor sandstone, conglomerate, limestone, marine	4350		
	Paleocene	U M L	65		Pounggyi Fm.	Conglomerate, gritty sandstone	1200		
MESOZOIC	Cretaceous		135	KABAW GROUP		Shale, clay, mudstone, calcareous sandstone, dark gray, soft, laminated, occasional limestone lenses	300		

* Age in million of years before present Fm: Formation ▬▬▬ : Unconformity

Source:"An Assessment of the Hydrogeology and geology in the Dry Zone, Central Burma, Coffey & Partners Pty Ltd, 1987"

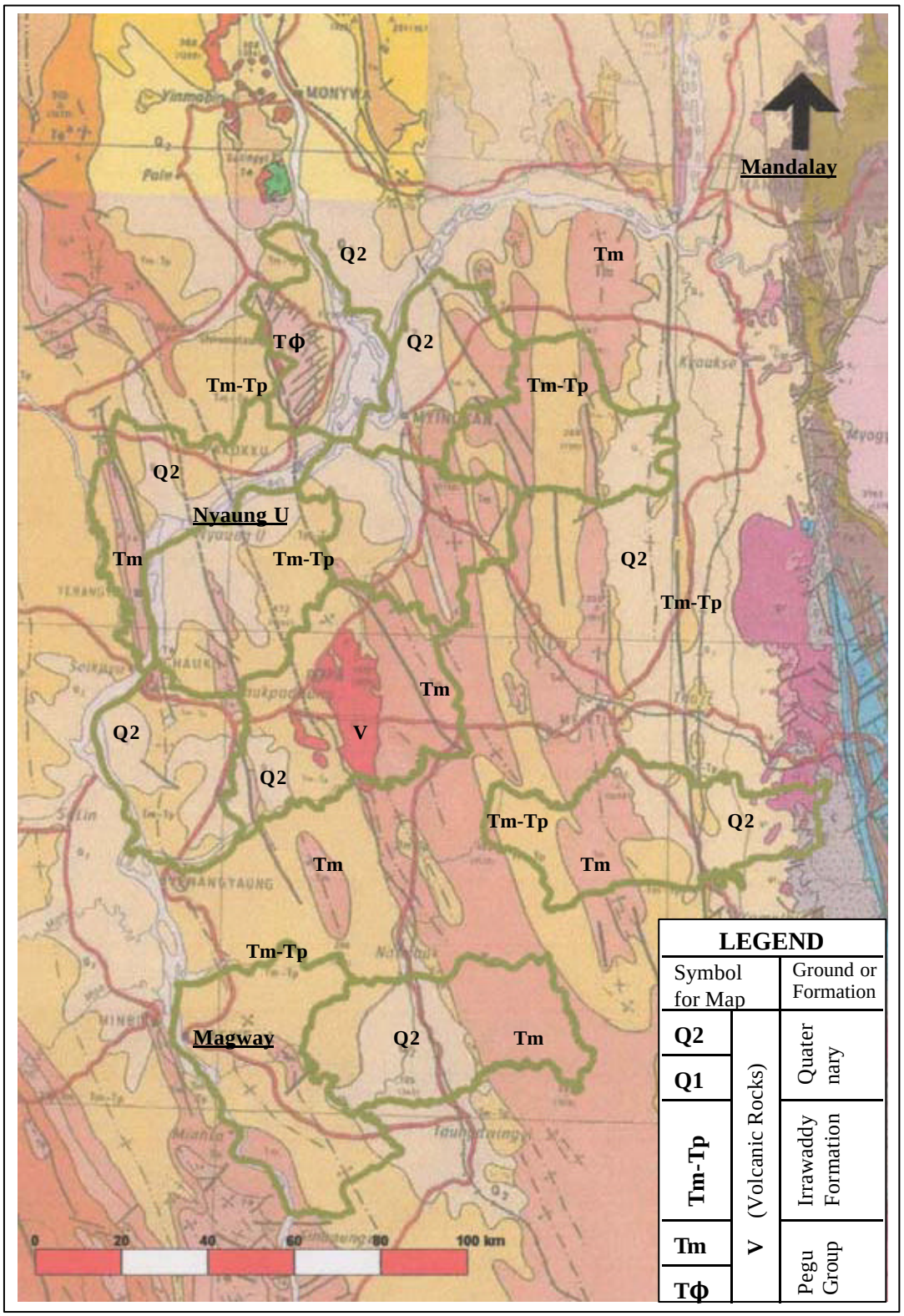

Fig. 1.1.3.1 Geological Map of the Study Area

(Geological symbols, see Table 1.1.3.1)

Source: "Geological Map of The Socialist Republic of The Union of Burma, 1977." Prepared under The Auspices of The Earth Sciences Research Division

(1) The Pegu Group (Oligo-Miocene)

The Pegu Group has a total thickness of over 7,500 m and the rocks have been subdivided into six formations, namely (in ascending order), the Shwezetaw, Padaung, Okhmintaung (Lower Pegu Group:Oligocene rocks), Pyawbwe, Kyaukkok and Obogon formations (Upper Pegu Group:Miocene rocks). The Shwezetaw, Okhmintaung and Kyaukkok formations are predominantly arenaceous; the Padaung and Pyawbwe formations are predominantly argillaceous and represent major marine transgression; the Obogon Formation is a sand-shale alternating sequence. An unconformity is present between the Lower and Upper Pegu Group.

The Pegu Group in the Study Area is mostly the Miocene rocks and occupies mainly a broad area of the Pegu Yoma Anticlinolium. The sediments are generally continental in the north and marine in the south.

(2) The Irrawaddy Formation (Pliocene-Pleistocene)

The Irrawaddy Formation occurs extensively throughout the Inner-Burman Tertiary Basin with a total thickness of over 3,000 m and overlies all older sediments with an unconformity which is often marked by development of red beds or old lateritic soils. The Irrawaddians are characteristically composed of medium to coarse, ferruginous sandstones with abundant quartz pebbles and silicified fossil wood. Clay lenses occur rarely within the arenaceous sequence. From numerous localities, the Irrawaddians have yielded the remains of terrestrial and aquatic vertebrates, mostly mammalian, which suggest a late Pliocene to Pleistocene age.

(3) Igneous rocks

In central Myanmar, there is the NNW-SSE striking Central (Inner) Volcanic Line and it is composed of a series of discontinuous, intrusive and extrusive basic intermediate and acidic igneous rocks of Miocene to Recent age. (see Fig. 1.1.3.2)

In the study area, there are two volcanic areas on the Central (Inner) Volcanic Line, the Mt. Popa and a part of the Lower Chindwin volcanic area.

Mt. Popa volcano is in Kyaukpadaung Township and of Upper Miocene to Sub Recent age. A part of the Lower Chindwin volacanic area is in Yesagyo Township and of Upper Miocene to Upper Pliocene age. Both of them are composed of andesites, tuff, rhyolite and basalts.

(4) Quaternary unconsolidated sediments (Middle Pleistocene to Holocene, Alluvium)

The fluviatile, unconsolidated Quaternary sediments of Middle Pleistocene to Holocene age occur along the Ayeyarwaddy River, associated watercourses and the piedmont plains.

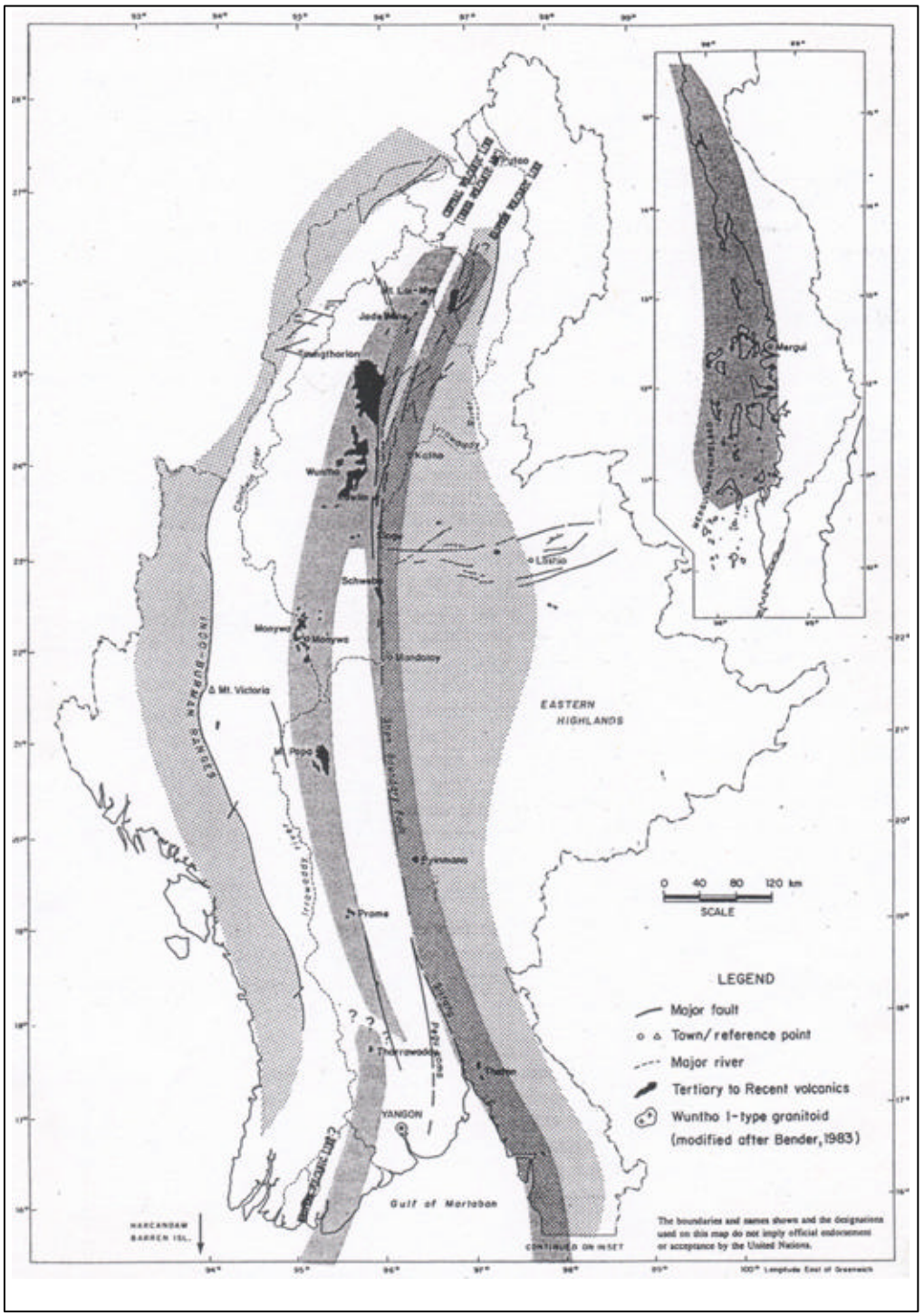

Fig. 1.1.3.2 Distribution of Young Volcanic Rocks in Myanmar

Source: "Geology and Mineral Resources of Myanmar, 1966 ESCAP"

They usually overlie the Irrawaddy Formation and infill synclinal troughs. The alluvium of Pleistocene age occurs mainly basins formed along the old river courses. The overlying younger alluvial sediments are found in significant amount in the valleys of the rivers such as the Ayeyarwaddy, Chindwin and Mu. The maximum known thickness of alluvium is 180 m near the Ayeyarwaddy River at Mandalay City.

The sequence of the Quaternary sediments appears as three physiographic features; (**i**) river terraces,(**ii**) alluvial plains, and (**iii**) piedmont plains.

The river terraces are composed mainly of quartzose gravel of variable size changing laterally into red ferruginous clay. These fluviatile deposits are found at high levels away from the present Ayeyarwaddy , Chindwin and Mu Rivers. Thickness of the deposits ranges from 0.3 to 12 m.

The alluvial plains are located along the intermountain valleys. Vast alluvial tracks of Central Burma such as Monywa , northern of Yesagyo and Taungdwingyi , southern of Myotit and along the Ayeyarwaddy River are occupied by unconsolidated sediments of Pleistocene age. These deposits frequently parallel geological structures and infill synclinal areas. They are composed of alternating beds of sand and clay and occasionally gravel and pebble lenses. The thickness of the sand and clay beds is irregular and lateral and vertical variations in lithology frequently occur.

The Holocene fluviatile alluvium is confined to the larger watercourses such as the Ayeyarwaddy, Chindwain and Mu Rivers. Generally the width of the recent unconsolidated alluvium is less than 1.6 km and it has a thickness of less than 60 m. The deposits are heterogeneous being composed of gravel, sand, silt and clay.

The piedmont plain colluvial deposits are found in the vicinities of the Eastern Highlands, Western Ranges and Pegu Yoma. These sediments are composed of a complex of non-sorted, non-stratified clastics varying from clay size to large boulders. In Yamethin area, southern to Pyawbwe, their thickness is between 180 to 200 m.

1.1.4 Hydrogeology

It is known that there are 11 different types of aquifer in Myanmar (see Table 1.1.4.1). In the study area, there are 3 major aquifers of the 11: 1) Pegu Group aquifer (Peguan aquifer), 2) Irrawaddy Formation aquifer (Irrawddyian aquifer), and 3) Quaternary unconsolidated sediments aquifer (Alluvial aquifer). Groundwater in the first two aquifers is mainly fissure

water in rocks and the last is stratum water in the Quaternary unconsolidated sediments.

The water that infiltrates into the ground but is not taken up by plants in the unsaturated zone moves downwards under gravity to the zone of saturation. Here it fills interconnected spaces in the unconsolidated sediments or fractures in the rocks. Rocks or unconsolidated sediments within the saturated zone that are sufficiently permeable to transmit usable quantities of water are called aquifers. The upper surface of the saturated zone is called water table or phreatic water table.

Depending on the rock type and degree of weathering and deformation, some rocks form better aquifers than others. Generally, permeability or transmissivity of rocks is affected by the frequency, continuity and openness, and amount of infilling, of fractures, therefore massive rocks generally form poor aquifers unless they have been tectonically fractured or highly weathered. By drilling along these fracture traces or in the weathered zone high yielding aquifers may be encountered. In general, the fracture openings in rocks and degree of weathering decrease with depth. Consequently groundwater potential also decrease with depth.

In the Study Area, the Quaternary unconsolidated sediments such as sand, gravel and cobble beds are the most important water bearing formations due to their high porosity, permeability and specific yield. On the other hand, consolidated sedimentary rocks such as sandstone and conglomerate of the Pegu Group and the Irrawaddy Formation, being cemented and compacted has reduced aquifer potential. Siltstone and shale generally make poor aquifers.

As presented in Table 1.1.4.2, groundwater from Alluvial and Irrawddian aquifers are more suitable for domestic use while groundwater from Peguan aquifer is not totally suitable for drinking purpose from hygienic point of view.

Groundwater usually contains considerably more dissolved salts than surface water. The quantity of dissolved salts in groundwater depends on the chemical composition of the water, the mineralogy and physical nature of the host rock, residence time of the water in the aquifer, temperature and pressure.

In arid regions, such as the Central Dry Zone, much of shallow groundwater is saline as salt is concentrated by evapotranspiration. Another reason for highly saline groundwater in Central Myanmar is said as the presence of marine shale and gypsum deposits.

Table 1.1.4.1 The Major Aquifers in Myanmar

No	Name of aquifer	Major rock units	Area of occurrences	Remarks
1	Alluvial Aquifer	Sand, gravels and mud	Major river basins and its tributaries, base of mountains and ranges	Fresh GW, seasonal water table changes
2	Irrawaddian Aquifer	Mainly sand, sandstones with gravels, grits, siltstones and	Central Lowland and Rakhine Coastal Plain	Thick aquifer fresh GW with high iron content
3	Peguan Aquifer	Sandstone, siltstones and shales	Central Lowland and Rakhine Coastal Plain	Mostly saline & brackish water, some fresh water in recharged areas
4	Eocene Aquifer	Sandstone, siltstones and shales	Periphery of Central Lowland	Probable GW source area
5	Flysch Aquifer	Interbeded units of sand, siltstones, shale and mudstone	Western Ranges	Probable GW source area
6	Cretaceous Aquifer	Flysch units and limestone units	Western Ranges and Northern	
7	Kalaw-Pinlaung-Lashio Aquifer	Loi-an Group & Kalaw Red Beds	Western boundary of Eastern Highland and Taninthari ranges	
8	Plateau Limestone Aquifer	Limestone & dolomite	Eastern Highland	GW is being extracted in some places
9	Lebyin-Mergui Aquifer	Greywacke, quartzeite, argillite, slate, mudstone	Western boundary of Eastern Highland and Taninthari ranges	
10	Cambrian-Silurian Aquifer	Molohein Group, Pindaya Group, Mibayataung Group	Eastern Highland	
11	Chaung Magyi Aquif	Low grade metamorphic rocks	Eastern Highland	

Source: "Water Resources, Water Quality Standard and Groundwater Management in Myanmar, WRUD"

Table1.1.4.2 Groundwater Quality of Alluvial ,Irrawaddian and Peguan Aquifers in Six Divisions

Division	Aquifer	E.C µS/cm	T.D.S mg/l	pH	Total Hardness mg/l	Total Alkalinity mg/l	Na+ mg/l	Ca++ mg/l	Mg++ mg/l	K+ mg/l	Fe+ mg/l	Cl- mg/l	SO4-- mg/l	CO3-- mg/l	HCO3- mg/l
Magway	Alluvial	804	507	8.37	255	369	178.48	48.4	37.8	7.14		112.18	95.52	84.3	317.2
	Irrawaddian	1033	666	8.41	254	372	135.01	46.8	35.64	8.97		147.32	87.84	73.2	254.37
	Peguan	3458	2368	8.44	485	534	365.47	38.4	31.68	10.53		235.01	173.28	105	397.11
Mandalay	Alluvial	1473	935	8.26	257	555	330.51	44.2	29.04	27.3		200.22	136.8	90.9	505.69
	Irrawaddian	1953	1283	8.52	268	521	430.79	51.6	35.4	14.43		237.14	195.36	146.4	443.47
	Peguan	3386	2247	8.84	330	567	504.62	13.2	38.76	15.6		298.91	198.72	85.8	666.12
Sagain	Alluvial	1298	847	8.36	293	379	230.23	52	28.68	47.58		225.43	60.96	94.5	310.49
	Irrawaddian	1636	1088	8.48	246	421	232.76	74.8	28.32	45.24		226.49	97.44	64.2	354.41
	Peguan	5376	3640	8.92	301	494	1338.6	78	107.2	75.27		1773.9	109.56	192	475.8
Irrawaddy	Alluvial	4895	3000	7.4	458	173	46.23	26	18.72	12.87		26.63	67.84	1.05	172.69
	Irrawaddian	1328	864	7.06	354	107	57.04	27.6	15.12	4.29		28.7	81.6	1.05	136.03
	Peguan	22292	14888	7.9	2432	342	331.2	99.2	67.8	5.07		657.11	55.68	1.05	369.66
Yangon	Alluvial	224	146	7.47	108	102	43.7	17.8	12.96	21.45		38.7	109.44	0.9	89.67
	Irrawaddian	507	352	7.53	190	155	142.6	33.2	21.72	60.45		157.98	158.4	0.84	211.06
	Peguan	4055	2637	7.25	389	208	356.5	91.4	42.72	79.95		669.53	168.96	0.96	207.4
Bago	Alluvial	352	223	7.58	169	144	625.83	154.4	202.3	55.83		1647.2	52.32	34.5	216.55
	Irrawaddian	392	258	7.27	184	188	393.76	99.6	82.8	35.88		389.39	131.04	20.7	175.07
	Peguan	5300	3400	8.25	828	1466	460.46	627.4	1556	352.2		9970.5	107.04	47.1	316.59
Proposed NDWQS		1500	1000	6.5-9.2	500	-	200	75-200	30-150	-	0.5-1.5	200-600	400		

Note; Proposed NDWQS: Proposed National Drinking Water Quality Standard

Source: "Water Resources, Water Quality Standard and Groundwater Management in Myanmar, WRUD, MOA&I"

2. EXITING CONDITIONS OF WATER USE

2.1 Outline of Water Use Conditions

2.1.1 Overview of Water Supply Condition

There are various manners being applied in the rural water supply in Myanmar. The typical examples generally observed in Myanmar can be summarized as follows:

1) Rainwater-fed pond, 2) Rainwater Roof Catchments, 3) Dug Well, 4) Shallow Well, 5) Deep Well, 6) Tube well and Diesel or Electric Pump, 7) Solar Pump, 8) Others

Table 2.1.1.1 Major Manners for Rural Water Supply

Measure		Accessibility	Advantage	Disadvantage	Recommendation
1)	Rainwater-fed pond	Most commonly spreaded and used as basic method.	Least maintenance. Low cost.	Easily water contamination by users and animals.	Capacity increase, Protection from the contamination.
2)	Rainwater Roof Catchment	More suitable in the high rainfall area.	Good quality. Low cost.	Small catchments area.	Storage capacity increase.
3)	Dug Well	2/3 of rural population accesses.	Low cost construction by the raw material.	Water level decrease in dry season.	Quality protection measures.
4)	Shallow Well + hand pumps	Commonly used	Usage of cheaper Local made pumps	Limitation of locality, where shallow ground-water is available	Anti-pollution measure against toilet & wastewater.
5)	Deep Well + Hand Pump	Over 1500 India Mark II installed by the program of Ministry of Agriculture & Irrigation.	No operational cost.	Limited applicability; for 15-45 meters deep well.	Training for villagers of the basic care.
6)	Tube well + Diesel or Electric Pump	Since 1979 by ADAB*1) & UNICEF assistance, over 30 % of the Dry Zone population.	Enable to use the deeper groundwater	Big burden of fuel cost on the villagers.	Expanding of maintenance & repairing service system.
7)	Solar Pump	Less experience	Low running cost.	High initial cost & high technological maintenance	More renovation for maintaining with low-cost product.
8)	Others: Direct use of River water or Irrigation Canal	Only Neighboring Villagers to the source.	Use of natural resources	Less quality & low reliable in dry season.	Awareness of the water use promotion.

2.1.2 Water Resources and Water Use Manners

There are various water supply situations of each village in the Central Dry Zone. However, those villages have rain-fed ponds or dug wells in general. There are lucky villages, which could have tube well donated by the local NGOs or international aid organizations. On the other hand, these tube wells are not always producing good water, the villager does not hope to use any more in case of salty or bitter ground water. The water utilization status of main water sources in the Central Dry Zone is summarized as follows;

(1) Rain-fed Ponds

Rain-fed pond is one of the most popular water sources in the zone. Although the pond is situated in favorable place to catch the rainwater from the surrounding area, its catchment's area is not so large generally and reserved volume is limited. Annual rainwater is recorded a range from 600 to 800mm, on the other hand, annual evaporation is estimated over 1000mm. Therefore the pond becomes dry up easily in the dry season. There are villages, whose water demand are rather big due to its population, cannot get enough water even in the rainy season. Water fetching is mainly task for women and children in case the source is located near the village. The pond water has normally high turbidity. When the turbidity become high due to water depth reduces less than about 50 cm in the pond, villagers tries to ladle water from near the surface of water whose quality may be better than the deeper one. In case of water carrying by bullock cart, the coachman usually leads the cart directly into the pond and ladles the water, the water would be disturbed and contaminated by soaking the cart, bullocks and coachman into water. As a preventional device for water contamination of pond water and also a device for easy water pouring into containers from the pond, PVC pipes laid into and through a bank of pond and faucets connected in the outside are observed. This device is effective when water level is higher enough than the level of pipe inlets. However, the device becomes not usable when water level decreases under the pipe inlet then villagers have to get directly into the pond and ladle water as same as before. Villagers should normally maintaining their pond by themselves and they sometimes excavate the bottom of pond to increase its capacity by contributing their physical labor in the dry season under their Water Committee's initiative.

(2) Dug Wells

Dug wells, which use shallow groundwater less than about 10 m deep, are also popular water source in the rural area. Since water level of dug well is normally fluctuated by seasons, villagers face sometimes into difficulties to take water from the well due to water level decreasing. There are successful cases of dug well installed just near a rain-fed pond. It stands on such idea that the water may be filtered by in the ground seeping from the pond and

also water would remain in the dug well after pond water dries out due to a deeper elevation of the well than the pond. However, there is still no authorized design manner established for this idea.

(3) Rain Water Harvesting by Roof Catchment System

Rain water harvesting by roof catchment systems are widely utilized in the Central Dry Zone. The systems donated to schools by some international aid organizations are highly appreciated. In case of application of private houses, since installation of rain collecting duct on roof with palm leave is difficult, the system is applied to only private houses with steel slates, which comparatively rich families can use in the village. Even in that case, some water containers of ceramic pot, which has normally a capacity of less than 50 gallon, or a concrete-made tank with 1 or 2m^3 capacity are usually used. These users may intend to lighten water-fetching work by catching and storing rainwater in their own compound in rainy season. Rainwater caught by roof is pure and free resource, however, there is no case that a large scale of the system is installed with intention to cover a part of water demand during dry season.

(4) Deep Tube Well*)

By the donations from international aid organizations, NGOs and many private donors, thousands of deep tube wells have been constructed. DDA and WRUD are main governmental organization, which have been involved in development of groundwater by constructing tube wells with up to some 200 m deep in rural area. In central dry zone there are many areas where groundwater exists but is not portable due to saline or bitter taste. And there are also some villages having a tube well but its production is too poor to cater the whole villagers. So groundwater development in the central dry zone is limitedly applicable.

Even in the village where a tube well is exist, villagers try to take domestic water from traditional pond or dug wells as long as water can be available. And after the water level of the pond or dug well gets shallow to take water from them, villagers have to buy diesel to operate the well pump. Water committees are formed widely in almost villages and it is in charge of operation and maintenance of water supply facilities such as ponds, dug wells and tube wells. The water committee also manages water selling in case of tube well water. In this case, price of water per 50gallon is normally 15 to 20 Kyats for their own villagers, and about a double price for buyers from other villages.

*) Deep well and shallow well are generally defined as follows: Deep well is the tube well. the depth is more than 30 m. The target aquifer is a confined aquifer.

Shallow well is the tube well with small diameter about less than 100 mm (4”), the depth is less than 30 m and the target aquifer is a unconfined aquifer.

There are cases where villagers do not use their tube well due to some damages or deterioration on machine of pump or engine. However, almost facilities are well operated in general.

There are many private well drilling firms, which consist normally a few members with a foreman or head driller and workers, in Myanmar. They drill normally 4" to 10" diameter and some 10s meters deep boreholes by rotating steel drill heads manually with flashing water into the hole, called "water Jet method". There are many tube wells made locally, whose material are 4" PVC pipe for casing and the same with sawed slits surrounding pipe for strainer. In cases of drilling depending on driller's gut feeling without geological survey and observation, it would sometimes fall through easily. Airlift pumps, which utilize air released into the riser pipe then water can be raised up with air babbles to the ground, are commonly used for drawing groundwater in rural area.

(6) Other Water Sources

As the other water sources, there are seen natural springs or surface waters like rivers, irrigation canals etc. in the Central Dry Zone. However, no village among the study villages, which locate at good accessible place to these water sources. Mt. Popa and surrounding area has a lot of perennial springs and creaks. Peoples who live in the area have a great advantage to access water. In Kyaukpadaung Township, one of the study townships, located in the area, water sources of the city water supply depend on natural springs and tube wells. The Sindewa River, which is one of rare perennial tributaries of the Ayeyawarddy River, flows from the origin on the foot of Mt. Popa to the north and turns to northwest at near Taungthar Township and joins to the Ayeyawarddy River at about 10 miles west of Myingyan Township in the Central Dry Zone. Villagers live along this river can easily use river water for their domestic water in all seasons.

2.1.3 Water Supply Sector in Myanmar

(1) General Condition

The major organizations, which are involved in rural water supply and sanitation sector in Myanmar, are as follows:

- Department of Development Affairs (DDA), Ministry of Progress of Border Areas and National Races and Development Affairs
- Water Resources Utilization Department (WRUD), Ministry of Agriculture and Irrigation
- Environmental Sanitation Division (ESD), Ministry of Health
- Central Health Education Bureau (CHEB), Ministry of Health
- External Support Organization

- Non Government Organization

DDA and WRUD were formerly main implementation agencies in this sector. It had been recognized that DDA should undertake the urban water supply and WRUD should bear the rural water supply. By the administration reform in 1993, however, it was stipulated that DDA should take charge of the rural water supply work as well. But this policy had not been functioned before an administrative reform taken in 2000 such that the whole responsibilities for improvement of rural water supply condition was transferred from the WRUD to DDA. Since then, DDA has been reforming its organization body and its budget has been increasing year by year to fulfill its new heavy tasks. Therefore the number of staff of DDA has been increasing by recruiting new officers from the public and qualified engineers or clerks from the other governmental organizations including WRUD. The reformation of DDA is still underway.

Ministry of Health renders consultancy services on water and sanitation activities for the country and provides small-scale water supplies to rural hospitals and medical clinics. Farther description is given hereunder about these organizations.

(2) Organization Concerned

1) Department of Development Affairs (DDA)

The Department of development Affairs (DDA) was formed on the occasion that Ministry of Progress of Border Areas and National Races and Development Affairs was organized in January 1994. Then all the Township Development Committees, which are administrative bodies for take care of development of infrastructures in their own Townships, were transferred under jurisdiction of the DDA from the same of former General Administration Department, the Ministry of Home Affairs. The Development Committees Law, which was enacted by the State Law and Order Restoration Council in April 1993, stipulated that the DDA should undertake development works in urban as well as rural area in the whole country and also be responsible in 31 works including water supply and sanitation work, disposal of sewage, town planning, etc. Excluding the Yangon City and Mandalay City, there are 286 Townships in the country. Out of them 285 Township Development Committee have been formed on township basis. Within the Township's administrative boundary, each Township Development Committee is in charge of various works in urban and rural areas.

There is an Engineering division at the Headquarters of DDA. Under its supervision there are the Engineering Sections at the State Division and Township Development Committees. Total number of engineering staff at the Headquarters, State/Division and Township Development Committees is 692 as of April 2001.

2) Water Resources Utilization Department (WRUD)

WRUD, which belongs to Ministry of Agriculture and Irrigation, was formulated in 1995 by merging the Underground Water Division of Irrigation Department with the Water Supply Division of Agriculture Mechanization Department (WSAMD), those were under Ministry of Agriculture then. The main objectives were to supply safe and adequate drinking water to the rural communities and to provide irrigation water to the rural areas. The Headquarter of WRUD is in Yangon, 14 Division Office and 50 District Office through the country. Total number of staff is 4,636 as of November 2000.

Until recently WRUD had been taking a task upon development of the rural water supply, on the other hand, DDA had been bearing the urban water supply field. Therefore WRUD had filled the role for years of the counterpart for various rural water supply projects implemented by cooperation with the international aid organizations such as UNICEF, UNDP and JICA etc. WRUD have constructed more than 5000 tube wells and recorded a highly successful drilling rate of 95%. Since the administration reform in 2000, the WRUD lost the duty for improvement of rural water supply.

3) Environmental Sanitation Division (ESD)

ESD of the Department of Health is the main governmental agency in the latrine construction program. The ESD's policies are subject to strategies defined by the National Health Plan and supported by international agencies. The major activities of ESD are to:

- Plan logistics and supplies for latrine and the related water supply facilities construction projects
- Provide project materials
- Monitor and evaluate project activities.

ESD has no filed staff at the township or village level. The Department relies on the Rural Health Staff in the villages to mobilize and supervise project activities in the communities. Especially UNICEF is the main donor to ESD.

4) Central Health Education Bureau (CHEB)

CHEB is designed to support health related implementation programs of the National Health Plan. CHEB's main specific roles are to:

- Develop health/hygiene education strategies
- Develop educational and communicational materials
- Coordinate activities with other department and international agencies, and

- Undertakes social mobilization campaigns and training activities at all levels in the country.

CHEB has been involved in promoting proper management of water and sanitation facilities in UNICEF funded and ESD implemented water and sanitation projects. CHEB has no staff at the village level, however, the Health Devotees (volunteers from villages) carry the hygiene messages into the households.

5) External Support Organization

- ADAB (Australian Development Assistance Bureau) cooperated with UNICEF in the development of rural water supply in the Dry Zone. From 1982 it also provided support to the Taun Zin Water Supply Scheme, which included facilities of water intake with pumps to draw water from the Ayeyawarddy River, treatment plant and related pumping facilities for water supply in the urban and rural area, in Nyaung U Township. However, This project was suspended in 1988 and has no any sign to resume.
- JICA (Japan International Cooperation Agency) provided two grant aid projects for improvement of 11 Townships' urban water supply facilities in the Dry Zone in 1981 and 1985 fiscal year. Each Township was planed to develop groundwater as the sources for water supply. The project was implemented on the basis of the procurement of equipment and materials assisted by JICA and the construction works undertaken by the Myanmar side through GAD (General Administration Department, Ministry of Home Affairs), which was the preceding organization of DDA.
- UNDP (United Nations Development Program) has been supporting to various sectoral programs. It has provided funding to feasibility studies of water supply for several townships in the country. UNDP is now implementing "HDI-Phase III, Community Water Supply and Sanitation Project", which aims to improve water supply and sanitary conditions for 11 townships located in the Dry Zone, the Delta Zone and Shan State by introducing of community participation manner. DDA, WRUD and ESD are the counterparts to the project. The implementation of this project is scheduled from July 1999 to February 2002.
- UNICEF (United Nations Children's Fund) has been one of the most active agencies in the rural sub-sector in Myanmar. It has provided support to the governmental departments concerning rural water supply and rural sanitation. It started supporting RWSD (Rural Water Supply Division of the Agricultural Mechanization Department), which was the antecedent of WRUD, in 1977 when priority was given to the Dry Zone. The first UNICEF/ADAB cooperation for rural water supply in this Zone was an integral part of UNICEF's Country Program for 1987-1990, when their assistance was

extended to Lower Myanmar. Through this program, a total more than 3,100 deep tube well were drilled in the Dry Zone.

UNICEF also supports gravity-flow water systems installations in other areas than the Dry Zone. More than 30 such systems have been completed in the country. UNICEF is providing support Hand pump Manufacture Project which aims at upgrading and producing hand pumps and spare parts in local workshops. In 1995 UNICEF formulated "Myanmar-UNICEF Country Program of Cooperation 1996-2000" and provided pumps for water supply in the rural area through WRUD. The same titled project for 2001-2005, which is seen as the second phase of the above project, is just about to begin as of June 2001.

- Non Government Organization

BAJ (Bridge Asia Japan) is one of the Japanese NGOs. BAJ has been involved in rural water supply activities in Nyaung-U Township since 1999. In July 2000 JICA and DDA made an agreement for implementation of rural water supply project in Bagan/Nyaun U. BAJ is implementation body of this project. JICA is financing this project through a program named "JICA Partnership Program". DDA, the implementation counterparts in Myanmar side, provides a drilling rig and related equipment with the operational staff. The project supposes to be continued by June 2003 and 36 deep tube wells will be completed in total by using two drilling rigs, the one of DDA and another of WRUD. Beside of well drilling, BAJ programs to rehabilitate of the existing water supply facilities, to give a training of geophysical survey to the local staff, to establish organization to be responsible for operation & maintenance of water supply facilities in each project site village.

2.2 Water Use Condition in 110 Selected Villages

2.2.1 Village & Population Enumerated by Questionnaire Survey

The Study Team conducted questionnaire survey for the people in the study villages in order to grasp the conditions on water-utility and sanitary, social organization, education, social welfare, etc. The results of the survey could be used for evaluating difficulties to access to good and stable water and basic data to design water supply facilities in each study village. The survey was conducted in 10 villages per each 6 Townships in Mandalay Division and 5 Townships in Magway Division, totally in 110 villages. The number of samples is accumulated up to 1804 households, 9959 peoples in Mandalay Division and 1500 households, 8443 peoples in Magway Division, those numbers proportionate at 15 % of the total population of the study townships.

About 200 villages belong to each Township in average. Township Development Committee has responsibilities for improving infrastructure such as water supply, sanitation, road etc. The study villages had been selected by each Township through acceptance of the headquarters of DDA in respect of difficulties of accessibility to water sources of domestic use. Those villages face evenly to severe difficulties of water use by depending on rain-fed pond, dug well, scarce production or saline water of tube wells etc.

Table 2.2.1.1 Number Enumerated by Questionnaire Survey

Division	Township	Enumerated Nos.		Actual		proportion (%)	
		Household	Population	Household	Population	HH	PP
Mandalay Division	Pyawbwe	302	1,786	856	5,051	35	35
	Taungtha	300	1,604	1,624	8,436	18	19
	Myingyan	300	1,644	2,549	15,666	12	10
	Natogyi	301	1,586	1,879	12,374	16	13
	Kyaukpadaung	300	1,589	1,525	8,389	20	19
	Nyaung U	301	1,750	1,666	9,403	18	19
	Sub total	1,804	9,959	10,099	59,319	18	17
Magway Division	Magay	299	1,569	2,271	10,245	13	15
	Myothit	300	1,784	4,369	24,858	7	7
	Chauk	300	1,719	1,476	8,328	20	21
	Pakokku	301	1,743	1,969	11,162	15	16
	Yesagyo	300	1,628	1,524	8,942	20	18
	Sub total	1,500	8,443	11,609	63,535	13	13
Grand Total		3,304	18,402	21,708	122,854	15.2	15.0

The results of the questionnaire survey are summarized in Table2.2.1.2(1)-(11) and reported in detail in A-4 of Vol. III, Supporting Report. Depending on these results, conditions of water utilization and socio-economy were evaluated and placed the order of priority of need of improvement of water supply conditions for each studied villages. However, no quantitative difference on the water supply conditions was observed so clearly among the study villages.

Each village desires similarly a deep tube well so as to solve such difficult. Some particular observation gained through the survey are summarized in the following chapters.

Table 2.2.1.2(1) Ranking of Villages on Water Supply Development base on Sociological Characteristics in Pyawbwe Township (Mandalay Division)

Sr. No.	Township	Village Tract	Village	Total HH & Pop. & Size of HH			Distance From WS in Miles		Time Taken To Fetch 50 Galon of water		WB Disease # Persons	Avg. Water Use per Day per HH (in Galon)	Nearest RHC	Avg. Income per Year per HH	Avg. Willingness to Pay per HH (Ks)		School	Rank
				HH	Pop	Size of HH	Max	Min	Max	Min					Monthly	First time / when need		
1	Pyawbwe	Magyigon	Magyigon	130	650	5.0	2.0	2.0	1:00	1:00	0	53	8 miles from Vl	96,600	-	407		5
2	||	Sabaegon	Pegan(N)	54	420	7.8	1.0	1.0	0:45	0:45	0	135	1 miles from Vl	62,900	-	373		8
3	||	Sabaegon	Pegan(S)	85	480	5.6	2.0	0.5	0:30	0:30	0	89	2 miles from Vl	63,267	-	443		9
4	||	Sabaegon	Nyandaw	68	331	4.9	2.0	1.0	0:45	0:45	0	135	7 miles from Vl	43,839	-	575		7
5	||	Faungtaw	Yebyu	84	535	6.4	6.0	beside Vl	2:00	0:30	11	92	1.5 miles from Vl	86,133	-	2350		1
6	||	Kongtha	Thabok	111	750	6.8	3.0	0.5	1:30	0:30	18	96	1.5 miles from Vl	85,619	-	806		2
7	||	Faungtaw	Paukaingyo	84	535	6.4	2.0	1.0	1:30	0:30	16	92	1 miles from Vl	-	-	-		3
8	||	Thabyeyo	Thabyeyo	-	-	-	1.0	1.0	1:30	1:30	17	88	1 miles from Vl	-	-	-		4
9	||	Osanwe	Yonbingon	60	350	5.8	1.5	3.0	1:00	1:00	3	106	3 miles from Vl	-	-	-		6
10	||	Kyette	Kyette	180	1000	5.6	0.125	0.125	0:15	0:15	0	92	0.125 miles from Vl	14,817	-	517		10
			Total	856	5051	6.0						97.8						

Table 2.2.1.2(2) Ranking of Villages on Water Supply Development base on Sociological Characteristics in Taungtha Township (Mandalay Division)

Sr. No.	*Township*	*Village Tract*	*Village*	Total HH & Pop. & Size of HH			Distance From WS in Miles		Time Taken To Fetch 50 Galon of water		WB Disease # Persons	Avg. Water Use per Day per HH (in Galon)	Nearest RHC	Avg. Income per Year per HH	Avg. Willingness to Pay per HH (Ks)		School	Rank
				HH	Pop	Size of HH	Max	Min	Max	Min					Monthly	First time / when need		
1	Taungtha	Simigan	Thazi	175	876	5.0	1.0	0.5	1:20	1:00	0	83	6 miles from Vl	79,000	-	-		9
2	||	Aungtha	Aungtha	196	1012	5.2	2.0	0.5	3:20	1:40	2	93	5 miles to Taungtha	69,967	-	920	1 PS 1 Mon. S	6
3	||	Thaputsu	Dahatan	87	453	5.2	2.0	0.125	4:40	0:15	3	92	2 miles from Vl	98,143	-	768		3
4	||	Magipinte	Pegingyaw	167	881	5.3	2.0	1.0	4:00	0:15	0	108	In Vl	77,733	-	1436		5
5	||	Zagyan	Tabaukkon	91	410	4.5	2.5	2.0	6:00	0:30	2	119	6 miles from Vl	91,931	-	-	1 PS 1 Mon. S	2
6	||	Zagyan	Kanthonesint	286	1332	4.7	3.0	2.5	5:00	0:45	3	83	3 miles to Zagyan	80,767	-	-	1 PS 3 Mon. S	1
7	||	Chaukgwa	Twinbye	286	1677	5.9	0.8	0.1	4:00	0:10	0	40	4 miles from Vl	91,786	-	-	1 PS	4
8	||	Thaputsu	Kyaukpon	157	824	5.2	1.0	0.5	1:00	0:40	0	100	2 miles from Vl	136,400	-	-	1 PS 1 Mon. S	10
9	||	Panpaung	Magyigon	73	413	5.7	2.0	Beside Vl	2:30	2:30	0	124	8 miles from Vl	127,267	-	-		8
10	||	Magincho	Sizongon	106	558	5.3	3.6	0.5	2:40	1:00	1	94	8 miles from Vl	132,167	-	-		7
			Total	1624	8436	5.2						93.6						

Table 2.2.1.2(3) Ranking of Villages on Water Supply Development base on Sociological Characteristics in Myingyan Township (Mandalay Division)

Sr. No.	Township	Village Tract	Village	Total HH & Pop. & Size of HH			Distance From WS in Miles		Time Taken To Fetch 50 Galon of water		WB Disease # Persons	Avg. Water Use per Day per HH (in Galon)	Nearest RHC	Avg. Income per Year per HH	Avg. Willingness to Pay per HH (Ks)		School	Rank
				HH	Pop	Size of HH	Max	Min	Max	Min					Monthly	First time / when need		
1	Myingyan	Pyawt	Chinmyitkyin	63	476	7.6	2.0	0.1	4:00	0.02	0	152	3 miles to Koke	78,067	-	318	1 PS 1 Mon. S	5
2	||	Koke	Koke	317	2500	7.9	1.5 (salty)	0.5	1:00	0:15	0	83	In Vl	114,548	-	581	1 PS 5 Mon. S	2
3	||	Ywatha	Ywatha	370	2800	7.6	0.5	0.1	1:20	1:20	0	97	In Vl	200,700	-	760	1 PS 3 Mon. S	9
4	||	Ywathaya	Ywathaya	235	1554	6.6	0.5	0.1	2:50	0:30	0	132	0.375 miles to Koke	133,800	-	490	1 Mid. S 3 Mon. S	8
5	||	Taywinbo	Kyaungbyugan	300	1000	3.3	0.25	50 Yards	0:40	0:30	0	94	In Vl	225,867	-	367	1 PS 1 Mon. S	10
6	||	Kuywa	Kuywa	380	2061	5.4	0.5	0.1	5:00	2:50	0	47	1 mile from Vl	97,633	-	267	1 PS 4 Mon. S	4
7	||	Saka	Saka	250	1001	4.0	0.5	0.1	2:45	1:00	0	94	In Vl	215,900	-	1060	1 PS 3 Mon. S	7
8	||	Gwebinyo	Gwebinyo	60	236	3.9	1 (salty)	0.1	1:00	1:00	2	78	3 mile tp Taungshe	125,143	-	382	1 PS 1 Mon. S	3
9	||	Gwebinyo	Taungshe	187	1000	5.3	(salty)	0.1	3:20	0:50	0	65	In Vl	85,828	-	263	1 PS 1 Mon. S	1
10	||	Pya	Pya	487	3038	6.2	1.0	In Vl	3:20	1:00	0	71	In Vl	138,233	-	608	1 PS 1 Mon. S	6
			Total	2649	15666	5.8						91.3						

Table 2.2.1.2(4) Ranking of Villages on Water Supply Development base on Sociological Characteristics in Natogyi Township (Mandalay Division)

Sr. No.	*Township*	*Village Tract*	*Village*	Total HH & Pop. & Size of HH			Distance From WS in Miles		Time Taken To Fetch 50 Galon of water		WB Disease # Persons	Avg. Water Use per Day per HH (in Galon)	Nearest RHC	Avg. Income per Year per HH	Avg. Willingness to Pay per HH (Ks)		School	Rank
				HH	Pop	Size of HH	Max	Min	Max	Min					Monthly	First time / when need		
1	Natogyi	Pegyet	Pegyet	258	1261	4.9	0.38	Beside Vl	3:50	0:30	0	51	0.125 miles from Vl	68,067	-	248	1 Mid. S 5 Mon. S	3
2	||	Thangwa	Thangwa S	138	774	5.6	0.38	In vl	1:40	0:30	0	117	4 miles to Natogyi	56,333	-	278	1 PS 1 Mon. S	7
3	||	Nyaungkon	Aungtha	152	902	5.9	2.0	1.0	2:00	0:15	0	103	2 miles to Aungpankon	39,000	-	377	1 PS 2 Mon. S	6
4	||	Thaminbe	Buthigyin	153	965	6.3	1.5	0.25	1:45 (Salty)	0:30	0	71	2 miles to Natogyi	55,267	-	247	1 PS 1 Mon. S	4
5	||	Nyaunggon	Nyaunggon	142	774	5.5	0.125	-	4:00	0:50	0	100		65,200	-	225	1 PS 2 Mon. S	2
6	||	Ketlan	Ketlan	272	3200	11.8	0.625	0.5	1:00	0:15	0	110	2 miles to Pyinsi	86,233	-	122	1 PS	9
7	||	Mogan	Mogan W	118	699	5.9	0.125	in vl	2:00	0:30	0	96	2 miles from Vl	68,533	110	-	None	8
8	||	Gwegon	Thapandaw	128	856	6.7	0.33	In vl	1:13	0:19	0	71	6 miles to Natogyi	47,067	-	121	1 PS 1 Mon. S	10
9	||	Letwe	Letwe	390	2087	5.4	1.00	0.13	4:10 (Salty)	0:15	0	63	2 miles to Tasoe Vl	77,800	-	313	1 HS 2 Mon. S	1
10	||	Pyayachaung	Thintabaw	128	856	6.7	2.5	0.125	2:00 (Salty)	1:00	3	29	3 miles to Tasoe	79,033	-	123	1 PS 1 Mon. S	5
			Total	1879	12374	6.5						81.1						

Table 2.2.1.2(5) Ranking of Villages on Water Supply Development base on Sociological Characteristics in Kyaukpadaung Township (Mandalay Division)

Sr. No.	*Township*	*Village Tract*	*Village*	Total HH & Pop. & Size of HH			Distance From WS in Miles		Time Taken To Fetch 50 Galon of water		WB Disease # Persons	Avg. Water Use per Day per HH (in Galon)	Nearest RHC	Avg. Income per Year per HH	Avg. Willingness to Pay per HH (Ks)		School	Rank
				HH	Pop	Size of HH	Max	Min	Max	Min					Monthly	First time / when need		
1	Kyaukpadaung	Gwaydaukkone	Gwaydaukkone	250	1560	6.2	3.0	0.5	3:00	0:45	0	65	4 miles to Sahtain	113,540	-	860	1 PS 1 Mon. S	7
2	||	Popa	Chaungbya	130	696	5.4	0.8	0.5	10:25	0:15	0	69	0.5 miles to Army Compound	98,000	-	500	1 PS 1 Mon. S	1
3	||	Tangakan	Tangakan	164	786	4.8	4.0	2.5	5:30	2:46	0	33	4 miles to Kani	157,767	-	717	1 PS 4 Mon. S	5
4	||	Letpanpin	Htantawgyi	136	780	5.7	4.0	0.25	8:20	5:30	7	44	1 miles to Letpanpin	177,517	-	1250	1 PS 1 Mon. S	2
5	||	Kanbauk	Kanbauk	185	1456	7.9	2.0	in vl	2:50	0:30	0	53	1 miles to Kyaukpadaung	172,467	-	645	1 PS 1 Mon. S	9
6	||	Twinphyu	Inbingyi	175	850	4.9	2.0	in vl	1:00	0:30	0	72	3 miles from vl	173,793	-	1253	1 PS 2 Mon. S	10
7	||	Sonywa	Salindaung	100	500	5.0	2.0	1.5	8:20	0:30	0	60	2 miles to soneywa	168,387	-	1172	1 Mon. S	4
8	||	Kauksayitkan	Lwinpinkone	180	800	4.4	2.0	0.5	3:00	0:30	0	82	8 miles to Kyaukpadaung	194,667	-	1467	1 Ps 1 Mid. S	8
9	||	Simdaikan	Sagyaw	125	461	3.7	2.0	1.5	4:10	1:00	0	43	4 miles to Kyaukpadaung	132,300	-	553	1 PS 1 Mon. S	6
10	||	Simdaikan	Sudat	80	500	6.3	1.0	0.25	8:20	1:00	0	37	2 miles to Kyaukpadaung	151,586	-	661	1 PS 1 Mon. S	3
			Total	1525	8389	5.4						55.8						

Table 2.2.1.2(6) Ranking of Villages on Water Supply Development base on Sociological Characteristics in Nyaung U Township (Mandalay Division)

Sr. No.	Township	Village Tract	Village	Total HH & Pop. & Size of HH			Distance From WS in Miles		Time Taken To Fetch 50 Galon of water		WB Disease # Persons	Avg. Water Use per Day per HH (in Galon)	Nearest RHC	Avg. Income per Year per HH	Avg. Willingness to Pay per HH (Ks)		School	Rank
				HH	Pop	Size of HH	Max	Min	Max	Min					Monthly	First time / when need		
1	Nyaung U	Phalankan	Phalankan	300	1500	5.0	6 (dry season)	1.0	1:40	0:15	34	116	1.5 miles to Setsetyo	85,400	-	-	1 Mid. S 1 Mon. S	3
2	||	Setsetyo	Setsetyo	150	1000	6.7	9.0	950 ft	0:30	0:10	13	95	In Vl	112,700	-	-	1 PS 1 Mon. S	9
3	||	Setsetyo	Myetkhataw	93	600	6.5	16 (dry season)	0.375	12:40 (8 hours)	0:35	41	112	2.5 miles to Setsetyo	118,452	-	-	1 PS 1 Mon. S	1
4	||	Htipu	Ywalu	70	600	8.6	3 (dry season)	2	3:00	1:00	45	133	2 miles from vl	119,533	-	-	1 Mon. S	6
5	||	Taungzin	Kaungpinsi	275	1708	6.2	4.0	0.5	5:00	1:15	34	88	1 miles from vl	109,232	-	-	1 PS 1 Mon. S	2
6	||	Kuywa	Kuywa	228	1000	4.4	4.0	0.5	3:00	0:25	38	88	0.5 miles to Taungshe	143,200	-	-	1 Mid. S 2 Mon. S	5
7	||	Tuywintine	Kangyikon(N)	138	700	5.1	2.0	1	1:15	0:30	8	36	2 miles to Thebintaw	153,567	-	-	1 PS 2 Mon. S	8
8	||	Tuywintine	Kangikon(S)	117	570	4.9	3.0	2.0	1:25	0:28	32	94	2 miles from vl	150,800	-	-	1 PS 1 Mon. S	7
9	||	Suti	Hta-naung-win	72	350	4.9	4.0	1.0	4:10	0:35	32	92	1 miles from vl	129,200	-	-	1 PS	4
10	||	Kantharyar	Kantharyar	223	1375	6.2	0.31	in vl	0:20	0:10	27	126	5 miles to Ngathayauk	89,267	-	-	1 PS 1 Mon. S	10
			Total	1666	9403	5.8						98						

Table 2.2.1.2(7) Ranking of Villages on Water Supply Development base on Sociological Characteristics in Magway Township (Magway Division)

Sr. No.	Township	Village Tract	Village	Actual HH & Pop. Size of HH			Distance From WS in Miles		Time Taken To Fetch 50 Galon of water		WB Disease # Persons	Avg. Water Use Per Day per HH (in Galon)	Nearest RHC	Avg. Income per Year per HH	Avg. Willingness to Pay per HH (Ks)		School	Rank
				HH	Pop.	Size of HH	Max	Min	Max	Min					Monthly	First time / when need		
1	Magway	Kanthagyi	Kanthagale	261	1146	4.4	1.5	0.125	12.00	0.25	4 Per. (Cor.) 2 die last Yr.	68	1 mile to Kanthargyi	105,510	-	455	1 PS 2 Mon. S	1
2	‖	Leya	Taungyartaw	84	470	5.6	2.0	0.125	9.00	3.00	Few HH every year	60	2 miles to Leya	98,567	169	667	1 PS 1 Mon. S	2
3	‖	Alebo	Inpinkan	100	610	6.1	1.0	0.4	1.00	0.15	Few HH every year	85	2 miles to Alebo	118,690	-	477	1 PS 1 Mon. S	9
4	‖	Alebo	Ywakuitsan	28	145	5.2	0.06 (300 Feet)	In Vl	4.30	0.10	2 Persons	55	2 miles to Alebo	67,345	195	556	None	6
5	‖	Thabyesan	Minywa S	110	540	4.9	0.375 (3F)	0.625 (5F)	0.30	0.15	7 Persons	68	0.625 miles to Minywa N	192,533	-	1222	None	10
6	‖	Thabyesan	Thabyesan N	50	250	5.0	1.0	0.625 (5F)	8.20	0.30	3 Persons	78	0.3 miles to Thabyesan S	188,467	-	528	1 Mon. S	4
7	‖	Papaesan	Ywataw	45	224	5.0	1.0	0.25 (2F)	2.30	0.20	10 to 15 Recent Few Last Yr.	58	1.3 miles to Saingka Vl	84,100	0	917	1 PS 1 Mon. S	7
8	‖	Kunon	Yonekone	140	815	5.8	0.375 (3F)	0.25 (2F)	1.30	0.26	10 Persons	82	5 miles away	100,767	50	342	1 PS 1 Mon. S	8
9	‖	Kyitsonbwe	Kyitsonbwe	1228	5000	4.1	3.0	0.5	3.00	1.30	20 Persons	104	13 miles to Magway	185,067	50	588	1 HS 5 Mon. S	5
10	‖	Payapyo	Payapyo N	225	1045	4.6	1.5	0.5	9.00	1.30	4 Persons	59	7 miles to Kanpya	145,133	-	683	1 PS 4 Mon. S	3
			Total	2271	10245	5.1						71.7						

Table 2.2.1.2(8) Ranking of Villages on Water Supply Development base on Sociological Characteristics in Myothit Township (Magway Division)

Sr. No.	Township	Village Tract	Village	Actual HH & Pop. Size of HH			Distance From WS in Miles		Time Taken To Fetch 50 Galon of water		WB Disease # Persons	Avg. Water Use Per Day per HH (in Galon)	Nearest RHC	Avg. Income per Year per HH	Avg. Willingness to Pay per HH (Ks)		School	Rank
				HH	Pop.	Size of HH	Max	Min	Max	Min					Monthly	First time / when need		
1	Myothit	Ledaingzin	Ledaingzin	1600	8000	5.0	0.5	0.1	3.00	0.15	31	57	12 miles to Laelu Village	90,000	-	870	1 Middle S 3 Mon. S	7
2	‖	Ledaingzin	Aungmyintha	160	750	4.7	1.0	0.2	1.00	0.20	55	114	6 miles to Magway	120,333	-	603	1 PS 1 Mon. S	8
3	‖	Ledaingzin	Thamyar	650	4550	7.0	3.0	0.1	3.15	1.00	25	72	1.5 miles to Kyakan	92,050	16	661	1 PS 2 Mon. S	4
4	‖	Yepyae	Natywa	180	1200	6.7	0.5	0.3	0.30	0.20	18	165	8 miles to Wagyiaing	124,643	-	1042	1 PS 1 Mon. S	10
5	‖	Ledaingzin	Pogyi	325	2000	6.2	4.0	0.25	6.00	0.30	33	79	6 miles to Wagyiaing	60,100	-	317	1 PS 3 Mon. S	3
6	‖	Yondaw	Myinsu	72	390	5.4	1.0	0.25	3.00	0.30	48	81	6 miles to Wagyiaing	90,567	290	1640	1 PS 1 Mon. S	5
7	‖	Wagyiaing	Ngwelay	193	1500	7.8	3.0	0.1	3.00	0.25	38	96	3 miles to Wagyiaing	156,667	-	2097	1 PS 1 Mon. S	6
8	‖	Wagyiaing	Wagyiaing	627	3000	4.8	1.0	0.1	6.40	0.30	45	71	in VI	115,733	-	511	1 PS 8 Mon. S	2
9	‖	Yondaw	Yondaw	362	2568	7.1	2.0	0.2	12.00	0.30	50	112	5 miles to Wagyiaing	142,333	-	1282	1 PS 1 Mon. S	1
10	‖	Gwegyo	Gwegyo (West)	200	900	4.5	1.0	0.5	3.00	0.20	21	81	0.5 miles to Gwegyo N	133,733	-	688	1 PS 1 Mon. S	9
			Total	4369	24858	5.9						92.8						

Table 2.2.1.2(9) Ranking of Villages on Water Supply Development base on Sociological Characteristics inChauk Township (Magway Division)

Sr. No.	*Township*	*Village Tract*	*Village*	Actual HH & Pop. Size of HH			Distance From WS in Miles		Time Taken To Fetch 50 Galon		WB Disease # Persons	Avg. Water Use Per Day per HH (in Galon)	Nearest RHC	Avg. Income per Year per HH	Avg. Willingness to Pay per HH (Ks)		School	Rank
				HH	Pop.	Size of HH	Max	Min	Max	Min					Monthly	First time / when need		
1	Chauk	Gwegyo	Sharbin	200	1200	6.0	4.0	1.0	3.65	0.30	5	51	1 miles to Gwegyo	120,933	150	1096	1 Middle S 10 Mon. S	9
2	||	Swebaukkan	Yela	170	957	5.6	4.0	1.0	6.00	1.00	34	85	2.5 miles to Gwebin	107,400	-	1567	1 PS 1 Mon. S	6
3	||	Swebaukkan	Zigyobin (S)	80	450	5.6	8.0	1.0	7.00 Whole day in dry season	1.00	37	57	2 miles to Swepaukkan	105,357	-	1873	1 PS 1 Mon. S	2
4	||	Thittogan	Sudat	193	1058	5.5	1.0	0.5	12.00	0.20	10	67	1 miles to Gwegyo	91,379	-	1247	1 PS 1 Mon. S	4
5	||	Thittogan	Sangan	150	700	4.7	1.0	0.5	12.00	0.30	8	75	1 miles to Kywedat	99,267	-	1115	1 PS 1 Mon. S	3
6	||	Kywedat	Kywedat Ywam	160	1000	6.3	2.0	0.4	2.15	0.15	2	47	In Vl (0.125)	72,833	-	837	1 PS 1 Mon. S	10
7	||	Suyitkan	Kyeiksu (S)	90	456	5.1	2.0	0.1	6.00	0.10	0	78	4 miles to Pakanngw	122,667	100	1071	1 PS	7
8	||	Wetthesan	Thayetpin	180	1150	6.4	4.0	1.5	18 Whole Night in dry season	0.30	13	73	5 miles to Gwebin	105,733	-	2260	1 PS 1 Mon. S	1
9	||	Thanbo	Kyauktaing	93	557	6.0	0.6	0.5	4.00	0.30	13	63	1 miles to Kanyaytaung	103,767	-	1627	1 PS 1 Mon. S	8
10	||	Thalonthwe	Pyaywa	160	800	5.0	2.5	In Vl	8.00	1.00	2	88	2 miles to Thalonthwe	113,100	217	1405	1 PS 1 Mon. S	5
			Total	1476	8328	5.6						68.4						

Table 2.2.1.2(10) Ranking of Villages on Water Supply Development base on Sociological Characteristics in Pakokku Township (Magway Division)

Sr. No.	*Township*	*Village Tract*	*Village*	Actual HH & Pop. Size of HH			Distance From WS in Miles		Time Taken To Fetch 50 Galon of water		WB Disease # Persons	Avg. Water Use Per Day per HH (in Galon)	Nearest RHC	Avg. Income per Year per HH	Avg. Willingness to Pay per HH (Ks)		School	Rank
				HH	Pop.	Size of HH	Max	Min	Max	Min					Monthly	First time / when need		
1	Pakokku	Chaukkan	Chaukkan W	280	1432	5.1	1	100yard In Vl	4.00	1:40	2	75	3.5 miles to Pakokku	103,867	-	390	1 PS 2 Mon. S	7
2	‖	Padaingchon	Myauklukan	355	1800	5.1	0.25	0.125	4.00	0.15	0	80	5 miles to Pakokku	114,133	-	595	1 PS 2 Mon. S	8
3	‖	Sabae	Sabae W	327	1444	4.4	0.5	Salty & Bitter	2.00	1.00	3	89	4 miles to Myitshay	129,484	-	482	1 PS 2 Mon. S	2
4	‖	Sabae	Sarkyin	111	800	7.2	1	3KM	2:00	0.25	4	87	6 miles to Myitshay	126,000	-	537	1 PS 1 Mon. S	9
5	‖	Kyathtoe	Kyathtoe	110	577	5.2	0.5	10 wells in Vl Very Salty	2:05	2:00	3	60	In Vl 100 feet	87,620	-	363	1 PS 3 Mon. S	1
6	‖	Magithonepin	Magithonepin	67	350	5.2	1.0	0.25	2:30	0:50	3	77	1 miles to Thanhmo	128,100	-	562	1 Mon. S	3
7	‖	Palan-O	Palan-O	320	2700	8.4	0.25	In Vl	6:00	0:25	14	103	1 miles from Vl	155,833	-	691	1 Middle S 3 Mon. S	4
8	‖	Palan-O	Kanpauksu	122	730	6.0	1.0	0.125	3:20	1:40	0	102	2 miles to Palan-O	145,000	-	358	1 PS 1 Mon. S	6
9	‖	Kanyet	Kyauksayitkan	125	379	3.0	1.0	0.25	8:20	0:25	0	62	3 miles to Kandaw	89,333	-	430	1 PS 1 Mon. S	5
10	‖	Kanyetkyi	Anaukponekan	152	950	6.3	2.0	0.25	1:00	0:15	3	66	3 miles to Kandaw	88,600	-	470	1 PS 1 Mon. S	10
			Total	1969	11162	5.6						80.1						

Table 2.2.1.2(11) Ranking of Villages on Water Supply Development base on Sociological Characteristics in Yesagyo Township (Magway Division)

Sr. No.	*Township*	*Village Tract*	*Village*	Actual HH & Pop. Size of HH			Distance From WS in Miles		Time Taken To Fetch 50 Galon of water		WB Disease # Persons	Avg. Water Use Per Day per HH (in Galon)	Nearest RHC	Avg. Income per Year per HH	Avg. Willingness to Pay per HH (Ks)		School	Rank
				HH	Pop.	Size of HH	Max	Min	Max	Min					Monthly	First time / when need		
1	Yesagyo	Tangedaw	Kunthigan	138	700	5.1	2.0	200 yard	1:30	0:15	7	63	7.5 miles to Pakokku	132,033	-	297	1 PS 1 Mon. S	10
2	‖	Tangedaw	Zidaw	80	640	8.0	1.0	0.125	6:00	0:15	0	52	2 miles away from VI	107,000	-	176	0 PS 1 Mon. S	7
3	‖	Kyaukka	Kyauktaga	58	324	5.6	5.0	0.125	2:05	1:00	6	55	0.25 miles to Kyaukka	89,848	-	247	1 PS 1 Mon. S	5
4	‖	Kyaukka	Kyaukka	80	420	5.3	6.0	1000 Feet	7:00	1:30	10	56	In VI	91,600	-	343	1 PS 1 Mon. S	3
5	‖	Kyaukka	Chinyagone	132	692	5.2	6.0	1000 feet	10:00	1:00	17	50	In VI	86,400	-	84	1 PS 1 Mon. S	2
6	‖	Zedaw	Seywa	186	1070	5.8	6.0	0.125	4:30	0:30	4	66	4 miles to Ma Ou VI	128,994	-	231	1 PS 1 Mon. S	4
7	‖	Wetkadaw	Thitkaukseik	150	655	4.4	1.0	0.06	5:50	0:30	49	95	1 miles to Wetkadaw	115,871	-	214	1 PS 1 Mon. S	8
8	‖	Byiba	Byiba	115	804	7.0	2.0	0.06	8:00	0:15	13	98	In VI	150,733	-	268	1 PS 1 Mon. S	6
9	‖	Thitkyidaw	Thitkyidaw	460	3000	6.5	1.5	150 feet	11:25	0:35	13	63	0.5 Miles away from VI	117,800	-	283	1 PS 1 Mon. S	1
10	‖	Salingon	Sattwa	125	637	5.1	0.5	0.125	3:20	0:30	7	47	2 miles to KyetKaukan	91,887		268	1 PS 1 Mon. S	9
			Total	1524	8942	5.8						64.5						

2.2.2 Water Sources and water consumption of the Villages

Water sources, that the study villages depend on, are shown in Table 2.2.2.1. The reason why numbers of answer is more than the same of study village is that most villages have to use several different water sources though a year. These villages use commonly rain-fed ponds and dug wells as the water source or both of them. In case of deep tube well, which villagers answered a lot, it means that these villagers have to access it in the neighboring villages in dry season or that villagers cannot fully depend their own tube well due to saline or bitter taste of well water. There are answers of piped water which include a case of direct pumping and supply system of Ayeyawarddy water in Nyaung-U Township and some cases of small scale pipe supply of spring water. Stream water can be used in rainy season in some of study villages.

Mean daily water consumption per household in the villages is in a range of 60 to 90 gallon. This amount may include water for livestock in their home. Average household members are about 6 persons. The water daily demand per person is a rage of 10 to 15 gallons.

Table 2.2.2.1 Water Sources in Study Villages

Township	Pond	Dug well constructed by		Tube well	Piped water	Stream	Total
		Machine	Hand				
Pyawbwe	2	-	1	5	1	0	9
Thaungtha	3	5	0	3	0	1	12
Myingyan	1	0	0	10	0	0	11
Natogyi	2	0	0	8	0	0	10
Kyaukpadaung	7	3	0	2	1	0	13
Nyaung U	10	1	0	1	1	0	13
Magway	3	3	7	7	0	1	21
Myothit	7	7	7	2	2	4	29
Chauk	9	6	5	0	1	0	21
Pakokku	7	6	2	2	0	2	19
Yesagyo	10	10	2	10	0	2	34
Total	61	41	24	50	6	10	192

2.2.3 Sociological Conditions

The study villages are the typical dry weather farming villages, which produce such as cereals of various kinds of beans and sesames, palm alcohol, tobacco, etc. Villagers consist of owner farmers and daily working farmers. Population of the villages is at a range from 500 to 1,000, and the same of some villages are over 3,000. Families are generally composed by 5 or 6 members (average 5.7 persons).

The incomes of the households are earned by selling their products in case of owner farmer or by daily wages in case of daily working farmers. The survey reveals the mean annual income of households is at a range from Ks 50,000 to Ks150,000. It is generally said that

owner farmers earn Ks 100,000 to Ks 300,000 and daily wage farmers also earn Ks 40,000 to Ks 50,000 per annum.

Villagers are generally eager in education for their children. There is a primary school and a monastery school in most of the village. Secondary school normally stands in the towns where the population is more than some thousands. Health clinics for the villagers are situated in towns a few miles apart from their native villages. Water-bone diseases of diarrheas or trachoma break out constantly in the study villages.

2.2.4 Willingness to Pay

Every village is equally eager to have a deep tube well to cater the water demand of the village by the good groundwater. Therefore without exception villagers explained that they will pay a necessary expense for their domestic water. The average amount of willingness pay of villagers to the water ranges from Ks 50 to Ks 100 per month. And they also show their willingness to pay of about Ks 1000 in cases of initial installation of the facilities or emergency water use. In some villages more than Ks 2000 were answered in case of the same. It means a trend that the villages facing more difficulties of water use show higher willingness to pay.

2.3 Difficulties of Water Use and Selection of 22 Tube Well Construction Site

2.3.1 Difficulties of Water Use

From the field reconnaissance on the conditions of water use in the study villages, the situation of water shortage are summarized as follows:

1) Village rely mostly on rain-fed pond or dug well or the both as a water source.
2) The ponds cannot sustain the water demand of the village during the dry season due to its limitation of the capacity. From March to May are mostly difficult months for villagers to obtain water.
3) Dug well also lessen usability as the water level is getting down in the dry season.
4) Water fetching work relies mostly on women and children in case the water source is near the villages.
5) After the pond and dug well dries up, villagers have to fetch water by bullock cart with water barrels from the nearest sources, which are mostly deep wells located in the neighboring village in a few miles apart from the native village.