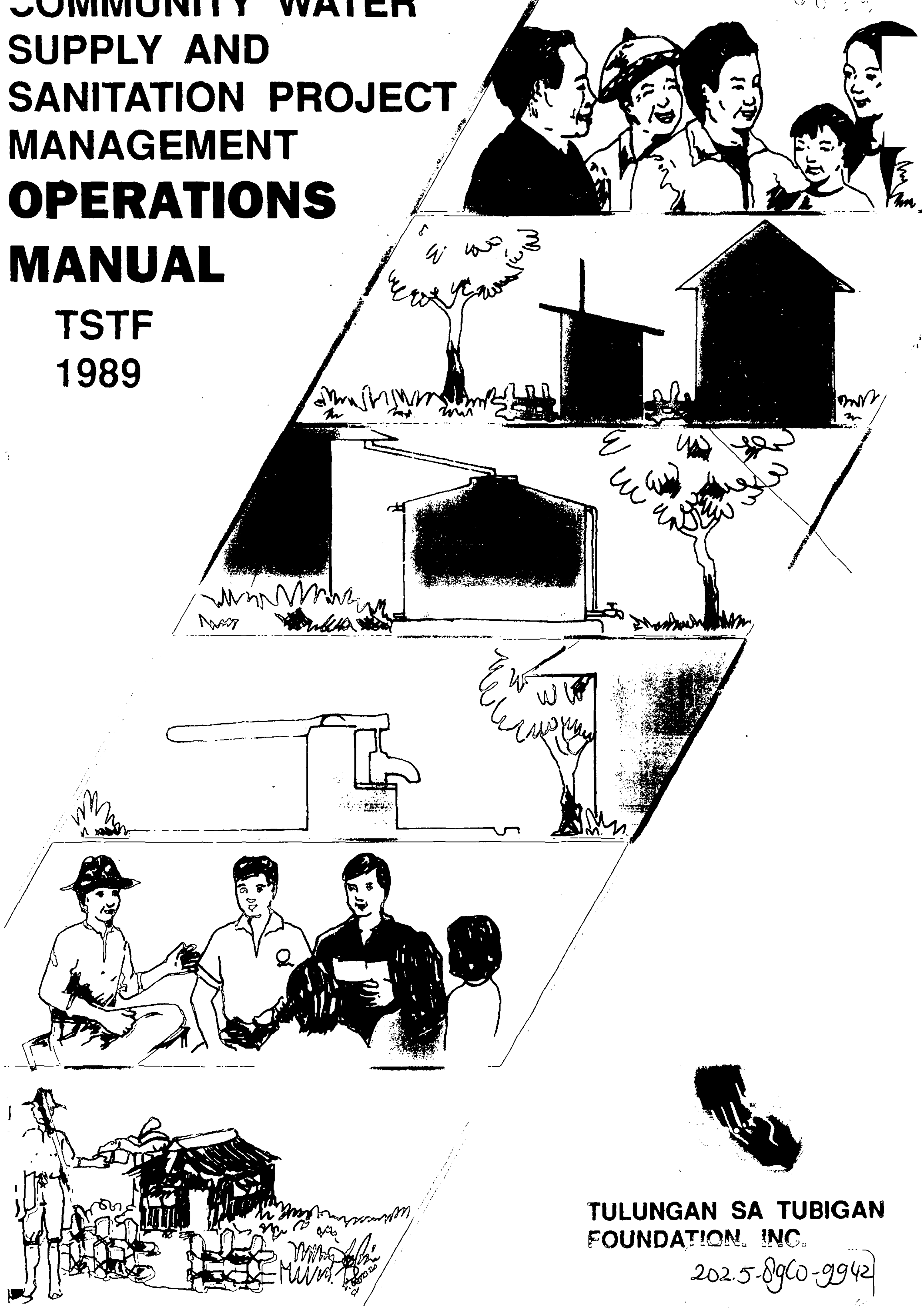
DIANNE ARBOLEDA

# COMMUNITY WATER SUPPLY AND SANITATION PROJECT MANAGEMENT

# OPERATIONS MANUAL

TSTF

1989



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COMMUNITY WATER SUPPLY
AND
SANITATION PROJECT MANAGEMENT

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# OPERATIONS MANUAL

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*PREFACE*

The development of a community's social, economic and educational potentials can be better realized with the presence of a well managed rural water supply and sanitation facility. The benefits derived from such a facility cannot be overemphasized especially when one recognizes that water supply and sanitation are basic needs of man for total development.

In support to the initiative and commitment of the United Nations Children's Fund (UNICEF) to implement its Third Country Programme for Filipino Children (CPC III) through the Area-Based Child Survival Development Program (ABCSDP), Tulungan sa Tubigan Foundation, Inc. (TSTF) was tapped to serve as a technical resource in the water and sanitation component of the program. The foundation implements technical assistance and supervision to the ABCSDP target communities through the local government units, namely: the Planning and Development Offices at the provincial and municipal levels (PPDO/MPDO). The program is jointly undertaken, participated in and coordinated by the representatives of implementing line agencies such as Integrated Provincial Health Office (IPHO), Department of Public Works and Highways (DPWH), Provincial Engineering's Office (PEO), Department of Education, Culture and Sports (DECS) and Department of Social Welfare and Development (DSWD), Department of Local Government (DLG). To assist the project staff and the local government units assume project management functions and ensure the effective and efficient sustenance of the water supply and sanitation project, the need for an Operations Manual was realized.

This Operations Manual will be a guide for provincial local government units and private organizations that may want to implement a Community Water Supply and Sanitation Project. It can serve as a standard model for the program and likewise can be used as a resource material for community water supply and sanitation project-related training programs. And since the content of this manual comes from the actual experiences of the people of depressed provinces of Mindanao, its value in the implementation of similar projects is immeasurable.

The organization and preparation of the Operations Manual were undertaken by the staff of Tulungan sa Tubigan Foundation, Inc. It was finalized together with representatives of the PPDO and the local government units of Sulu, Basilan, Tawi-Tawi and Lanao del Sur. The manual is actually intended for the direct and indirect implementors of the community water supply and sanitation projects. They are the PPDO and other TSTF proponents. The indirect users of the manual are the funding agencies and TSTF partner organizations.

Through this manual, it is hoped that the communities' water supply and sanitation projects are better managed resulting in an improved quality of life especially for the depressed areas. And as this manual contributes its share of knowledge and insight, may those who use it be true to its intent and purposes.

# ACKNOWLEDGEMENT

Deep gratitude and appreciation are sincerely extended to all those who contributed to the preparation and completion of this Operations Manual on Community Water Supply and Sanitation Project Management.

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....and most especially to the people of Sulu, Basilan, Tawi-Tawi and Lanao del Sur in the ABCSDP 1988 target areas, who have not only dreamed of having an effective and efficient community water supply and sanitation project but actually worked hard for it.

## COMMUNITY WATER SUPPLY AND SANITATION PROGRAM FRAMEWORK

This model answers the need to plan, implement, monitor and evaluate water supply and sanitation projects with the active rural communities. For these projects, the national line agencies, local government units and the people should share the responsibility in responding to the needs of the communities. Thus, the model indicates a systematic and dynamic process that assures a community of a functional and well-maintained water supply and sanitation system.

The community water supply and sanitation program framework, as illustrated in Figure A is represented by nine blocks. These blocks clearly show the interventions involved in the process. It indicates how essential are these interventions in the effective and efficient management of a water supply and sanitation project.

The model starts with various social and initial technical preparations arranged in order, such as : program orientation and planning, community study, social investigation and preliminary technical investigation, community mobilization through Community Development Volunteers or Community Water Project Volunteers, and organization building through the formation of water committees/task force or water association before going into highly technical concerns.

The first four blocks are concerned with training and education. These blocks ensure that a community is not only prepared to participate in a program but is ready to assume the reponsibilities over it. The ideal situation cannot, of course, be achieved overnight. But experience has shown that a community can learn, step-by-step, how to work together for a common goal.

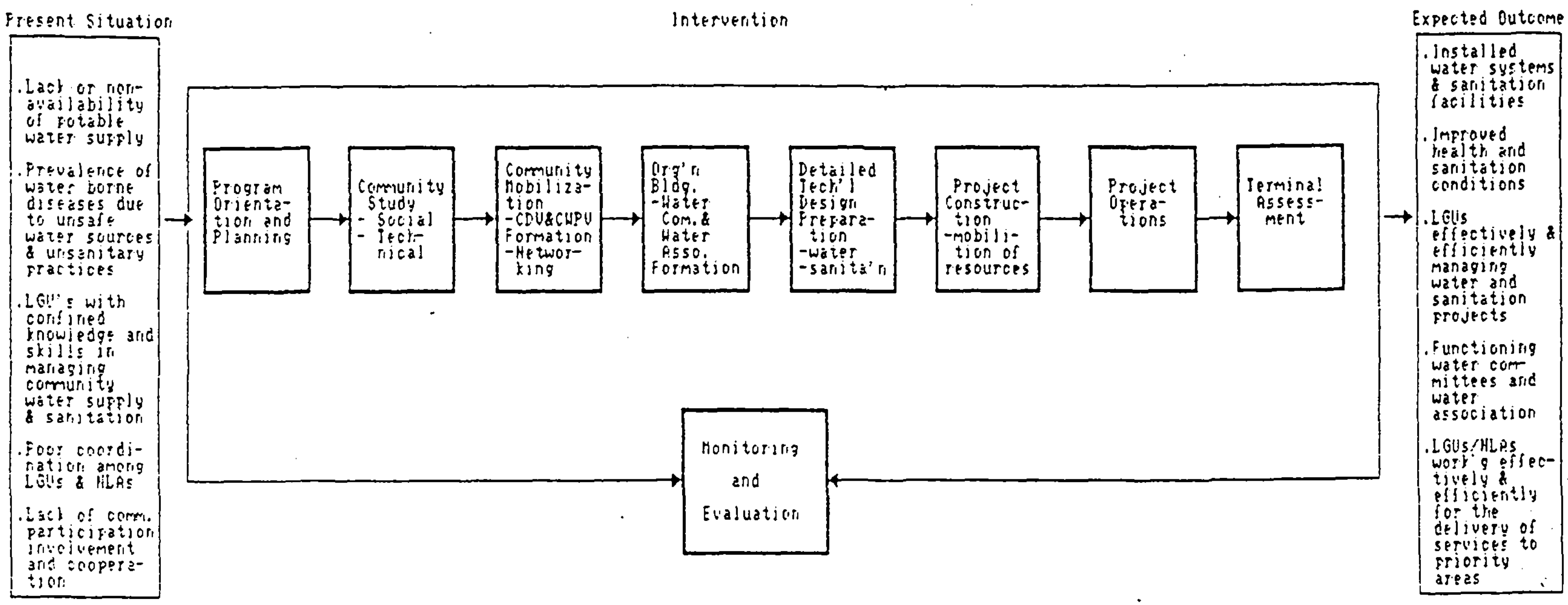
Progressing through the blocks indicates an increase in the knowledge, skills and attitude of the community in water supply and sanitation project management. The project implementors also make sure that the capability of the community in terms of the social and technical components of the project is continually upgraded until it becomes self-reliant.

Now that the community has been organized and its systems strengthened, the next blocks - detailed technical design preparation, project construction and project operations - will see the community immerse itself in technical tasks which will culminate when it will do its own repair and maintenance of the system.

Through the program framework, the communities are likewise shown the importance of assessing the results of implementation per block before moving into other interventions. They are then taught to use various evaluation methods and monitoring tools as instruments. The final block includes terminal assessment. This provides a built-in mechanism to check the extent to which the community has been able to practice and apply the skills acquired. In order to achieve the end result, the community should ideally follow the model's block sequence. However, a certain amount of flexibility is needed should the realities dictate such. But the emphasis should still be on the completion of the entire process.

It is through the nine blocks where the social and the technical components of the community water supply and sanitation projects are integrated. This is when the communities learn to handle their problems on water supply and sanitation thereby ensuring the project's success.

Fig. A COMMUNITY WATER SUPPLY & SANITATION PROGRAM FRAMEWORK

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# CHAPTER I - PROGRAM ORIENTATION AND PLANNING

There are more local and international agencies now involved at programs to improve water supply and sanitation condition in developing countries. The need to effectively and efficiently plan community based water projects is ever present.

A number of water projects had false starts - that is giving importance to the construction phase rather than giving the same importance to other factors that influence the outcome of the project.

It is in this light that these implementing guidelines are drawn - so that misconceptions are corrected.

The start of any water supply and sanitation projects should be made with a formal program orientation and planning. This phase sets the project in the right direction as both the project implementors and beneficiaries are thoroughly briefed on the project itself.

## A. Objectives of Program Orientation and Planning

Many water projects were labelled a failure because of inefficient and ineffective planning.

The main objective of the planning and orientation activities is to inform the different provincial government units and private organizations about the program with the end in view of getting well motivated and committed provincial teams that are capable of formulating provincial plans of operation.

It also aims to acquaint the beneficiary groups or the community of the possible good effects or benefits that the project would bring. In this way, involvement, support and participation in the project can be effected.

## B. Components of Program Orientation and Planning

The Program orientation activity has three major components: the Orientation Proper, the Group Building/Team Building (GB/TB) Component and the Planning Element.

The orientation phase is where the program's rationale, objectives, strategies, and approaches are presented. The second component seeks to establish a good working relationship among the project actors, properly motivating them to pool their time, effort and expertise in the field.

The planning element calls for the formulation, discussion and validation of the provincial plan of operations. A structured program of work, whether for a one year or a quarter period, is prepared; then agreed upon by the concerned people. This is also the time when responsibilities in carrying out the projects are pinpointed.

C. Strategies of Program Orientation and Planning

The methodologies to be utilized vary according to the target audience of the project at that particular time. These groups include partner agencies, proponents, local government units, beneficiary groups and the general public.

1. Partner Agencies, Local Government Units, Proponents

Workshop

A workshop is a seminar where in participants exchange ideas, where practical methods and processes on the subject matter are discussed.

A workshop usually consists of the following general modules - orientation module, that includes orientation of program, topics or field of discussion, objective, mechanics and others; workshop per se and synthesis module.

Symposium

Symposium is a conference where in a panel of speakers, each an authority in his own field of expertise, deliver their speeches, lectures or reports to an audience. Inquiries are accommodated through a moderator and addressed to respective speakers.

Conduct of Courtesy Call, Agency Visit on Local Regional and National Government Agencies

Since a water supply and sanitation project is to be implemented within a community, it would be wise to pay a courtesy call to the heads of involved local, regional or national government agencies and to the head of the locality itself. These calls/visits can be used as a venue in informing the leaders of the community of the project, the actual benefits to be derived from it thus soliciting their support even before the actual implementation of the project.

Consultation Meeting

A consultation meeting is held when a decision that has already been reached is thrown back to the group for an opinion or even for a new consensus.

Introduction to the Water Task Force Formation

Because of the many water projects now being implemented in the country, the Provincial Planning and Development Office (PPDO) has its hands full. An implementing arm of the PPDO for water and sanitation projects has been created.

This activity calls for the organization of a Provincial Water Task Force (PWTF) that will oversee, implement and assess the water projects in the locality. The staff of the task force is usually drawn from the provincial government and other line agencies and appointed by the provincial leaders like the Governor, Provincial Planning Coordinator and other members of the Provincial Water Committee.

2. Beneficiary Groups

Community Dialogue

A *community dialogue is a gathering of people to ventilate* an issue or to resolve a concern. All sides of the issue or concern at hand will be brought to light in order that this could eventually be better understood and/or resolved.

Community Assembly

A community assembly is the gathering of people called by a certain person or agency aimed to appraise the participants of a current situation or just to impart vital information to them. As an information dissemination activity, a variety of topics is discussed during the assembly. It does not necessarily mean that the community has to come up with solutions or answers to an issue/concern since none has formally been brought up yet.

3. General Public

Information Dissemination

Communicating with the general public is the best way of getting the water supply and sanitation project's features known. However, communicating with a large public needs a formal information dissemination program.

An information dissemination program utilizes all available means/ways of communication; such as the print and electronic (radio and TV) media. But for a community where these media may not be present, the best way is still the personal, one-on-one approach.

Through an information dissemination program, not only can issues and concerns be aired and clarified; but feedback made known so that approriate action be taken.

The initial phase of community-based water supply and sanitation project is thus designed to get the full commitment and win total support of the partner agencies, LGU's, other water agencies and community beneficiaries. This will guarantee not only the maximum participation from the involved project actors but will also motivate other project implementors to adopt the same strategies to attain successful delivery of services.

# CHAPTER II - COMMUNITY STUDY

The lasting success of a community water supply and sanitation project can come from the degree of its preparation from both social and technical considerations. It is basic and essential to start focusing on first hand comprehensive information about the community. The result will be a community study write-up which is a scientific collation and synthesis of the data gathered, giving one a clearer picture of the community.

Social investigation, which is knowing the various structures and forces in the community, is conducted side by side with site investigation. It gives more emphasis on the basic technical data necessary to come up with a preliminary assessment of the project.

Finally, the community study will help the technical staff and representative of line agencies identify the project that will be socially, economically and technically feasible for implementation in the community.

## A. Social Preparation

### 1. <u>Social Investigation</u>

#### a. Concept of Social Investigation

Social Investigation (SI) is the process of systematically learning and analyzing the various structures and forces in the community, economic, political, socio-cultural and technical. It results into a community study which is both a phase of a long process and a process in itself. As a phase of community study, organizing it comes at the beginning; but as a process, it is a continuing activity with definite periods of minimum and maximum expectations. This means that the Community Development Worker (CDW) and the community leaders do not only wait for every available information to come in before proceeding with the organizing work. It is during all project phases that a full, accurate and well coordinated data on the various aspects and structures of the community for a water supply and sanitation project is attended.

#### b. Importance of Social Investigation

- It provides data on the geographic, economic, political and socio-cultural situation of the community in order to identify and understand the problems and issues that need immediate and long term solutions. Major emphasis is given on the community's problems/needs related to water supply and sanitation;

- Classes and sectors present in the community are identified; while that the interests and attitudes of the people towards their identified problems and issues are known; -It helps determine the correct approach and method of organizing;

- It provides a basis for planning and programming of organizing activities/mobilizing the people for water supply and sanitation projects;

c. Components of Social Investigation

Social investigation involves a preliminary and in-depth study of the community. The preliminary community study is concerned with the physical characteristics of the area such as the size of the community, location, climatic condition as well as the demographic characteristic such as population age, sex composition and occupational groupings.

The in-depth community study explores deeper on the different economic, political and social structures and their various interrelationships. The major data to be gathered include the following:

- Geographic and demographic data: physical description, area, population and population characteristics such as religion, civil status, educational attainment;

- Economic status: occupation, average income, average family income other sources of income, existing resources, household possessions;

- Health and sanitation: type and number of existing and potential source of water, type and number of toilets, common illnesses or diseases, mortality and morbidity rate, drainage system, garbage disposal systems. Emphasis is given to the additional information which is essential to the water supply and sanitation project implementation. These are sanitation problems; community priorities and goals for water and sanitation improvement; community willingness and capability to participate in the project; priorities and goals of the water agencies assisting the community and its willingness and capability to provide assistance; comparison of current water supply with community water needs. This information can be related to water use patterns of the people; atittude of the people towards health education, preferences for water supplies, beliefs and taboos on sanitation and drinking water and water sources;

- Political system/decision-making structure: existing organizations, decision-making systems, responses and attitudes of people towards structures, people's perception of leadership;.

- Socio-cultural system: community problems and issues cultural media and institutions present in the community, values and beliefs they propagate, agencies/organization existing in the community and its objectives/projects and services.( Please refer to Appendix __A__)

d. Strategies/Activities in Social Investigation

Integration facilitates social investigation and vice versa. It is establishing rapport with the people in a continuing effort to imbibe community life by visiting them in their respective houses, undergoing the same experiences, sharing their hopes, aspirations and hardships towards building mutual trust and cooperation. It is apparently expected that ordinary people cannot be expected to open up with their problems and opinions to a complete stranger. And it is only the people who can supply the most revealing picture of themselves and their community through the information they will express or share.

Good integration leads to better data and better data serves as basis for deeper integration.

d.1 Primary Strategy of Gathering Data

Interviews which may be conducted through:

- Courtesy call to the Governors, Agency Heads, Mayors, Barangay Captains & traditional leaders.
- Ocular Survey or House to house visits
- Informal/social gatherings
- "Fact-finding meetings" - It may be inviting a representative sample from all sectors/classes or representative sample from a particular class. It is important that the people to be invited should have broad knowledge/experience.
- Participate in production activities

Observation:

- Pure observation

- Participant observation - by participating in the activities of the people, the observer feels and experiences the events in the community thus adding to his deeper comprehension of the situation.

d.2 Secondary Strategy of Gathering Data

- Examination/Review of Secondary Data - This method assumes that much of the initial information needed are already available.

2. Selection of Leaders

a. Concept of Selection of Leaders

Potential leaders are identified at the initial phase of the organizing process. Simultaneous to integration and social investigation, conscious efforts are already made to identify potential indigenous leaders in the community. These potential leaders are seen as capable of assisting the Community Development Worker/organizer in providing or validating data about the community and eventually assist in the organizing activities. It has been a common experience as well with the community leaders, that they normally are capable of providing encouragement and guidance to the community residents to participate in water supply and sanitation projects with its hygiene education component.

The Community Development Worker/Organizer continuously assists the identified potential leaders; formal and informal leaders, to develop potentials and capabilities to work for change through their gradual involvement in the different community activities.

b. Importance of Selection of Leaders

Community Organizing is an enabling process that revolves around the leaders of the community. The selection of leaders is an opportunity for potential indigenous leaders to build or strengthen their self-confidence and capabilities in initiating and leading community activities specifically starting with a water supply and sanitation project.

Exchanges of knowledge and insights among the community residents during the early part of the organizing process become deeper and meaningful especially if facilitated by the community leaders themselves. It brings about a deeper understanding of the dynamics of the community.

The Community Development Worker (CDW) is then able to delegate to the indigenous leaders certain responsibilities. They can already help facilitate in the laying out of plans and tasks for the formation and maintenance of a water committee or a community-wide organization with functioning officers and members to ensure democratic collective and shared leadership. In this manner, the process prepares the leaders to take on the role of the Community Development Worker/Organizer upon phase-out.

c. Strategies/Activities of Selection of Leaders

- Groundwork - Directly asking the people-primarily the barangay captain and officials or traditional leaders to identify people in the community using the following criteria:

  * Well-respected by the members of the community and are relatively interested in working on water supply and sanitation

projects;

* desirous of change and are willing to work for change;
* can find time, conscientious and resourceful in working with people;
* must be able to communicate effectively (i.e., listens to community members while at the same time must be able to articulate their problems and needs)

- Observation - getting to know better the identified potential leaders. Finding out who among the identified leaders have the qualities that meet the criteria by keeping close watch on the behaviour of the person under the normal circumstances.

- Home visits - a one-to-one discussions aimed to know the leaders' family background, personality characteristics as influenced by his socio-economic status and related experiences. Assessing the leaders political orientation and potentials for leadership in managing water supply and sanitation project.

- Review of program reports and other documents-getting additional information on the leaders' involvement/participation with the agency/office and with other workers.

- Community Assembly - A gathering of community residents who have realized the possibility of identifying solutions to their problems in water supply and sanitation. In doing so, they themselves are able to choose if who among them will lead the collective efforts to be undertaken. The array of leaders are then selected by majority of the community members.

Social investigation and selection of leaders contribute to a foundation in preparation for the water supply and sanitation project. It is generally known that in the process of developing a good and effective water supply and sanitation system, it involves various factors. These factors are efficiently managed when the data gathered during social investigation are essentially exact and thorough. It will definitely help the selected leaders do their task and successfully achieve the expected outcome together with the community residents/water subscribers.

## B. PREPARATION OF PRELIMINARY TECHNICAL DESIGN

The first step prior to any activity of the project is an ocular or preliminary survey. In this step, projects that are technically, economically and socially feasible are identified for implementation. The project cost must be commensurate with the expected output or objective set for the project.

Before a field staff goes to the community for a study, they must know the basic technical information that would be gathered in order to come-up with a preliminary assessment of the project. This will provide the project necessary information from which the government and the funding group can decide whether or not to proceed with the final and detailed engineering design. In order to carry out all of these , the staff must be equipped and capable to undertake the study otherwise, they will need basic training on Technical Design of Potable Water Systems.

### 1. Potable Water Systems

#### a. Selection of Water Source

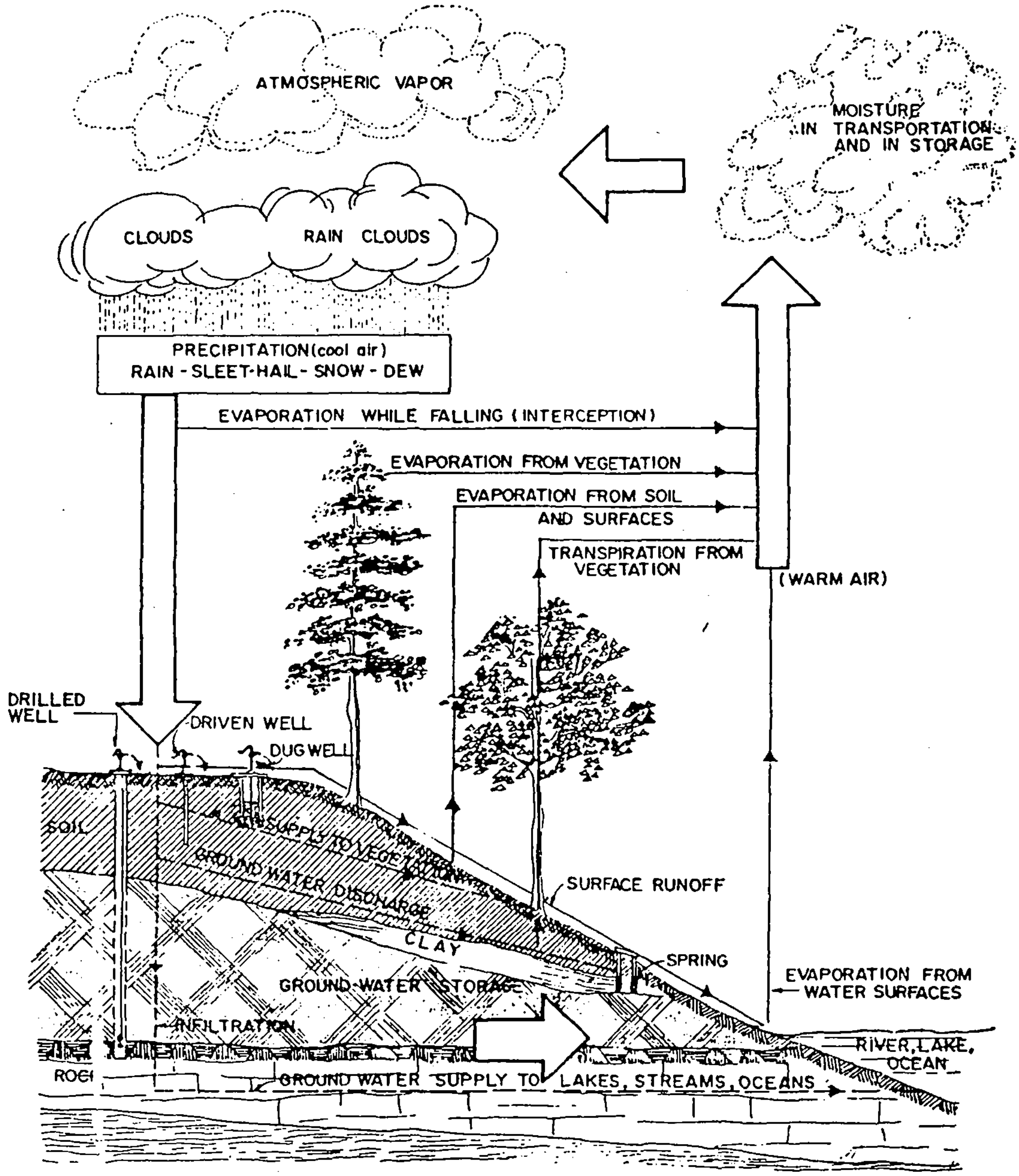
##### a.1 Hydrologic Cycle

About 97.5% of all the reserves of water in the world is saltwater. Of the 2.5% fresh water, about 70% is polar ice caps while 30 % is groundwater.

Water falls on earth as rain or snow only to reunite within the one great ocean encircling the globe. This continuous natural recycling of water forming a closed system where water is neither lost nor gained is called Hydrologic Cycle. The sun and gravity are the sources of energy that sets the cycle in motion.

The sun's heat warms the ocean and land causing the water to evaporate in the air. Plants also transpire water through its pores. The invisible water in the air condenses into visible clouds, fog, or dew. Clouds drift by wind around the globe. At colder atmosphere, the clouds precipitate in the form of rain, hail, snow or sleet and returns to earth. Of all rainfall, about 20 % fall on land and 80 % fall over the sea. Part of the falling water infiltrates and sinks into the soil to recharge the groundwater or aquifer. In areas where the absorbing capacity of the ground is less, especially in denuded or areas with less vegetation, surplus water just flows over the land and streams as surface runoff and flows back to the seas or oceans. Below the ground, the water that seeps by gravity moves slowly towards the sea. Both surface and groundwater unite into a bigger body of water. This cycle is illustrated in Fig. 2-01.

The cycle does not always progress through a regular sequence, steps may be omitted or repeated at any point.




OF THE TOTAL PRECIPITATION ABOUT ONE-THIRD RUNS OFF TO STREAMS, LAKES, AND OCEANS; ONE-THIRD PERCOLATES INTO THE GROUND TO FORM THE UNDERGROUND WATER SUPPLY; AND ONE-THIRD RETURNS TO THE ATMOSPHERE ALMOST IMMEDIATELY BY EVAPORATION AND TRANSPIRATION.

FIGURE 2.01

THE HYDROLOGIC OR WATER CYCLE

a.2 Classification of Water Source based on Relative Location on Earth's Surface

a.2.1 Rain or Atmospheric Water - as the heavy clouds condense, it precipitates as rain which can be used as a source of water supply.

a.2.2 Surface Water - these are surface runoff and form bodies of water like ponds, lakes, creeks, streams, rivers. Since the quality of surface water needs high cost of treatment, it is not recommended to use this as a source of potable water supply for rural communities.

a.2.3 Groundwater - is the part of the atmospheric water or rain that percolates through the ground and recharges the aquifers or water bearing formations. It may be extracted through the following:

1. Springs - occur when water in water- bearing strata, reaches the surface ground appearing as small water holes or wet spots. There are two categories of springs: gravity and artesian. Gravity can be further classified as:

   Depression Springs - formed when the land surface drips and makes contact with the water table in permeable material. Amount of water fluctuates seasonally and may dry up. Because of this, it is not a good source of community water supply. This is also known as seasonal springs.

   Fracture and Tubular Springs - formed when water comes from the ground through fractures or joints in rocks. This is a good source for community supply.

   Artesian springs occur when water is trapped between impervious layers and is under pressure. These can be further classified into:

   Artesian Fissure Springs - result from water under pressure -reaching the ground through a fissure or joint.

   Artesian Flow Springs - occur when confined water flows underground and emerges at a lower elevation. This type of spring occurs on hillsides and will offers an excellent supply of water. This type of springs are also known as perennial springs

2. Wells - are holes that pierces an aquifer, so that water maybe withdrawn by pumping. These may be classified according to method of construction: dug, bored, driven, jetted or drilled.

3. Infiltration Galleries - are horizontal wells, constructed by digging a trench into water bearing sand, installing perforated pipes. Water is withdrawn by pumping.

a.3 Classification of Water Source based on Level of Services

1. Level I (Point Source) - A protected dug or drilled well, a rainwater tank, or a developed spring with outlets but without a distribution system. Water can be conveyed from the source to the reservoir provided with outlets. This facility can serve about 15 to 25 households and its outreach must not be more than 250 meters from the farthest user.

2. Level II (Communal faucet System or Standpost) - A system composed of a source, transmission pipe, reservoir, piped distribution network and communal faucets located not more than 25 meters from the farthest house. The system must deliver about 40 to 60 liters per capita per day to an average of 100 households, with one faucet per 5 to 10 households. This system is generally suitable for areas where houses are clustered densely to justify a simple piped system.

3. Level III (Waterworks System or Individual House Connection) - A system with a source, transmission pipes a reservoir, a piped distribution network and household taps. It is generally suited for densely populated areas.

a.4 Guidelines in the Selection of Appropriate Water Source

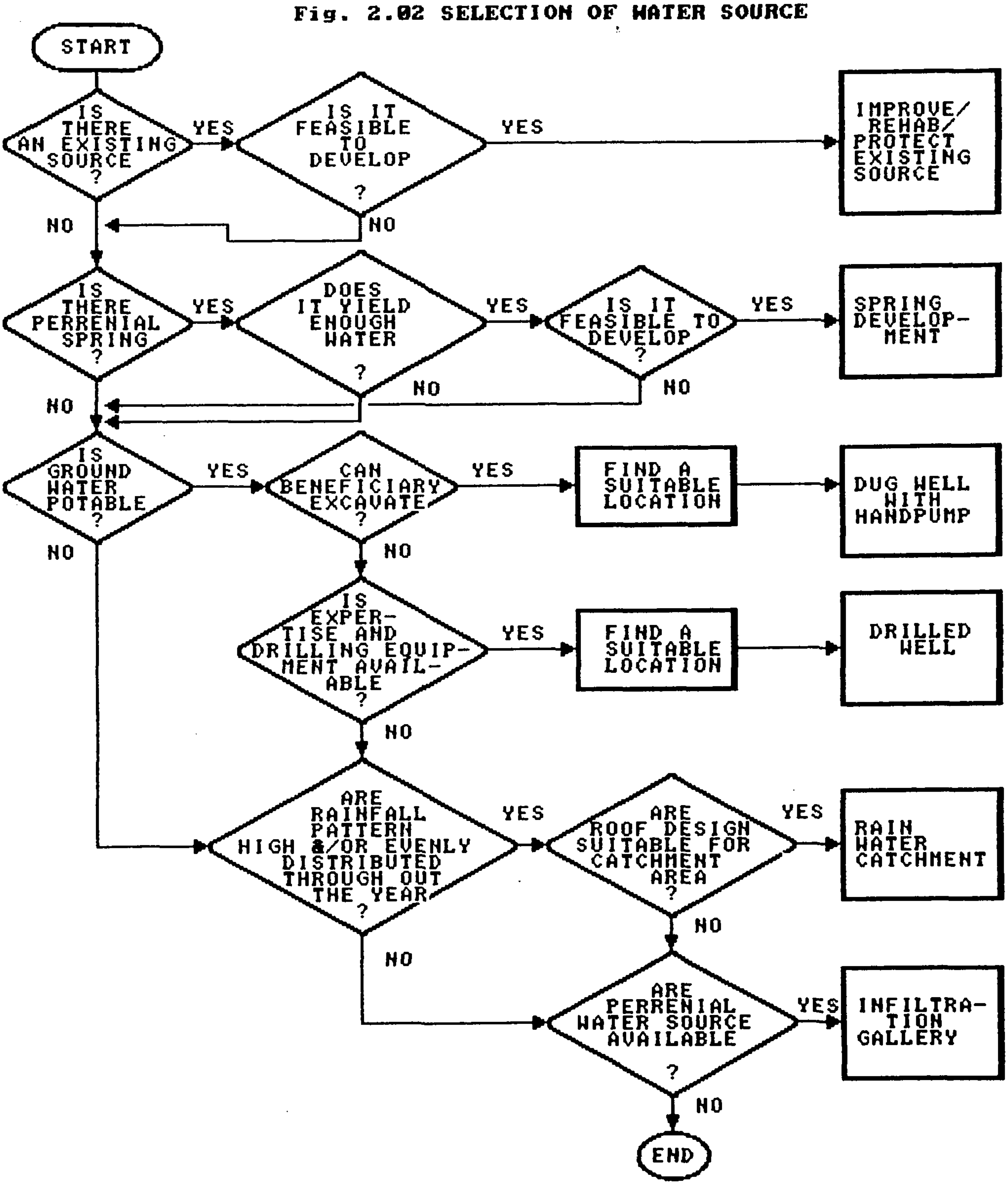
During the preliminary investigation, a decision has to be made on what type of technology will be adopted or recommended for a specific community. This is especially true when there is already an existing water source or more than one alternative source.

The steps in the selection of a water source are presented in Figure 2-02.

The first involves locating, determining and identifying potable water sources within (open dug well, shallow or deepwell, mountain spring) or outside (spring source several kilometers from the community or source next barangay or town) the target service area.

The second major question would be in establishing the feasibility of developing the water source. A thorough feasibility study is not needed. So long as the water is potable (quality), the source can meet the required volume (quantity), and its economically feasible to develop, any new or chabilitated system can be considered.

Fig. 2.02 SELECTION OF WATER SOURCE



Water quality - before the development of any water resources, the quality of water it yields must be examined to determine potability for drinking purposes. The Philippine Standard for Drinking Water sets the minimum limit of standards for the physical chemical and bacteriological characteristics of water.

The most simple test in determining water quality is to find out if the inhabitants who have been using the water for so long, like the water. Decisions about drinking water are often based on sensory perception, color, taste or smell rather than technical purity.

Water Quality - Domestic water must be available in adequate quantity to satisfy minimal requirements form drinking, cooking, and food preparations as well as sanitation requirements. Listed below are the daily requirements per person.

| Daily Consumption (1pcd)[1] | Uses |
|---|---|
| 8-10 | minimum estimated request for drinking, cooking, food preparation |
| 12-20 | bathing, personal hygiene, washing utensils |
| 25-40 | minimum requirement for basic sanitation and usual daily use |
| 40-60 | average requirement for rural communities |
| 60-100 | backyard gardening, animal project |

Average of 20-40 li/cap/day which is good enough for improved health condition can be adopted as minor requirement.

Where an adequate supply of potable water is considered for development, cost of installation and consequently, its operation and maintenance must be looked into. Per capita cost of water systems might vary according to site, characteristics and distance of the water source and king of technology used. But this must be within the range as set in the following tables.

TABLE 2-01

| Project Type | Allowable no. of Users Person | Household | Allowable Cost Per Capita (P)[2] |
| --- | --- | --- | --- |
| a. Handpump | | | |
| 1) deepwell | 60 | 10 | 150 - 200 |
| 2) shallow well | 60 | 10 | 100 - 150 |
| b. Spring Dev't | | | |
| 1) level I | 400 | 80 | 100 - 200 |
| 2) level I (per faucet) | 60 | 10 | 250 - 300 |
| c. Rainwater Catchment[3] | | | |
| 1) family type | 6 | 1 | 0.70 - 1.00 |
| 2) community type | 60 | 10 | 1.00 - 1.50 |

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1 lpcd - liter per capita per day
2 21 pesos is to 1 dollar
3 Construction Cost per liter of stored water (P/li.)

b. Design of Water Source

b.1 WELLS

Wells are holes dug or pipe sunk into the earth to a depth below the water table or water-bearing strata. Water can be withdrawn using the bucket attached to a rope , chain on pole or can be improved with the use of a pump.

Selecting the proper type of well and the method of construction of well requires important consideration to ensure that the well will tap into reliable source of good quality of water, that the well will not be contaminated in the future and that the well will be able to supply the required demand of the beneficiaries.

In the preliminary investigation or occular survey of the proposed well project, the first requirement for the engineer or the planner to investigate is if there is/are existing well(s) in the community either currently operational or already not functioning.

b.1.1 Existing wells are the best indication of the presence of ground water. The history of the existing well(s) will provide adequate information regarding the type and method of construction to be done later. These information are as follows:

Depth of the water table - the depth of the water level or table or static water level will indicate what type of well should be constructed (shallow or deepwell).

Depth of the well - it will also indicate what type of well should be constructed. The new well should be if possibly deeper than the existing one.

Casing diameter - it will indicate what method of construction such as dug well, driven well, bored well and drilled well.

Ground/soil Formation - indicate the type and method of construction.

COST- for funding requirements.

After determining the proper type of well and method of construction for a certain community the next step the engineer or the planner should do is to make a rough estimate of the project. The cost of constructing a well depends on the above information. Furthermore, the cost also depends on the locality of the proposed project site, peace and order situation and accessibility. The cost is also variable from province to province. For example, the cost for drilling a well in the province of Bulacan is much lower compared to the cost for Cebu province.

The last step in making a rough estimate of the project is the preparation of the bill of materials. The planner or the engineer should also take into consideration the counterpart share of the beneficiaries.

b.1.2 In areas where there are no existing well, the presence of ground water can be indicated by surface water, topography and ground surface and certain vegetation.

SURFACE WATER - the presence of a river is an example where ground water is available. The depth and bed formation of the river will indicate what type of well should be constructed.

TOPOGRAPHY AND GROUND SURFACE - ground water gathers in low areas. The lowest ground elevation is generally the best place to construct a well. The condition of the ground surface will give the planner or engineer an idea of what method of construction should be used.

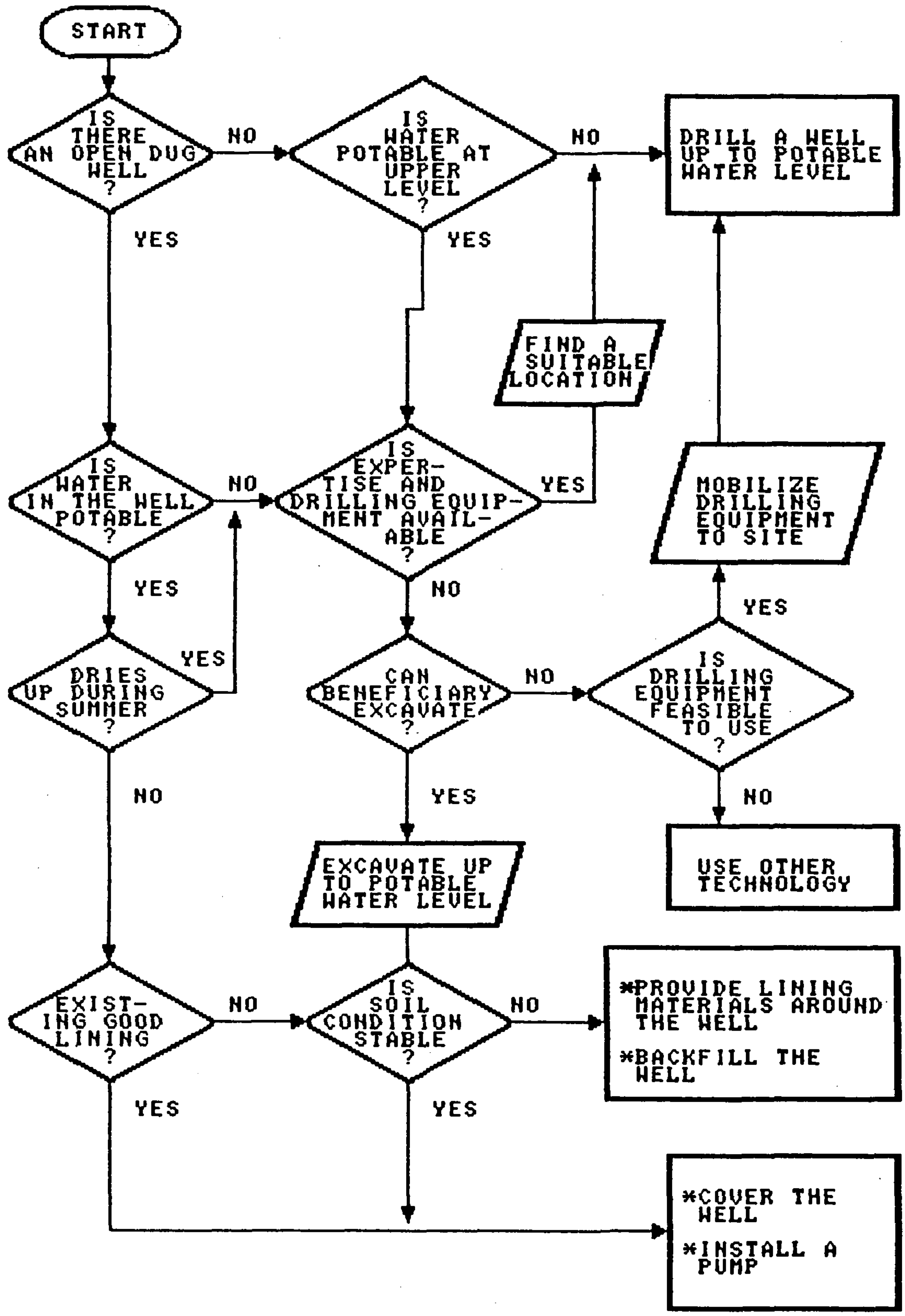
VEGETATION - certain types of vegetation can indicate that groundwater lies near the surface. The most useful indicator of ground water are perennial plants (those that are present the whole year round) especially trees and shrubs. The best time to survey vegetation is during dry season.

b.1.3 Criteria for Selection of Well Site

- Well shall be located higher and within 20 meters from any source of contamination: toilet, cemeteries, canals, sewers, garbage dumps;
- Well shall not be located in a ravine or depression where it will be subjected to flooding;
- Site should be accessible to the public;
- Well should be centrally located;
- It should have at least 10 household users per pump and;
- Agreement/donation of the lot where the well shall be installed must be secured.

b.1.4 Guidelines for Selection of Wells Type
(Please refer to Fig. 2.03)

Fig. 2.03 SELECTION OF WELL TYPE



b.2 Spring Development Project

Spring are usually mountain springs that occur on the earths's surface as wet spots with flowing water. This water source has several components.

- Intake box - usually a concrete structure constructed at the eye of the spring for the purpose of protecting water from any contamination and to direct all spring flow into an outlet. It is provided with appurtenances such as air vent, overflow pipe, covered marble, intake pipe, drain pipe, drain ditch and fence to protect the structure for an efficient operation.

- Transmission pipe- enclosed conduit usually made of galvanized iron (G.I.) or Polyvinyl Chloride (PVC) that conveys the water from the intake box to a storage facility commonly known as reservoir.

- Reservoir - usually a cylindrical or cubical water tank made of concrete, galvanized iron or steel that stores water during low hour demand. It can be elevated to a certain height to demand gravity or on a ground level at higher elevation than the service area. It is provided by inlet line, outlet line, drainpipe, overflow pipe, covered manhole, water level indicator and control valves for a smooth operation.

- Distribution pipes - connect the reservoir to the service area. Along the pipe are installed 1 public standposts. This line can be G.I. or PVC or any other material suitable in the area.

- Public standposts - are common faucets installed along the sides of the road for easy access by the public.

For water sources that are located below the service area, a pump is installed to lift water to the reservoir.

In the conduct of site investigation for spring development projects, it is important for the engineer/implementor to make an ocular inspection prior to line and profile survey of the area that will be covered by the proposed spring development.

During the ocular inspection the engineer must note the geographic location, topography, approximate elevation and distance of the spring with respect to the service area, shortest feasible route of transmission line, river crossing, sledge crossing, condition of existing water supply if any and its causes of breakdown if no longer operational. If a map of the area is not available a freehand sketch indicating the location of water sources, clustering of houses, bridges and other important landworks in the area should be prepared.

b.2.1 Methods of Measuring Spring Discharge

Spring yield or spring discharge can be determined by either the volumetric method or weir method.

Volumetric Method - Flows can be determined by volume measurement. The equipments necessary are watch or timer and a bucket or any container of known volume. The method consists of noting down the time required to fill the container. For more accurate results, several trial measurements should be done, and the average of these trials is taken.

V-Notch Weir Method - A weir is an overflow structure built across an open channel for the purpose of measuring the rate of flow of water. Weirs may be rectangular, trapezoidal or triangular in shape. The Triangular or V- Notch Weir is a flow measuring device particularly suited for small flows. The V- Notch Weir usually used in flow measurements is the 90 V-Notch shown in Figure 2-04. Discharge can be taken in liters per second or gallons per minute.

A 90 V-Notch Weir can be cut from a thin sheet of metal or plywood and is placed in the middle of the channel and water is allowed to flow over it. The water level in the channel is then measured using a gauging rod as shown in Figure 2-04. The zero point in the rod should be level with the bottom of the notch. For a known height of water above the zero point in the rod, the flow in liter per second can be obtained by using the formula;

$$Q = 4.4\ H^{2.48}$$

Where:

Q - Discharge rate, liters per second

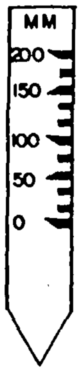
H - Height of water level on the weir, decimeters.

b.2.2 Consideration in Engineering Design

The design and lay-out of the water supply system involve the selection of water source(s), arrangement of storage tanks, pumping stations, if needed pipings and controls together in a system that best fits the condition of the area under consideration.

Selection of Water Sources:

Select a source which is closer to the user to minimize transmission piping cost. The source selected must be feasible to develop. This means its quality is acceptable for drinking purposes, it has enough yield to supply the average daily demand of the benefeciaries at least 20 li/person/day and it must be a perrenial source.

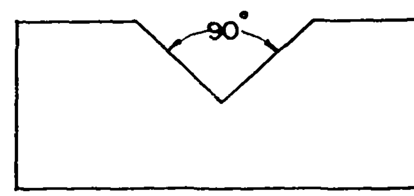



GAUGING ROD

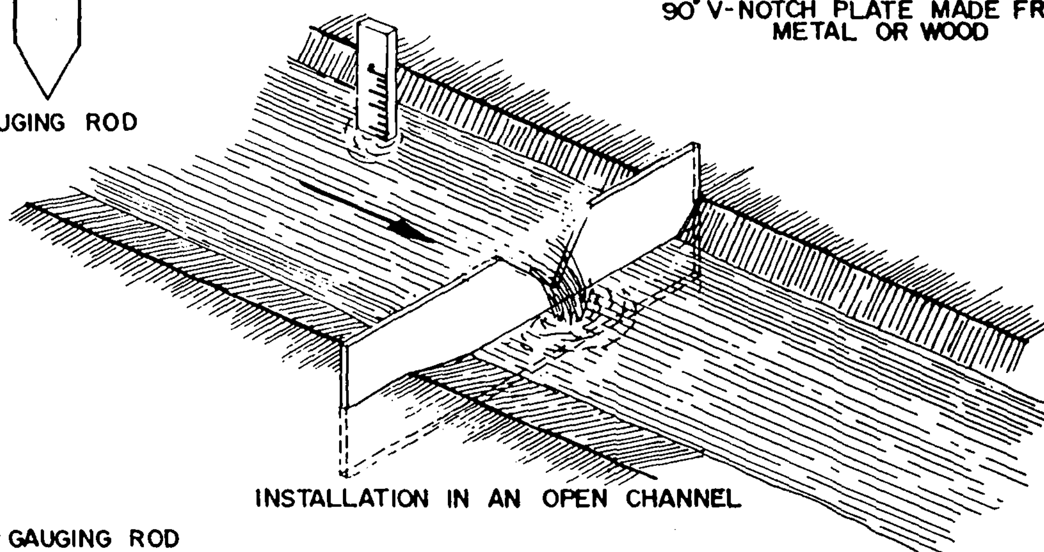
$Q = 4.4\,H^{2.48}$

Q = LPS

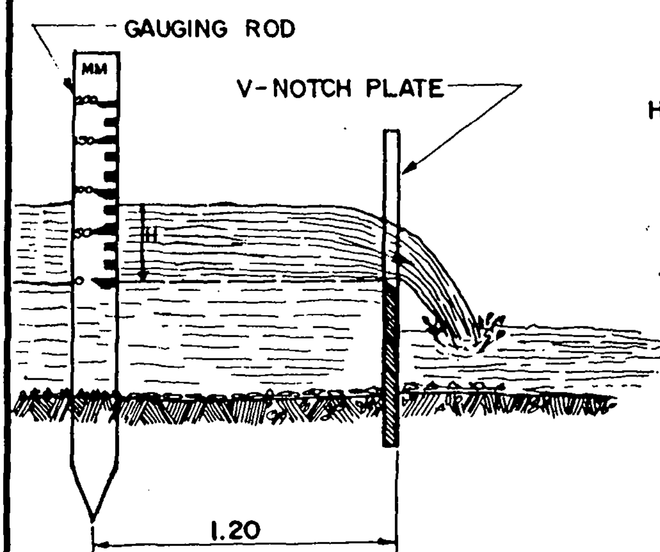
H = in DECIMETERS




90° V-NOTCH PLATE MADE FROM METAL OR WOOD



INSTALLATION IN AN OPEN CHANNEL




CROSS SECTION
USING A 90° V-NOTCH TO MEASURE FLOW

FROM: SMALL WATER SUPPLIES, THE ROSS INSTITUTE.

TABLE A
FLOW OVER A 90° V-NOTCH

| HEIGHT OF WATER H (mm) | FLOW (LITERS/SEC.) |
|---|---|
| 50 | 0.8 |
| 60 | 1.2 |
| 70 | 1.8 |
| 80 | 2.5 |
| 90 | 3.4 |
| 100 | 4.4 |
| 110 | 5.6 |
| 120 | 7.0 |
| 130 | 8.4 |
| 140 | 10.1 |
| 150 | 12.0 |
| 160 | 14.1 |
| 170 | 16.4 |
| 180 | 18.9 |
| 190 | 21.6 |
| 200 | 24.5 |

FIGURE 2-04

**METHOD OF MEASURING FLOW USING A V-NOTCH WEIR**

Solution:

a) Calculate the total volume of water collected, V

V = Volume of oil drum used
= 200 liters

b) Calculate the yield of well, Y

Y = Volume of water collected per unit time
= 200/2 = 100 liters per minute
= 1.67 LPS

2) *V-Notch Weir Method* — A weir is an overflow structure built across an open channel for the purpose of measuring the rate of flow of water. Weirs may be rectangular, trapezoidal or triangular in shape. The Triangular or V-Notch Wier is a flow measuring device particularly suited for small flows. The V-Notch Weir usually used in flow measurements is the 90° V-Notch shown in Figure 10.2.

A 90° V-Notch Weir can be cut from a thin sheet of metal or plywood and is placed in the middle of the channel and water is allowed to flow over it. The water level in the channel is then measured using a gauging rod as shown in Figure 10.2. The zero point in the rod should be level with the bottom of the notch. For a known height of water above the zero point in the rod, the flow in LPS can be obtained by using Figure 10.2 Table A or using the formula;

$$Q = 4.4\ H^{2.48}$$

Where:

Q = Discharge rate, liters per second
H = Height of water level on the weir, decimeters.

Example 10.2: Water from the spring is discharged into an open channel and is metered using the V-Notch Weir Method.

Data:
Height of water on the weir measured using the gauging rod = 100 mm

Required:
Water yield of spring.

Solution:

a) Calculate the yield of spring using Figure 10.2 Table A.

Locate under the column "Height of Water" the value H = 100 mm and draw a horizontal line to intersect in the column "Flow". The reading in column "Flow" is,

Q = 4.4 LPS

In cases where two or more spring sources are necessary to meet the future demand, develop first the water source which would satisfy the present demand only. However, provision for connecting the additional source(s) which will meet the future demand has to be made.

Plan Lay-out

Map of the area or a scaled lay-out showing the location of water source(s), clustering of houses, rivers, bridges, regularity of terrain, obstacles, etc. in the area is needed in the lay-out of transmission line, position of storage tank, arrangement and distribution of public taps and location of control valves.

Basic Design Data and Design Criteria

A fundamental understanding of hydraulics is necessary to design a pressure pipeline. Water should be sufficiently flowing along the system to supply the basic needs of the community. Head loss should be sufficient to overcome pipe friction.

Definition of Terminology

- Population (P) - refers to the number of persons to be served by the proposed water system.

- Design Period (DP) - the number of years which the designer intends to design the system. The design period recommended for rural water supply system is 5 years.

- Annual Growth Rate (AGR) - The percent increases of population per annum. Statistics put it at 3% growth per annum.

- Design Population (DP) - projected population of the service area at the end of the design period.

- Water Demand/Water Consumption (WD) - amount of water consumed by all residents, institutions, etc. when provided with water service facilities. Approximate daily water needs of different consumers is in Table 2-02.

- Average Day Demand - the average day demand is the product of the daily consumption per capita multiplied by the design population.

- Maximum Day Demand - largest one day water demand. Normally this occurs during dry season generally on a Monday. A demand factor of 1.3 is applied to the Average Day Demand to get the figure.

| NO. OF HOUSE-HOLDS | PRESENT POPULATION | DESIGN POPULATION | FLOW RATE, (Q) LPS | WATER MAIN(mm) | | RESERVOIR SIZES (LITERS) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | PLASTIC | GI | PF* | HH* | PF** | HH** |
| 10 | 60 | 69 | 0.14 | 25 | 25 | 2070 | 3450 | 880 | 1470 |
| 20 | 120 | 138 | 0.29 | 31 | 38 | 4140 | 6900 | 1760 | 2950 |
| 30 | 180 | 207 | 0.43 | 38 | 38 | 6210 | 10350 | 2640 | 4400 |
| 40 | 240 | 276 | 0.58 | 38 | 50 | 8280 | 13800 | 3520 | 5870 |
| 50 | 300 | 345 | 0.72 | 38 | 50 | 10350 | 17250 | 4400 | 7350 |
| 60 | 360 | 414 | 0.86 | 50 | 50 | 12420 | 20700 | 5280 | 8800 |
| 70 | 420 | 483 | 1.01 | 50 | 63 | 14490 | 24150 | 6160 | 10260 |
| 80 | 480 | 552 | 1.15 | 50 | 63 | 16560 | 27600 | 7040 | 11730 |
| 90. | 540 | 621 | 1.29 | 50 | 63 | 18630 | 31050 | 7920 | 11730 |
| 100 | 600 | 690 | 1.44 | 63 | 63 | 20700 | 34500 | 7920 | 11730 |
| 125 | 750 | 863 | 1.80 | 63 | 75 | 25890 | 43150 | 7920 | 13000 |
| 150 | 900 | 1035 | 2.16 | 63 | 75 | 31050 | 51750 | 9300 | 15500 |
| 200 | 1200 | 1380 | 2.87 | 75 | 100 | 41400 | 69000 | 12420 | 20700 |
| 250 | 1500 | 1725 | 3.59 | 75 | 100 | 51750 | 86250 | 15525 | 25900 |
| 300 | 1800 | 2070 | 4.31 | 75 | 100 | 62100 | 103500 | 18630 | 31000 |
| 400 | 2400 | 2760 | 5.75 | 100 | 100 | 82800 | 138000 | 28840 | 41400 |
| 500 | 3000 | 3450 | 7.19 | 100 | 150 | 103500 | 172500 | 31050 | 51800 |
| 600 | 3600 | 4140 | 8.62 | 100 | 150 | 124200 | 207000 | 37260 | 62100 |
| 800 | 4800 | 5520 | 11.50 | 150 | 200 | 165600 | 276000 | 49680 | 82800 |

* BASED ON 1/2 AVERAGE DAY DEMAND

** RESERVOIR IS USED ONLY TO SUPPLY WATER IN EXCESS OF THE MAXIMUM DAY DEMAND [(MAX. HOUR DEMAND – MAX. DAY DEMAND) X 3 HRS. OF PEAK DEMAND]

BASIS : AVERAGE DAY DEMAND RATE

PF = 60 LPCD

HH = 100 LPCD

DESIGN PERIOD = 5 YRS (MULTIPLIER 1.15)

NO. OF PERSONS PER HH = 6

PIPE DESIGN IS BASED ON MAX. HOUR DEMAND

Table 2-02

WATER SYSTEM TABLE

- Maximum Hour (peak hour) Demand - an hour of a day when the water demand is at its maximum. In most places this occur early morning between 7 to 8.

- A demand factor of 2.5 is applied to the Average Day Demand to get this figure.

b.2.3 Guidelines in the selection of spring source

- Discharge of the spring during the dry season must meet the average daily requirement of the target community at about 40-60 li/p/day;

- Service area must be lower in elevation than the spring source with generally downward slope;

- Source must be 1.5-2.0 km. away from the service area;

- Spring must have continuous flow all year round.

b.2.4 Initial Design

Given:

Present Population = 500
Elev. of Spring Source = El 100.00
Elev. of Storage Tank = El 95.00
Elev. of Service Area = El 75.00
Actual Flow of Spring = 0.5 lps.
Distance from Source to reservoir = 500 m
Distance from reservoir to service area = 400

Assumption:

Annual growth rate = 3% per annum
Design Study period = 5 years
Per Capita Water Consumption = 60 li/cap/day

Required:

a) Design Water Requirement
b) Size of Reservoir to be built
c) Size of Transmission pipe
d) Size of Distribution pipe

Solution:

a) Design Water Requirement
Compute for Design Population after 5 years,
Dp = Present population(P) x (1 + AGR/100)5
= 500 x 1.035
= 580

Compute for Design Water Requirement

Ave. Daily Demand = Dp x WD
= 580 x 60 li/cap/day
= 34,800 li/day
(or 0.411 lps)

Max. Daily Demand = ADD x demand Factor
= 34,800 x 1.3
= 45,240 li/day
(or 0.535 lps)

Max. Hourly Demand = ADD x demand Factor
= 34,800 x 2.5
= 87,000 li/day
(or 1.03)

ADD < actual flow of spring .
∴ . source is OK

b) Size of Reservoir to be constructed

CR = ADD/4
= 8,695 li (2,300 gal.)

c) Size of Transmission line

The minimum pipe size can be obtained when the available head or pressure will equal to frictional losses when water is flowing at the desired Q = 1.03

Headloss
(HL) = (Elev. of Spring-Elev. of Reservoir)/Length of pipes x 100
= (100.00 - 9.5)/500 x 100
= 1.0

Referring to Table 2.03 locate Q = 1.03 and move horizontally until HL/100 = 1.0 is formed in or any value which is nearest to 1.0. Move vertically to find diameter of pipe. The nearest value is 1.28 that corresponds to 50 mm diameter G.I. pipe. Referring to Table 2.04, the value is nearest 0.64 that corresponds to 50 mm diameter PVC pipe. Therefore, use either G.I. or PVC pipe which ever is feasible to transmit water from spring to the reservoir.

d) Size of Distribution pipe

Following the same procedure above:

Headloss(HL) = (Elev. of Reservoir - Elev. of Service Area)/Length of pipe x 100
= (95 - 75)/400 x 100
= 5.0

| Q | PIPE SIZES (mm.) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| LPS | 13 | 19 | 25 | 31 | 38 | 50 | 63 | 75 | 100 | 150 |
| 0.01 | 0.20 | | | | | | | | | |
| 0.02 | 0.80 | | | | | | | | | |
| 0.03 | 1.60 | 0.22 | | | | | | | | |
| 0.04 | 2.80 | 0.38 | | | | | | | | |
| 0.05 | 4.20 | 0.60 | | | | | | | | |
| 0.06 | 6.00 | 0.82 | 0.20 | | | | | | | |
| 0.07 | 8.0 | 1.00 | 0.26 | | | | | | | |
| 0.08 | 10.00 | 1.30 | 0.34 | | | | | | | |
| 0.09 | 12.60 | 1.64 | 0.44 | 0.15 | | | | | | |
| 0.10 | 15.20 | 2.12 | 0.52 | 0.18 | | | | | | |
| 0.11 | 18.20 | 2.36 | 0.62 | 0.22 | | | | | | |
| 0.12 | 21.40 | 3.00 | 0.72 | 0.26 | | | | | | |
| 0.14 | | 4.00 | 0.96 | 0.34 | 0.13 | | | | | |
| 0.15 | | 4.20 | 1.10 | 0.36 | 0.15 | | | | | |
| 0.16 | | 5.00 | 1.24 | 0.44 | 0.16 | | | | | |
| 0.18 | | 6.20 | 1.54 | 0.54 | 0.202 | | | | | |
| 0.20 | | 7.60 | 1.88 | 0.64 | 0.262 | 0.70 | | | | |
| 0.25 | | 11.60 | 2.84 | 0.96 | 0.400 | 0.10 | | | | |
| 0.30 | | | 4.00 | 1.34 | 0.46 | 0.14 | | | | |
| 0.40 | | | 6.80 | 2.30 | 0.94 | 0.24 | | | | |
| 0.50 | | | 10.20 | 3.48 | 1.42 | 0.36 | 0.12 | | | |
| 0.60 | | | 14.40 | 4.80 | 2.00 | 0.50 | 0.17 | 0.70 | | |
| 0.70 | | | | 6.40 | 2.66 | 0.66 | 0.22 | 0.91 | | |
| 0.80 | | | | 8.20 | 3.40 | 0.84 | 0.28 | 0.117 | | |
| 1.00 | | | | 12.60 | 5.20 | 1.28 | 0.42 | 0.177 | | |
| 1.20 | | | | 17.60 | 7.20 | 1.78 | 0.60 | 0.248 | | |
| 1.40 | | | | | 8.80 | 2.40 | 0.80 | 0.330 | | |
| 1.50 | | | | | 9.80 | 2.70 | 0.88 | 0.374 | | |
| 1.60 | | | | | 11.00 | 3.04 | 1.02 | 0.422 | 0.104 | |
| 1.80 | | | | | 14.70 | 3.76 | 1.28 | 0.524 | 0.129 | |
| 2.00 | | | | | 16.80 | 4.60 | 1.54 | 0.640 | 0.157 | |
| 2.50 | | | | | | 7.00 | 2.40 | 0.96 | 0.238 | |
| 3.00 | | | | | | 9.90 | 3.30 | 1.36 | 0.332 | |
| 3.50 | | | | | | 13.90 | 4.38 | 1.80 | 0.442 | |
| 4.00 | | | | | | 18.40 | 6.00 | 2.30 | 0.368 | |
| 4.50 | | | | | | 23.70 | 7.20 | 2.86 | 0.706 | |
| 5.00 | | | | | | | 9.00 | 3.48 | 0.858 | 0.12 |
| 6.00 | | | | | | | 12.40 | 4.88 | 1.200 | 0.17 |
| 7.00 | | | | | | | 17.20 | 6.40 | 1.60 | 0.22 |
| 8.00 | | | | | | | | 8.30 | 2.40 | 0.28 |
| 10.00 | | | | | | | | 13.00 | 3.10 | 0.42 |

FRICTION HEAD LOSS IN METERS PER 100 METERS
GALVANIZED IRON PIPE (GIP)

TABLE 2.03

## FRICTION HEAD LOSS IN G.I. PIPES

| Q | PIPE SIZES (mm.) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| LPS | 13 | 19 | 25 | 31 | 38 | 50 | 63 | 75 | 100 | 150 |
| .01 | 0.1 | | | | | | | | | |
| .02 | 0.4 | | | | | | | | | |
| .03 | 0.8 | 0.11 | | | | | | | | |
| .04 | 1.4 | 0.19 | | | | | | | | |
| .05 | 2.1 | 0.30 | | | | | | | | |
| .06 | 3.0 | 0.41 | 0.10 | | | | | | | |
| .07 | 4.0 | 0.50 | 0.13 | | | | | | | |
| .08 | 5.0 | 0.65 | 0.17 | | | | | | | |
| .09 | 6.3 | 0.82 | 0.22 | | | | | | | |
| .10 | 7.6 | 1.06 | 0.26 | | | | | | | |
| .11 | 9.1 | 1.18 | 0.31 | 0.11 | | | | | | |
| .12 | 10.7 | 1.50 | 0.36 | 0.13 | | | | | | |
| .14 | | 2.00 | 0.48 | 0.17 | | | | | | |
| .15 | | 2.10 | 0.55 | 0.18 | | | | | | |
| .16 | | 2.50 | 0.62 | 0.22 | | | | | | |
| .18 | | 3.10 | 0.77 | 0.27 | 0.101 | | | | | |
| .20 | | 3.80 | 0.94 | 0.32 | 0.131 | | | | | |
| .25 | | 5.80 | 1.42 | 0.48 | 0.20 | | | | | |
| .30 | | | 2.00 | 0.67 | 0.23 | | | | | |
| .40 | | | 3.40 | 1.15 | 0.47 | 0.12 | | | | |
| .50 | | | 5.10 | 1.74 | 0.71 | 0.18 | | | | |
| .60 | | | 7.20 | 2.40 | 1.00 | 0.25 | | | | |
| .70 | | | | 3.20 | 1.33 | 0.33 | 0.11 | | | |
| .80 | | | | 4.10 | 1.70 | 0.42 | 0.14 | | | |
| 1.00 | | | | 6.30 | 2.60 | 0.64 | 0.21 | 0.089 | | |
| 1.20 | | | | 8.80 | 3.60 | 0.89 | 0.30 | 0.124 | | |
| 1.40 | | | | | 4.40 | 1.20 | 0.40 | 0.165 | | |
| 1.50 | | | | | 4.90 | 1.35 | 0.44 | 0.187 | | |
| 1.60 | | | | | 5.50 | 1.52 | 0.51 | 0.211 | | |
| 1.80 | | | | | 7.35 | 1.88 | 0.64 | 0.262 | | |
| 2.00 | | | | | 8.40 | 2.30 | 0.77 | 0.320 | 0.079 | |
| 2.50 | | | | | | 3.50 | 1.20 | 0.48 | 0.119 | |
| 3.00 | | | | | | 4.95 | 1.65 | 0.68 | 0.166 | |
| 3.50 | | | | | | 6.95 | 2.19 | 0.90 | 0.221 | |
| 4.00 | | | | | | 9.20 | 3.00 | 1.15 | 0.184 | |
| 4.50 | | | | | | 11.85 | 3.60 | 1.43 | 0.353 | |
| 5.00 | | | | | | | 4.50 | 1.74 | 0.429 | 0.06 |
| 6.00 | | | | | | | 6.20 | 2.44 | 0.60 | 0.09 |
| 7.00 | | | | | | | 8.60 | 3.20 | 0.80 | 0.11 |
| 8.00 | | | | | | | | 4.15 | 1.20 | 0.14 |
| 10.00 | | | | | | | | 6.50 | 1.55 | 0.21 |

FRICTION HEAD LOSS IN METERS PER 100 METERS
PLASTIC PIPE - PVC, PE, PB C = 150

TABLE 2.04

FRICTION HEAD LOSS IN PLASTIC PIPES

Referring to Table 2.03 at Q = 1.03 headloss nearest 5.0 is 5.28 which corresponds to G.I. pipe with diameter of 38 mm. While in Table 2.04 HL value of 5.0 is nearest 6.30 for a PVC pipe diameter of 31 mm.

This initial figure is necessary to evaluate the initial technical and financial feasibility of the project. Comparison of the actual flow of spring and the design water requirement will aid the planner in deciding whether source will be sufficient the whole year round for the need of the beneficiaries. The approximate length and diameter of pipes as well as the size of reservoir will give us an idea of the approximate cost of the project.

b.2.5 Cost

Based on the initial design computation, rough cost of a spring development project can now be prepared.

Given:

Transmission pipes
Length = 500 m
Diameter = 50 m
Material = G.I.
Distribution pipes
Length = 400
Diameter = 38
Material = G.I.
Reservoir Size = 8,700 li

Required
a) Approximate Total Project Cost
b) Cost per Capita

Solution
a) Approximate Total Project Cost
Population = 500
No. of Households = 500/6
= 83
No. of Public Faucet = 83/5
= 17 PF

TABLE 2.04

| ITEMS | Unit | Qty. | Unit Cost(P) | Amount(P) |
|---|---|---|---|---|
| A. Materials | | | | |
| 1.Spring Box | LS | 1 | 5,000 | 5,000 |
| 2.Transmission pipe | l.m. | 500 | 115.00 | 57,500 |
| 3.Ground Reservoir | li | 8,700 | 3.00 | 26,100 |
| 4.Distribution pipe | l.m. | 400 | 85 | 34,000 |
| 5.Public Faucet | set | 17 | 500.00 | 8,500 |
| 6.Pipe Fitting | LS | | | 4,550 |
| | | | | -------- |
| Total A | | | | 135,650 |
| B. Labor | | | | |
| 1.Hauling | LS | | 5,000 | 5,000 |
| 2.Excavation | l.m. | 900 | 25 | 22,500 |
| 3.Concreting(10%) | LS | | | 13,565 |
| | | | | -------- |
| Total B | | | | 41,065 |
| | | | | -------- |
| Total Construction Cost | | | | 176,715 |

These are rough costs (April 1989 prices) in which contingency and allowances are already included in the unit costs.

b) Cost Per Person

Total Construction Cost divide by No. of Beneficiary users
176,715/500 = P 353.43

Significance of Various Water Demand Figures:

- Average Day Demand - used in the design of reservoir capacity
- Maximum Day Demand - used in determining the minimum pump capacity
- Maximum Hour Demand - used in designing the diameter of transmission and distribution pipes.

Reservoir and Storage Tanks

In rural distribution systems, whether water is obtained by gravity or by pumping, the construction of distribution reservoirs is important for the following reasons:

- To balance the supply and demand in the system. In small distribution systems, such variations may be three times or more than the average hourly consumption.

- To maintain adequate and fairly uniform pressure through the distribution system

- To avoid the total interruption of the water service when repairing pipes between the source of supply and reservoir.

- When water is pumped directly to the reservoir, pumps can be much smaller than would be required otherwise.

In areas where lowest flow of spring exceeds the maximum hourly demand, the installation of reservoir is not necessary.

Design of Reservoirs

- Capacity - to a great extent depends upon the water demand. Also, provision should be made to cover the demand during normal breakdown or maintenance. For spring sources with natural flows the storage tank volume should be at least equal to one-fourth of daily water demand of the community.

- Site of Storage Tank - should be located in place above the service area to command gravity and allow natural flow without the use of any pumping equipment.

- Structural Design - the structural design of reservoirs must meet the standards set by the National Structural Code of the Philippines. The reservoirs must be structurally stable to withstand all loads such as hydrostatic pressure, earth pressure, wind loads, seismic loads and other dead or live loads.

Reservoir used in Spring Development

Ground water reservoir must be used where there is naturally elevated ground. And this is commonly true in the spring development project. Ground water reservoirs may be made of reinforced concrete pipe, fiber glass, steel of ferrocement.

Transmission and Distribution Pipes

Pipelines serve as the arm of a water supply system. Its primary function is to convey water from the source to the service area.

In spring development projects, pipelines could be classified mainly into transmission and distribution lines. Transmission lines transport the water from spring source to the reservoir and from the reservoir water is distributed to end users by the distribution pipes.

- Design of Pipelines

Using the sketch/map of the area, determine the location of public faucets such that a cluster of 5-10 households will be served equally.

Referring still to the map, prepare a schematic diagram of the transmission and distribution lines. indicating the source, reservoir and public faucets. Pipe junctions, public faucet connections, reservoir and source having each corresponding node number, arrange in such a way that the noding starts from the furthest faucet to the reservoir. Refer to Appendix B.

- Flow and Sizes of Pipes

The pipelines must be designed to handle the maximum hour demand of the area to be served maintaining the Minimum Pressure of 3.5m (Approximate 5 psi) at the remotest end of the system.

With the aid of *Form 001 (Pipeline Design)* calculate the flows in each pipe section and each corresponding pipe diameter. Table 2.03 and 2.04 can be used in determining the pipe diameter.

After determining the pipe sizes, find out if there are sizes with relatively short lengths. The diameter of the short length pipes can be changed to correspond to the nearest larger size. This will reduce the number of sizes of pipes and fittings required, simplifying the bill of materials, delivery and installation.

- Pipeline Material Selection

Having determined the flow and diameter of the pipelines, the next step is to select the kind of material which will be used in the water supply system. Factors in selecting pipeline materials are as follows:

e) Flow Characteristics - The friction head loss is dependent on the flow characteristic of pipe. Friction loss is a power and this may affect the operating cost of the systems if a pump is used.

b) Strength of Pipe - Select the pipe with working pressure and bursting pressure rating adequate to meet the operating condition of the system. In low pressure rural water supply systems, any standard water pipe can be used.

c) Durability - Select the type of pipe with good life expectancy under the operating conditions and in the soil conditions of the system. G.I. pipes has life expectancy of about 20 years while plastic pipes (PVC, PE, or PB) has 50 years.

d) Type of Soil - Select the type of pipe that is suited to the type of soil in the area under consideration. For instance acidic soil, usually near seashore, could easily corrode G.I. pipes and very rocky soil can damage plastic pipes unless properly bedded in sand or fine gravel.

e) Cost - Calculate the cost of pipes plus installation cost. Select the type of acceptable pipe which has the lowest investment cost. Polyvinyl Chloride (PVC) pipe has the advantage.

### b.3 Rainwater Catchment

Places where ground water and surface water are not available, but rain is uniformly distributed throughout the year, rainwater may be used as a source of water supply.

Rainwater harvesting is a means of collecting rainfall from a roof and channel it through a gutter into a storage tank for use by individual households. The amount of water available for use depends on three factors: the amount of annual rainfall, the size of catchment area and the capacity of storage tank.

Roofs are an obvious choice for a catchment surface as their elevation protects them from contamination and damage which are common to ground surface catchments. Tanks located close to homes highlight the convenience of this system.

Advantages of a rainwater collection system :

- The quality of water is high.
- The system is independent, and therefore suitable for scattered settlements.
- Local materials and craftmanship can be used in rainwater system construction.
- No energy cost are needed to run the systems. - Ease of maintenance by owner or user.
- Convenience and accessibility of water. - Valuable time is saved in collecting water.

Disadvantages of rainwater collection system:

- The high initial capital cost may prevent a family from buying a system.
- The water available is limited by rainfall and roof area. For long dry seasons, the required storage volume may be too high.
- Mineral free water has a flat taste while people may prefer the taste of mineral-rich water.
- Mineral free water may cause nutrition deficiencies in people who are already on mineral-deficient diets.

#### b.3.1 Components of a Roof Catchment System

Roof Catchment - available rainfall data for about 10 years must be secured. This can be obtained from any weather station with in the area. Availability of large roofs as catchment areas must be determined. Materials must be of G.I., cement or any other smooth-surfaced roofs with minimal seepage and less contamination of rain water.

Storage Tank - must be durable and can be easily maintained and low cost.

The Gutter System- Effective guttering is an important part of the rainwater roof catchment. Water must be efficiently conveyed from the roof to the tank to meet the homeowner's demands. A good gutter material should be light weight, water resistant and easy to join. To reduce the number of joints and thus the likelihood of leakages, a material which is available in long, straight sections is preferred. Examples of materials used for gutters include bamboo, wood and sheet metal.

Metal gutters are the most durable and require the least maintenance. However, they are the most expensive. Materials such as wood and bamboo are widely available and inexpensive, but they will deteriorate.

Regardless of the material selected, the gutter should be large enough to channel water from heavy rains without overflowing.

Downpipe must be installed - The downpipe channels the water from the gutter into a cistern for storage. The joint where the downpipe and gutter connect must be sealed. If metal gutters are used, a connection can be sealed with a chaulking compound. If bamboo is used, coal tar will prove the best material for sealing the connection.

Provision of By-pass Line for first Flush or Foul Flush. During periods of no rain, dust, bird droppings and dead plant matter will accumulate on the roof. These materials are washed off with the first rain and may contaminate the water in the tank. Contamination can be avoided by diverting the first 5 - 15 minutes of rain.

b.3.3 Considerations in Designing Rainwater Catchment

Before deciding to use roof catchment, determine :

- if each family has adequate resource available
- which is the most effective cistern type in terms of cost and size (family or community type )
- space must be available for the users to maintain, clean and disinfect the system periodically.

Roof catchment differ from other sources of potable water. Responsibility for the operation and maintenance rest with users than with whole community. Water quality will depend on the user cleaning the pipes and gutters and disinfecting stored water.

2. Design of Sanitation Facilities

Water supply is synonimous with sanitation. However, most of those who work to improve water supply tend to leave out sanitation which is an important component for the health in the community.

It is a universal knowledge that the health benefits of water and sanitation are often difficult to quantify. It is in this course that a chapter on sanitation is included in this operations manual.

Sanitation is not limited to excreta disposal but embraces even garbage and wastes water disposal. This chapter discusses further types of sanitary facilities based on level of services and other sanitation aspects.

a. Types of Sanitation Facilities based on Level of Services

1. Level I - Pit Latrines

Sanitary Pit Privy

This type of toilet facilities is usually seen in serveral areas and is made up of a pit, squatting plate, superstructure, and exhaust pipe and a pit. Contrary to the traditional pit latrine that smell badly, attract flies and is dangerous to use, this pit privy has ventilation of its own thereby avoiding the formation of foul-odor. (See Fig. 2.05)

Antipolo Type

This type of toilet has the same principles as that of the sanitary pit except its location. This toilet is situated in an elevated area and can be considered an indoor facility. (See Fig. 2.06)

VIP

A much sophisticated type of latrine called the ventilated improved pit latrine (VIP) has been developed. It has two distinct features that sets it way above its contemporaries. It is designed to be safe for user and is built to last for at least a year and it has a superstructure that is slightly away from the pit and a tall, vertical vent pipe with a fly screen that is fitted outside of the latrine superstructure.

Types of VIP Latrine

Single-pit VIP latrine design to last for at least two years and generally suitable for use in areas where soil is deep and pit size is unlimited.

Two important actions take place in the pit which reduce the rate at which it fills. The solid in the excreta are broken down into simple compound by biological digestion. Soluble produces of this process are carried into the soil by the liquid portion of the excreta and the gases produced are removed by the vent.

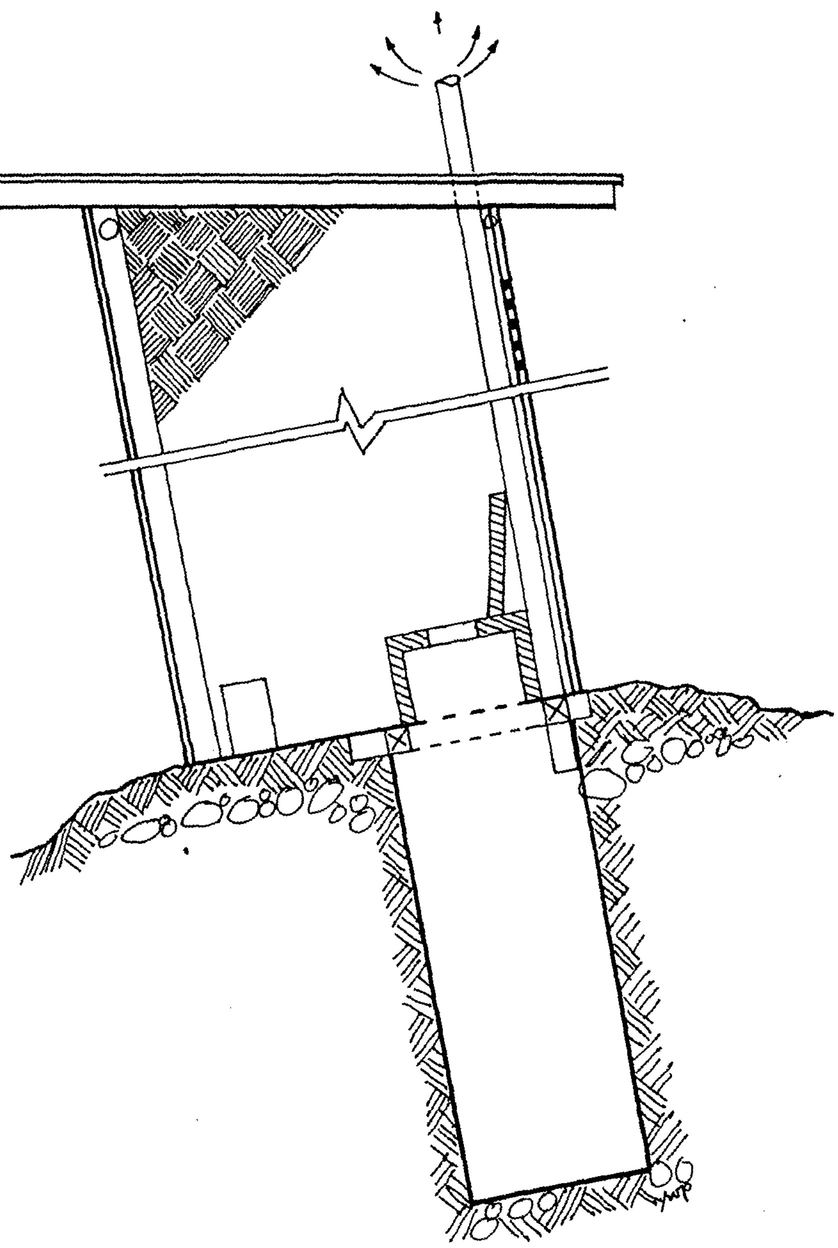


FIG. 2.05 SANITARY PIT PRIVY

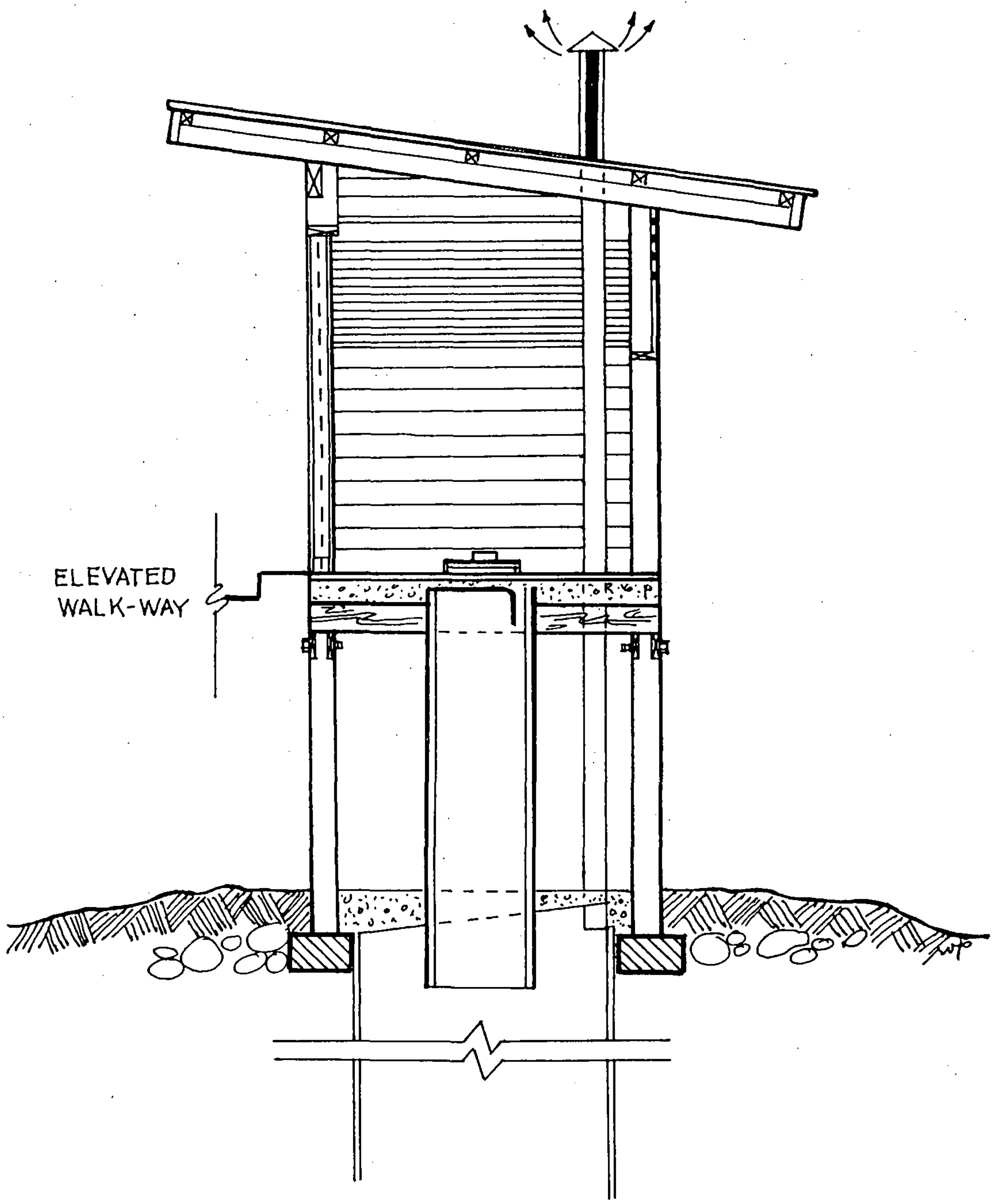



FIG. 2.06 ANTIPOLO SYSTEM

Single VIP latrines are particularly suitable for rural areas. The construction can be based on traditional house-building tecnologies and thus the householders can build much all of their own latrines. Very few materials that are not available locally, such as the fly screen are needed.

It could also be built in urban areas if there is enough space for two latrines in each house plot. The two sites are used alternatively - one pit is used until it fills and then it is covered over with soil. The superstructure is located over the second pit site. Where there is less space or where it is desirable to build a permanent facility, a double pit VIP latrine can be use. Communal facilities can be provided where space is very limited or where each household cannot afford its own latrine.

This system can also be used in areas where bulky anal cleansing materials such as corn cobs or mud balls are traditionally used. However, pit life will be longer if bulky materials are not used in the VIP. Most other sanitation systems cannot handle these materials. Where the local preference is for defecating in a sitting (rather than a squatting) position, latrine can be designed with a seat.

Alternating double-pit with two (2) pits that are use alternately. These latrines are more appropriate in urban area and where people can afford to pay for a permanent latrine that does not require relocation every few years.

Multiple-pit VIP Latrine - latrine with more than one cubicle. These are suitable for institutions such as school.

ROEC

A variation of the VIP latrine in the Reed Odorless Earth Closet (ROEC). In the ROEC, the excreta is deposited into the pit via a chute located at the base of the squat hole or seat. The ROEC is fitted with a vent pipe to control odor and insect nuisances. This latrine is common in Southern Africa, where some units have been in use for over 20 years. However, the major problem of the ROEC is that the pit is easily fouled with excreta, thereby providing a site for insect and odor nuisance. The chute has to be regularly cleaned with a long-handled brush. Despite this disadvantage, there are several advantages of the ROEC - the pit is larger and this has a longer life than VIP. In addition, the pit can be easily erupted. Another advantage is that the pit is slightly away from the bowl thereby eliminating the danger of children falling into it.

Composting Toilet

Compost latrine are facilities which have been designed with permeable basin to allow excess fluid to soak away. (See Fig. 2.07)

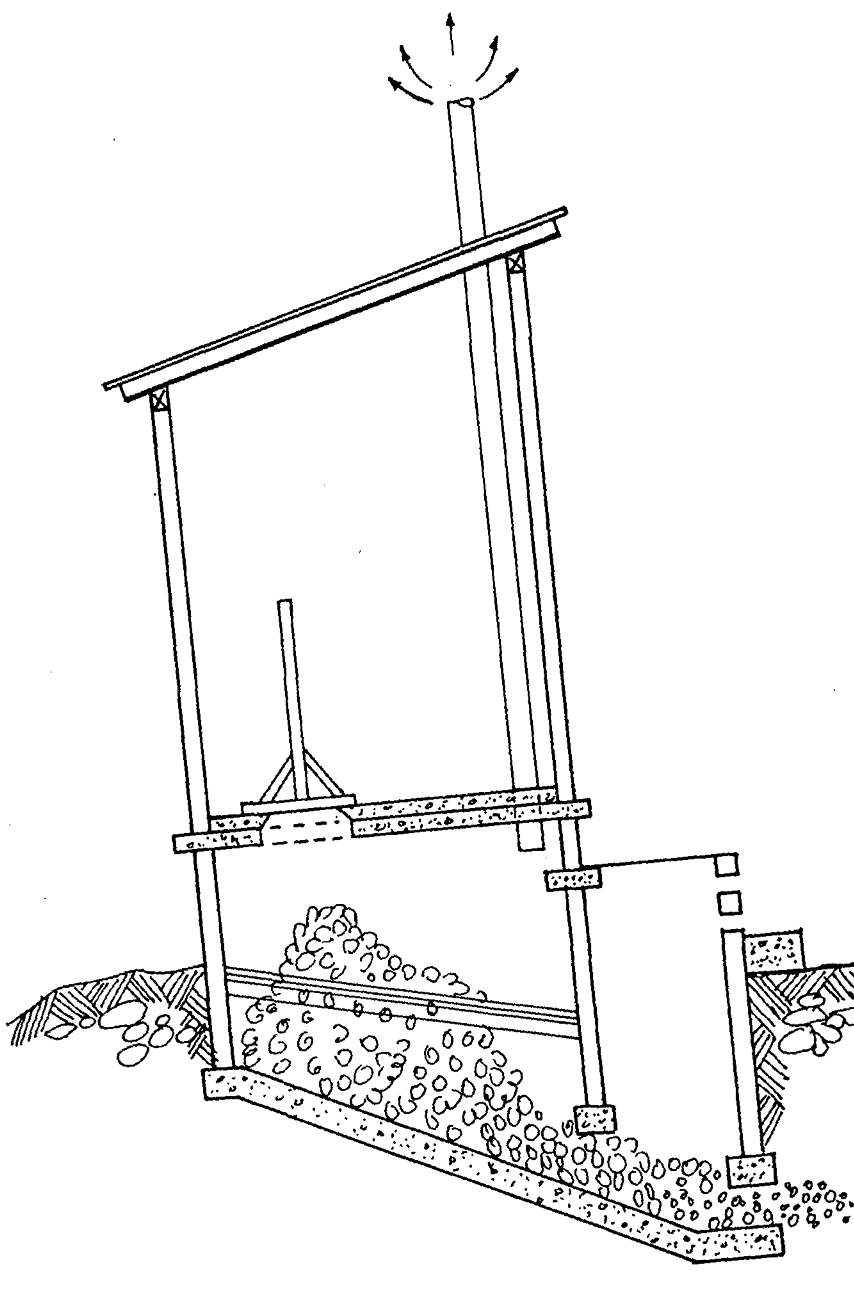


FIG. 2.07 CONTINUOUS - COMPOSTING TOILET

There are two distinct composting processes aerobic and anaerobic. Aerobic comporting takes place with the presence of oxygen. This heat generating process increases the temperature of the compost and the rate at which pathogenic organisms in the excreta die.

Anaerobic composting is a much slower process that takes place without oxygen. As a result, little heat is produced, and the compost has to be stored longer before it can be use safely. This is because the disease causing organism can thrive longer in the cooler temperature.

<u>Batch Compost Latrine</u>

The most common type of compost latrine is similar in many ways to the alternating double-pit VIP latrine. They have two chamber or vaults which may be constructed either above or below ground and may have sealed or impermeable bases.

The vault is used until really full and the remaining space is filled with dry soil or organic matter, such as leave a grass, and then it is sealed which the second vault is used. The vaults are usually designed to take at least one year to fill. The excreta in the sealed vaults are digested anaerobically for at least a year.

For efficient composting, the correct balance of nutrients must be present for the microbes to digest and degrade the material. These microbes need carbon for energy and nitrogen to form proteins for growth.

To achieve suitable C:N ratio, it is necessary to add organic carbon in the form of leaves, grass or some other easily composted material. To reduce the audity and odor of the compost and speed up the composting process, wood ash can be added regularly to the composted. Likewise urine should be separated to reduce nitrogen and moisture levels in the compost pile, For the same reason water should not be added to the pile.

The humus produced by a compost latrine is functioning will be dark, friable and inoffensive material rather than good, moist organic soil.

<u>African Batch Compost Latrines</u>

Double vault batch compost latrines have been tried experimentally in several parts of Africa. Most of the latrines have been designed with permeable bases to allow excess fluids to soak away. (Pls. see Fig. 2.08)

No attempt has been made to exclude urine from the latrine. This is partly for cultural reasons, but also because of the preavalence of urinary schistosomiasis in parts of Africa.

Organic materials such as crop residues, leaves, grass or sawdust must be added to correct the balance of carbon to nitrogen

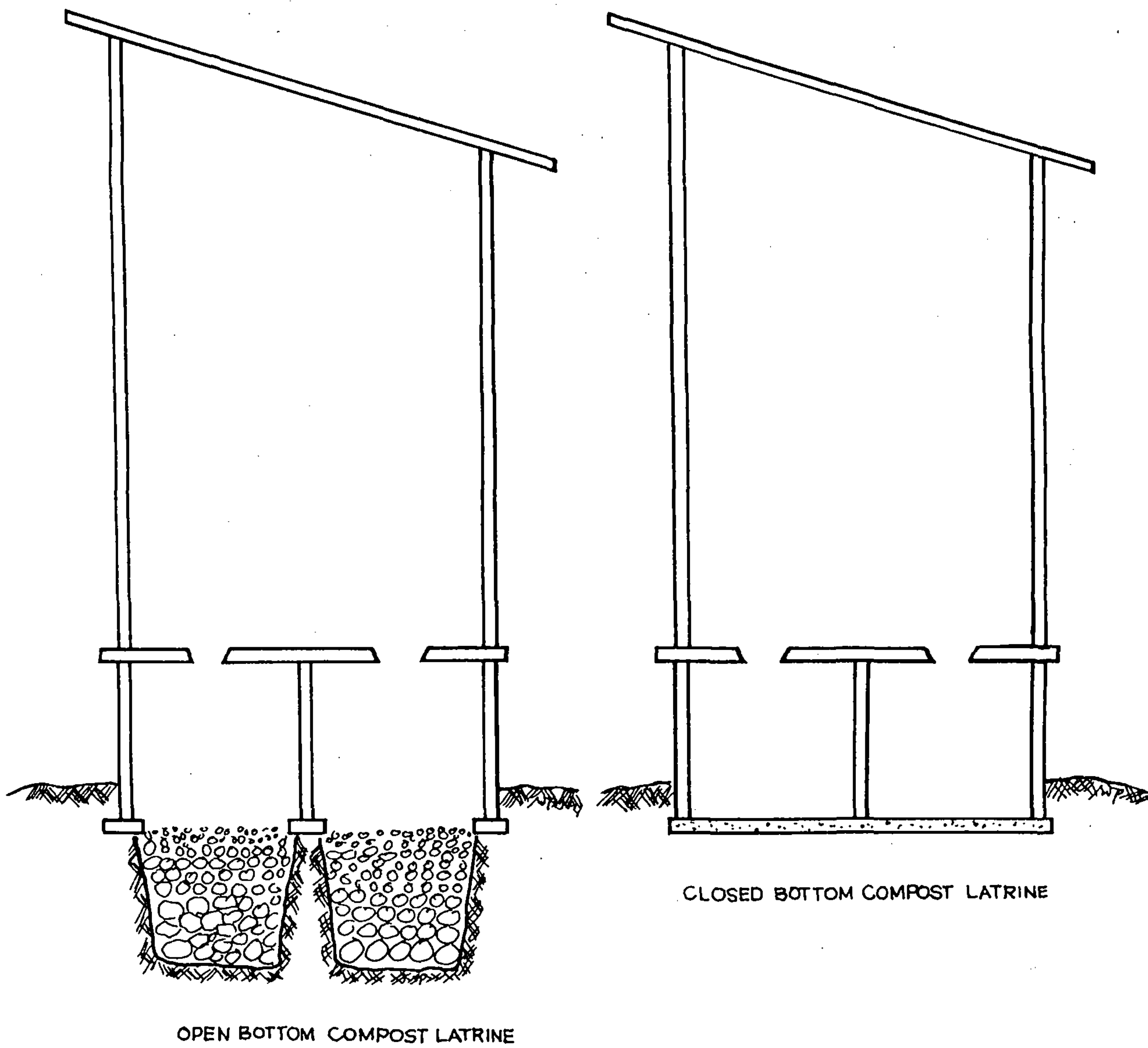



FIG. 2.08 AFRICAN BATCH COMPOST LATRINE

and also to absorb liquids. Wood ash is a useful addition because it absorbs moisture and counteracts the acids produced during the composting process. Experience suggests that the temperatures in the compost pit seldom use above 50 centigrade under normal operating conditions.

Because the compost is not safe to until it is at least a year old, the size of the vault is selcted so that it will take more than a year to fill. An allowance of 0.3 $m^3$ per person per year has been recommended for calculating the necessary volume for the vaults. The required vault volume is given by:

$$Vv = N\ R\ P$$

where:

Vv = required vault volume ($m^3$)
N = number of users
R = rate of filling ($m^3$/person/year)
P = emptying period (usually one (1) year)

(The factor 1.33 is necessary to allow for the vaults to be sealed when level of materials reach 3/4)

The latrines are usually constructed on a concrete base slab if they are above ground, with walls of concrete blocks or brick work. If they have permeable bases, the walls must extend at least 200 mm below ground level.

Cover slabs are usually made from reinforced concrete. Sometimes each vault has a separate slab, one which is plain with no hole and the other which has a squat hole. When it is time to seal a freshly filled vault and remove the compost from the other one, the slabs are changed around so that the one with the squat-hole is over the newly emptied vault. Alternatively, each slab has a squat-hole, or a hole into which a seat unit fits. One is sealed with a cover or plug while the other is in use. This type usually has remarkable cover slabs to allow the compost to be removed.

Compost latrines can be useful where there is a need for a soil conditioner. This particularly is important in topical areas where nutrients are quickly leached from the soil. Compost latrines are most appropriate for use in areas where human excreta is used as fertilizer, but the compost should not pose health risks to the crop consumer or users.

Compost latrine toilets need no water for flushing because composting is most efficient if the materials is moist but not wet.

It need not penetrate the subsoil and can therefore be built on rocks. It also poses low pollution risk, particularly the toilets are completely sealed units, so they can be used where it is important to prevent contamination of a vulnerable water supply.

Despite these advantages, it also has its shares of constraint. Compost latrines need organic waste to correct the carbon-nitrogen ratio if the excreta and provide the right condition for composting. Thus, a substantial amount of biodegradable organic matter must be locally available.

These toilet facilities need care in their operation so a strong commitment to producing and using compost must be shown by the latrine's users. If the correct measures are not taken, the contents of the latrine can easily become too wet and fly breeding will result.

If the wastes are not stored for a long enough period of time, pathogenic organisms will persist in the compost, resulting in health risks for those handling it.

Overhung Latrine

This latrine technology is popular in Southeast Asia. The latrine consists of a platform with a squat hole built over a body of water, and a superstructure which provides privacy. Overhung latrines are used in urban or rural areas where streams or canals are used for excreta disposal. However, major health problems result from the overhung latrine system. The water receiving the water becomes heavily polluted and children and adults who use the water down stream for washing drinking or cooking are exposed to pathogens in the water. This technology is not recommended because it facilitates transmission of disease. Possible sanitation alternatives include the VIP latrine or the pour-flush toilet.

Advantages/Diadvantages

This toilet system possesses a great number of advantages as well as disadvantages. It's good point are a) low annual cost; b) easy construction and maintenance; c) all types of anal cleansing materials may be used; d) absence of odor and minimal fly and mosquito nuisance; e) minimal water requirements; f) low level of municipal involvement and g) minimal risks to health. The limitations of this system are: a) lack of space for relocating the pit in dense urban areas, b) potential for groundwater pollution; c) difficulty of construction in rock or boulder laden subsoil; and d) does not dispose of large quantities of sullage water.

2. Level II - Pour - Flush Toilet

The pour-flush toilet is a much cheaper sanitation technology that needs only a fracation of the volume of water a conventional flush toilet requirement. Because of its water-seal, this toilet is hygienic to use as a conventional cistern-flush toilet. (fig. 2.09)

ADVANTAGES/DISADVANTAGES

The advantages of the pour-flush toilets are a) they are inexpensive; b) offer a long term ( and appropriate) solution for

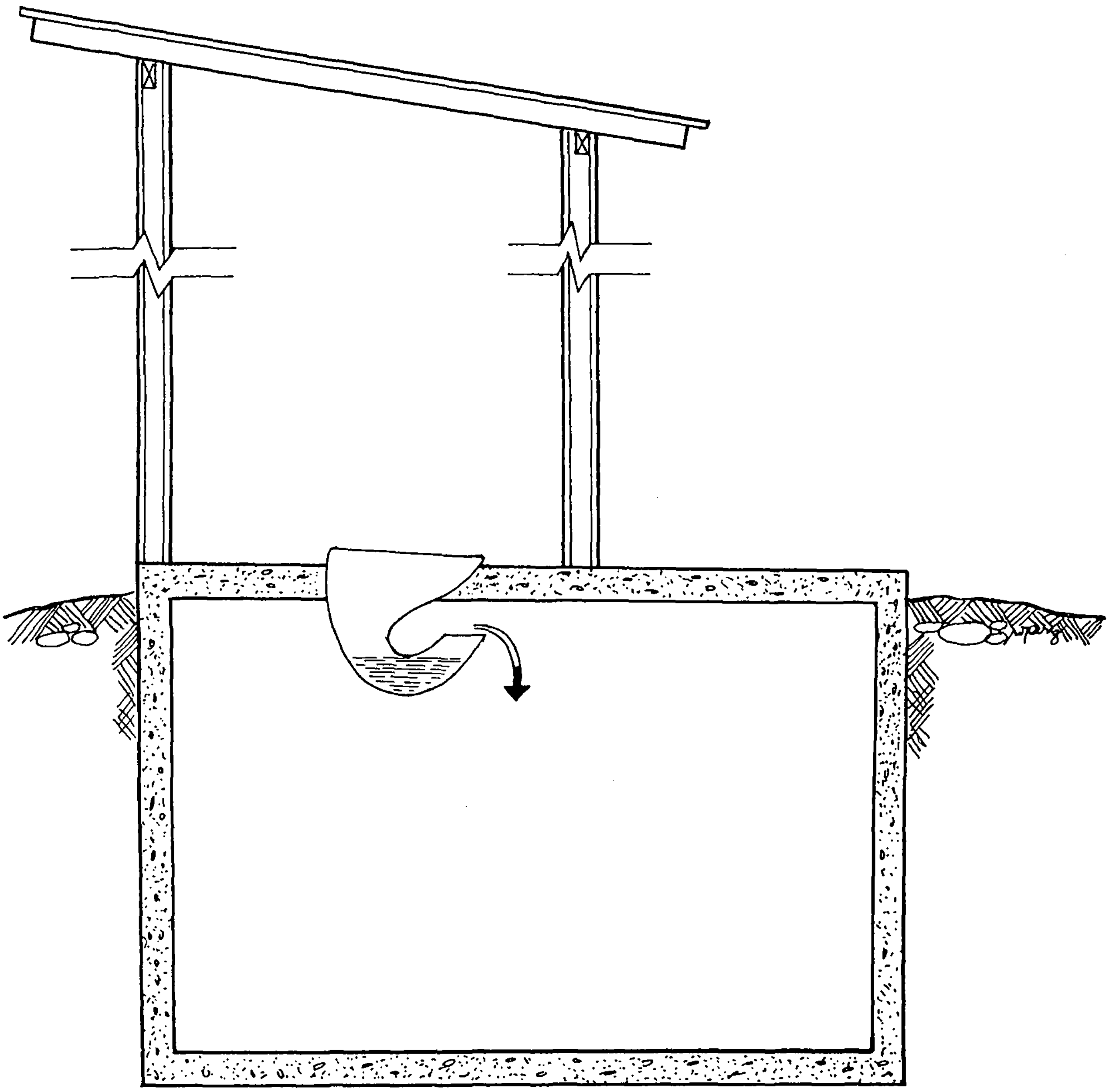


FIG. 2.09 POUR - FLUSH TOILET

excreta disposal; c) they use low volumes of warer for flushing; d) they can be upgrade to connect to a sewer system; e) they eliminate odors, insects and fly breeding; f) they involve easy construction and maintenance; g) only low level of municipal involvement required; h) the possibility of in-house location; i) there is potential for resource recovery; j) they abolish the need for excavenging system where workers have had to carry and transport excreta; k) the pour-flush toilet is very much cheaper to build.

Although they have a great number of good points, the disadvantages are; a) it requires separate sullage disposal facilities; b) the water to be use must be available throughout the year; c) the bulky cleansing materials clogs the toilet easily; d) shallow soil underlying hard rock or impermeable soil and in areas with high groundwater, construction is more difficult and expensive and; e) their is a risk of polluting water supplies.

There are two (2) types of pour-flush toilet namely the (1) pour-flush with pit and (2) pour- flush with septic tank.

3. Level III - Flush Toilets

Level III toilet facilities are usually found in urban areas, progressive and industrialized nations.

This indoor toilet technology has 2 major components- the latrine and septic tank[5]. Soluble solids settle to the tank bottom, accumulate and are then anaerobically digested. A sum of light weight materials rises to the top. The clarified liquid flows through an inlet structure just below the floating scum layer and is normally treated through a subsurface soil absorbtion system.

There are two variations of flush toilets- the flush toilet with septic tank and the flush toilet with septic tank connected to a screen. (Pls. see Figs. 2.10 & 2.11)

The later is usually used as a sanitation technology in industrialized countries. The socio- cultural, economic and technical developments should be examined just before concluding that it will be appropriate in the area.

ADVANTAGES/DISADVANTAGES

The main advantages of septic tank systems is their flexibility and adaptability to a wide variety of individual household disposal requirements. Another advantage is that the septic tank has no moving parts and therefore needs little mechanical maintenance.

A major disadvantage of the system is its high cost. Septic tanks are more expensive than other on- site waste treatment system and are generally only found in wealthy area. The systems require a permeable subsoil structure so the effluent can be distributed. If the subsoil structure is too impermeable the septic tanks effluent can contaminate surface or groundwater, creating public health

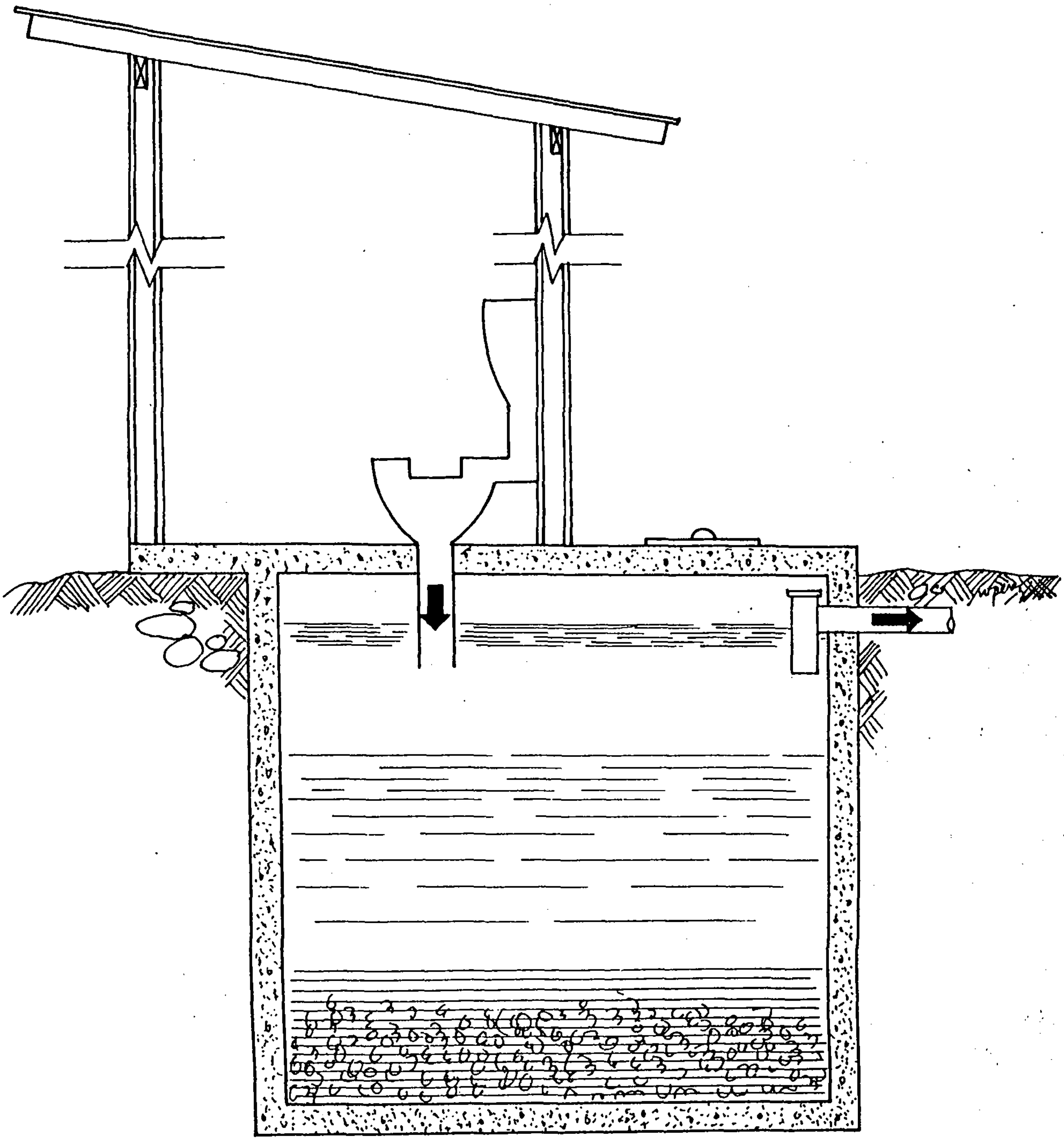


FIG. 2.10 FLUSH TOILET WITH SEPTIC TANK

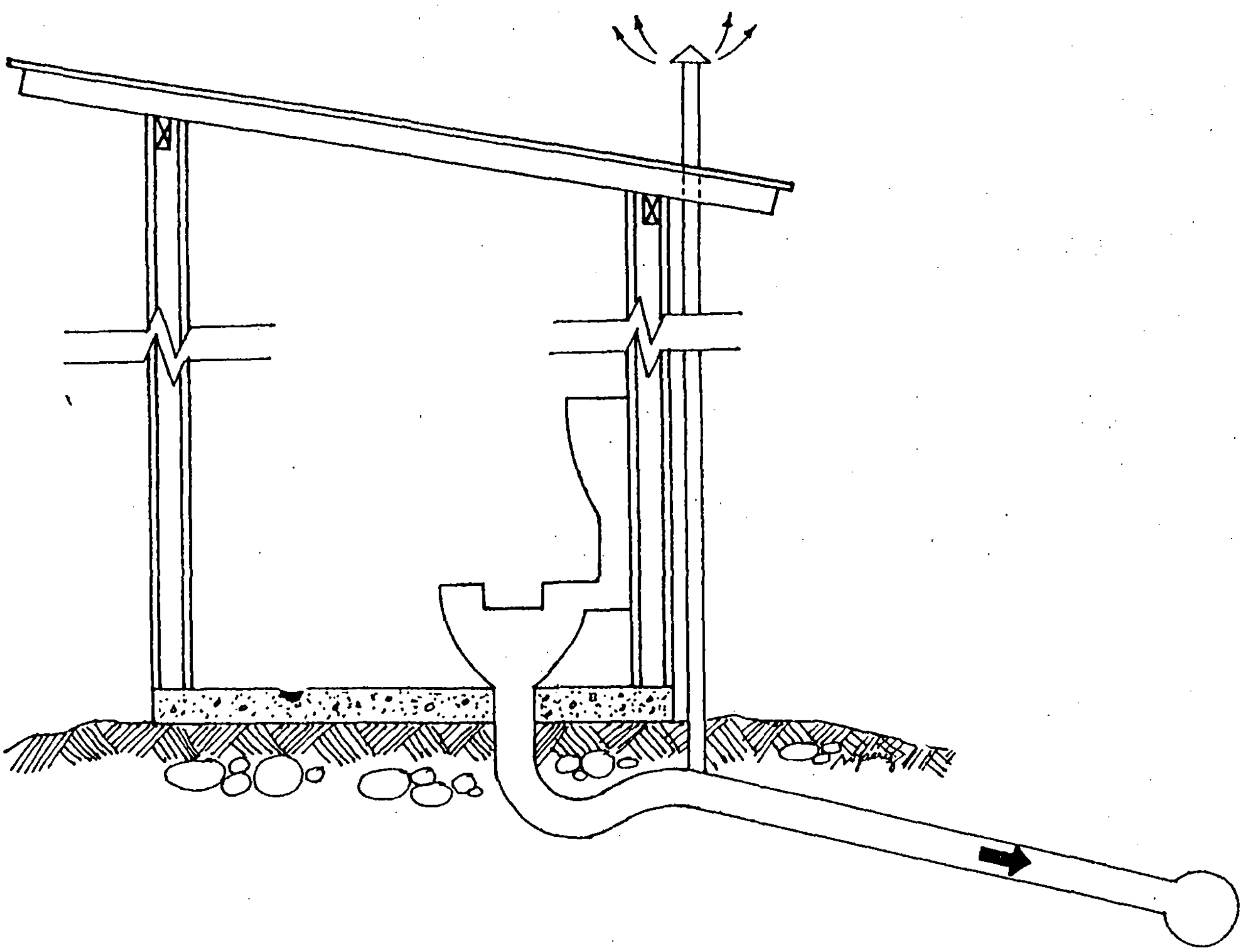


FIG. 2.11 FLUSH TOILET DIRECTED TO SEWER

hazard. Space for drainage field is also required and all drinking water must be set away from the septic tank system. As well, septic tank systems need piped water.

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[5] A septic tank is a rectangular or cylindrical chamber usually located below ground level that receives both excreta and flush water from the toilet as well as other household wastewater.

b. Design

1. Level I - Pit Latrines

<u>Vent</u>

The vent and fly screen have three very important functions:

- It controls odors. The vent creates a strong draught of air that carries all the foul-smelling gases from the fecal material in the pit up the vent pipe.

- It excludes flies. Flies are attracted by the fecal odors coming out of the vent pipe and not the interior of the superstructure, which does not smell if kept clean. They cannot get in through the vent because of the fly screen. As a result, fly infestation of the pit is kept to very low levels.

- It traps flies. The very few flies, that do find their way in through the squat hole and lay their eggs in the pit, are prevented from leaving by the vent pipe. Flies are attracted to wards light and, provided that the inside of the superstructure is kept shaded, they will fly up the vent pipe which will be the brightest source of light entering the pit. But, they can not escape because of the fly screen and they eventually fall back and die in the pit.

Material commonly used for the vent are asbestos cement (AC) and unplasticised polyvinyl chloride (PVC) pipes, brick and concrete blocks. Lower cost materials more suitable for rural areas include anthill soil and cement renderings applied to a framework of reeds, saplings, split bamboo, or of hessian (cotton sack) supported by welded steel mesh. Large-diameter bamboos with the nodes removed can be also used effectively.

To provide sufficient air to flow and admit light to the pit, the following internal dimensions for the vent are recommended.

AC or PVC - 150 mm diameter
brick or blockwork - 225 mm (square)
cement-rendered reed or hessian -250 mm dia.

In exposed locations where there is usually a good wind, the vent size maybe reduced to 100 mm diameter for AC or PVC pipes and 200 mm for the rural vent.

The main force causing the air flow up the vent is the wind blowing across its top. To work efficiently, the latrine should not be built on sites that are sheltered from the wind by trees or buildings. The top of the vent should project about 0.5 m above the highest point of a sloping roof and be at least as high as the apex of a conical thatch roof.

Also, orient the latrine so that the entrance and the ventilation openings face into the prevailing wind.

The vent must be securely fixed to the superstructure. An effective fixing can be made from a trip of galvanized steel sheet bent to shape and built into the superstructue.

The connection between the vent and the latrine slab should be secure and must easily be made with mortar.

Fly Screen

PVC-covered glass fiber is a durable fly-screen material. The holes in the material should not be larger than 1.5 mm square. If the holes are too small proper ventilation will not happen. An alternative material that can be used as a fly screen is the standard steel fly screen.

The simplest method of fixing the fly-screen to the vent pipes is to place it over the end of the pipe and bind it tightly with wire.

2. Level II - Pour-Flush Toilets

Location of Pits

There are many factors which must be taken into account when selecting the sites for the pits for pour-flush toilets. The pits should be as close as possible to the toilet compartment and within the house plot. If there is no sufficient room for the pits within the house plot, they can be built under adjacent floorpaths or roads up to 25 m away from the toilet compartment.

Easy access for emptying the pits is desirable but this is not essential where manual methods will be used.

The risk of contaminating groundwater can be minimized by placing a 500 mm thick envelope of sand around the pit and constructing an impermeable pit botton. The impermeable bottom can be made from plastic sheet or puddle clay. The minimum horizontal distance of separation from drinking water sources should be 15 m.

Do not build the pits too close together because the sealed pit may become contaminated with fresh disease-causing organisms from the pit that is in use. The minimum distance between them is the effective depth of the pits or 1 m, whichever is greater.

Pit Volume

The effective volume (Ve) of the pit is the volume below the inlet pipe. The required effective volume is:

$$Vc = AR \times N \times T$$

where

AR - sludge accumulation rate (cu.m/person/year)

N - number of users

T - filling time in year

Sludge accumulation rates are usually about 0.04 cu.m/person/year, although some variation should be allowed. Local experience should, where possible, guide the selection of the accumulation rate.

In double-pit pour-flush toilets, the filling time should be at least two years. This is necessary for the disease-causing organisms in the excreta to die, before emptying the pit.

Pit Shape

If the soil is not very permeable or if liquid is expected with the excreta. The surface area available for infiltration may have to be increased. A large pit can be dug, but it is also possible to increase the area of the walls of a pit of a given volume by building it deeper.

Pit Lining

The pits must be lined to their full depth because of the possibility of the soil collapsing when saturated with water from the pit.

The most common lining materials are brick and stone, although concrete blocks or cement-stabilized soil blocks can also be used. Concrete blocks can be specially made with holes in them to allow liquids to pass through.

The lining below the inlet pipe should be built in honeycomb brickwork with unmortared vertical joints. This is necessary to allow the flushing water and liquid portion of the feces to pass through and infiltrate into the surrounding soil. Any gaps between the lining and the surrounding soil should be filled with gravel and loosely compacted in layers as the lining is built up.

The top 300 mm of bricks or masonry should be fully mortared and watertight to provide a firm foundation for the pit covering and to prevent stormwater from entering the pit.

In areas where there is a high water table, it maybe difficult to dig the pit and line it with bricks or blocks, so cylindrical precast concrete or burnt clay liners can be sunk as the pit is dug. These liners must either be made with holes in them or with porous concrete.

In areas with a high water table, it may also be necessary to raise the pit so that it is partly above ground level. The section of the walls above ground level should be watertight and should be supported by building up an earth mound around them.

Pollution of the groundwater is most likely to occur in areas where the bottom of the pit extends below the water table. If there are wells nearby, build a sand filter around the pit to limit disease-causing micro-organisms from reaching the water supply. Seal the bottom of the pit. Dig the hole larger than usual so that there is a gap of 500 mm between the outside of the pit lining and the edge of the hole. This space should then be filled with sand.

Pit Cover

The pits are generally covered by slabs, usually of reinforced concrete, but sometimes stone slabs are used. They can be made in one piece, but it may be more convenient to split the cover into two more pieces that will be easier to handle. Large concrete cover slab normally is provided with access manhole.

The pit covers can be located above or below ground level or actually at ground level. If they are at or above ground level, it will be necessary to carefully bed the slabs on weak mortar and to seal any gaps to prevent insects or odors escaping from the pit. If they are at ground level, it will be difficult to prevent storm-water from entering the pit, but with the raised pit covers, this problem is overcome. If the pit cover is below ground and covered by soil, the sealing does not have to be as thorough and the pit covers will not cause any obstruction.

Pour-Flush Pan

Pour-flush pans or bowls can be made from concrete or ferrocement, but these are not entirely satisfactory because of the difficulty in creating a smooth finish and attractive appearance with these materials. Pans made from glass-fiber, injection-molded plastic and glazed ceramics are more popular because they are easier to keep clean and need less water to flush them.

The pan bottom should slope at angle of 30 towards the back which minimizes splashing of urine. The overall size is about 450 mm by 200 mm wide and it should be installed so that the rear edge is at least 200 mm from the wall of the toilet compartment.

Trap

The water-seal trap is best made separately from the pan so that it can be fixed with the outlet pointing in any direction relative to the pan. This gives greater flexibility when laying out the various components of a pour-flush toilet.

The design of the trap is crucial to the successful operation of the toilet. Experience has shown that the depth of the water seal should be 20 mm since smaller seals are unreliable because of the high risks of misalignment during installation. The diameter should be as smooth as possible.

The trap can be of concrete but smoother finishes can be coated with plastic or glass fiber or ceramic material. The trap has to be robust because it can be broken by rodding necessary to clear a blockage. The trap must be firmly fixed for the same reason.

Plinth

To prevent stormwater from entering the toilet and to help provide enough slope for the pipe, the toilet compartment is usually raised about 150 mm on a plinth. The plinth is supported by a brick that is placed under the trap and the pan is firmly bedded in position on a layer of sand or weak concrete. The toilet floor should be of concrete (mix-1:3:6) about 50 mm thick and is placed over a filling of compacted soil or broken brick.

Footrests of precast concrete, ceramic or glass fibre can all be built into the floor, mainly to help the users to position them selves over the toilet.

The floor should be finished level with the rim of the pan for squat type should slope towards the pan, all around, so that water drains easily. An attractive, smooth surface that is readily accepted by the users can be built using white cement and colored marble chips.

The floor finish can be continued, 300 mm or so up the wall to make an easily cleaned toilet compartment.

Pipe

The pits can be some distance away from the toilet but the layout of the connecting pipe is very important because it can easily get blocked if not properly designed.

The connecting pipe should slope by at least 1 in 30, and have a minimum diameter of 75 mm larger pipes are not be able to transport the feces along them. Wherever possible, bends should be avoided, but they will be less likely to cause blockages if they are of a large radius or if, for instance, two 45 bends are used in place of a 90 one.

The pipes that are must easily available and resistant to corrosion are made from asbestos cement or PVC. If suitable pipes are not available, a covered channel can be built instead, although this is often more expensive.

In installation with double-pits, a small chamber is constructed at the point where the pipe divides. One of the outlets from this chamber is blocked off either with a flat brick set in a weak mortar or with wet mortar packed in a plastic bag and jammed in the pipe to block it.

The junction chamber should be 250 mm square. The inside should be plastered with cement mortar to give a smooth waterproof lining and round off the sharp corners.

The end of the pipe where it enters the pit should project at least 100 mm from the pit lining to prevent the excreta from running down the pit wall.

Superstructure

Local materials used for building houses will be suitable and cheap for building the latrine superstructure. Traditional building materials that might not be very durable such as thatch should not be ruled out.

The toilet must be well ventilated and openings for this purpose are usually at the top of the walls where they do not reduce the user's privacy and where the overhang of the roof prevents rainwater from entering.

The cubicle can be 1 m square or larger if a large container for water is to be kept inside the toilet.

Septic Tank Design

A septic tank should be designed to remove almost all solid and to decompose organic matter anaerobicaly.

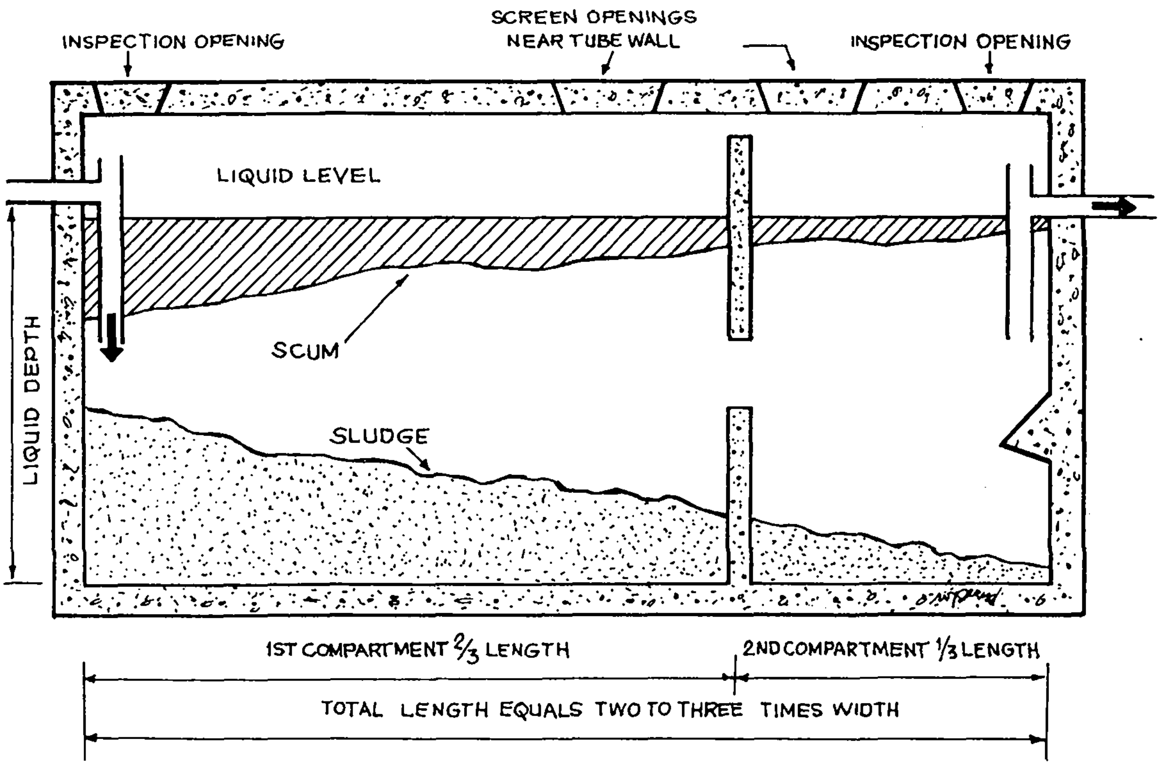
To accomplish this, the tank must provide the following:

- Proper volume of septic tank to adequately retain the waste. For effective sedimentation of the savage solids, the liquid retention time should be at least 24 hours. Two-thirds of the tank volume is normally reserved for the storage of accumulated sludge and scum, so that the size of the septic tank should be based on three days retention at start-up. This ensures that at least one day of retention still remains just before each desludging operation.

  Tanks of cylindrical shape, made of several pipe of ample size, are less costly to install. A rectangular shape for a single-compartment tank is most favored with a length two to three times its width, and a depth of 1 to 2 meters.

- Proper placement of inlet and outlet devices and adequate sludge and scum storage space to prevent the discharge of sludge and scum in the effluent.

The inlet to a septic tank (Figure 2.12) can be sanitary tee or an elbow with diameter greater than 10 centimeters, its vertical leg should extend to about 20 percent of the liquid depth. The outlet of a septic tank can also be a tee or a baffle placed in




# FIG. 2.12 CONVENTIONAL SEPTIC TANK

such a way that the bottom of the horizontal leg is below the level of the inlet pipe, its vertical leg must extent above the top and bottom of the scum layer and to about 40 percent of the liquid depth. Manholes should be provided to serve as a means to inspect the septic-tank and to empty the settled sludge.

These manholes should also be airtight to prevent odors from escaping.

- Since the digestion process is anaerobic, requiring no oxygen, no direct ventilation is necessary. However, provision should be made to permit the escape of the gases produced in the tank, through a ventilation pipe.

Construction and Operation of Septic Tanks

Septic tanks must be water tight, structurally durable and stable. Reinforced concrete and ferrocement meet these requirements, but the bituminous coating or other materials with equivalent properties.

Other materials include polyethylene and fiberglass which are light-weight, easily transported, and resistant to corrosion and decay.

Steel is another material that has been used for septic tanks, however, despite a corrosion-resistant coating, tanks can also become deteriorated at the liquid level.

The inlet and outlet pipes should be sealed with a bonding compound that adheres to both concrete and the pipes.

After installation, the tank should be tested for watertightness by filling it with water.

The most important installation requirement is that the tank be on a level grade and a depth that provides adequate gravity flow from the house, matching the invert elevation of the house sewer. It should also be easily accessible to facilitate inspection, maintenance, and sludge pump-out.

3. Level III - Flush Toilets

Flush toilets are usually situated indoor. Bowls adopted are made of vitreous china including the water closets. Wastes are coveyed by the water flush to septic tank for digestion. Normally, septic tank is connected to a sewer line for waste water disposal. Sewer network consists of small diameter pipes collecting the settled wastewaters and discharging them into an existing sewerage or treatment plant.

Bathroom is usually constructed with the flush toilet. The floor level of the bathroom must be higher than the toilet for proper drainage.

c. <u>Factors to be Considered in Selecting Appropriate Sanitation Facilities in Rural Areas</u>

- Soil

  The soil type and its permeability should be investigated for the whole project area. The depth to any rock or other layer which will limit the depth of excavations should be mapped.

- Groundwater

  The depth to the groundwater table should be mapped and any seasonal variations noted.

- Climate

  Data on rainfall and temperature will be useful and so existing records should be checked.

- Population Density

  The population of the project area should be estimated from census data where this is possible, or this can be obtained from socio-economic surveys. It is very important to forecast population changes in the future.

- Household Structure

  The size and composition of households should be investigated.

- Income

  Household income should be surveyed and projections for future changes made.

- Beliefs and Attitudes

  Local beliefs and attitudes affecting sanitation should be thoroughly investigated as should habits, such as the preferred type of anal cleansing material. The people should be asked what in their opinion are their real problems and how they should be tackled.

- Health

  A survey of the state of health of the people should indicate what their particular problems with regards to water supply and sanitation are likely to be.

- Housing

  The type of house, the number of people per room and most important the type of tenure and security of tenure should be observed.

- Size of Plots

The plot size will govern to a large extent which types of sanitation are feasible.

- Existing Sanitation and Drainage/Sanitation in Adjoining Areas

Existing facilities for excreta and sullage disposal should be carefully examined and the good and bad points noted.

Sanitation facilitites such as sewers or vault emptying services in adjoining areas will affect the feasibility of some sanitation systems in the project area.

- Water Supply

The level of water supply should be determined and the reliability of the water source should be assessed. Any plans for improving the water systems should be considered.

- Institutional Framework

Any national, municipal and local institution that is responsible for sanitation, water supply, drainage, refuse disposal, street cleaning, health, education, housing should be known as well as their effectivity as project implementors.

- Local Organizations

Any organization within the community that could form a group that would focus on motivating, educating or training the community should be determined.

There are many other factors- primarily social and economic- which must be investigated.

- Social Acceptability

The acceptability of the selected technology depends upon the compatibility with local attitudes, habits and beliefs.

- Maintenance

It is necessary to know or infer if the sanitation system can be maintained by the owner or not and thus employ the need for a sanitation authority. If the owner can do the work himself, the next thing to know is whether there is a need to educate, train on pit emptying and other details in sanitation maintenance or simply orient him on the processes.

- Political Acceptability

The selected technology should be politically acceptable. It should be assessed whether it necessitate spending too much or too little on the target population .

- Finance

If the people cannot afford or would be unwilling to pay the full cost for their sanitation services, the financial assistance should be sourced out and the manner it is to be adminstered must be determined.

- Organization

There is a need to pinpoint any organization that can form a focus for mobilizing community action and organizing self-help labor that will eventually take over the project or system to ensure the maximum service of the said structures.

d. Waste Water Management

Water-borne Sanitation

It is apparent that excreta are not solely the waste that should be given enough attention. This also includes wastewater from household, bathing and washing. Any attempt to ignore the proper disposal of these sullage can endanger the public health.

- Sewerage

Waterborne sewers or sewerage systems are very suitable in some areas because they are able to dispose of both excreta and household wastewater or sullage with an absolute minimum of health risk to the users.

Sewerage is the conventional means of wastewater collection in industrialized countries. However, the same technology has been adapted in many tropical countries. But it is expensive that is why thiscannot be adopted here in our country.

Sewerage is a sanitation technology. Control of human wastes, particularly feces, minimizes the occurence of a large number of diseases, some of which cause death to the infants, children and adults alike. Sewerage aids in disease control by rapidly conveying wastes away from the households.

It is not a requisite for good sanitation. In fact, if the wastewater is not treated and disposed into bodies of water, the health risk to water users is greater.

Proper cooking, dishwashing, bathing and infant feces handling must be practiced or disease may be passed on. A knowledge of hygiene will help protect an individual even in an environment without any waste control technologies. Therefore hygiene education is a fundamental component of sanitation.

Water and Sanitation Interaction

One of the most important constraints on the provision of sanitation is the level of water supply service. For instance, sewerage system is not possible where there is not enough water available to flush the toilet snd on-site sanitaiton systems can be overloaded if the water supply is improved and water consumption increases.

Water supply services can be divided into three (3) types namely a) bucket-carried supplies; 2) yard tap; and 3) multiple tap in-house or house to house connection.

- Bucket-carried Water Supplies

With bucket-carried water supplies the sanitaion technology chosen should ideally need no water for flushing although some will be necessary for cleaning. The first question also deals with the source of water and also very importantly, with people's preferences- "Is the water supply adequate for pour-flush or low-volume flush toilets?". (Figure 2.13) If the water source is reliable and a good supply is available throughout the year, then pour-flush or low-volume flush toilets are technically feasible. However, the people will not always be willing to carry extra water for flushing their toilets and so flush toilets are only likely to be appropriate in areas where water is traditionally used for anal cleansing.

Most commonly there will not be an adequate supply and so we take the "No" branch which leads to the question: "Is there rock near the round surface?" For single-pit latrines the pits should ideally be 3 m deep or more but often pits cannot be dug this deep due to the presence of hard rock close to the ground surface. If the pit cannot be more than say 1.5 m deep, it is possible to increase its volume and hence its useful life by building walls to extend the pit above ground. An extra 0.5 m of pit depth can be easily achieved like this.

Another problem is groundwater and if the answer to the question: "Is the water table near the ground surface?" If "yes" similar raised pits can be constructed. The pit may extend below the water surface, but there must be a clearance of at least 0.5 between the underside of the squatting slab and the water surface.

The question: "Can raised latrine pits be built?" is to find out whether latrines raised above ground level would be a problem. The pit walls must be surrounded by a mound of soil and so there may not be enough room for raised latrines or they may be very inconvenient.

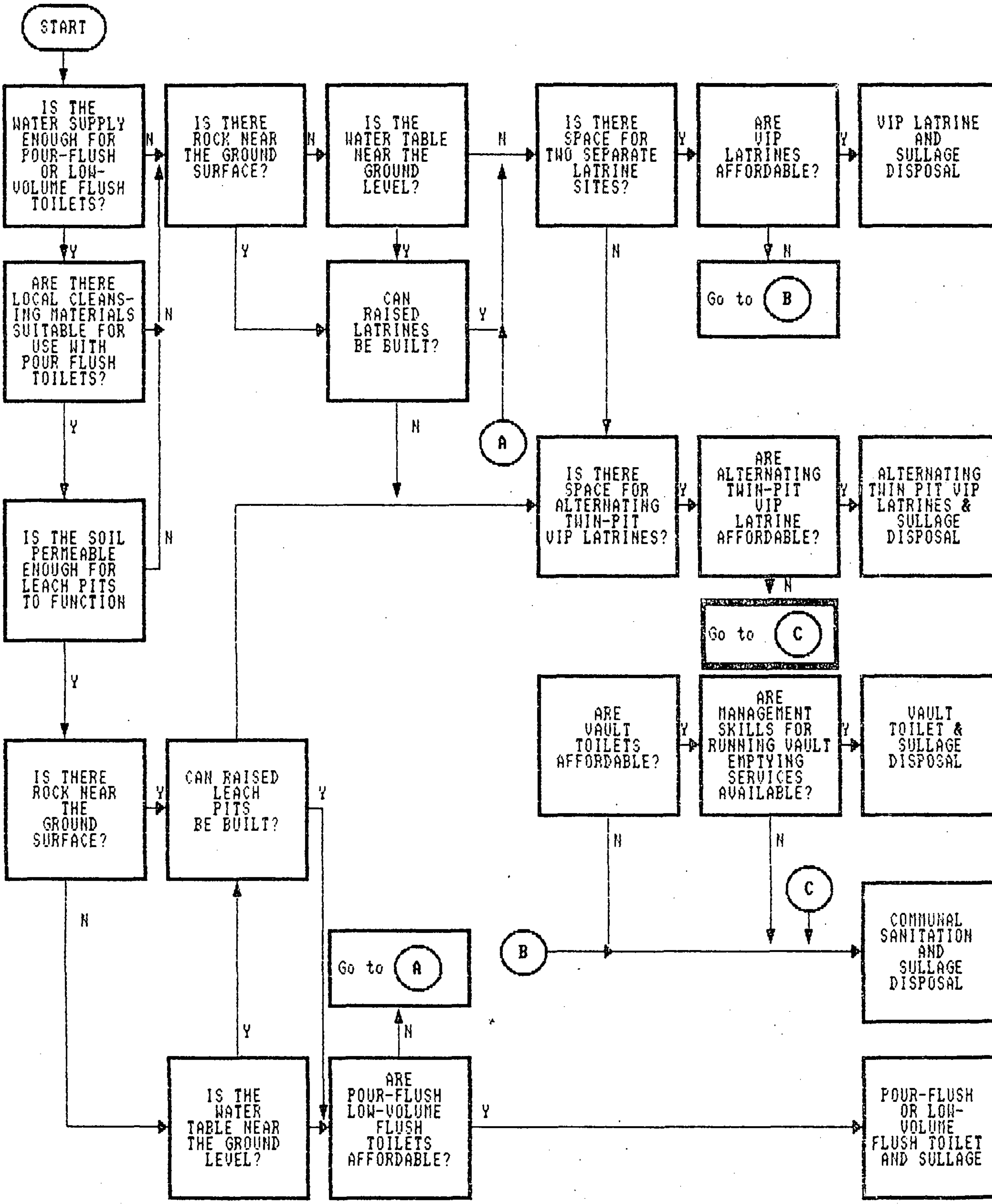



Fig. 2.13 SELECTION GUIDE FOR BUCKET CARRIED WATER SUPPLIES

If we assume that raised pits can be built we then come to the question: "Is there space for two separate latrines sites? Here we must remember that raised pits occupy more space and so larger house plots will be necessary to accommodate single pit VIP latrines.

Assuming that there is enough space, we come to the question: "Are VIP latrines affordable" The people may be too poor for each family to be able to pay for their own latrine. Loans can be made available, either interest free, or with low rates of interest, or grants of materials can be made. This reduces the financial cost to the households but the economic cost to the local and national economy must be considered as well.

If VIP latrines are affordable we will have provisionally selected VIP latrines with raised pits to be the most feasible sanitation technology. There are, however, some wastes, such as sullage, which are not handled by VIP latrines and so usually special facilities must be provided for its disposal.

If single-pit VIP latrines could not be built, either because of rock or water below the ground, or because of a shortage of space, we would arrive at the question "Is there space for alternating twin-pit VIP latrines? Twin-pit VIP latrines do not require very much space and so they can often be built in quite densely populated areas. Twin pits are very much shallower than single pit VIPs and so the presence of rock or groundwater is not likely to be a serious problem.

If there is not space enough for twin pit VIP latrines we ask: "Are vault toilets affordable?" Vault toilets are quite expensive to build and also have high running costs and so they may not be economical. In addition to their cost they have one other major disadvantage that is the difficulty of organizing the service. Unfortunately the answer to the question "Are management skills for running vault emptying services available?" is often 'No' and so the only alternative is to provide communal sanitation facilities.

Communal sanitation has many disadvantages and so the ideal should be to provide each household with its own latrine whenever possible. Only if there are existing social structures suitable for organizing the cleaning and maintenance of the toilets should communal sanitation be used as a permanent or long term provision.

- Yard tap water supplies

With a yard tap level of water supply, the sanitation system may need some water for flushing and pour-flush or low-volume flush toilets discharging into leach pits is a likely choice.

The first question in this algorithm: (Figure 2.14) "Are local anal cleansing materials suitable for use with flush

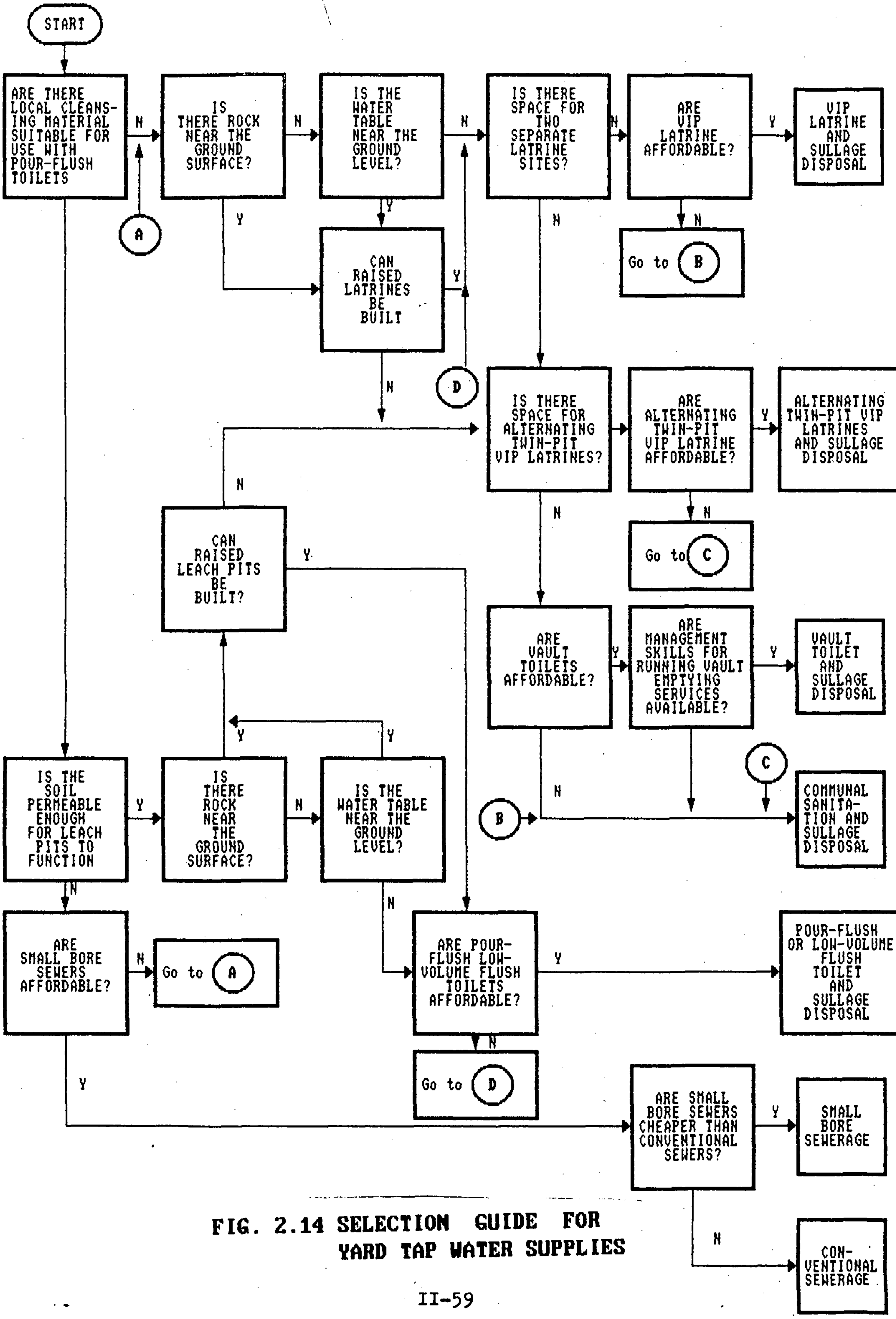



**FIG. 2.14 SELECTION GUIDE FOR YARD TAP WATER SUPPLIES**

toilets?" is fundamental to the feasibility of using flush toilets. If corn cobs, mud balls or other bulky materials are traditionally used, it will usually be better to install VIP latrines than to try to change people's habits to suit the sanitation technology chosen.

We can assume that water is used for anal cleansing and so we move on to the question: "Is the soil permeable enough for leach pits to function?" This is very is quite small (usually 6-10 litres per person per day), all but the most impermeable soil are suitable.

If the soil is extremely impermeable we have to ask: "Are small bore sewers affordable?" This will depend on many things and should not be dismissed until a detailed examination of the cost of small bore sewers has been carried out. Often the possibility of connecting into an existing or planned sewerage scheme serving a nearby area will reduce the cost of small bore sewers so much that they may become economic for an area with lower family incomes than would normally be expected to be able to afford sewers. If small bore sewers can be afforded this would be the preferred sanitation technology to install because it disposes of sullage as well as excreta.

Assuming that the soil is permeable enough for leach pits to function properly we move on to two questions: "Is there rock near the ground surface?" and "Is the water table near the ground level?" These are the same questions we asked in connection with VIP latrines, but the answers will not necessarily be the same.

Leach pits tend to be about 1.2 - 1.5 m deep and so they can be built in areas where the much deeper pits used with single-pit VIP latrines would be limited by rock or groundwater. We can assume that there is hard rock less than 1 m below the ground surface and so we have to ask: "Can raised leach pits be built?" These are similar to raised VIP latrine pits, but two can be built quite close together and surrounded by the same mound. Space may be a problem with raised pits, particularly as the toilet must be raised as well so that the pipe discharges into the top of the pits.

If for our example we assume that raised pits can be constructed we return to the question: "Are pour-flush or low-volume flush toilets affordable?" Again this applies both to the financial cost to the households, that is how much should one have to pay for each toilet, after any financial assistance that may be necessary, and also to the wider question of the economic cost of the toilet. The financial cost must include the amount of money the household would have to pay for water to flush the toilet and for pit emptying. The economic cost must include all costs including managing the sanitation projects and the cost of providing and administering any grants, loans or other financial assistance and also the costs of running a pit emptying service.

If pour-flush toilets are too expensive, VIP latrines may be cheaper to build and the households may be able to afford them.

The algorithm contains no questions relating to the amount of space required for pour-flush or low-volume flush toilets. This is because the leach pits are quite small and can be some distance away from the toilet, which may even be located on the upper floors of low-rise buildings. The pits may be built under footpaths or side roads outside the house plot if there is not enough room elsewhere and so the lack of space to build the toilet is unlikely to be a problem. In this case we have provisionally selected pour-flush toilets discharging into leach pits partially raised above ground level as our sanitation technology. The toilets can easily be upgraded at a later date to include low-volume cisterns for flushing and may be connected to small bore sewers when water supplies and economic circumstances improve.

Sullage disposal facilities will usually have to be provided in addition to the toilets. Although sullage may be used for pour-flush toilets, only 6- 10 liters per person per day are needed, while water consumption may be as high as 100 liters per person per day. If the toilet is used for disposing of sullage the leach pits are likely to overflow.

- In-house water supplies

The algorithm (Figure 2.15) for use with in- house water supplies is most useful for deciding which type of sanitation system will be most appropriate in areas where the housing is not yet built or in-house water supplies are planned, but not yet installed. Where there are existing in- house water supplies there will usually be some sort of sanitation system that can be upgraded at a lower cost than the installation of an entirely new system.

The main problem associated with in-house water supplies is caused by the large volumes of wastewater that must be disposed of. The first question of the algorithm: "Is the soil permeable enough for septic tanks and soakaways?" is intended to find out whether on-site sanitation is technically feasible. A more permeable soil is required than with pour-flush or low-volume flush toilets and leach pits, because of the larger volumes of wastewater to be disposed of.

If the soil is not permeable enough for on- side disposal to be possible small bore sewerage is the next technology to consider.

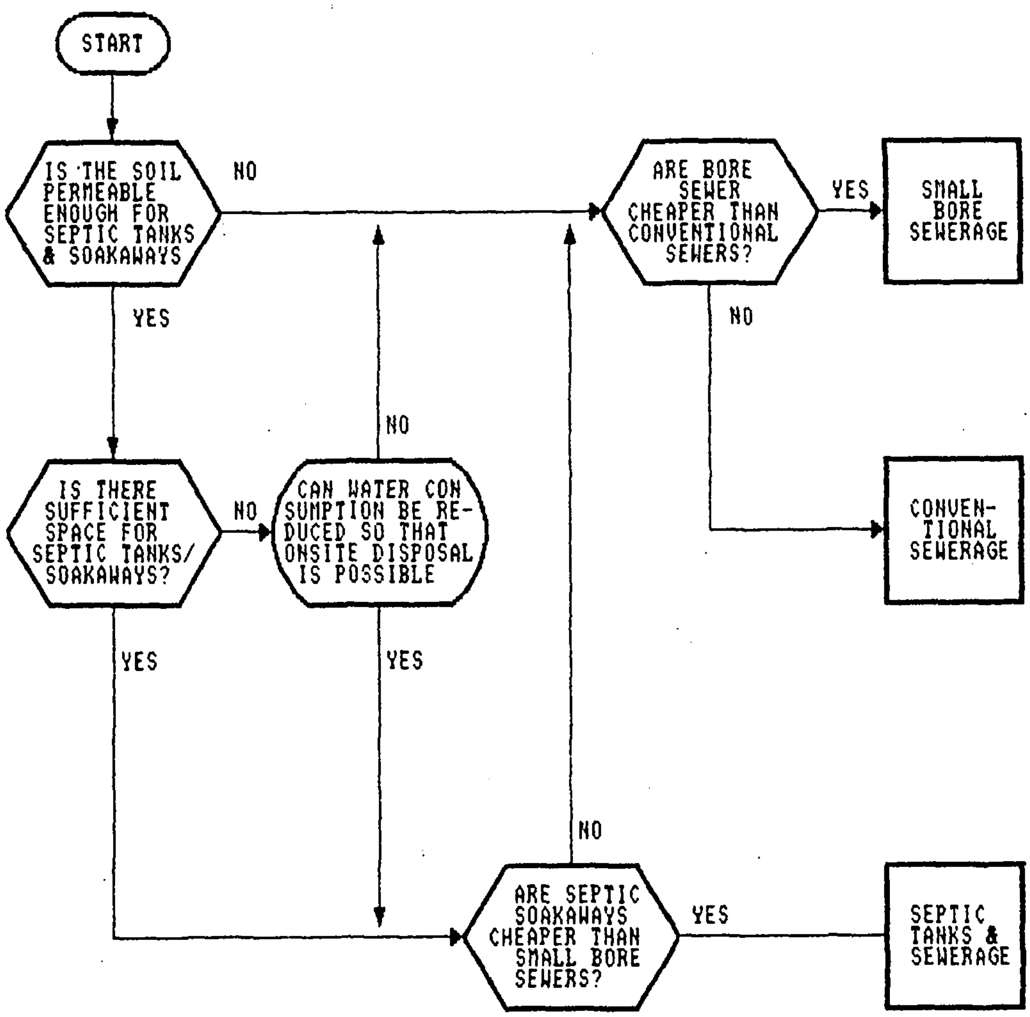



FIG. 2.15 SELECTION GUIDE FOR HOUSE CONNECTIONS WATER SUPPLY

For our example we can assume that the soil is permeable enough and on-site sanitation is possible. The answer to the next question; "Is there sufficient space for septic tanks and soakaways?" will depend to a large extent on the rate of water consumption. The septic tank for a single household is not very large and can be installed under pathways, but the soakaway or drain field necessary for the septic tank effluent to infiltrate into the ground may have to be quite large.

In our example we can assume that for the expected water consumption, drain fields larger than the area of space available on each house plot will be required. The 'No' branch takes us to the question: "Can the water consumption be reduced so that on-site disposal is possible?" Considerable reductions in the rate of water consumption can be achieved by minimizing waste and installing more efficient fixtures such as low-volume flush toilets, showers and self-closing taps. But this means it may be possible to install smaller soakaways that can be accommodated on the house plots and can handle the reduced volumes of wastewater.

If water conservation is feasible we then have to ask: "Are septic tanks and soakaways cheaper than sewerage?" This can be determined by comparing realistic cost estimates for sewerage and on-site sanitation. If septic tanks and soakaways are the most economical alernative, this would then be sanitation *technology provisionally selected to serve the area.* It is extremely important that water-saving appliances must be installed and water consumption monitored in order that the sanitation system does not become overloaded.

In the algorithm for in house water supplies there is no consideration of the affordability of any of the sanitation systems indicated by the algorithm. This is because there are no alternatives to these sanitation systems that can accommodate the wastewater flows that are generated by in-house water supplies.

When comparing the cost of the alternative sanitation systems it is most important that the full economic cost is considered. The financial cost to the households depends to a great extent on government policy and may be very much lower than the full economic cost, which will generally be quite high. Whichever sanitation system or combination of systems has the lowest economic cost should be the one selected because there is no difference in the level of service they provide for the user.

The algorithms we have looked at ignore one very important factor: the existing sanitation services in the area under consideration. It is often cheaper. easier, and more acceptable to the users to upgrade the existing sanitation than to start installing a completely new system. This may be the first stage of an upgrading sequence which will improve the sanitation provisions as water supply, incomes and other services in the community improve over time.

## CHAPTER III - Community Mobilization

Community mobilization refers to the activities undertaken by the people to solve the problems they are confronted with. It involves realization of the need to prioritize perceived/felt problems and determine the actions to take with the use of available community resources both local and external.

The community plays an important role in the implementation of water supply and sanitation projects. It is essential that the community undergoes the process of problem identification, priorization and strategy setting to be assured that they understand and accept the whole project. In the same manner, full participation can be expected from the people themselves. Whatever output they acquire becomes a community property.

Mobilizing people for a water supply and sanitation project is hastened through the identification of Community Development Volunteer (CDV) and Community Water Project Volunteers (CWPV). These volunteers who are especially trained in social mobilization for community water and sanitation projects will assist the beneficiaries realize the need to develop their sensitivity/awareness, responsibility and feeling of confidence to cooperatively work together. Community activities are continuously conducted even without the presence of the CD worker or organizers and representatives from implementing line agencies.

### A. Community Development Volunteers (CDV) Formation

1. Concept of Community Development Volunteer (CDV)

   A Community Development Volunteer (CDV) is a person who is willing to spend time and effort to perform community work without expecting financial remuneration.

   The CDV is expected to assist in facilitating the developmental activities in the community and eventually take over upon the phasing-out of the Community Development Worker (CDW)/Organizer.

2. Community Development Volunteer Formation

   Community Development Volunteers (CDV) formation is very much related to the concept of self-reliance. True self-reliance which is achieved when people as a community are able to manage its problems/needs with the maximum use of local and external resources. It is the stage when dependence from outside changes agents end and the trained indigenous leaders take over the community management functions.

   In implementing community water supply and sanitation projects, it is during social preparation that indigenous leaders are already spotted and identified. They start assisting the CDW/Organizer and in the process acquire basic knowledge, skills and approriate attitude on community organization with emphasis on mobilizing people for water. The CDV then becomes an instrument in initiating changes which have to be integrated into the lives of the people. Changes are not only limited to water supply and sanitation but include other aspects of development.

a. Importance of Community Development Volunteer Formation

CDV formation is viewed as an important aspect in mobilizing people for water supply and sanitation projects.

- It insures continuity of the organizing process where values of social concern and human development are consciously inculcated;

- Water committee/association is able to maintain and sustain its cohesiveness and level of functioning;

- Leadership functions are continuously shared among officers and members of the water committee/association;

- Community action skills acquired by the beneficiaries are monitored if effectively used into practice.

b. CDV's Criteria for Selection

- He should be a resident of the area;

- He knows how to read and write;

- He is physically capable: health allows physical and mental work;

- He is well-adjusted and socially accepted by the group and community;

- Has demonstrated his interest, willingness, sacrifice and concern for the work and the people;

- He is respected and recognized as a leader by the organization and community;

- He is the choice of the organization and or community;

- He is willing to undergo continuous, Community Development Volunteers Training;

- He has experiences with organizations, clubs, groups, projects seminars and other-related activities.

c. CDV's Job Description

General:

- To assist organize viable groups in sustaining and improving skills in problem-solving, decision-making, resource development on a self-help basis;

- To support community leadership in the integration of the people through participation in community projects and activities;

- To maintain lines of communication among all segments of the community among the need and resource sectors;

- To continuously identify and train potential leaders;

- To sustain community concern and involvement.

Specific:

- Conducts and attends community meetings, holds informal discussions and contacts;

- Runs leadership and group development seminars;

- Assists in mobilizing and tapping internal and external community resources;

- Provides technical assistance in developing and strengthening organizational structure;

- Assists community groups in implementing community projects and activities;

- Assists in solving conflicts in the community;

- Coordinates with and makes referrals to the different program and social agencies;

- Provides continuous motivation for community concern towards self-sufficiency;

- Explains the programs and objectives of the agency and the community.

d. Contents of CDV Training

For the Community Development Volunteers (CDV) to acquire the skills needed in community organizing he will have to undergo a 10-day training. The training duration can be shortened or prolonged depending on the learning pace of the CDVs and on the adequacy of the training inputs.

The training will be both theoretical and practical. After formal sessions on concepts and theories, the application of such will immediately follow. Practicum is always undertaken with the CDVs which will become a regular forum to discuss new ideas, doubts, and difficulties derived from their experiences while applying the theories they have learned from the formal sessions. Conceptualization and strategizing sessions will be conducted based on the existing community situation and prevailing community issues.

The content areas for the Training include the following:

- Orientation on the goals/objectives, programs and schemes of the Water Supply and Sanitation Program;
- Understanding human behavior and group behavior;
- Job expectation and job description of Community Development Volunteer (CDV);
- Understanding community needs and dynamics of community life;
- Different models of Community Organization practice;
- How to conduct and use a Community Survey;
- Knowledge, attitude and practice of team building skills
  * interpersonal skills
  * organizational skills
  * leadership skills
  * planning, implementation and evaluation skills
  * coordinating skills
  * Trainer's training

B. Community Water Project Volunteers (CWPV) Formation

1. Concept of Community Water Project Volunteer (CWPV)

A Community Project Volunteer (CWPV) is similar to a CDV. He is a person who is willing to spend time and effort to perform community work without expecting financial remuneration. The CWPV is committed to organize the water committee/association and assist these groups in community water supply and sanitation project management.

2. Community Water Project Volunteers (CWPV) Formation

The Community Water Project Volunteers (CWPVs) are participants who are able to actively partake in the Community Water Project Management Health and Sanitation (CWPMHS) Training and commit themselves to assume the responsibilities at hand. The formation of the CWPV is another mechanism developed for areas without the direct service assistance of the Community Development Workers/Organizers of the foundation. Implementation however, is still facilitated as expected with the active support of line agency representatives is done as expected.

a. Importance of Community Water Project Volunteers Formation

With the formation of the Community Water Project Volunteers, the social preparation aspect of the water supply and sanitation project will be hastened. The technical staff together with the representatives of the various local government units will be sharing the community mobilization and organization building activities with the trained CWPV. Project planning operations and maintenance are facilitated by CWPVs with the community even without the presence of the technical staff or line agency representatives.

b. CWPV's Qualification for Training

- He must be resident of the area (barangay, municipality) for at least one (1) year;

- Ages between 20-55 years old;

- At least high school graduate;

- Physically fit for training and supervisory responsibilities;

- Have been involved in the planning, implementation and evaluation of community projects and activities;

- Willing, can set aside time and can supervise water and sanitation projects/activities in the community;

- Willing to be trained and to train about water, health, hygiene/sanitation and water supply projects management;

- Preferably must be chosen by the community

c. Community Water Project Volunteer's Task Functions

- To orient the community on the community water and sanitation project management;

- To facilitate community acceptance of the water supply and sanitation project management;

- To organize a water committee which will assume primary responsibilities in the planning, construction, and maintenance of the water supply and sanitation systems;

- To formalize the organization of a water association composed of subscribers;

- To provide necessary informations to PPDO or technical representative of line agencies regarding water and sanitation program.

d. Contents of the Community Water Project Management, Health and Sanitation (CWPMHS) Training

The general objectives of the training indicate that at the end of a 6-day training, the participants would have acquired basic knowledge, skills and appropriate attitude in community water project management, health and sanitation.

In specific terms, the participants would have:

- related the water supply situation and its importance to health and sanitation;
- identified proper health and hygiene practices;
- identified basic concepts and skills essential to mobilizing individuals, groups and communities to actively act on their water supply and sanitation problems and needs;
- identified the different technologies, models and scheme in managing community-based potable water supply and sanitation projects;
- formulated their program of work assuming the role of a Community Water Project Volunteer (CWPV);
- identified methods and technologies in facilitating community water supply project management, health and sanitation sessions.

The Modules include:

Module I - Water, Health and Sanitation
Module II - Mobilizing People for Water
Module III - Community Water Supply and Sanitation Project Management

Community mobilization through the Community Development Volunteer (CDV) and Community Water Project Volunteer (CWPV) hastens actions of the people involved in the project with maximum and optimum use of the resources available. The community resident /subscibers with the CDVs, CWPVs and the representatives of the different line agencies are the most important resource of the project. Altogether with the proper and efficient use of the other resources (Ms): money, material, machineries, methods and moments, it will entirely be impossible not to have a very successful project.

C. Networking

1. Concept of Networking for Maintenance

Networking is a strategy in the organizing process that aims at consciously building an interconnected, interrelated system of exchange among institutions organized in a common endeavor. It is a process of reaching out, building and maintaining linkages with various local national and international groups/organizations and agencies either it be government or non-governmental. The process involves tapping and maximizing of assistance in carrying out projects and activities toward achievement of agency objectives. The exchange of information and services must be perceived as beneficial and advantageous to all those who belong to the network. The coordinative image of the different local agencies has to be sustained. It interrelates various aspects of the program by which cooperation, understanding and agreement are secured. Its implementation aims to develop and strengthen mechanisms in converging services at different levels- regional, provincial and municipal.

The water supply and sanitation project needs to establish linkages with the other line agencies to expect functioning and well-maintained water supply and sanitation projects. Although certain agencies such as Development of Public Works and Highways (DPWH) Water Districts are identified to be in-charge of the water supply and sanitation projects, other agencies may complement and provide useful assistance in other aspects. For instance, the Integrated Provincial Health Office (IPHO) is able to teach mothers on its immunization and control of diarrheal diseases. The Department of Agriculture (DA) is building the capability of the families and the communities to respond to nutrition at family and community levels.

2. Importance of Networking

The whole process of networking helps the community gain moral, official support and acceptability. This implies more sytematic and purposive efforts to tap and harness financial, institutional and human resources available in the face of scarcity of resources. It ensures alternative assistance in cases where plans formulated by the people are not possible.

Through networking, community participation and mobilization of local resources increase.The agencies involved become aware of each others goals/objectives, program scheme, and coverage that it helps determine the nature and extent of assistance each can offer on the 6Ms; money, manpower, machine, materials, method and moment.

3. Strategies/Activities in Networking for Maintenance

   a. Inter-agency meetings where each agency defines its objectives, programs and services and their roles and responsibilities. Program of support is formulated.

   b. Periodic reporting/updating

   c. Effective communication system through the committees, staff meetings/conferences, group decision- making sessions.

## CHAPTER IV - ORGANIZATION BUILDING

Organization building involves the creation /formation and development of a provincial water task force, a water committee and/or a water association. This becomes one of the major components in community water supply and sanitation project management.

At the moment the people realize the need to take action on water supply and sanitation related problems and needs, the organizing process already starts. They begin to see the importance of cooperation and collectively working together for an organized support to whatever program of work they are able to agree on.

Prior to the creation of a provincial water task force, a water committee and/or association, it is necessary to confer with the results of the community study on existing structures. This is to identify existing sectoral groups which can be responsible for the project rather than creating a new one to avoid confusion among the project implementors.

At the provincial/municipal level is the water task force which is the implementing structure of the province on water supply development program composed of technical staff representing various agencies at the community level, after a water committee is formed, other members of the community may eventually be enjoined to form into a water association composed of subscribers. The members of the task force and subcribers need to undergo series of trainings and meetings to prepare themselves for effective and efficient collective activities. The water task force, committee/association simultaneously defines and set up its organizational structure, leadership systems and program of work.

Community mobilization through the CDVs/CWPVs and organization building through the water committee and/or water association is important.

- It builds the self-confidence and develops the collective spirit of the task force members and water subscribers to solve water supply and sanitation problems which enables them to continuously manage other projects and activities of the community on a collective basis.

- It enables leaders and individual members acquire basic knowledge and skills in problem-solving/decision making on the technical aspect of the project.

- It provides opportunities for project implementors to explore and utilize to the fullest available local and external resources at any given situation.

For example, in implementing the water supply and sanitation activities, project cost will considerably be lowered, especially where labor is done by local volunteers in place of paying skilled workers from outside the community.

A. Provincial/Municipal Level

1. Formation of Water Task Force

a. Concept of Water Task Force Formation

Water task force formation is the process of bringing together representatives of national line agencies and local government units in the provincial or municipal level who will perform various functions of providing technical assistance to the community water structure in the management of water supply and sanitation projects.

With the seriousness and urgency of potable water problems in the rural areas it calls for the need to have an implementing structure at all levels such as this, to perform more developmental roles and functions to ensure that the projects will leave behind viable and organized beneficiaries who can manage and maintain with competence appropriate community-based water supply and sanitation systems.

b. Functions of the Provincial /Municipal Water Task Force

- assists in identifying the communities/barangays in need of potable water;

- assists the communities to identify possibilities and opportunities for a potable water supply project;

- leads the community to opportunities where they can tap resources within and outside the province which can be utilized;

- helps facilitate organization of beneficiaries into a viable community water association;

- helps provide training and technical assistance to the association as how to manage and maintain potable water system project;

- initiates the development of a water supply program plan of action at the provincial level;

- formulates systems and procedures, guidelines in implementing a provincial water supply program;

- assists communities in the preparation of water feasibility study, installation, maintenance and repair of the water system;

- serves as data bank which provide information to all development agencies in the province regarding the present water supply profiles of all barangays and municipalities in the province.

c. Strategies and Activities in Water Task Force Formation

- Meetings - a series of gatherings of representatives of national line agencies and local government units at the provincial/municipal levels, committed to cooperatively work together in helping community water supply and sanitation projects. The members start to define the purpose, work structure, role negotiations, systems/procedures and organizational development plan of water task force.

- Organizational Assessment - is the process of appraising the task force capabilities to respond to the needs of its beneficiaries, maximize opprotunities and utilize the given resources to meet its goal. It is simply a review of the past and present accomplishments, practices of the task force as an organization and find out its relevance in the future.

- Organizational Development Planning - is a conscious effort of the task force to collectively decide and come up with a design on how to improve the current organizational functioning of the task force. It utilizes the results of the Organizational Assessment as basis for improving the task force functioning in preparing the plan.

  As a group, the task force can come up with innovative interventions to solve its problems. The members could already respond to their present needs.

  To come up with a workable organizational development plan, various steps are suggested : setting of assumptions, problem/need identification and priority setting, goal and objective setting, action planning, identification of support systems required and identification of potential problems and alternative solutions.

- Implementation of Organizational Development Plan - is the process of carrying out courses of action by the task force to improve their organizational function as stated or described in the Organizational Development Plan. In the process of implementation, there are suggested development intervention in facilitating organizational growth of the task force, such as : team building, staff training and development, systems development and provision of technical assistance and consultancy.

B. Community Level

1. Water Committee Formation

a. Concept of Water Committee Formation

Water Committee formation is a conscious effort of bringing together residents of a community to lay down the foundation of a strong people's organization to represent the community and work directly with the implementing governmental or non-governmental organizations.

The CDW/organizer or technical representatives of the implementing agencies has to work closely with the CDV in organizing the water committee. Ideally, the composition of the committee to be formed should come from all the sectoral groups so that the committee is representative of the entire community. There are communities however, which have existing local committees/organization already where the water and sanitation projects may be integrated with. In which case, there is no need to create another committee.

b. Importance of Water Committee

With the water committee, community involvement in a water and sanitation project paves the way for people to become aware of and identify appropriate solutions to their own water and sanitation problems.

The water committee becomes the first vehicle to transfer to the people technical skills needed to maintain water supply and sanitation systems.

It involves transfer of the basic understanding about water, water resources and community water project management. It is apparently unsafe to leave skills in the hands of people who do not have any understanding of the principles involved.

Having an established water committee indicates a high level of assurance for an efficient operation and maintenance of water and sanitation projects. It has been experienced in many projects all over the country that without proper care on the water supply and sanitation facilities, it will deteriorate and fail to provide the services for which it was designed or built. A malfunctioning system will almost certainly be improperly used and will eventually be abandoned by the community.

It is then essential that through the water committee, training, evaluation and monitoring activities are facilitated to enable subscribers/members the members to play their role in developing the project they can call their own.

c. Functions of a Water Committee

- Assists in gathering field data with the technical staff of the implementing agencies;
- Reports and explains to the community members or water subcribers during meetings the status of the project, technical alternatives and decision-making factors;
- organizes community education on the benefits of the members/subscribers of water supply and sanitation project, especially health education;

- Organizes follow-up support for the project and generates active community involvement;

- Makes contact outside the community such as with government agencies, technical people and other implementing agencies;

- Establishes and enforces sanctions for any misuse of the system.

- Obtains money from many sources for the development and maintenance of the systems.

d. Strategies and Activities in Water Committee Formation

In water committee formation, the following strategies/activities are facilitated:

1. Integration/data gathering - continuously establishing rapport with the people and at the same time gathering information essential to the creation of the water committee. The CDW & CDV identify the appropriate style in dealing with the people to help them realize the importance of identifying and analyzing the need to do something about their water supply and sanitation situation.

   - Ocular survey
   - House-to-house visit
   - Orientation on the Community Water Supply and Sanitation Program

2. Meetings - a series of gatherings of interested and committed community residents collectively discussing the organization of a water committee. The members define in precise terms the objectives, scope, functions and responsibilities of the water committee.

3. Organization Building - the formal setting up of the committee's systems and procedures and other related activities that will enable the members to manage the affairs of the group.

4. Action Planning and Implementation - drawing up of the committee's plan to determine the detailed activities of the project prior to implementation. Emphasis is likewise given to the eventual formalization of the water committee to an association. Furthermore, the committee establishes its working relationship with the representatives of the various line agencies that will be directly and indirectly involved in the course of project implementation.

2. Water Association Formation

a. Concept of Water Association Formation

Water association formation is a conscious effort of bringing together residents of a community who share similar problems concerning water supply and sanitation. They are people who are interested and willing to do substantive and collective action to plan, construct, maintain and sustain water supply and sanitation projects and activities.

b. Importance of Water Association Formation

With the water association, the community is able to effect its own self-development through collective efforts. It helps develop deeper awareness among the people their potentials to manage projects/activities thereby ensuring active and full participation from them.

An effective communication system is likewise developed among the residents themselves and with the various sectors of the community either it be government or non-governmental organization.

Through the water association that will be formed, the residents are able to acquire basic knowledge on problem-solving and practical skills which is expected to create a full understanding of the water supply and sanitation projects. The whole process basically develops a sense of ownership and pride among the members of the water association that such feelings enable them to accept, properly use and maintain the systems.

c. Functions of the Water Association

- Sustains interest and motivation of the community residents in developing and improving water supply and sanitation systems;

- Provides a venue for the community residents to acquire knowledge and skills in the management of both technical and administrative operations; planning, implementation/installations, maintenance and repair of water supply and sanitation facilities;

- Provides a venue to establish hygiene education program reaching to all sectors of the community especially the children and women to effect behavioral changes leading to improved sanitation habits;

- Promotes the water and sanitation projects in the community so that economic capabilities and other educational needs are continuously determined and specific objectives are set;

- Provides supervision during all phases of the project and back-up support for water supply and sanitation systems in the form of continuing education and operation and maintenance training;

- Facilitates coordination and collaboration with other groups/association or implementing governmental and non-governmental agencies.

d. Strategies and Activities in Water Association Formation

- Integration/data-gathering (same with WC Formation)
- courtesy call
- ocular survey
- house-to-house visit
- orientation on the community water supply and sanitation program

Even at this early stage, the CDW/CDV with the other selected leaders start establishing rapport with the local officials and representatives of the different line agencies. The role of each participating sector in the water supply and sanitation project is defined.

- Problem-identification/Situational Analysis - recognition, identification, analysis and prioritizing of community perceived/real problems and needs with the people. It is through this process that the people will realize that their decision to take actions must not be based on opinions or feelings alone but should be a result of a more deliberate, well thought-out and data-based process. The collective effort that goes into problem-identification becomes in itself a factor for preparing the community to be involved in the succeeding stages of the process.

- Organizational Orientation - the process of helping the people realize the importance of working together in solving their problems and needs in the community. The importance of forming a water association is thoroughly discussed and initial activities essential towards it are identified. Motivational exercises may also be facilitated to affirm interest and commitment of prospective members.

- Goal-Setting - enabling the members to stop and think more deeply about the problems they have selected and prioritized and define the changes they would like to effect. It is at this stage that the people should already have a general grasp of the community's thrusts and how they can manage.

- Structures and Systems Building - centers on organization development-related concerns enabling the members to establish and employ suitable structures to respond to the need of the association. It is the organization and strengthening of a community-based structure to effectively and efficiently manage potable water supply and sanitation projects. The association undergoes series of workshop/sessions and meetings on creation of working committees, formulation of systems and procedures/constitution and by-laws to insure continuous functioning of organization and implementation of projects.

It is at this stage that the association members/subscribers must be able to continuously find meaning in what they are doing and to improve their life as an association. The members' commitment has to be developed, continuously nurtured and enhanced so that after the water supply and sanitation projects, they can continue working on other aspects of development like indulging in income generating projects and other socio-cultural activities.

Project Planning and Implementation - the process of organizing and using resources to accomplish the goals and objectives established for the water supply and sanitation project. It is primarily concerned with the efficient use of resources that is, achieving a certain performance with fixed and limited money and time.

The whole process involves:

Planning of water supply and sanitation project at two levels:

Provincial/Municipal Planning - the Provincial and Municipal Planning and Development Offices with the representatives of the different implementing line agencies or the provincial/municipal water development task force determine and define goals, purpose of the program and what resources will be alloted to each project. Planning is based on community needs and the social goals of the province/municipal. It involves planning with the most efficient use of the 6 Ms; Men or Manpower, Money, Material, Method, Machines and Moments.

Barangay/Community Planning - this is the actual planning together with the community residents or subscribers of the water association. Planning should be done in such a way that good performance is achieved from the money and time allocated to the project.

Getting Resources Organized - it involves identifying and tapping the project resources needed. It includes people (men and women) who is the most important among all resources. It is impossible to complete the project efficiently, however, without using the right method, materials, money and machines in a careful and planned manner. Time has to be properly managed also.

Preparing the Action Plan - as a guide to action, it should reflect the conside rations to take note in the planning process. For potable water projects, the action starts in the setting up of the project's goals and objectives. Responsibilities of each group or person involved in the project are specified. It needs to include several documents like budget, schedule and the plans or working drawings along with the specifications.

- Setting Up of Control System - establishing a monitoring and evaluation system to assure that resources are not being wasted and that these systems must be set up before any work begins.

- Recruiting and Selecting Workers - once the budget and schedule have been prepared and control systems established, the next step is to recruit and select the workers who will directly be involved in the construction; sub-contractors may also be identified.

- Getting the Work Done

- Getting the resources on site - refers to the activities that are involved in getting the resources to the project site at the right time.

- Supervising the Work

- Monitoring and Evaluation - involves constant checking of the project's progress and observing all activities in a critical way to identify warning signs. Monitoring involves viewing, listening, evaluating, analyzing, supervising and overseeing. In evaluation, the aim is to identify what went wrong and why. Even if the objective was accomplished, the problem that occurred during the project should be reviewed so that they can be avoided the next time. Making the final check is a process which should assure that people learn from their mistakes.

People's participation in this stage is as important as planning and implementation. This could be done through workshop, dialogues and other activities involving maximum participation from the people. These mechanisms should provide information for feedback and education.

Organization building through the water committee and or water association is highly important. The appreciation of a good water supply and sanitation system primarily starts on the concern and acceptance of the people who are actively participating in the whole process. Their participation in the formation, building sustenance of the water committee and or water association becomes a functional part of the project operations. The people will always try to preserve, develop and improve the system which they themselves will build and consider as their community property.

# CHAPTER V - DETAILED TECHNICAL DESIGN

Detailed technical design is carried out for projects found feasible for development after several options have been considered. These designs are necessary for the preparation of the detailed engineering designs and drawings where the cost estimate and bill of materials will be based.

These design and technical drawings should be prepared and checked prior to actual construction to prevent and spot potential problems in the implementation phase of the project. These will also be used as guide during the construction stage.

Detailed technical design has several components:

1. Engineering Design
   a. Structural
   b. Hydraulic
2. Plans and Drawings
3. Constuction Specifications
4. Cost Estimates

## A. Wells

### 1. COLLECTION OF FIELD INFORMATION

The first step in the planning of an individual water well or multiple well ground water project is the collection and interpretation of technical field information. The success of any type of water well undertaking will depend on the accuracy and completeness of this information. There are four basic types of technical information required to plan a well design and select the proper drilling equipment:

1.1 Subsurface Geologic Data - this consists information regarding ground and soil formation and different types of rocks.

1.2 Hydrological Data - this includes information regarding the depth of the water table (aquifer), well capacity and rate of draw down.

1.3 Well Quality Data - this includes information regarding the physical and chemical properties of water and bacteriological analysis .

1.4 *General Project Data - this includes information regarding the* location of the well(s), ground elevation, type of pump installed, cost of drilling, cost of construction materials, names of available local drilling contractor in the area.

Majority of this information will be readily available from existing technical reports, project documents or well drilling logs of Project Management Office - Rural Water Supply, Department of Public Works and Highway, (PMO- RWS, DPWH) , National Water Resources Board (NWRB), drilling and waterworks organizations members such as the Well Drillers Association of the Philippines (WELDAPHIL) and Philippine Waterworks Association (PWWA), Pilipino Professional Water Systems Inc. (PPWSI), and different Water District Offices.

Physical, chemical quality of water and bacteriological analysis data can usually be obtained from the Department of Health (DOH), Integrated Provincial Health Offices (IPHO) and Water Districts.

In areas where previous ground water development has taken place, existing records may contain basic geological and hydrological data to be used for selecting the appropriate drilling equipment and designing an efficient water well project. However, in areas where there are limited ground water development, a test drilling in the proposed project area will be of help in gathering the geological and hydrological information.

## 2. DESIGN OF WELLS

A water well is designed to utilize available aquifer potential as efficiently as possible. Well design is based on geological and hydrological conditions at the well sites, as well as the physical condition in the project area and economics or well cost. There are two main elements of a well. One element is the part of the well that serves as a housing or borehole for the pumping equipment, either a handpump or a motor pump. The housing also serves as a conduit through which the water flows upward from the aquifer to the level where it enters the pump. This is commonly the cased portions of the wells, although some of its length may be uncased depending on the geological condition of the well below.

The other element is the intake portion of the well. Since this is where the water enters the well from the aquifer, the design of this element requires a careful consideration of the hydrologic factors that influence well performance, the geological conditions and the aquifer supplying the water.

In a consolidated rock aquifer, the intake portion (screen) of the well is usually an open borehole (uncased portion), drilled into the aquifer to an adequate depth. The yield of such a well varies with the number, size and continuity of the openings in the rock.

### 2.1 Initial Well Design

The engineer or the planner after completing the collection of field information is now ready to design the well to be able to come out with the appropriate cost of the project. It should be noted that what the engineer or the planner is designing, is just the initial design. The final design of the well will have to be verified after reaching the target or program depth or upon encountering water bearing formations.

In making the initial well design, the engineer or planner should consider the following: depth of well, depth and size of casing materials, water level and ground formation. These will serve as a guide for the engineer or the planner in determining the type of well to be constructed, the method of construction or drilling and type of pump cylinder/prime mover to lift the water.

After having completed the intial well design, the engineer or planner is now ready to prepare the necessary bill of materials which will serve as the basis for the quotation being submitted by different drilling contracts. (See Table 5-03 for the Bill of Materials on the different types of handpumps used. Also please refer to page V-5 for sample quotation on well drilling)

## 2.2 Final Well Design

After reaching the target/program depth or upon encountering water bearing formations, the engineer or the planner with help from the drilling contractors, is now ready to prepare the final well design. The final well design will be based on the soil samples taken during the drilling of the borehole. (Refer to the well log on page VI-8a for more details.)

In the final well design, the engineer or the planner should consider the following:

- well depth
- well diameter
- well casing
- well screen
- gravel packing
- well development
- sanitary seal
- pumping test
- disinfection
- pumping facilities

For further discussion on the details of the final well design, please refer to Chapter VII - Project Construction.

2.3 Water well drilling selection guide

Table 5-01 shows an example of well design based on the type of formation encountered during the construction of the project. This table will also serve as a guide for the engineer or planner on what type of well and method of construction will be needed after conducting the ocular survey.

TABLE 5-01

| WATER WELL DRILLING SELECTION GUIDE | | | | |
|---|---|---|---|---|
| | | TYPE OF FORMATION | | |
| Geologic Origin | | Igneous and Metamorphic | Sedimentary | |
| Examples | | Granite Gneiss<br>Basalt Quartzite<br>Trap Rock Schist | Limestone, Sandstone,<br>Shale | Clay<br>Sand<br>Gravel |
| HARDNESS | | VERY HARD - HARD | HARD - SOFT | UNCONSOLIDATED |
| Acquifer potential and ground water occurencé | | Generally Low yield In cracks joints weathered zone | Highly variable yields: usually moderate to very good in cracks and cavities | Sand-high to moderate yield Gravel - very high yield |
| Sample Well Design | Diam. | Small (4"-6") | Small-medium (6"-12") | Small-Large (8"-24") |
| | Depth | Shallow (50'-200') | Shallow-deep(50'-1000') | Shallow-deep (50'-1000') |
| | Casing | Open hole or surface only | Open hole or surface only or full depth | Usually full depth |
| | Screen slotted pipe. | None | Dependent on formation characteristics | Yes |

3. Well Cost

The cost of the project will depend on what type of well and method of construction to be used. For a small community well there are several types of well commonly used. These are dug well, shallow well and deepwell using a handpump as a prime mover. For a dug well with concrete cement as the lining material and a jetmatic pump as the prime mover, the cost ranges rom P3,000 to P6,000 per unit. Depth of dug well ranges from as low as 10 feet (depending on the water level) to as deep as 50 feet in some areas. For shallow well with a G.I pipe casing and a jetmatic handpump and concrete platform, the cost ranges from P3,500 to P5,500 per unit. Depth ranges from 20 feet to 40 feet depending on the water level. For deepwell, the cost will depend on the type and setting of the handpump, diameter and depth of the well. The cost ranges from P10,000 to P40,000 per unit (1989 prices).

3.1 Shallow Well (Ave. depth - 40 Ft.) (Refer to Fig. 5-01)

TABLE 5-02

| A. MATERIALS | UNIT | QTY. | COST |
|---|---|---|---|
| G.I. Pipe Sch.40x20' | | | |
| *2'dia w/ coupling | pcs. | 2 | P |
| 1 1/4"dia w/ coupling | pcs. | 2 | |
| Brass check valve, 1 1/4" dia | pc. | 1 | |
| Def. Bar, 3/8"x20' | pcs. | 2 | |
| Cement, Portland | bags | 3 | |
| Form Lumber, 6" x 1/2" x 10' | bdf. | 7.5 | |
| Washed Sand | cu.m. | 1 | |
| Gravel | cu.m. | 1 | |
| B. JETMATIC PUMP, 1 1/4"DIA | set | 1 | |
| C. DRILLING COST | | | |
| 40 ft. | per ft. | | |
| D. HAULING COST | | | |
| E. LABOR | | | |
| Unskilled | | | |
| 2 person x 2 days | | | |
| Skilled | | | |
| 1 person x 2 days | | | |
| TOTAL COST OF A+B+C+D+E | | | P |

LEGEND: * - optional, depending on ground formation

3.2 DEEPWELL (AVE. DEPTH - 120') (Refer to Fig. 5-02)

3.2.1 Type A

TABLE 5-03

| ITEM/DESCRIPTION | UNIT | QTY. | UNIT COST |
|---|---|---|---|
| A. Pump Base & Platform | | | |
| Cement, Portland | bags | 9 | |
| Def. Bars,3/8"x20' | pcs. | 8 | |
| Sand | cu.m. | 2 | |
| Gravel | cu.m. | 2 | |
| Tie Wire #16 | kilo | 1/2 | |
| CW Nails (assorted) | kilos | 2.0 | |
| Plywood,1/4"thick | pc. | 1 | |
| Form Lumber,2"x1.5"x12 | pcs. | 10 | |
| Teplon Tape, 1/2"dia | rolls | 4 | |
| B. BEAM & PIVOT ASSEMBLY | | | |
| Wooden Beam (Yakal), 2" x 6" 10' | bdf. | 10 | |
| Steel Plates, 1/4" x 6" x 24" | pcs. | 2 | |
| Cap Screw w/ nut & washer, 3/8"diax3" | pcs. | 5 | |
| Cold rolled shaft, 1 1/4"dia x 12" | pc. | 1 | |
| Anchor bolt w/ nut & washer, 1/2"dia x 8" | pcs. | 4 | |
| Wooden Block (Yakal) 3"x4"x8" | bdf. | 1.33 | |
| C. SPOUT & BASE PLATE | | | |
| G.I. Nipple, 2"diax12" | pc. | 1 | |
| Steel Plate, 1/2"x8"x8" | pc. | 1 | |
| G.I. Tee Red, 2"dia x 1 1/4"dia | pc. | 1 | |
| G.I. Nipple, 1 1/4"dia x 12" | pc. | 1 | |
| G.I. Elbow, 1 1/4"diax90$^{o}$ | pc. | 1 | |
| G.I. B. Red. 2"dia x 3/4" dia | pc. | 1 | |
| G.I. Coupling, 2" dia H.D. | pc. | 1 | |
| PVC Male Adoptor,3/4"dia | pc. | 1 | |
| Spring Wire, 6x4" | pc. | 1 | |
| Concrete Nail, 4" | pc. | 1 | |
| Anchor Bolts w/ nuts & washer 1/2"dia x 4" | pcs. | 4 | |

D. Yoke Assembly

| | | | |
|---|---|---|---|
| Flat Bar | | | |
| 3/16"x 1/2"x21" | pcs. | 2 | |
| Cold Rolled Shaft | | | |
| 5/8"dia x 4" | pc. | 1 | |
| Cap Screw w/ nuts & | | | |
| washer 3/8"diax3 1/2" | pc. | 1 | |
| G.I. STD Tee, 3/8"dia | pc. | 1 | |

E. Pipes & Cylinder

| | | | |
|---|---|---|---|
| G.I. Pipes, sch. 40 w/ | | | |
| Coupling 2"dia x 20' | pcs. | 6 | |
| 3/8"dia x 20' | pcs. | 6 | |
| Brass Cylinder w/ spring | | | |
| dog 1 13/16" I.D. | pc. | 1 | |

| | | | |
|---|---|---|---|
| F. Pea Gravel -3/8"dia | bags | - | * |

G. Drilling Cost

| | | | |
|---|---|---|---|
| 120 ft. | per ft. | | |

H. Labor

Fabrication(lump sum)

Unskilled (4 persons)

P50/day x 2 days

Skilled (1 person)

P70/day x 2 days

Total Cost of Drilling

Labor and Materials P

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* - Optional, depending on ground formation

3.2.2 Type - B (Refer to Fig. 5-03)

TABLE 5-04

| ITEM/DESCRIPTION | UNIT | QTY. | UNIT COST |
|---|---|---|---|
| A. Pump Base & Platform | | | |
| Cement, Portland | bags | 9 | |
| R. Bars,3/8"x20' | pcs. | 8 | |
| Sand | cu.m. | 2 | |
| Gravel | cu.m. | 2 | |
| Tie Wire #16 | kilo | 1/2 | |
| CW Nail (assorted) | kilos | 2.0 | |
| Plywood,1/4"thick | pc. | 1 | |
| Form Lumber,2"x1.5"x12 | pcs. | 10 | |
| Teplon Tape, 1/2"dia | rolls | 4 | |

B. BEAM & PIVOT ASSEMBLY

| | | |
|---|---|---|
| Wooden Beam (Yakal), 2" x 6" 10' | bdf. | 10 |
| Steel Plates, 1/4" x 6" x 24" | pcs. | 2 |
| Cap Screw w/ nut & washer, 3/8"diax3" | pcs. | 5 |
| Cold rolled shaft, 1 1/4"dia x 12" | pc. | 1 |
| Anchor bolt w/ nut & washer, 1/2"dia x 8" | pcs. | 4 |

C. SPOUT & BASE PLATE

| | | |
|---|---|---|
| G.I. Nipple 1 1/4"dia x 12" | pcs. | 2 |
| Steel Plate, 1/2"x8"x8" | pcs. | 2 |
| G.I. STD Tee, 1 1/4"dia | pc. | 1 |
| G.I. Elbow, 1 1/4"diax90 | pc. | 1 |
| G.I. B. Red. 1 1/4"dia x 3/4"dia | pc. | 1 |
| G.I. Coupling, 1 1/4"dia | pc. | 1 |
| PVC Male Adoptor,3/4"dia | pc. | 1 |
| Spring Wire, #6 x 4" | pc. | 1 |
| Concrete Nail, 4" | pc. | 1 |
| Anchor Bolts w/ nuts & washer 1/2"dia x 4" | pcs. | 4 |

D. Yoke Assembly

| | | |
|---|---|---|
| Flat Bar 3/16"x 1/2"x21 | pcs. | 2 |
| Cold Rolled Shaft 5/8"dia x 4" | pc. | 1 |
| Cap Screw w/ nuts & washer 3/8"diax3 1/2" | pc. | 1 |
| G.I. STD Tee, 3/8"dia | pc. | 1 |

E. Pipes, Cylinder & Screen

| | | |
|---|---|---|
| G.I. Pipes, sch. 40 w/ Coupling 2"dia x 20' | pcs. | 6 |
| 1 1/4"dia x 20' | pcs. | 6 |
| 3/8"dia x 20' | pcs. | 6 |
| Brass Cylinder w/o spring dog 1 13/16" I.D. | pc. | 1 |
| Brass Screen 1 1/4"dia x 12" | pc. | 1 |

F. Pea Gravel 3/8"dia* bags

G. Hauling Cost

I. Drilling Cost

120 ft. per ft.

H. Labor Cost

Fabrication(lump sum)
Unskilled (4 persons)
P50/day x 2 days
Skilled (1 person)
P70/day x 2 days

----------------------------------------

* - Optional, depending on ground formation

3.2.3 Type C (Refer to Fig. 5-03)

TABLE 5-05

| ITEM/DESCRIPTION | UNIT | QTY. | UNIT COST |
|---|---|---|---|
| A. Pump Base & Platform | | | |
| Cement, Portland | bags | 9 | |
| Def. Bars,3/8"x20' | pcs. | 8 | |
| Sand | cu.m. | 2 | |
| Gravel | cu.m. | 2 | |
| Tie Wire #16 | kilo | 1/2 | |
| CW Nail (assorted) | kilos | 2.0 | |
| Plywood,1/4"thick | pc. | 1 | |
| Form Lumber,2"x1.5"x12 | pcs. | 10 | |
| Teplon Tape, 1/2"dia | rolls | 4 | |
| B. BEAM & PIVOT ASSEMBLY | | | |
| Wooden Beam (Yakal), 2" x 6" 10' | bdf. | 10 | |
| Steel Plates, 1/4" x 6" x 24" | pcs. | 2 | |
| Cap Screw w/ nut & washer, 3/8"diax3" | pcs. | 5 | |
| Cold rolled shaft, 1 1/4"dia x 12" | pc. | 1 | |
| Anchor bolt w/ nut & washer, 1/2"dia x 8" | pcs. | 4 | |
| C. SPOUT & BASE PLATE | | | |
| G.I. Nipple | | | |
| 2"dia x 12' | pc. | 1 | |
| 1 1/4"dia x 12" | pc. | 1 | |
| Steel Plate, 1/2"x8"x8" | pcs. | 2 | |
| G.I. Tee Red 2"dia x 1 1/4"dia | pc. | 1 | |

| | | |
|---|---|---|
| G.I. Elbow, 1 1/4"diax90 | pc. | 1 |
| G.I. B. Red. | | |
| 2"dia x 3/4"dia | pc. | 1 |
| G.I. Coupling, Red 2"dia | pc. | 1 |
| PVC Male Adoptor,3/4"dia | pc. | 1 |
| Spring Wire, #6 x 4" | pc. | 1 |
| Concrete Nail, #4" | pc. | 1 |
| Anchor Bolts w/ nuts & | | |
| washer 1/2"dia x 6" | pcs. | 4 |

D. Yoke Assembly

| | | |
|---|---|---|
| Flat Bar | | |
| 3/16"x1 1/2"x22 1/2" | pcs. | 2 |
| Cold Rolled Shaft | | |
| 1/2"dia x 4" | pc. | 1 |
| Cap Screw w/ nuts & | | |
| washer 3/8"diax3 1/2" | pc. | 1 |
| G.I. STD Tee, 3/8"dia | pc. | 1 |

E. Pipes, Cylinder & Screen

| | | |
|---|---|---|
| sch. 40 w/ coupling | | |
| 2 1/2"dia x 20' | pcs. | 6 |
| 1 1/4"dia x 20' | pcs. | 6 |
| 3/8"dia x 20' | pcs. | 6 |
| Brass Cylinder, w/o | | |
| spring dog 2" I.D. | pc. | 1 |
| Brass Screen | | |
| 1 1/4"dia x 12" | pc. | 1 |

F. Drilling Cost

| | | |
|---|---|---|
| 120ft. | per ft. | |

| | | |
|---|---|---|
| G. Pea Gravel, 3/8"dia* | bags | |

H. Labor Cost

Fabrication (lump sum)
Unskilled (4 persons)
P50/day x 2 days
Skilled (1 person)
P70/day x 2 days

Total Cost of Drilling

| | |
|---|---|
| | ----------- |
| Labor & Materials | P |
| | =========== |

---

* - Optional, depending on ground formation

Duration

The right type of drilling equipment and method of construction should be considered by the engineer or planner in determining the timetable to be followed for the project construction. The selection on the type of drilling equipment and method of construction is based on the information gathered during the site investigation and other data taken from various water agencies and drilling contractors. The drilling period ranges from 30 feet per hour (for ordinary soil formations) to one foot per hour (for rocky formations).

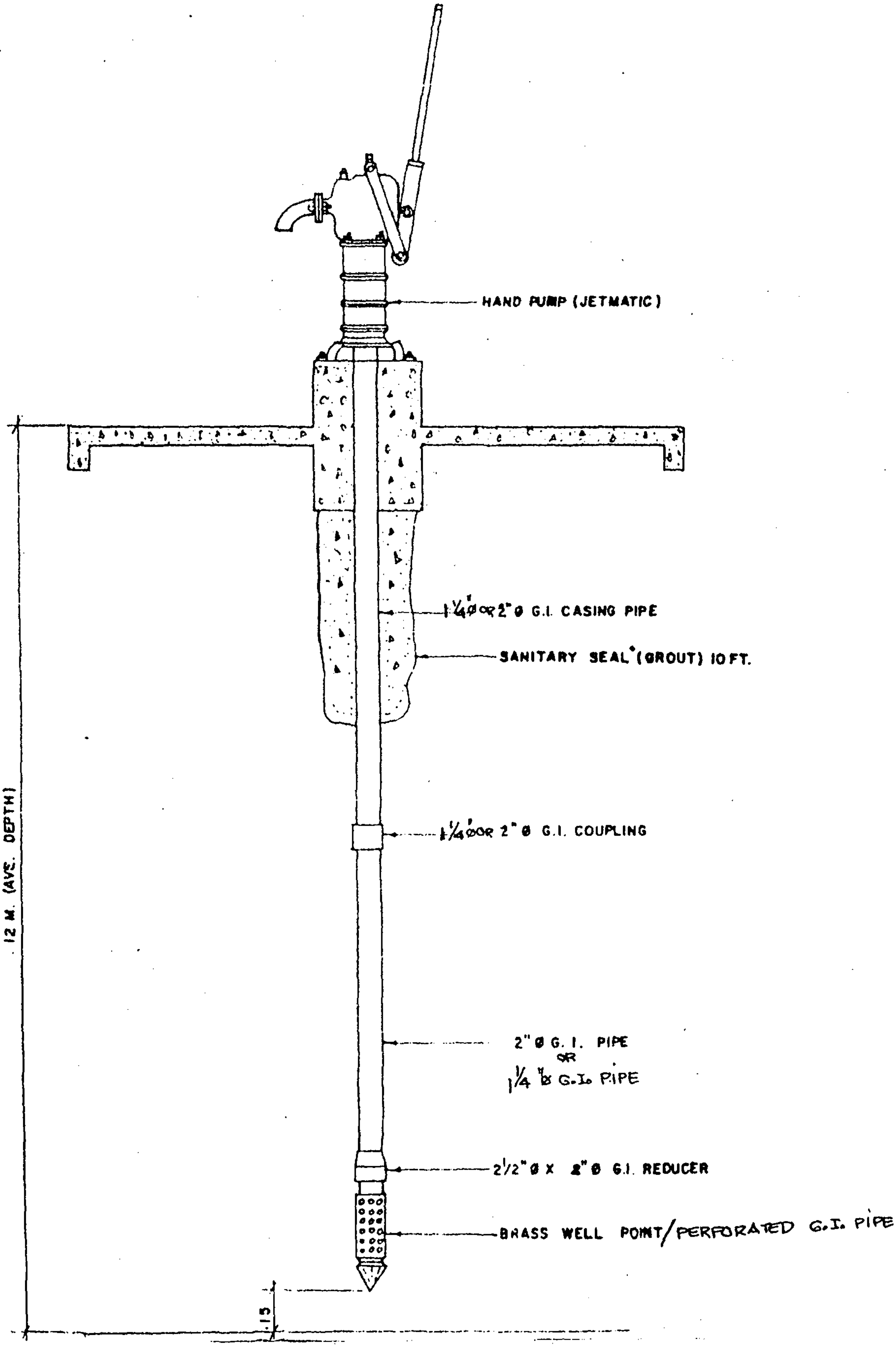



FIG. 5.01 TYPICAL WATER PUMP SYSTEM (SHALLOW WELL)

NOT DRAWN TO SCALE

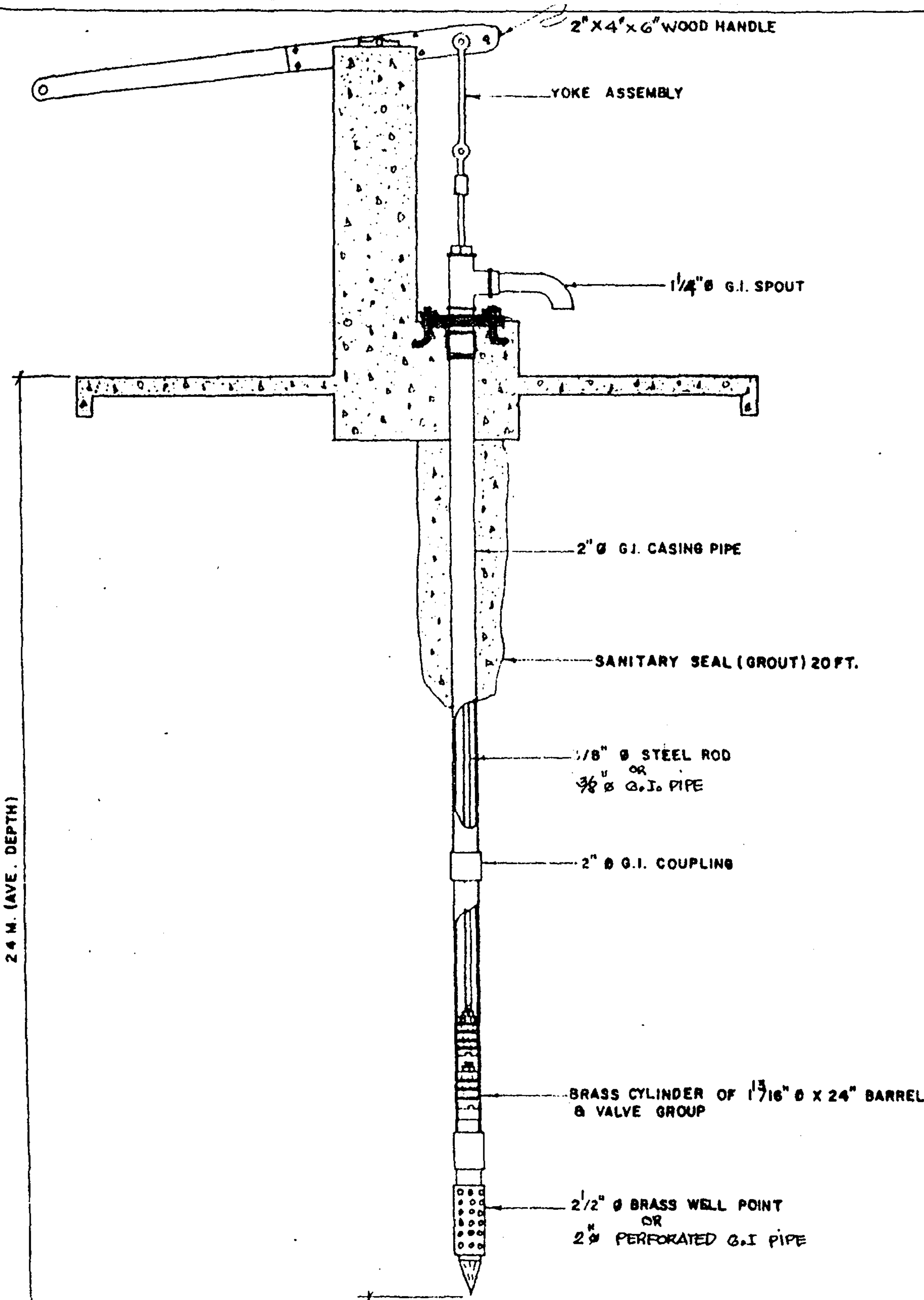



FIG. 5.02 TYPICAL WATER PUMP SYSTEM (DEEPWELL HIGH DUTY) TYPE A

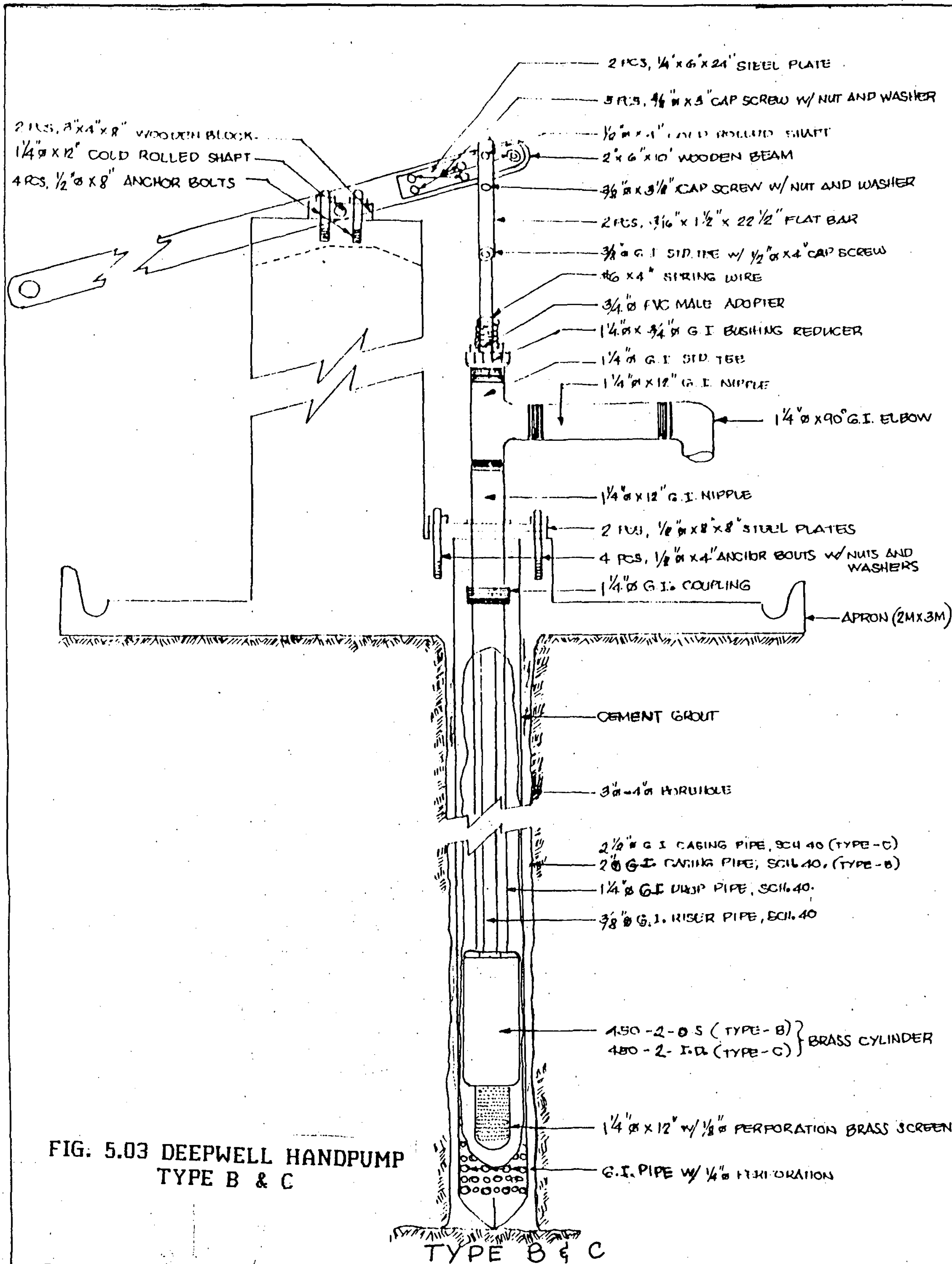



FIG. 5.03 DEEPWELL HANDPUMP
TYPE B & C

## B. SPRING DEVELOPMENT

### 1. Collection of Field Information

Basic data/information required for the detailed technical design of a spring development project are:

a) Topographic map of the area showing spring source and household distribution of the whole target service areas. Existing natural and man-made structures such as schools, churches and municipal halls, creeks, rivers, farms, marshland, canals , railroads and all other structures necessary for the design. Map must be drawn to scale from 1:1,000 to 1:5,000 and a contour interval of 2 meters.

b) Strip profile of proposed pipeline from spring source to proposed reservoir site and up for the farthest standpost. All lateral pipes coming from main distribution pipes should also be provided by this.

c) Actual flow of spring at source. Methods of measurement are discussed in Chapter II.

d) Present population of the target area.

e) Status of existing water system, if any. Conditions of the pipes and all parts of the system must be described thoroughly.

f) Canvass of all materials necessary for the project must be secured. Prices must indicate if it includes hauling/transport charges from supplier to site. Cost of transporting the materials must also be provided.

g) Availability, number and kind of skilled and unskilled laborers, steelmen, plumber and their tools at hand must also be known.

Items above can be secured in two ways. First, is to look for any available map at the municipal or provincial planning offices. Required scale may not be available, but any scale may be helpful, as you can reduce or expand as appropriate. Map may also be secured at the Bureau of Coast and Geodetic Survey (BCGS) at Binondo, Manila for a fee. The second alternative is to survey the area. Output of the survey activity will be both a topographic map and strip profile of pipeline.

### 2. Detailed Design Plan

Using the schematic diagram previously drawn, layout the pipelines, final location of reservoir and source. Indicate the diameter, length and type of pipes to be used, position of valves, public faucets and other fittings like reducer, elbows , tee, etc. in the plan. Detailed plan of standpost, spring box, reservoir and connection of special fittings, if any, must be properly illustrated.

Hydraulic analysis deals mainly with water pressure on pipes, either it is on rest or on motion. When water is not flowing, the pressure developed is equal to the difference in elevation of reservoir or source and the point being considered.

This is called Static Water Pressure. The significance of knowing the static water pressure of the water system is for the designer/engineer to know if the pipe could withstand the maximum pressure in the system.

Pressure at any particular point with a given quality of water flowing at that point is called dynamic water pressure. Dynamic water pressure varies all throughout the system due to the friction losses during the transport of water.

Friction loss is the loss of pressure caused by water flowing through the pipe in a system. Flow in pipe is usually turbulent and the roughness of the inside walls of pipes have a direct effect upon the amount of friction loss.

Friction loss is thus determined by the type, size and length of the pipe and the amount of water flowing through it.

Friction loss in plastic pipes and galvanized iron (G.I.) pipes can be estimated using Table 2-03. The information necessary to determine the pressure are the pipe size and the discharge rate.

In chapter 2 we already listed the pipe length, diameter and discharge. Our next step then is to compute for the headlosses of pipe for every section listed therein, using Table 2-03. Sum up the headlosses along the farthest faucet or critical path and compared it to the Static Water Head of the System. Static Water Head or Potential Head must be greater than or equal to 3.5m or 5 psi. In the event that the difference between the two is less than 3.5m, redesign the system by either increasing the diameter of the pipes or increasing elevation of the reservoir.

Sample Detailed Plan

Table 5.06 Project Summary Application DAta

I. GENERAL INFORMATION: Population Data

| | |
|---|---|
| ____________ | Present Pop. : ________ |
| Name of Asso. | No. of HH : ________ |
| | No. of HH to be served : ________ |
| ____________ | |
| Location | |
| | Level of Service : ________ |

## II. FEASIBILITY STUDY INFORMATION:

### A. Technical Data

1. Type of source _____
2. Type of system _____
3. Design Pop. _____
4. Total Average Daily Demand _____
5. No. of faucets _____
6. Storage tank capacity & type _____
7. Pump Discharge capacity _____
8. Pump Horsepower _____
9. Pumping time _____

### b: Financial Data

1. Cost of System_____
2. Amount Requested _____
3. Funding per HH _____
4. Local Equity _____
5. Type of local equity _____
6. Total monthly expenses _____
7. Monthly Fee per HH _____

## III. ORGANIZATION INFORMATION

1. Date group organized ______
2. Total No. of members ______
3. Potential No. of members ________

Table 5-07 Survey Form

### A. LOCATION

Barangay :__________ Province :____________
Municipality:__________ Region No.:____________

### B. GENERAL INFORMATION

1. Population _______________
2. No. of HH _______________
3. Distance from Poblacion _______________
4. Availability of electricity _______________
5. Distance from electric line _______________
6. Power cost per KWH _______________
7. Avalability of public transportation _______________
8. Main livelihood of residents_______________

### C. TECHNICAL INFORMATION

1. Are there reliable source of potable water?

_____ YES _____ NO

a. For wells

Well capacity : ____ gpm ____ lps
Casing Diameter: ____ in. ____ mm
Casing depth : ____ ft. ____ m
Water level from top of well:_______ ___ ft. ____ m
Location: _____ Within service area
_____ Outside _____ m from service area

( if no data is available on propsed well source, avail data of wells in the neighboring area)

b. For springs

Average dry season flow : ___ gpm ____ lps
Relative Elevation of Spring:

______ ft. _______ m. Above service area
______ ft. _______ m. Below service area

If spring is below service area, indicate distance nearest electric line ________ m.

Can the electric line be extended near the spring?

______ Yes ______ No

Location: ______ Within the service area
______ Outside ______ m.from service area

2. Are there water supply system materials and equipment (pumps, pipes, fittings) available in the barrio?

_____ Yes ______ No

For pumps : Type : ______ Power:_______ hp:______
For pipes : ____ G.I _____ PVC
____ Others, specify ______________

3. Is there an existing water tank that can be used?

_____ Yes _______ No
Type :_____ Steel ____ Reinforced concrete ____ others
Capacity : _____ Gallons _____ Liters
Location: (Please indicate in the map of the project area)

4. Are there sites where the water tank can be erected?

______ Yes _____ No
Location: (Please indicate in the map of the project

area)

Relative elevation with respect to
service area ____ ft. ______ m.

5. Does the barrio have skilled personnel?

_____ Yes ____ No

If yes, how many? Number

| | |
|---|---|
| Plumber | __________ |
| Mason | __________ |
| Carpenters | __________ |
| Others | __________ |

If no, are there competent contractor near the area?

| | | |
|---|---|---|
| Plumbing contractor | ____ Yes | ____ No |
| Tank fabricator | ____ Yes | ____ No |

6. Are there suppliers of materials ( pumps, pipes, fittings ) in the province?

____ Yes _____ No

Table 5-08 Design Criteria and Basic Design Plan

I. DESIGN CRITERIA

1. Design Period : 5 years
2. Population

| | |
|---|---|
| Annual Growth | : 3 % |
| Ave. HH Size | : 6 persons/HH |
| Design Population | : Present pop. x 1.16 |

3. Per capita water consumption

| | |
|---|---|
| Level I | : 20 - 40 lpcd |
| Level II | : 40 - 60 lpcd |

4. Water Demand

| | |
|---|---|
| Average Day Demand | : Des. Pop. x per capita comsumption |
| Maximum Day Demand | : 1.3 x Ave. Day Demand |
| Maximum Hour Demand | : 2.5 x Ave. Day Damand |

5. Pump Operation

| | |
|---|---|
| Pumping hours | : 8 - 15 hours |
| Pumping rate | : Max. Day demand / Pumping hours |

6. Storage Capacity : 1/4 of Ave. Day demand

7. System Pressure : 5 psi at the farthest faucet (for brgy. system)

8. HH served per faucet : 5-10 HH

II. BASIC DESIGN DATA (EXAMPLE)

| | | |
|---|---|---|
| 1. Present Population | | : 519 |
| 2. Des. Pop. (Present Pop. x 1.16) | | : 602 |
| 3. Ave. Day demand | 60 x 602 | : 32,120 lpd. |
| 4. Max. Day demand | 1.3 x 36,120 | : 46,956 lpd. |

Table 5.09 Design for Reservoir and Pump

A. DESIGN OF RESERVOIR

1. Determination of capacity of reservoir (Cr)
   Cr = 1/4 x Ave. day demand
   Cr = 1/4 Da (LPD)
   Cr = ____________
   Reservoir Dimension = _______ _______ ________
   Actual capacity = gallons

2. Determine minimum water elevation (WLM)
   WLM = total head loss + Minimum pressure in pipe(m)

   for barangay, minimum pressure = 5 psi (use 3m)

   for poblacion, minimum pressure = 10 psi ( use 7m)

   WLM = _______ m
   Bottom elevation of reservoir __________ m

B. DESIGN OF PUMP

1. T = Operating Time in seconds
   T = ______ sec.

2. Determine Pump capacity, Qp (lps)
   Qp = Max. Day demand (lpd) / Operating Time (sec.)
   Qp = 78 pd/t where pd = des. population
   Qp = ______ lps

3. Pumping level ______ Pump setting ______

4. Calculate Pump Total Dynamic Head (TDH) (m)

TDH = Depth of pumping level + Max. reservoir elevation + Friction loss

TDH = ________ m

5. Calculate Brake horsepower requirement:

$$\text{Brake Horsepower} = \frac{Qp \times TDH}{75 \times \text{efficiency}}$$

Where :

Efficiency for centrifugal pump = 40 - 60 %
Efficiency for submersible pump = 50 - 60 %
Efficiency for jetmatic pump = 20 - 30 %

Brake Horsepower = __________ hp

Table 5-10 Cost Summary

I. ESTIMATED COST OF THE SYSTEM

1. a) Cost of pipes P ________
   b) Cost of fittings ________

   Total cost of pipes & fittings P __________

2. Cost of spring box (existing) __________

3. Cost of tools __________

4. Labor cost __________

   a) 10% of pipes & fittings (for G.I pipes)
   b) 25% of pipes & fittings (for PVC pipes)

5. Cost of freight & handling __________

6. Contingencies 5% (pipes & fittings & labor) __________

   TOTAL COST OF SYSTEM P__________

II. FINANCIAL DATA

1. Total cost of the system P ___________
2. Local equity ___________
3. Amount requested ___________

Table 5.11 Bill of Materials

| QUANTITY | UNIT | DESCRIPTION | UNIT COST | TOTAL COST |
|---|---|---|---|---|
| | | I. G.I. PIPES SCH 40 | | |
| 8 | PCS | 13 mm Ø x 6 m | ฿ 159.90 | ฿ 1279.20 |
| 94 | PCS | 25 mm Ø x 6 m | 319.70 | 30,051.80 |
| 51 | PCS | 31 mm Ø x 6 m | 411.30 | 20,976.30 |
| 12 | PCS | 38 mm Ø x 6 m | 526.00 | 6,312.00 |
| 43 | PCS | 50 mm Ø x 6 m | 686.70 | 29,528.10 |
| 219 | PCS | 63 mm Ø x 6 m | 1,102.70 | 241,491.30 |
| | | | SUB - TOTAL | ฿ 329,638.70 |
| | | II G.I. FITTINGS | | |
| | | 1. COUPLING | | |
| 70 | PCS | 25 mm Ø | ฿ 9.00 | ฿ 630.00 |
| 37 | PCS | 31 mm Ø | 11.00 | 407.00 |
| 7 | PCS | 38 mm Ø | 14.00 | 98.00 |
| 33 | PCS | 50 mm Ø | 21.00 | 693.00 |
| 173 | PCS | 63 mm Ø | 31.00 | 5363.00 |
| | | 2. UNION PATENTE | | |
| 15 | PCS | 25 mm Ø | ฿ 18.50 | ฿ 277.50 |
| 6 | PCS | 31 mm Ø | 20.50 | 123.00 |
| 1 | PC | 38 mm Ø | 29.00 | 29.00 |
| 7 | PCS | 50 mm Ø | 42.50 | 297.50 |
| 37 | PCS | 63 mm Ø | 63.00 | 2,331.00 |
| | | 3. STANDARD TEE | | |
| 1 | PC | 31 mm Ø | ฿ 14.30 | ฿ 14.30 |
| 1 | PC | 50 mm Ø | 42.00 | 42.00 |
| | | 4. TEE REDUCER | | |
| 5 | PCS | 31 mm x 13 mm Ø | ฿ 17.50 | ฿ 87.50 |
| 1 | PC | 31 mm x 25 mm Ø | 18.00 | 18.00 |
| 1 | PC | 38 mm x 13 mm Ø | 19.20 | 19.20 |
| 2 | PCS | 38 mm x 25 mm Ø | 23.50 | 47.00 |
| 5 | PCS | 63 mm x 13 mm Ø | 53.60 | 268.00 |
| | | 5. BUSHING REDUCER | | |
| 3 | PCS | 31 mm x 25 mm Ø | ฿ 15.50 | ฿ 46.50 |
| 2 | PCS | 38 mm x 31 mm Ø | 17.80 | 35.60 |
| 2 | PCS | 50 mm x 38 mm Ø | 27.50 | 55.00 |
| 1 | PC | 63 mm x 50 mm Ø | 37.50 | 37.50 |
| | | 6. ELBOW STANDARD 45° | | |
| 2 | PCS | 25 mm Ø | ฿ 12.30 | ฿ 24.60 |
| 5 | PCS | 50 mm Ø | 32.50 | 162.50 |
| 16 | PCS | 63 mm Ø | 41.50 | 664.00 |
| | | 7. ELBOW STANDARD 90° | | |
| 26 | PCS | 13 mm Ø | ฿ 4.70 | ฿ 122.20 |
| 1 | PC | 63 mm Ø | 41.50 | 41.50 |
| | | | | |
| | | | | |

Table 5.12 Bill of Materials

| QUANTITY | UNIT | DESCRIPTION | UNIT COST | TOTAL COST |
|---|---|---|---|---|
| | | 8. ELBOW REDUCER | | |
| 6 | PCS | 25 mm x 13 mm Ø | ₱ 12.60 | ₱ 75.60 |
| | | 9. BRASS FAUCET | | |
| 17 | PCS | 13 mm Ø | ₱ 34.50 | ₱ 586.50 |
| | | 10. NIPPLE | | |
| 1 | PC | 31 mm Ø x 100 mm | ₱ 12.00 | ₱ 12.00 |
| 1 | PC | 38 mm Ø x 100 mm | 14.50 | 14.50 |
| | | 11. GATE VALVE | | |
| 2 | PCS | 38 mm Ø | ₱ 320.00 | ₱ 640.00 |
| 2 | PCS | 63 mm Ø | 460.00 | 920.00 |
| | | 12. PLAIN COAT | | |
| 5 | CANS | | ₱ 150.00 | ₱ 750.00 |
| 45 | PCS | 13. TEFLON TAPE | ₱ 7.50 | ₱ 337.50 |
| | | | SUB - TOTAL | ₱ 15,270.50 |
| | | III RESERVOIR / SPRING BOX | | |
| | | 450 GALS / CAP EXISTING | | |
| | | SPRING BOX | ₱ 20.00/GAL | ₱ 9,000.00 |
| | | IV TOOLS | | |
| | | 1. PIPE WRENCH | | |
| | | 13" RIDGID, STRAIGHT | | |
| 2 | PCS | PIPE WRENCH | ₱ 682.00 | ₱ 1,364.00 |
| | | 2. RATCHET PIPE THREADER | | |
| | | № 12-R, RIDGID | | |
| 1 | SET | 1/2" THRU 2" Ø | ₱ 13,827.00 | ₱ 13,827.00 |
| | | | SUB - TOTAL | ₱ 15,191.00 |

Table 5.13 Design of pipe lines

| SECT'N | NODES | | SECTION LENGTH (m) | HH SERVED | PEAK-FLOW lps | PIPE DIA mm | HEAD LOSS per 100 m | ACTUAL HEAD-LOSS | REM |
|---|---|---|---|---|---|---|---|---|---|
| | From | To | | | | | | | |
| a | 1 | 2 | 222 | 6 | 0.07 | 25 | 0.26 | 0.58 | |
| b | 2 | 4 | 24 | 11 | 0.13 | 31 | 0.34 | 0.08 | |
| c | 3 | 4 | 24 | 4 | 0.05 | 25 | 0.14 | 0.03 | |
| d | 4 | 7 | 60 | 15 | 0.18 | 31 | 0.54 | 0.33 | |
| e | 5 | 7 | 24 | 3 | 0.04 | 25 | 0.10 | 0.02 | |
| f | 6 | 7 | 18 | 5 | 0.06 | 25 | 0.20 | 0.04 | |
| g | 7 | 8 | 18 | 23 | 0.28 | 38 | 0.46 | 0.08 | |
| h | 8 | 15 | 18 | 27 | 0.33 | 38 | 0.62 | 0.11 | |
| i | 9 | 10 | 156 | 4 | 0.05 | 25 | 0.14 | 0.22 | |
| j | 10 | 11 | 72 | 9 | 0.11 | 31 | 0.22 | 0.16 | |
| k | 11 | 14 | 12 | 13 | 0.16 | 31 | 0.44 | 0.05 | |
| l | 12 | 13 | 90 | 4 | 0.05 | 25 | 0.14 | 0.13 | |
| m | 13 | 14 | 120 | 9 | 0.11 | 31 | 0.22 | 0.26 | |
| n | 14 | 15 | 30 | 27 | 0.33 | 38 | 0.62 | 0.19 | |
| o | 15 | 16 | 246 | 54 | 0.65 | 50 | 0.57 | 1.40 | |
| p | 16 | 17 | 108 | 60 | 0.72 | 63 | 0.23 | 0.25 | |
| q | 17 | 18 | 198 | 67 | 0.81 | 63 | 0.28 | 0.55 | |
| r | 18 | 19 | 210 | 73 | 0.88 | 63 | 0.32 | 0.67 | |
| s | 19 | 20 | 276 | 80 | 0.97 | 63 | 0.39 | 1.08 | |
| t | 20 | 21 | 462 | 86 | 1.04 | 63 | 0.44 | 2.04 | 204 |
| | | | | | | | | | |
| | | | | HEAD LOSS FROM THE FARTHEST FAUCET = <br> MINIMUM PRESSURE = | | | | 7.17 m <br> 3.00 m <br> 10.17 m | |

Table 5.14 Design of pipe lines

| SECT'N | NODES | | SECTION LENGTH (m) | HH SERVED | PEAK-FLOW lps | PIPE DIA mm | HEAD-LOSS per 100 m | ACTUAL HEAD-LOSS | R E M |
|---|---|---|---|---|---|---|---|---|---|
| | From | To | | | | | | | |
| a | 1 | 2 | 222 | 6 | 0.07 | 25 | 0.26 | 0.58 | |
| b | 2 | 4 | 24 | 11 | 0.13 | 31 | 0.34 | 0.08 | |
| c | 3 | 4 | 24 | 4 | 0.05 | 25 | 0.14 | 0.03 | |
| d | 4 | 7 | 60 | 15 | 0.18 | 31 | 0.54 | 0.33 | |
| e | 5 | 7 | 24 | 3 | 0.04 | 25 | 0.10 | 0.02 | |
| f | 6 | 7 | 18 | 5 | 0.06 | 25 | 0.20 | 0.04 | |
| g | 7 | 8 | 18 | 23 | 0.28 | 38 | 0.46 | 0.08 | |
| h | 8 | 15 | 18 | 27 | 0.33 | 38 | 0.62 | 0.11 | |
| i | 9 | 10 | 156 | 4 | 0.05 | 25 | 0.14 | 0.22 | |
| j | 10 | 11 | 72 | 9 | 0.11 | 31 | 0.22 | 0.16 | |
| k | 11 | 14 | 12 | 13 | 0.16 | 31 | 0.44 | 0.05 | |
| l | 12 | 13 | 90 | 4 | 0.05 | 25 | 0.14 | 0.13 | |
| m | 13 | 14 | 120 | 9 | 0.11 | 31 | 0.22 | 0.26 | |
| n | 14 | 15 | 30 | 27 | 0.33 | 38 | 0.62 | 0.19 | |
| o | 15 | 16 | 246 | 54 | 0.65 | 50 | 0.57 | 1.40 | |
| p | 16 | 17 | 108 | 60 | 0.72 | 63 | 0.23 | 0.25 | |
| q | 17 | 18 | 198 | 67 | 0.81 | 63 | 0.28 | 0.55 | |
| r | 18 | 19 | 210 | 73 | 0.88 | 63 | 0.32 | 0.67 | |
| s | 19 | 20 | 276 | 80 | 0.97 | 63 | 0.39 | 1.08 | |
| t | 20 | 21 | 462 | 86 | 1.04 | 63 | 0.44 | 2.04 | |
| | | | | | | | | | |
| | | | | HEADLOSS FROM THE FARTHEST FAUCET = MINIMUM PRESSURE = | | | | 7.17 m<br>3.00 m<br>10.17 m | |

Table 5.15 Fittings Schedule (G.I. Pipes)

| NODES/ SECT'N | TEE STANDARD | TEE REDUCER | CROSS TEE | BUSHING REDUCER | ELBOW STANDARD | ELBOW REDUCER | COUPLING REDUCER | FAUCET | NIPPLE | VALVE | REMARK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-2 | | | | 31 x 25 mm | 13 mm x 90° | 25 x 13 mm | | 13 mm BF | | | |
| | | | | | 25 mm x 45° | | | | | | |
| | | | | | 25 mm x 45° | | | | | | |
| 2-4 | | 31 x 13 mm | | | 13 mm x 90° | | | 13 mm BF | | | |
| | | | | | 13 mm x 90° | | | | | | |
| 3-4 | | | | | 13 mm x 90° | | | 13 mm BF | | | |
| | | | | | 13 mm x 90° | 25 x 13 mm | | | | | |
| 4-7 | | 31 x 25 mm | | 38 x 31 mm | | | | | | | |
| 6-7 | | | | | | 25 x 13 mm | | 13 mm BF | | | |
| | | | | | 13 mm x 90° | | | | | | |
| 5-7 | | | | | | 25 x 13 mm | | 13 mm BF | | | |
| | | | | | 13 mm x 90° | | | | | | |
| 7-8 | | 38 x 25 mm | | | 38 mm x 90° | | | | 38 x 100 mm | | |
| | | 38 x 25 mm | | | | | | | | | |
| 8-15 | | 38 x 13 mm | | 50 x 38 mm | 13 mm x 90° | | | 13 mm BF | | 38 mm GV | |
| | | | | | 13 mm x 90° | | | | | | |
| 9-10 | | | | 31 x 25 mm | 13 mm x 90° | 25 x 13 mm | | 13 mm BF | | | |
| 10-11 | | 31 x 13 mm | | | 13 mm x 90° | | | 13 mm BF | | | |
| | | | | | 13 mm x 90° | | | | | | |
| 11-14 | | 31 x 13 mm | | | 13 mm x 90° | | | 13 mm BF | | | |
| | | | | | 13 mm x 90° | | | | | | |
| 12-13 | | | | 31 x 25 mm | 13 mm x 90° | 25 x 13 mm | | 13 mm BF | | | |
| 13-14 | | 31 x 13 mm | | 38 x 31 mm | 13 mm x 90° | | | 13 mm BF | | | |
| | | | | | 13 mm x 90° | | | | | | |
| 14-15 | 31 mm | 31 x 13 mm | | 50 x 38 mm | 13 mm x 90° | | | 13 mm BF | 31 x 100 mm | 38 mm GV | |
| | | | | | 13 mm x 90° | | | | | | |
| 15-16 | 50 mm | | | 63 x 50 mm | 50 mm x 45° | | | | | | |
| | | | | | 50 mm x 45° | | | | | | |
| | | | | | 50 mm x 45° | | | | | | |
| | | | | | 50 mm x 45° | | | | | | |
| | | | | | 50 mm x 45° | | | | | | |
| 16-17 | | 63 x 13 mm | | | 63 mm x 45° | 13 mm E 90° | | 13 mm BF | | | |
| | | | | | 63 mm x 45° | 13 mm E 90° | | | | | |

Table 5.16 Fittings Schedule (G.I. Pipes)

| NODES/ SECT'N | TEE STANDARD | TEE REDUCER | CROSS TEE | BUSHING REDUCER | ELBOW STANDARD | ELBOW REDUCER | COUPLING REDUCER | FAUCET | NIPPLE | VALVE | REMARK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 17-18 | | 63 x 13 mm | | | 63 mm x 45° | 13mm E 90° | | 13mm BF | | | |
| | | | | | 63 mm x 45° | 13mm E 90° | | | | | |
| 18-19 | | 63 x 13 mm | | | 63 mm x 45° | 13mm E 90° | | 13 mm BF | | | |
| | | | | | 63mm x 45° | 13 mm E 90° | | | | | |
| | | | | | 63 mm x 45° | | | | | | |
| 19-20 | | 63 x 13mm | | | 63 mm x 45° | 13mm E 90° | | 13mm BF | | | |
| | | | | | 63 mm x 45° | 13 mm E 90° | | | | | |
| 20-21 | | 63 x 13 mm | | | 63 mm x 45° | 63mm E 90° | | 13 mm BF | | 63mm GV | |
| | | | | | 63 mm x 45° | 63 mm E 45° | | | | 63mm GV | |
| | | | | | 63 mm x 90° | 63 mm E 45° | | | | | |
| | | | | | 63 mm x 45° | 63 mm E 45° | | | | | |

Table 5.17 Pipe Schedule

| DIA of PIPES | SEC | SECT'N LENGTH | PIPES REQ'D. | ACTUAL NO. of PIPES REQ'D | ADDTN'L PIPES | TOTAL NO. of PIPES | COUPLING REQ'D | UNION PATENTE |
|---|---|---|---|---|---|---|---|---|
| 25 mm | a | 222 m | | 37 | | 37 | 30 | 6 |
| 31 mm | b | 24 m | | 4 | | 4 | 3 | |
| 25 mm | c | 24 m | | 4 | | 4 | 3 | |
| 31 mm | d | 60 m | | 10 | | 10 | 8 | 1 |
| 25 mm | e | 24 m | | 4 | | 4 | 3 | |
| 25 mm | f | 18 m | | 3 | | 3 | 2 | |
| 38 mm | g | 18 m | | 3 | | 3 | 2 | |
| 38 mm | h | 18 m | | 3 | | 3 | 2 | |
| 25 mm | i | 156 m | | 26 | | 26 | 20 | 5 |
| 31 mm | j | 72 m | | 12 | | 12 | 9 | 2 |
| 31 mm | k | 12 m | | 2 | | 2 | 1 | |
| 25 mm | l | 90 m | | 15 | | 15 | 12 | 2 |
| 31 mm | m | 120 m | | 20 | | 20 | 16 | 3 |
| 38 mm | n | 30 m | | 5 | | 5 | 3 | 1 |
| 50 mm | o | 246 m | | 41 | | 41 | 33 | 7 |
| 63 mm | p | 108 m | | 18 | | 18 | 14 | 3 |
| 63 mm | q | 198 m | | 33 | | 33 | 26 | 6 |
| 63 mm | r | 210 m | | 35 | | 35 | 29 | 5 |
| 63 mm | s | 276 m | | 46 | | 46 | 38 | 7 |
| 63 mm | t | 462 m | | 77 | | 77 | 64 | 12 |
| | | | | | | | | |
| | | | | | | | | |

3. Project Cost

The cost of the system will be determined by the bill of quantities plus cost of labor to construct the system. The system is said to be financially and economically viable if it has a per capita cost of P250 - P300 based on the Total Project Cost (TPC).

- Bill of Quantities

  The first step to determine the cost of the system is to make the bill of materials. To avoid confusion and missing out some items in the preparation, it is suggested that the system be divided into concrete work and pipe work. Concrete work will be composed of spring box, reservoir valve boxes and splush box for the standpost. Pipeworks will be pipes and fittings and valves for trasnmission and distribution lines.

- Canvass of Material

  In order to have a reasonable unit price of each, get a price/quotation from supplier/manufacturers of the listed materials in the bill of quantities. If the quantity is not large enough to attract suppliers to submit quotation, you could still get a good price by inquiring unit price from supplier through telephone or by personally giving them the canvass form. Do not rely on one supplier only. Canvass should be at least from three suppliers/manufacturers.

- Price Escalation

  If the project is not for immediate implementation, then an escalation price of approximately 5-10% of the prevailing cost per annum should be added to the estimates. This cost must be built-in per item unit cost and must not be shown as "Contingency Cost".

- Labor

  Labor for our purpose will be counterpart of the beneficiaries. It is the experience of Tulungan sa Tubigan Foundation, Inc. that involving beneficiaries in the construction of their water system develops a sense of responsibility among them, thus operation and maintenance of the system will not be a problem.

  However, for the purpose of quantifying their counterpart, the following figures are suggested for estimating the labor cost.

  concrete works - 30% of materials
  pipelines (G.I.) - 5%-10% of materials
  pipelines (PVC) - 15%-20% of materials, dependent on the depth and soil type to be excavated

## C. RAINWATER CATCHMENT

### 1. Collection of Field Information

Before constructing a cistern or storage tank, site investigation must be initiated to gather information needed.

Selection of a Site. Special consideration should be given to the selection of tank sites. The following factors should be taken into account :

- The site shoud not hinder future extension of the house.
- The site should be located near the roof gutter.
- In places where piles are to be used, ground should not be low-lying or soft.
- The site should not be near any latrine.
- The roof of the house should be of corrugated iron, or tiles, and locally available materials.

Water Consumption. It is important to know the number of households, average number of person per household and their maximum water demand per day in order to determine the size of the tank. In the household, water is used for drinking , cleaning, cooking and personal hygiene only.

Availability of Water. For a roof catchment to be worthwhile, there must be sufficient rainfall. The amount and monthly distribution of annual rainfall for the area can be obtained from PAGASA or any local weather station (airport, agricultural farms, etc.) within the vicinity. This data will help in planning for storage capacity during the dry months. Another important source of the longest period of drought in the area are the farmers or local inhabitants who have been staying in the area for many years.

Catchment Area. Roof catchment can only be used where roofing materials are suitable. Do not plan to develop rain catchment on thatched, painted or lead roofs. A plan of the roof catchment system with all measurements is necessary. For pre-existing houses, check the roof structure for strength. If the structure appears weak, it should be changed or reinforced. The effective roof area for collecting water is not the roof area itself but the ground area covered by the roof.

Availability of Resources. It is necessary also to compile a resource inventory of local skills, materials and experience which can be used in rainwater roof catchment system. Materials which are easy to obtain by local people who know how to work with the materials will result in a roof top system that is cheap and simple to build and repair. An appropriate resource inventory check list includes availability and cost of materials and construction skills.

Eventually, the community members will decide if they are willing to participate in the project and the amount of time and money households is willing to commit to the project.

2. Engineering Design

After seeing the basic data we can now plan for adequate storage and design the most appropriate type of storage facility.

Tank Size Determination. The design stage of the project involves sizing storage tank. There are a number of methods that can be used to determine tank volume.

One of a more accurate methods of sizing a tank involves an analysis of data using the mass curve technique. Successful use of the technique requires approximately 10 years of rainfall data.

First, an approximation of the run-off coefficient is required. Some rainwaters will be lost during collection. This amount is represented as a fraction called the run-off coefficient: (amount of run-off entering the tank)/(rain falling on roof).

The average annual rainfall and the collecting area determine the amount of water which can be collected. One millimeter of rain falling on one square meter of roof will yield 0.7 to 0.9 liters of water depending on the type of roof. If you are unsure of the run-off coefficient, it is safer to use a low value such as .75 or .80 rather than a high one.

For example, if the annual rainfall is 2,360 mm and the available collecting surface has the dimension of 5 x 10 meters, the amount of water which can be collected in a year is equal to :

2,360 mm x 0.8 l/m /mm x 5 m x 10 m = 94,400 liters

Volume of Water Available from a Roof Catchment

For a family of six, each person would be able to use 14-20 liters of water per day. During some months, more than 2,400 liters will be available, while during the dry months, no rain may fall at all. Cistern will be needed to ensure adequate storage during the dry months.

To calculate the amount of water available from the catchment: Assume rainfall of 750 mm per year with roof area of 6m x 8m or 48 sq. m.

1. Multiply annual rainfall by the catchment area.

   750 mm x 48 $m^2$ = 36,000 liters/year

2. Multiply this product by 80 percent. Not all water will be available because of losses due to evaporation and runoff that

does not flow into the gutters. To be safe, figure a 20% loss for rain catchment.

36,000 liters/year x .80 = 28,800 liters/year

3. Divide the total by 12 to get average monthly rainfall.

$$\frac{28{,}800 \text{ liters/day}}{12 \text{ months/year}} = 2{,}400 \text{ liters/mo.}$$

4. Divide again by 30 to determine liters per day.

$$\frac{2{,}400 \text{ liters/mo}}{30 \text{ days/month}} = 80 \text{ liters/day}$$

Rainfall Storage in a Cistern

Rainwater needs to be collected and stored if for drinking. In order to plan for adequate storage and design the most appropriate type of storage facility data on the following items should be collected:

- amount of monthly rainfall
- potential rainfall supply, available each month
- the amount of water likely to be consumed by the family

With this information, the size of the cistern can be estimated.

Data on average monthly rainfall can be acquired from a national weather agency, the military or an airport. Data for a specific location may not be available, but regional data can be used for an estimate.

The potential available water supply depends on the amount of rainfall and catchment surface area. If a catchment area has a length of 8m and a width of 6m, the area of the catchment is 8m x 6m or $48m^2$. To determine the available water, multiply the monthly rainfall figures by $48m^2$ and then by 0.8, a loss factor which takes into a account water that does not make it to storage from the catchment area. For example, using January rainfall figures, the total amount of water available to the familiy is 8678 liters. This amount is arrived at using the following:

Volume of water = Catchment area x rainfall x 0.8
Volume = $48^2$ x 226mm x 0.8
Volume = 8678 liters

Remember that these are average estimates that will differ with cyclical climatic changes. Each number is arrived at by taking the average monthly rainfall figure and using it in the above equation.

After this, the steps that should be undertaken are the following. First, graph the cumulative available rainfall from a catchment throughout the year. The graph represents the amount of rainfall run-off available from a catchment throughout the year. The heights of the bars are determined by adding a particular month's average rainfall to the sum of the rainfall for the previous months. For example, April shows a cumulative run-off of 24,306 liters which is the sum of the run-off for January, February, March and April.

Secondly, a diagonal line representing yearly demand is drawn. The line assumes that people will use the same quantity of water each month, although generally greater quantities are used in the wet season and much less in the dry. The demand line should touch only one point on the run-off curve. It is the greatest distance between the demand line and the run-off curve. This amount of storage should be provided to ensure that water is available throughout the year at this level of consumption.

In this, the yearly demand for water is 31,000 liters and average of approximately 2,600 liters per month, or 87 liters per day per family. In order to supply a family with 87 liters per day throughout the entire year, a cistern or storage jar with a 16.5-17$m^3$ (16,500-17,000 liter) capacity would be needed. Unless inexpensive ferrocement storage jars are constructed of a cistern of such a large volume would be beyond the means of most families. A smaller structure would be designed instead. With a smaller cistern, water use during the dry season would have to be restricted to the essential minimum of drinking and some cooking.

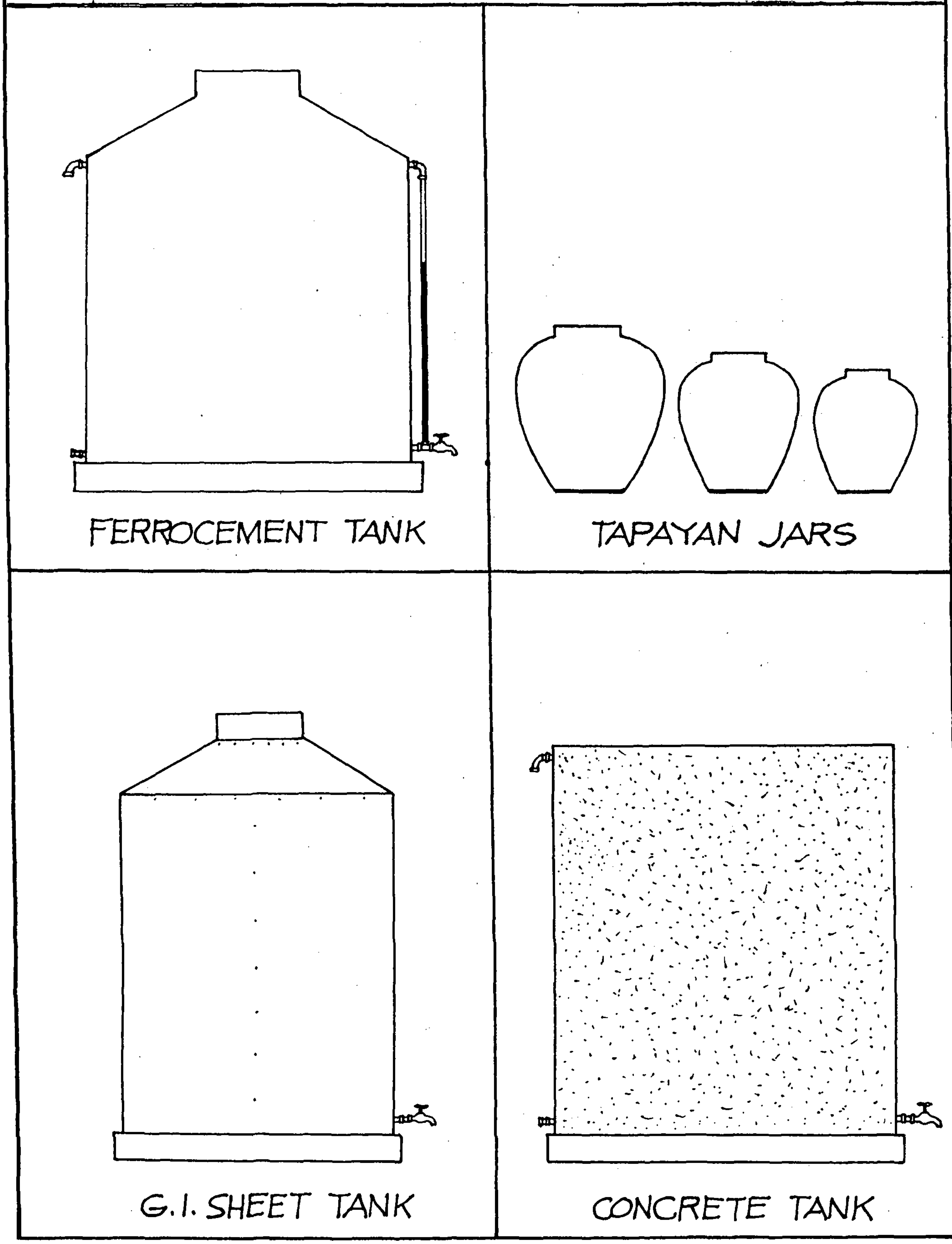
Ideally, cisterns and storage jars should be large enough to store water for the entire year. Where economic conditions prevent this, special measures, like the use of storage jars, should be taken. Water should be collected during the rainy season and stored for use during the dry season. Special care should be taken to prevent water loss through evaporation. When planning a cistern or storage reservoir, attempt to build a cistern either of adequate volume or as close to the desired volume as economic resources permit. This is necessary when no other water source of suitable quantity, quality, accessibility or reliability is available.

Types of Storage Tank

There are several types of tank that can be used to store rainwater (refer to fig. 5-04). Each has its own advantages and disadvantages in terms of construction methods, material costs and labor requirements.

- Cement Mortar Jars - these jars were first used in Thailand and their use has spread to Southeast Asia and Africa. In the construction process, cement mortar is plastered around a jar shaped mold. The mold usually constructed from a cloth sacking filled with rice husks, saw dust or vegetable wastes, others use clay mound

# FIG. 5-04 DIFFERENT TYPES OF STORAGE TANK



jars have volume that ranges from 200 to 1,000 liters 300, 600 and 1,000 litres.

- Ferrocement Tanks - The main advantage of ferrocement tank is that they use commonly available materials such as cement, sand and gravel, water and wiremesh. Simple skills are usually all that is required, so users of the tank can help with the construction process with use of the basic hand tools. For these reasons ferrocement tanks are a suitable technology for low-income rural areas. Ferrocement tank is cheaper than other tank construction materials such as galvanized metal and has proven to be more durable. Reports of ferrocement tanks with over 25 years of service are not uncommon. Ferrocement techniques also require less total material than conventional concrete tanks. Minimum thickness of walls is 2 cm. for 1 meter high tank, and 4 cms. for a 2 meter high tank (refer to Fig. 5-05).

- Sheet Metal Tanks - These tanks have been used for many years in many areas. However the cost of these tanks is high. Another disadvantage is that the corrugated metal from which these tanks are made may not last longer than five years in damp climate, even though they may be galvanized.

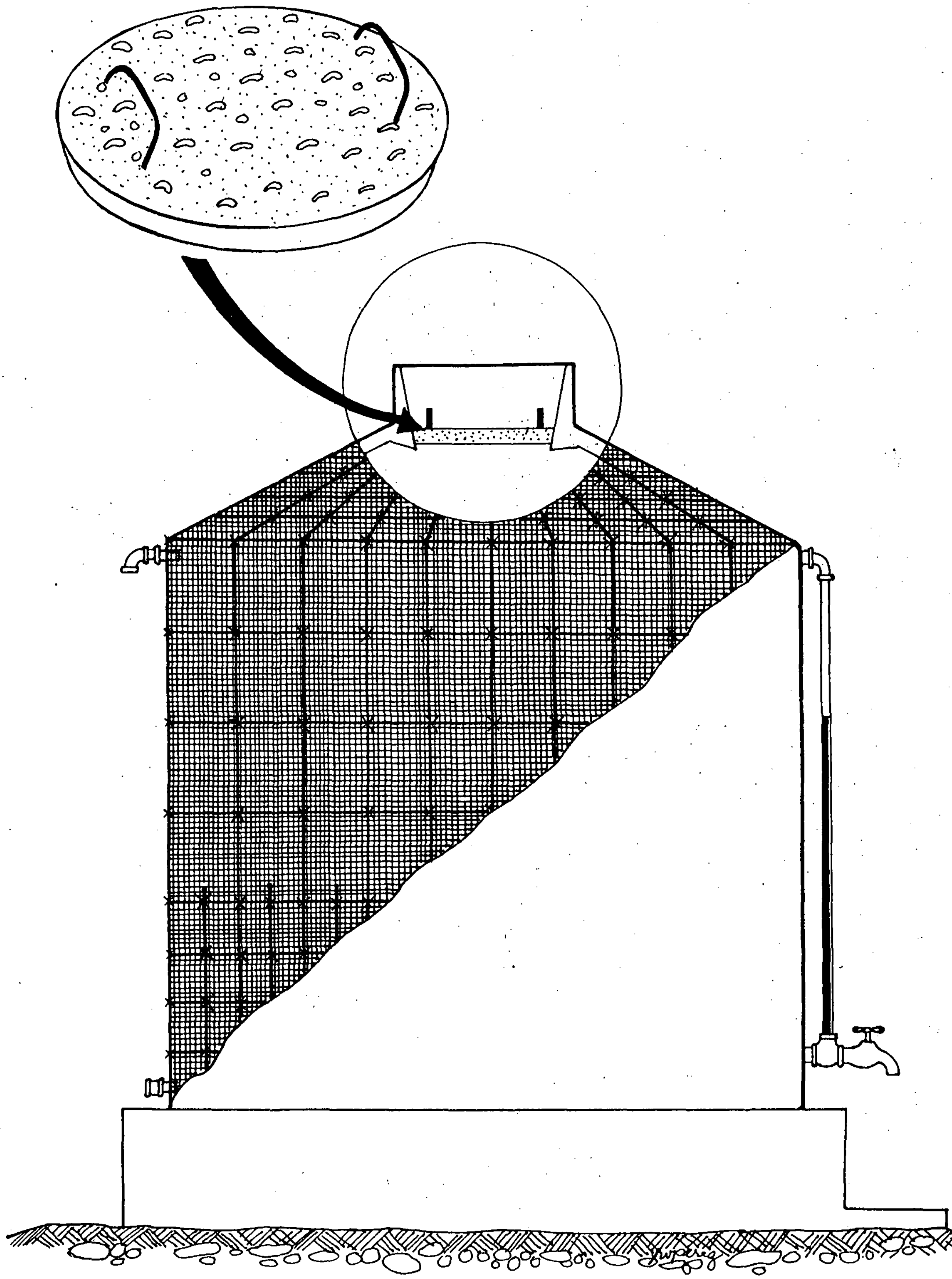
- Reinforced Concrete Tanks - Steel and bamboo reinforcing has been used in many areas for large tank construction. Reinforced Concrete Tanks uses locally available materials and construction skills are highly recommended for durability and reliability.

The following table compares the different types of tanks.

TABLE 5-18 Different Types of Tanks

| TANK TYPE | MATERIAL COST | DURABILITY | REMARKS | TECHNOLOGY REQUIREMENT |
|---|---|---|---|---|
| 1. Cement Mortar Jars (Tapayan) | P500-600 | Temporary (5-10 years | Water good quality For smaller capacity only. | No special skills indeed |
| 2. Ferrocement Tanks | 1600-2000 | Permanent (25-50 years) | Water good quality | Special skills not needed |
| 3. Sheet Metal Tanks | 6000-10000 | Temporary | Prone to rust. Water may be contaminated. | Special skills needed |
| 4. Reinforced Concrete | 8000-12000 | Permanent (25-50 years) | Water good quality | Special skills needed |

# FIG. 5-05 FERROCEMENT TANK



Useful Definitions:

1. Cistern - a storage tank for water

2. Foul Flush - the first run-off from a roof after a rainfall

3. Catchment - a surface from which rainfall run-off is collected. Common catchments are roofs and ground areas.

4. Overflow - the flow of water over a structure.

5. Watersheds - the area of ground over which rainfall flows into the bodies of surface water.

6. Ferrocement - economical and simple to use made of reinforced concrete, wire mesh, sand, water and cement.

7. Average Monthly Rainfall (mm) - The total amount of rainfall should start at the beginning of a rainy season.

8. Monthly Supply (liters) - It is the rainfall multiplied by the runoff coefficient and the catchment area.

9. Cummulative Supply (liters) - The total supply coefficient since the first month.

10. Monthly Demand (liters) - It is constant based on 50 liters/day consumption/person, although it could change from month to month.

11. Monthly Amount Stored (liters) - This is monthly supply minus monthly demand. It can be positive or negative. Positive numbers means the tank is filling, while negative numbers indicate water is being taken out of the tank.

12. Total Amount Stored (liters) - This is the cumulative sum of the monthly stored.

13. Required Tank Volume - The least amount stored during the dry season is subtracted from the largest amount stored during the wet season. The difference represents the storage required for that particular year. The difference between the largest and least amounts stored/year is calculated. The largest difference yields the tank size.

3. Cost Estimates

The most commonly used types of storage tanks for rainwater catchment are the reinforced concrete, hollow blocks, and galvanized iron. Special type of technologies is being adopted by TSTF in most of its rainwater catchment projects. These are the ferrocement, interlocking blocks and cement water jars (or Thai jars).

Ferrocement tank costs about P1.30 to P1.50 per liter while cement water jar is about P0.20 to .30 per liter (1989 prices). The following are some of the materials in approximating the cost of constructing water tanks.

TABLE 5-19

REINFORCED CONCRETE TANK
Bill of Materials
Class "A" no.( 1:2:4 mix)

| ITEMS | Unit | Capacity in gallons | | | | | |
|---|---|---|---|---|---|---|---|
| | | 5,000 | 6,000 | 7,050 | 9,000 | 10,000 | 12,000 |
| Capacity, liter | liter | 8,340 | 9,460 | 1,102 | 1,250 | 1,440 | 1,534 |
| Capacity, gallon | m. | 5,000 | 6,000 | 7,050 | 9,000 | 10,000 | 12,000 |
| Height, m | m. | 3.0 | 3.0 | 3.6 | 3.6 | 3.6 | 3.8 |
| Length | m. | 2.4 | 2.7 | 3.0 | 3.0 | 3.3 | 3.6 |
| Width | m. | 2.4 | 2.7 | 3.0 | 3.0 | 3.3 | 3.6 |
| Wall Thickness | | | | | | | |
| 1. Cement, Portland | bag | 67 | 76 | 89 | 100 | 116 | 123 |
| 2. Sand, S-1 | cu.m | 5 | 5 | 6 | 7 | 8 | 8 |
| 3. Gravel, G-1 | cu.m | 9 | 10 | 11 | 13 | 15 | 16 |
| 4. Rein Steel Bars, 10 mm x 6 m | pc. | 177 | 196 | 208 | 99 | 96 | 114 |
| 5. Rein Steel Bars, 12 mm x 6 m | pc. | | | 28 | 40 | 60 | 12 |
| 6. Rein Steel Bars, 20 mm x 6 m | pc. | 28 | 30 | 15 | 134 | 83 | 192 |
| 7. Rein Steel Bars, 20 mm x 6 m | pc. | 16 | 16 | 18 | 23 | 45 | 51 |
| 8. Rein Steel Bars, 25 mm x 6 m | pc. | | | 20 | 20 | | |
| 9. Common Wire Nails, assorted | kls. | 20 | 20 | 20 | 25 | 25 | 25 |
| 10.Tie Wire, #16 | kls. | 20 | 20 | 20 | 25 | 25 | 25 |
| 11.Form Lumber, rough | bd. ft. | 752 | 752 | 752 | 752 | 1,800 | 2,040 |
| 12.Plywood, 6 mm thick | pc. | 18 | 20 | 24 | 28 | 32 | 35 |

Multiply these materials with the prevailing unit cost in the area and sum up to get the total material cost. Include the transportion cost of these materials from the source to the project site. You may use a 3% - 5% of total material cost to approximate this. Labor cost can be approximated between 30% - 35% of these cost to get total construction cost.

TABLE 5-20

LITER CAPACITY FERROCEMENT TANK
Bill of Materials

| Materials | UNIT | Capacity in liters | | | |
|---|---|---|---|---|---|
| | | 4,000li | 6,000li | 10,000li | 16,000li |
| Portland cement | bags | 12 | 18 | 28 | 45 |
| Washed sand | cu.m | 1.5 | 2 | 3 | 5 |
| Washed gravel | cu.m | 1 | 1 | 2 | 2 |
| CHB 150 x 200 x 400 mm | pcs. | 40 | 32 | 60 | 64 |
| RSB, 10 mm x 6 m | pcs. | 27 | 19 | 8 | |
| RSB, 10 mm x 9 m | pcs. | | 14 | 26 | 35 |
| RSB, 12 mm x 9 m | pcs. | | | | 7 |
| G.I. cap, 38 mm dia | | 1 | 1 | 1 | 1 |
| Wire mesh, #26 x 13 mm x .9 m | rolls | 1 | 1.5 | 3 | 4 |
| Tie Wire, #18 | kls. | 2 | 3 | 4 | 8 |
| G.I. elbow, 38 mm dia | pc. | 1 | 1 | 1 | 1 |
| G.I. nipple, 13 mm dia | pc. | 1 | 1 | 1 | 1 |
| Brass Faucet, 13 mm dia | pc. | 1 | 1 | 1 | 1 |
| G.I. nipple, 13 mmx 200 mm | pcs. | 2 | 2 | 2 | 2 |
| G.I. tee, 13 x 13 x 10 mm | pc. | 1 | 1 | 1 | 1 |
| G.I. nipple, 13 mm x 50 mm | pc. | 2 | 2 | 2 | 2 |
| G.I. elbow, 13 mm x 90 | pc. | 1 | 1 | 1 | 1 |
| G.I nipple, 13 mm x 150 mm | pc. | 2 | 2 | 2 | 2 |
| G.I. gutter, #28 x 2.5 m | pc. | 1 | 3 | 5 | 5 |
| Screen Strainer(plastic) | pc. | 1 | 1 | 1 | 1 |
| Plastic Hose, 13 mm | m | 2 | 2 | 3 | 3 |
| Rough Lumber, 2" x 2" x 10' | bd.ft | 5 | 8 | 10 | 10 |
| C.W. nails | kgs. | 1 | 1 | 1 | 1 |

4. Implementation Schedule

The time required to finish one tank depends on the type and size of structure. Other factors that may affect the time of construction is the availability of skilled and unskilled workers which are knowledgeable in the construction method. Usually it takes 10 to 11 days per tank at favorable working conditions. The following is the schedule of activities for the construction/installation of a rainwater catchment project.

Sample Implementaion Activities

I. PREPARATORY WORKS

A. Community Preparation

1. Discussion of proposed project

2. Planning with Beneficiaries
3. Formation of Water Committees
4. Other Community Works

B. Site Investigation/Data Collection

1. Assessment of Roofs and other potential Catchment Areas
2. Rainfall Data Collection
3. Canvass of Materials
4. Check on Skilled Labor/Tools

C. Technical Requirement Preparation

1. Technical Design/Drawing
2. Prepare Cost Estimate
3. Prepare Specifications
4. Prepare Construction Schedule

II. CONSTRUCTION WORKS

A. Preparation of Resources

1. Purchase of Materials
2. Form Labor Groups
3. Transport/Haul Materials

B. Project Implementation

1. Mobilization Works
2. Clean/Grub/Strip Foundation
3. Preparation of Base
4. Preparation of Steel Reinforcement
5. Preparation of Formworks
6. Installationof Appurtenances
7. Concreting Works
   a. Base/Foundation
   b. Wells
   c. Cover
8. Curing of Concrete
9. Stripping of Forms
10. Repair of Flushing works
11. Installation of Filter System
12. Installation of gutter and sprout
13. Disinfection of cathment, conveyance
14. Backfilling works
15. Demobilization Works

D. Alternative Technologies

Characteristics type of water supply that TSTF provides can be generally divided into spring box, handpumps and rain catchment for Level I and standpipes for Level II. The costs and potentials benefits differ with each option. Measuring benefit is difficult and involves technical, economic, cultural and health factors. But since the target beneficiaries to be served are from depressed communities and a water supply should serve large population as possible, there is a need to present an appropriate water technology with the least possible cost and can be easily operated and maintained by the community.

For handpumps, whether it be newly drilled or an existing open dug wells, decision for the choice of pump to be used is left to the user. The one that can be easily operated and maintained will be adopted. Where there would be no major breakdown within one to two years time.

For rainwater catchment, the costly part of the system is the provision of the cistern or storage tanks. Several options on the type of storage tank has been discussed and presented in this chapter of this manual. After looking at the pros and cons, the TSTF is recommending the use of Ferrocement tank as storage facility for a rainwater catchment system. It can also be used as reservoir in spring development project. Sizes or capacities range from 4,6,10, and 16 cubic meters.

For family tanks, the use of water jars (tapayan) out of cement mortar is also recommended. It is a low cost technology since it can be contructed by any household with minimum knowledge in construction. Materials can be obtained from any ordinary hardware.

For a spring development project, priority is given for sources above the service area. Water will be flowing by gravity and thus eliminate the use of a mechanically operated pump. In areas where spring source is below the service area and there is a need to mechanically pump the water to serve the beneficiaries, TSTF considers this on a case to case basis.

To eliminate the costly operation and maintenance of a mechanical pump, TSTF recommends, wherever applicable, the use of a hydraulic ram pump (Hydram). This is a kind of technology wherein water from a drive pipe is being pumped up to a delivery pipe where water is being discharged. The system is energized by water hammer. With only two moving parts, the only maintenance needed is to replace the rubber washers in both valves when worn out.

<u>Hydraulic Ram Pump (Hydram)</u>

It is capable of pumping water up to the height of 100 meters. There are three major factors to consider for technological appropriateness of the ram:

1. Enough height for the water to fall
2. Enough water from source

3. Considerable proportional vertical lift ( the height to which the water is raised)

The operation of Hydram

The hydram makes use of the sudden stoppage of flow in a pipe to create a high pressure surge. This is commonly known as water hammer. This high pressure wave is utilized to pump some water to a higher elevation or to location that is displaced horizontally from the pump. If the flow in an inelastic pipe is stopped instantaneously, the theoretical pressure rise that can be obtained is:

$$H = \frac{-Vc}{g}$$

where H = pressure rise (m)
V = the original velocity in the ppe (m/s)
c = the speed of an acoustic wave in the fluid (m/s)
g = acceleration due to gravity ($9.8 m/s^2$)

The above represents the maximum pressure rise possible. The actual value will be lower since all pipes have some elasticity, and it is impossible to instantaneously stop the flow in a pipe.

The hydram is simple in construction. It contains only moving parts, the waste valve and the delivery valve. There are two pipes, the drive pipe leading the water into pump and the delivery pipe directing the water to the place where it will stored and subsequently used. An air chamber and air valve are the other two components in the body of the hydram. (Refer to Fig. 5-06)

The pumping cycle of the hydram begins with the waste valve open. In a natural stream, the supply is taken from upstream, perhaps from a small dam created in the stream.

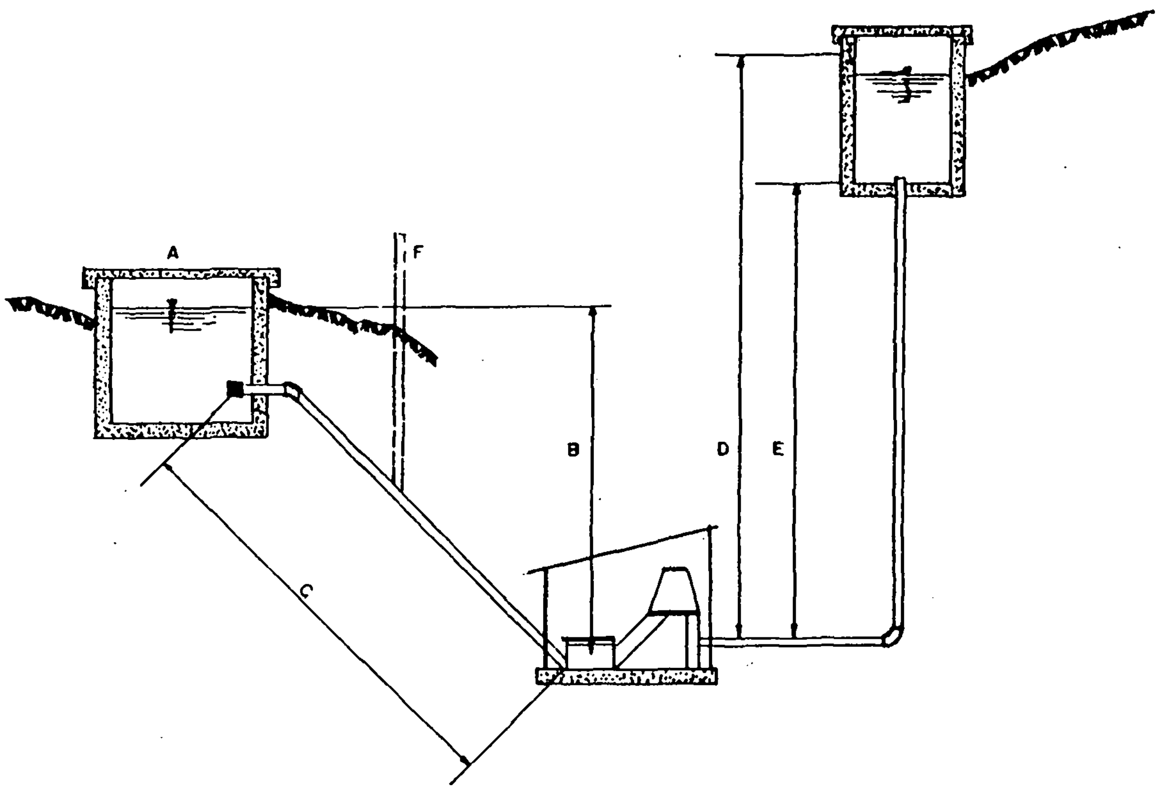
Because of the head created, water accelerates in the drive pipe and leaves through the waste valve. The equation for this acceleration is well known in fluid mechanics and can be given as,

$$\frac{H - M^{V2}}{2g} = \frac{L\,dV}{g\,dt}$$

where $\frac{M^{V2}}{2g}$ expresses the total friction loss

and
L = length of the drive
V = velocity of flow pipe
t = time

Eventually this flow will accelerate enough to begin to close the waste valve. This occurs when the drag and pressure forces in the




A – SUPPLY— LITRES/MINUTE
B – DIFFERENCE IN ELEVATION BETWEEN RAM AND SUPPLY-POWER HEAD
C – LENGTH OF DRIVE PIPE
D – DIFFERENCE IN ELEVATION BETWEEN RAM AND HIGHEST POINT TO WHICH WATER IS TO BE ELEVATED–PUMPING HEAD
E – TOTAL LENGTH OF SUPPLY PIPE
F – STAND-PIPE, NECESSARY IN CASE OF EXCEEDINGLY LONG DRIVE PIPE

SOURCE: WATER SUPPLY FOR RURAL AREAS AND SMALL COMMUNITIES BY: E.G. WAGNER and J.N. LANOIX

FIGURE 5.06

HYDRAULIC RAM

water equal the weight of the waste valve. For the purpose of analysis, the force on the valve can be represented as a drag force, Fd , given by the equation.

where Av = cross sectional area of the waste valve

= specific weight of water

Cd = drag coefficient of the waste valve

For the optimum operation, the closing of the valve should be as fast as possible. On this basis alone a light valve with a short length is best. However, if the stroke is too light, it will open soon enough later in the cycle; on the other hand, if the stroke is too short, not enough water can escape out of the waste valve opening, this limiting pipe velocities and thus reducing water hammer pressures. The proper design of the waste valve must therefore be an optimal balance between all the various factors involved.

The sudden closing of the waste valve creates a high pressure surge as explained previously. This surge is great enough to open the delivery valve and release some of the water into the delivery pipe. With the release of this water, the high pressure surge in the drive pipe collapses and slight negative pressure recoil occurs.

Three significant things occur when the pressure wave collapses in the drive pipe. The air chamber cushions the pressure pulse so that a resonably continous flow is sent to the delivery pipe. In this cushioning process, the air-water interface is continually agitated and moving. This tends to dissolve the air into the water. The air supply is replenished by a second phenomenon that occurs at this time. The slight negative pressure pulse enables air to be sucked into the air chamber. This air valve can be on-way air valve or it can be a very small drilled hole (1 mm) which releases water during the pressure surge and sucks in air during the collapse of the pressure wave.

The third event that occurs at the end of the pressure pumping phase is that the waste valve opens, either by the action of its own weight or by means of an activating spring. When this happens, the flow is ready to begin again. The hydram cycle thus repeats itself continually, at a frequency between 40 to 200 beats per minute. The fact that this pumps operates 24 hours per day with only minimal maintenance is one of its main advantages.

## E. Packaging of Projects for Presentation and Funding

Projects that have been identified and have been found feasible for implementation should be put together.

Presentation of projects should be complete and detailed, such that questions which the funding committee may pose will be satisfactorily answered. The presentation must contain the project background, type and description; the beneficiaries and implementation;. guidelines, goals and objectives; plan of action with detailed discussion on project's organization, schedules and financial requirement; and all the technical data and information relevant in project evaluation. Appendix C details the suggested format for a project proposal.

# CHAPTER VI - PROJECT CONSTRUCTION

## A. Mobilization of Resources for Construction

Following the planning phase and initial community mobilization, the total project budget must be presented for approval and funding. The funding group will review and evaluate the whole program activities and the detailed engineering design and its costing. This shall provide their basis for the project's approval or disapproval. Once it has passed their criteria, project will be approved and funds will be ready for the implementation of the project.

The implementation schedule should serve as the guide in all the activities of the project. When possible, specific activities should be done ahead of its schedule.

The main pre-construction activity involves the mobilization of resources. Materials have to be purchased and transported to the job site. If needed, equipment have to be rented. A skilled and unskilled labor force has to be recruited and arranged for specific jobs.

Following are some of the general considerations in the pre-construction stage:

- Construction Materials and Supplies

  The exact requirements for materials and supplies must be anticipated in advance to assure that these will be available to meet the project's needs. This requires a careful study of the quantities and kinds of materials required, sources of supply available, transportation requirements, priorities of deliveries and the need for storage facilities. The use of locally available indigenous materials should be maximized. Hence, if bamboo poles or forest wood trunks could substitute for G.I. pipes in constructing scaffoldings and head frames, the former should be used.

- Construction Equipment

  Because of the prevailing economic condition, construction equipment normally found in urban sectors are seldom available in rural areas. Whenever possible, the use of sophisticated equipment should be avoided in favor of manual labor. Thus, for example, the use of a hand-operated pump in jetting a well operation should be resorted to in favor of a power-driven pump whenever applicable.

- Labor

  The use of local labor should be availed of in favor of sophisticated machines. Usually, that there is an excess of cheap labor in rural areas. Trenching operation and mixing concrete should be done manually instead of mechanical equipment.

This serves a three-fold purpose: (1) provide employment opportunities in the otherwise unproductive manpower, (2) it mazimizes economy in costs, and (3) it provides the users knowledge with the work, thereby facilitating operation and maintenance. Of course, cheap labor should not mean exploitation of labor.

- Construction Time

The time factor in any project relates to the need of the community to utilize the system at the earliest possible time. It has been established that people in the rural areas strongly appreciated an impact project that benefits them directly. Such impact projects are better appreciated when people are made aware of the benefits especially if they have long been suffering from the low water supply. For this reason, the construction of the project must not drag.

- Safety and Durability

These are an important factors to consider in constructing the system and should not be sacrificed for speed and economy. Because of limited resources, it is often difficult for rural communities to afford frequent repair costs, so that as much as possible, all constructed system parts should be durable enough to withstand rough handling and the elements of nature. This can be achieved through proper selection of needed equipment and materials and close supervision during the construction.

- Simplicity and Economy

Simple design, requiring locally available construction materials and supplies and the minimum of skilled labor should be adopted. During construction, the types and sizes of wires, lumber and other materials needed should be reduced to the minimum, but without compromising the safety of workers. Sizes of materials common in the area should be used. Also the re-use of these materials as related to construction planning should be considered. Drainage should be by open ditches. Open storage areas should be used as much as the weather, security and nature of materials to be stored would permit.

- Weather

Construction is best be done during the dry season. It has been the experience that the construction costs usually come out higher when work is done during the rainy season. The following have been cited as the probable reasons for higher costs:

1. The material for construction may be lost, destroyed or contaminated if not stored and handled properly due to flooding of trenches and the like.

2. Increase in labor cost. The progress of work is usually slower for the same job item, hence, there is a corresponding increase in labor cost.

3. Increase in energy cost. In pipe laying, it is necessary to render the trench dry before pipes are laid. Removal of water, usually by pumping, would entail additional cost.

4. Weakening of structures and foundations.

5. Working conditions are difficult. In the excavation of trenches, it is usually necessary to provide additional support to avoid cave-ins.

6. Detection of leaks during leakage testing is rendered more difficult.

Wells

Unlike with the other type of technology (Spring development, and Rainwater Catchment), well drilling needs less support from the beneficiaries concerned because of the nature on the type of work to be done. It takes experience in well drilling technology to be able to understand the different methods and techniques required of a well driller (Supervisor, operator, foreman and helper).

However, community participation can be tapped when conducting site investigation for the proposed project. Community participation is limited to the following:

- If the project calls for the construction of dug wells, the community should undertake the construction of this project since it needs a little expertise in digging. Furthermore, the community should fabricate instead of purchasing the required lining materials (if necessary) while digging is going-on, thru the supervision of the proponent or other NGO's concern.

- if the project calls for the drilling of small diameter wells (shallow and deepwell) using handpumps as the prime mover, the community can participate in terms of supplying unskilled labor for the construction of pump base and platform, materials necessary to construct the wells such as sand, gravel, cement and form lumber or the cash equivalent as their counterpart to the project.

- Supply the unskilled labor force if the project calls for the drilling of large diameter well wherein a big drilling rig will be needed.

B. Actual Construction

1. Wells

DIFFERENT TYPES OF WELL CONSTRUCTION

Wells may be constructed by either one of the following methods. (Please refer to Fig. 6-01) Each method has advantages over the other under certain conditions.

a. Drilled Well

Rotary Hydraulic

The rotary hydraulic method of drilling wells is based upon the principle of flushing cuttings out of the well with the aid of water, thus the name hydraulic. A local clay bentonite, or gel is usually mixed with the water to make a slurry or drilling mud. The consistency of the drilling mud is varied by adding either barite clay or water; depending on the mud weight needed to stabilize the hole and the character of the material being penetrated. This mud is pumped under pressure through a hollow drill stem to the bottom of the hole where it is discharged through an opening in the bit. The bit is designed to cut materials from the bottom of the hole as the drill stem and bit are spaced between the drill stem and wall of the hole by the drilling mud.

The cuttings settle out of the mud before the mud is recirculated. Mud pressure and consistency must be adequate to maintain circulation in the system and carry drill cuttings out of the hole while drilling. The hydraulic rotary method is effective for drilling most rocks. With calyx shot, bort and diamond bits, the hardest rock may be drilled. Drilling is rapid in all except the hardest rocks. Difficulty is encountered in penetrating loose, hard boulders.

Reverse Hydraulic

The reverse hydraulic method is similar to the rotary hydraulic except the drilling fluid is circulated in reverse order. It is best suited for drilling large diameter wells, because reverse circulation maintains a high velocity in the water rising in the drill stem and efficiently removes cutting. Water is used instead of drilling mud. The drill stem is larger and is connected with a suction pump instead of a pressure pump. Water and drill cuttings are removed from the drill stem by the suction pump and "jet ejector" and discharged into pits. To avoid caving, it is important to keep the hole full of water.

Cable Tool

The cable tool, percussion, or standard method of drilling is based upon the principle of applying sufficient energy to pulverize the soil or rock by percussion. The energy applied is varied by controlling the length of the stroke and the weight of the drill stem and bit. Bits vary in diameter from a few inches up to two feet depending on the desired depth and diameter of the well. Bits and drill stems vary in length depending upon the weight needed to furnish the desired impact. The bits need not be very sharp but the drill end must be kept considerably larger than the shank to allow free movement of the bit in the hole. The bit is connected to a cable and by means of a rocker arm on the drill rig, it is raised and released to exert its energy on the bottom of the hole. To remove the drill cuttings, water is introduced to make mud that can be removed by means of a bailer.

The cable tool method must rely upon casing when the hole begins to cave in. The hole often caves in when the drill enters or passes through a non-cohesive water-bearing stratum. In order to penetrate some water-bearing formations, it becomes necessary to introduce casing into the well and by means of the bailer remove sand that enters the casing. The casing will usually settle by its own weight for a short distance before it becomes necessary to drive it to penetrate the water-bearing stratum.

This method of drilling is designed primarily for hard rock and cobbly or bouldery materials. It tends to compact the unconsolidated sediments so that the wells of the hole become dense and tight.

Jetting

The jetting method of drilling wells is usually employed in sandy formations where water is developed by entry from the bottom of the casing. Perforated casing is not used. The casing, usually a two-inch diameter galvanized or black iron pipe, is used to drill the hole. Jagged edges are cut into the lower end for chopping purposes. The drill stem is lifted and dropped in the operation and water is forced under pressure through the drill stem to remove cuttings. When the drill pipe has entered the zone of saturation far enough to have several feet of water in the casing, it is then considered to be in proper place and jetting is terminated. This method is never used for test drilling that requires collection of representative samples.

b. Bored hole

The boring methods of well drilling is based upon the principle of the Iwan Auger. It is designed for unconsolidated sediments and successfully used where water-bearing formations are very fine-textured and permeabilities are low. The auger is connected to a shaft that is rotated slowly. It is designed to retain drill cuttings and pulled out of the hole to empty the bucket. Diameters may vary from 12 to about 36 inches and will usually average about 18 to 20 inches.

These wells can be bored up to depths of 100 to 150 feet providing rock or caving soils are not encountered. They have the advantage of developing reservoir capacity within the dug space where water-bearing formations release water at a relatively slow rate. Where diameter is important to storage within the augered portion of the zone of saturation, it may be the basis for selecting a given diameter. The volume of water in a cylinder 12 inches long is given by the formula:

width in inches $\quad 0.0408\ d^2 = \text{gallons}$

or

width in feet $\quad 5.8752\ d^2 = \text{gallons}$

c. Dug Well

Dug wells are best suited to areas with a shallow water table and where thickness of the water-bearing materials is not great. They present problems in construction. There is little possibility of improving them by development because only a limited area of openings may be left in the sidewalls. Their large diameter makes it difficult to apply usual development methods. They may be unsanitary because it is difficult to seal out surface contamination and subject to failure because of yielding foundations. Dug wells are usually more expensive than wells constructed with drilling equipment.

d. Driven Well

Wells constructed by driving are useful under certain conditions for developing water and draining areas. Their use is limited to areas underlain by unconsolidated clay, silt and sand relatively free of gravel, cobbles or boulders. Depth to water, including drawdown, must be less than the suction limit at the elevation of the well. The practical limit of suction lift for pumps is 22 feet at sea level, 17 feet at 5,000 feet elevation and 14 feet at 10,000 feet elevation.

Driven wells are constructed by driving pipes fitted with a well point sufficiently below the water table so that fluctuations and drawdown from pumping will not lower water below the point.

A well point consists of a forged steel point attached to a short length of perforated pipe. The perforated pipe is wrapped with either brass screen or spiral wound brass bands having a trapezoidal cross section.

The bands form a relatively non-clogging slot that is narrowest at the outside.

In driving the point through materials containing consid-

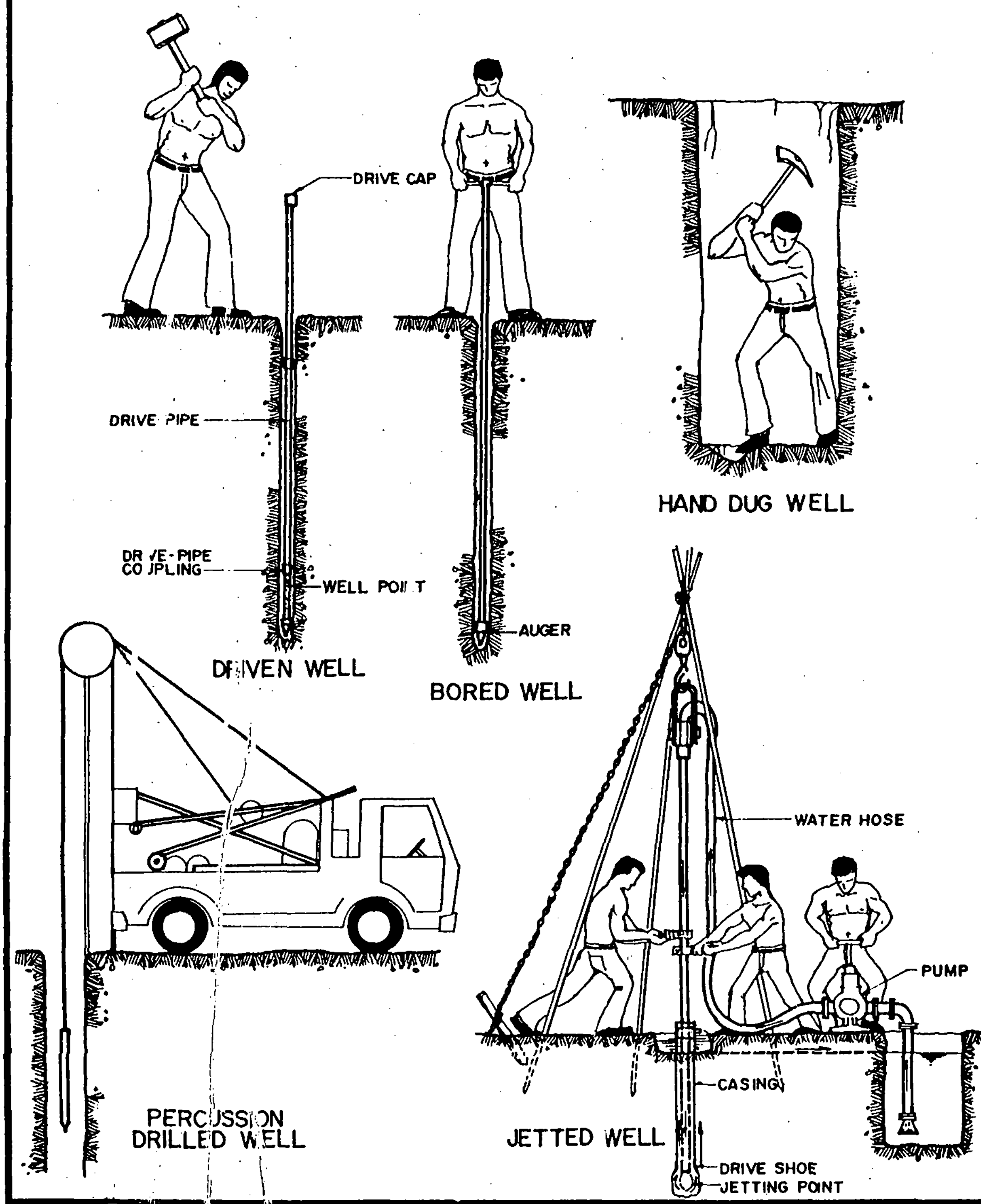



FIGURE 6.01
FIVE BASIC METHODS OF WELL CONSTRUCTION

erable amounts of clay, the openings often become clogged. It may prove advisable to auger or jet the hole through the clay layers.

Single driven wells are an efficient and economical means of obtaining small amounts of water under conditions outlined. Multiple driven wells connected to a common pump are useful in developing irrigation supply and for drainage.

e. Well Logs

A great deal of information needed in the design and construction of an efficient well, as well as information for locating new wells are based on the soil samples taken from the well while drilling, and these are called sample logs. (Refer to Fig. 6-02)

Soil samples should be collected at least every five foot interval of hole drilled and at every change in formation that is discernible by the action of the drilling equipment.

Soil samples taken from the rotary hydraulic are subject to some contamination by caving and recirculation of materials in the drilling mud. This can be minimized with the proper construction and location of the mud pits. A sample box placed between the well and the mud pit is a satisfactory method of obtaining good soil samples.

Soil samples from wells drilled by cable tool can be quite variable. In consolidated formations, samples are good. In unconsolidated formations, if the casing follows closely behind the bit (drill and drive), samples are usually good and if the casing is bailed down, they are excellent.

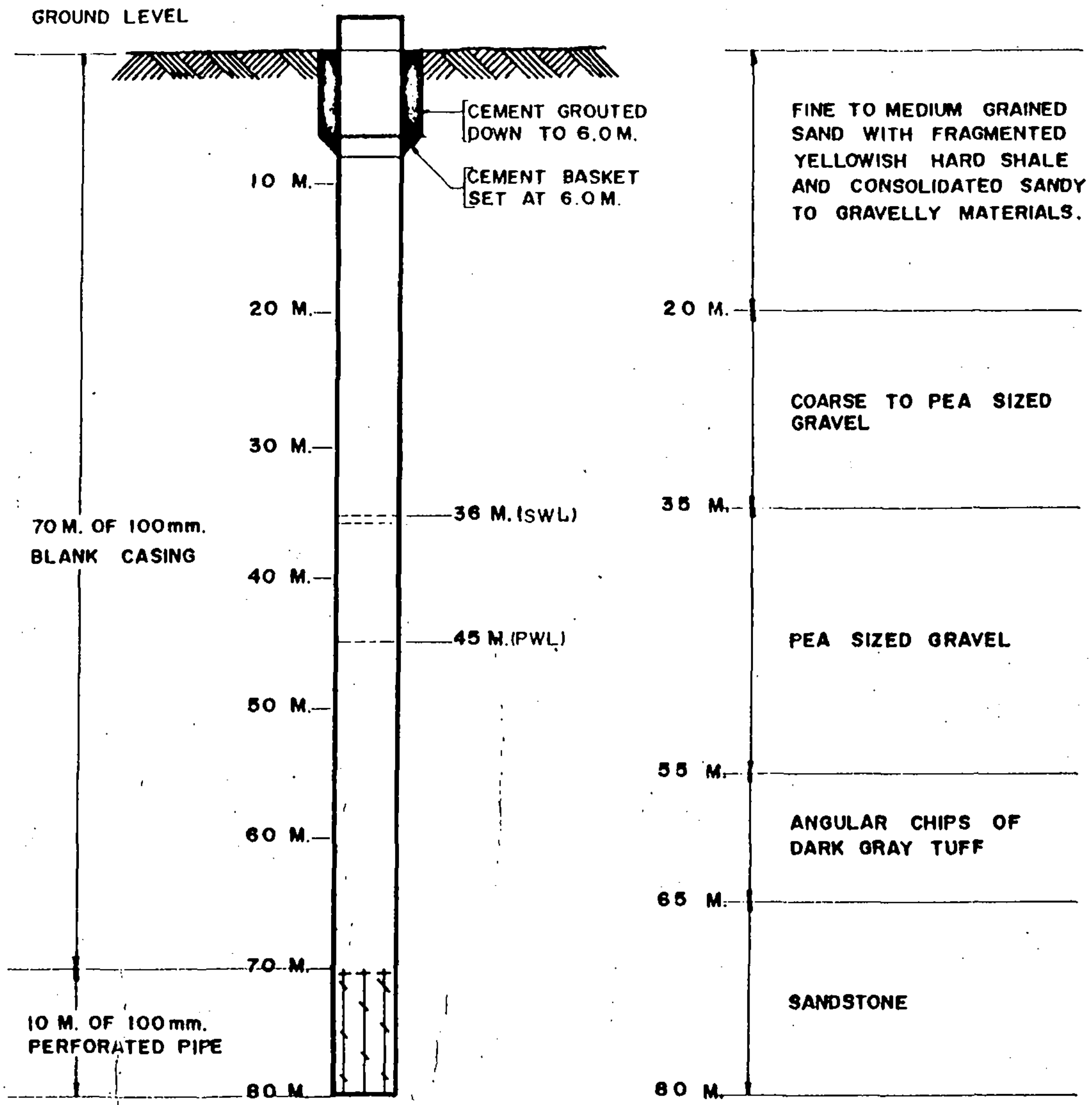
Samples are inadequate or not available from wells that are jetted or driven. Bored or dug wells are usually very shallow but yield adequate soil samples.

The samples taken from various well construction methods are described for grain size, color, composition and any other feature that can be seen. Aquifer samples are then analyzed by sand analysis to determine the screen slot opening and length and if necessary the use of filter pack materials.

The descriptions of each sample are then plotted on a strip log using the same scale when plotting the well for correlation and comparison purposes. It is also important to record the time consumed during drilling operation. Slow drilling time may indicate hard indurated zones. Fast, smooth drilling indicate fine sands.

Soil samples should be marked separately, corresponding to what depth they were taken from and must be placed and sealed in a plastic container.

SAMPLE
CROSS-SECTION OF WELL DRILLED FOR
BO. SALOMAGUE, PANIQUI, TARLAC




PUMPING DATA:

| | |
|---|---|
| STATIC WATER LEVEL | — 36 M. |
| PUMPING LEVEL | — 45 M. |
| DRAWDOWN | — 9 M. |
| DISCHARGE (Q) | — 1.25 LPS |
| EQUIPMENT USED | — 5 HP. DEMING PUMP SET 50 M. |
| SPECIFIC CAPACITY | — 0.14 LPS/M. (1.25/9) |

| | |
|---|---|
| DATE STARTED | AUG. 20, 1978 |
| DATE COMPLETED | SEPT. 5, 1978 |
| WELL DRILLER | |

FIGURE 6-02
SAMPLE ONLY
WELL LOG & REPORT

2. Water Well Construction Guide

Presented below is the summary of the different methods of well construction. Each method shows what kind of soil formation it is best suited for, water table depth for which it is best suited, usual depth, usual diameter range and casing materials commonly used.

TABLE 6-01

WATER WELL CONSTRUCTION GUIDE

| TYPE OF WELL | MATERIAL FOR WHICH BEST SUITED | WATER TABLE DEPTH DEPTH FOR WHICH BEST SUITED | USUAL DEPTH | USUAL DIAMETER RANGE | CASING MATERIALS |
|---|---|---|---|---|---|
| 1. DUG WELL | Clay,silt,sand Gravel | 5-40 feet | 30 ft. | 2-3 ft. | Concrete, Brick Rock |
| 2. DRIVEN WELL | Silt,Sand,Gravel less than 2" | 5-15 feet | 50 ft. | 1-1/4-6" dia. | G.I. Pipes |
| 3. JETTED WELL LIGHT, PORTABLE RIG | Silt,Sand,Gravel | 20-40 feet | 40-100 ft. | 1-1/4-3" dia. | G.I., PVC |
| 4. DRILLED WELLS | | | | | |
| a) Cable Tool | Unconsolidated and Consolidated Medium Hard Rock | Any Depth | 100'-1000' | 4" - 10" dia. | GI, BI, PVC, FRP |
| b) Hydraulic Rotary | Silt, Sand, Gravel, less than 1 inch, Soft to Hard Consolidated Rock | Any Depth | 100'-1500' | 4" - 14" dia. | GI, BI, PVC, FRP |
| c) Reverse Circulation | Unconsolidated Formation | 5 - 100 ft | 200' | 16" -24" dia | Steel, BI Pipe |
| d) Air Rotary | Consolidated and Unconsolidated Formation | Any Depth | 100'-1500' | 4" -14" dia. | GI,BI,PVC,FRP |

## 3. Final Well Design

### a. Well Depth

Geological and hydrological conditions at the well site play an important part in determining the depth of a well. Based on the field information collected, the Engineer or the planner can determine how far down the well should go. Generally, wells are completed to the bottom of the aquifer or to the bottom of the water bearing strata. This is advisable for several reasons:

- Penetrating the entire aquifer will result in more effective available drawdown,
- The greater the number of aquifers penetrated, the larger the volume of water yield will be,
- Depth of the casing determines how far below the water table the pump will be positioned.
- Depth of the well determines the method of well construction, since different methods have their own penetration range. (Please see Fig. 6-03)

### b. Well Diameter

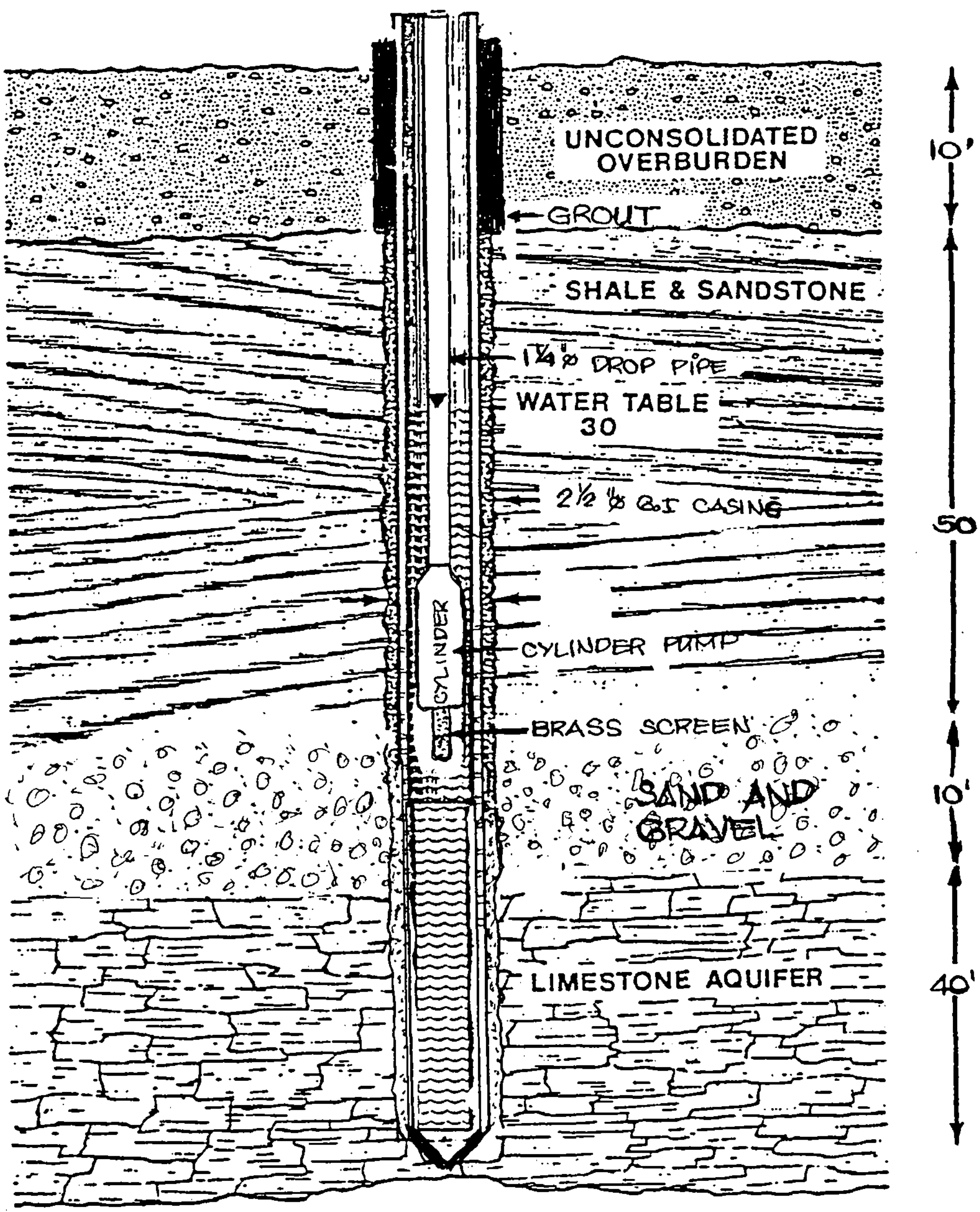
Well diameter is determined by the volume of water you want to extract from the well, the porosity of the aquifer which controls the rate at which water enters the well and the cost of the well.

In a porous sand formation, water can move easily so a small diameter well may be able to supply water at a higher pumping rate. However, in tighter clay formations where water moves more slower, a larger diameter well is necessary to meet the volume of water required.

The diameter of the well is important because it significantly affects the cost of the well. The bigger or larger the diameter of the well, the bigger the cost. The well may or may not be the same diameter from top to bottom, it being a telescopic well. Well diameter must be chosen to satisfy several requirements:

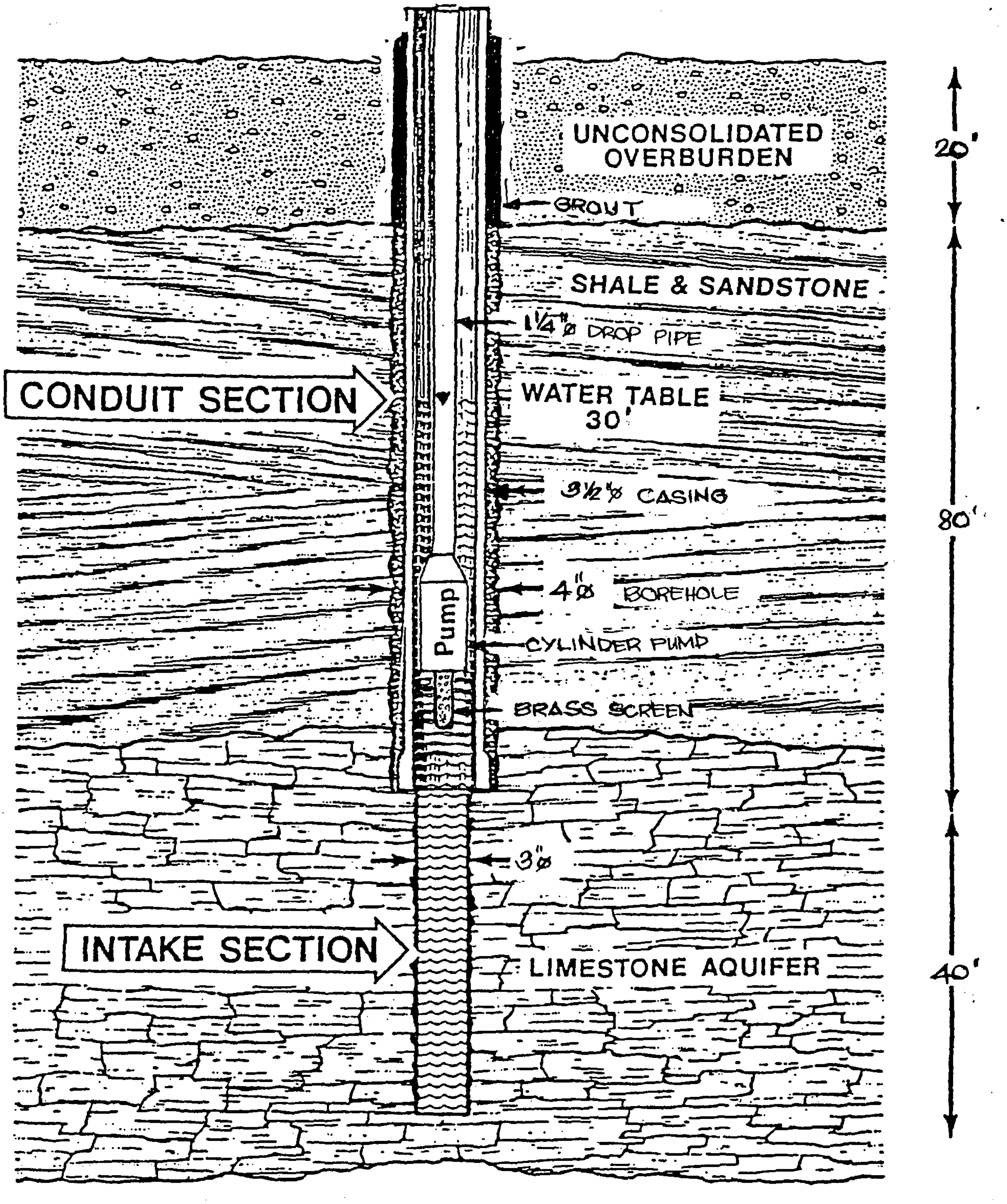
- The housing element either cased or uncased, must be large enough to accommodate the pumping unit with proper clearance for installation and efficient operation.
- The diameter of the intake section of the well must be such as it will ensure good hydraulic efficiency of the well. (Fig. 6-04)
- The diameter of the borehole and screen determines the type of drilling equipment to be used in the project.

# FIG. 6-03 WELL DEPTH




setting must be far enough below static water level to provide adequate drawdown

# FIG. 6-04 WELL SECTION



An oversized hole doesn't increase yield proportionately. For example, an 8 inch well will yield only 8% more water (with the same drawdown) than an identical 4 inch well at the same location.

Table 6-02 Comparison of Well Diameter and its Relative Yield

| WELL DIAMETER (inches) | RELATIVE YIELD (%) |
|---|---|
| 4 | 1.00 |
| 6 | 1.04 |
| 8 | 1.08 |
| 12 | 1.15 |
| 24 | 1.27 |
| 48 | 1.42 |
| 120 | 1.65 |
| 240 | 1.92 |

c. Well Casing

Watertight construction of the case portion of a well should be carried into an impervious subsurface formation which caps the aquifer. The casing should also be lowered to a safe depth below the anticipated pumping level. Normally, a well casings may be lowered into position once drilling has been completed. However, in some instances well casing maybe driven or lowered into place as drilling proceeds.

Depending on well design, the casing may range anywhere from one and one fourth inch (1 1/4 in.) diameter for shallow wells to twenty-four inches (24 inches) in some large industrial well. Depths at which casing is set range from ten feet (10 ft.) or less to over one thousand feet (1,000 ft.). Well casing may or may not be of the same diameter from top to bottom. This will only apply if the borehole is telescopic.

There are several well casing materials that can be used in well construction. The most popular or known casing materials for shallow or deep well handpump projects are steel and plastic pipes. The most common steel pipes are those of galvanized iron which are available in twenty (20') foot lengths G.I. pipes casing sizes range from one and one fourth inch diameter (1 1/4") for shallow wells to six (6") inches diameter for deepwell handpumps and are of threaded or coupling type. The thickness of G.I. pipe can be determined by the schedule (Sch.) either schedule 20, 40 and 80. For well casing purposes, schedule 40 is usually used. Polyvinyl Chloride Pipe (PVC) is the most commonly used plastic well casing pipe. Size and length range is the same with G.I, pipes. PVC pipes can be connected through the coupling with the use of solvent cement and special rivets. The thickness of PVC pipe can be determine by its class, depending on the designer's specification. For water well plastic casing, class 12.5 is commonly used. Poly

Butelyn pipe (P.B.) is another plastic pipe casing used for shallow wells. The fiber reinforced pipe (FRP) is another type of plastic pipe casing usually used by the DPWH in their foreign assisted projects.

For deepwells that require an electric motor pump, black iron pipes (BI) are commonly used. Most steel pipes are available as butt welded, electric resistance welded (ERW) or seamless pipe. Pipes larger than six (6") inches in diameter are jointed by welding.

d. Well Screens

Well screens are used to draw water from the aquifers located in unconsolidated formation materials such as sand. Simply stated, well screens let the water into the borehole and keep the sand out. It also serve as the structural retainer to support the loose formation materials. Screens form the working end of the water well. The characteristic, type and position of the screen in the borehole govern the efficiency and life of the well. The life of a well depends on the ability of the screen to resist corrosion, electrolysis and other types of chemical element that are present in the water. Corrosion resistance is governed by the nature of the formation water and the type of materials used to make the screen. (Refer to Fig. 6-05)

Screen Length

In artesian aquifers - 70-80% of the aquifer thickness. The available draw down is the distance from the static water level (SWL) to the top of the aquifer.

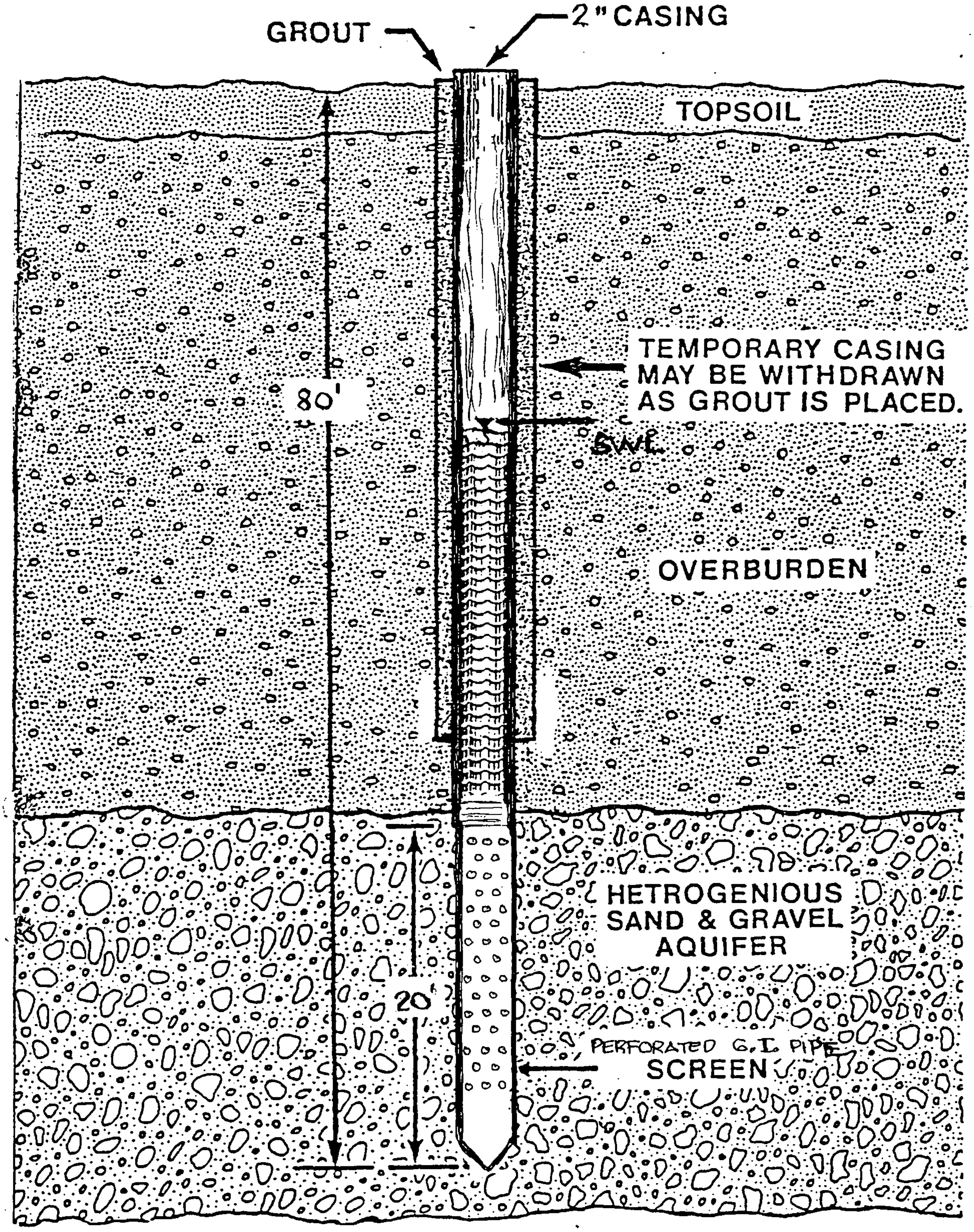
In water table aquifers - screen the lower half to one third of the aquifer. The available draw down is the distance from the static water level to the top of the screen.

Three basic factors may limit the screen length. First is the cost. For small diameter wells, assuming that the right type and screen material will be used, probably the screen will cost much higher than a set of cylinder pump or jetmatic pump. For large diameter well or for industrial wells, the cost of screen may be higher or lower the cost of either the casing material to the pumping unit. The second factor is the thickness of the aquifer formation available, i.e. for artesian aquifers - 70-80% of the aquifer thickness and 1/2 to 1/3 thickness for water table aquifers. The third factor is the anticipated water level in the well when it is pumped. Good design requires that the screen should be set or positioned so that the its top will always be submerged in water.

Screen Diameter

Increasing the diameter of the well has little effect on its yield. Therefore, increasing the diameter of a screen likewise

FIG. 6-05 SCREENED WELL




MAXIMUM ENTRANCE VELOCITY .1 ft/sec

has little effect on its yield. Screen diameter is selected according to water entrance velocity through the screen slot openings. To check entrance velocity, divide the yield by the total area of openings in the wells. Entrance velocity should be kept at less than 0.1 ft/sec. (2.5mm/sec) to minimize friction losses, reduce incrustation and minimize the rate of corrosion.

Screens are classified by their slot width. This is expressed as a whole numbers, e.g. No. 10, No. 20 etc. where the number refers to the slot width opening, in units of one thousandth of an inch. Therefore, No. 10 slot has a slot width of 10/100" = 1/100". Most manufacturers gives the total slot area per foot length of screen for each size.

Screens are available as small as 1-1/4" nominal diameter and can be as large or greater than 36" diameter. They are available in a variety of prefabricated lengths and can be joined together by several methods, depending on the screen materials to make a screen of any desired length.

The percentage of open area of screens vary from 3% to 5% for slotted or perforated pipe, 3% to 15% for louvered and punched type and 12% to 30% for vertical rodded wire wrapped types. The variation being related to the size of the opening. A very fine slot screen such as 0.010 inch, will have the lowest percent of open area while the larger slot sizes, such as 0.100 inch, having the highest percent of open area.

To provide a screen which will minimize friction loss, select that which has the greatest percentage of open area compatible with other design and economic factors, 2) has the longest length of screen which the aquifer formation and economics of the installation will justify and 3) has the largest diameter warranted by the particular installation.

<u>Sand Analysis</u>

One of the most important factors in achieving a "sand free" well is that of obtaining representative samples of the native formation from the selected aquifers and having them accurately sieved (measured) to determine the size distribution of the materials. The driller, by good sampling techniques, must obtain these representative samples. Once the proportions of the various sized sand grades are known, a slot screen size can be selected, when called for , the artificial gravel wall materials can be selected to ensure a "sand free" well.

If too much sand is removed by the use of large slot openings, a danger exists that the formation around the well may collaspe or cave in, thus a sand free well will permit the greatest inflow rate of water into the well.

The complete sieve analysis of a sand sample is plotted on graph paper to provide a curve which shows the distribution of the various grain sizes- from fine to coarse that make up the sample . To be able to compare the grading of one sample with another sample, it is important to follow a uniform procedure for testing the sand samples.

Select four to six sieves with a series of openings that will classify the samples into various sizes. The coarsest sieve should not retain more than 20% of the sample. The opening in the testing sieve are designated both by the actual size of the openings in thousandth of an inch and by the mesh number of the wire cloth.

Nest the sieve with the finest one resting on the bottom pan and the coarsest on the top of the series. Weigh the dried sample, record this weight, and pour the sample of sand on the top sieve.

Empty the material retained by the top sieve into a pan or on a large sheet of paper. Then transfer this material to the weighing pan on the balance and weigh it. Record this weight against the size of screen openings on which the material was retained.

Empty the portion of the sample retained on the second sieve, and add it to the material already in the weighing pan on the balance. Record the combined weight. Empty each sieve successively and record the weight of the accumulated amount in each case. Finally, add the finest material from the bottom pan and weigh. This weight should check the original weight of the sample within 2 or 3 grams.

Screen Materials

Well screens should be fabricated from corrosion resistant materials to ensure long useful life. The most commonly used screen materials are stainless steel, PVC, brass, galvanized steel, plastic coated steel and sometimes plain steel casings. Metal screens have spiral wire wound around several vertical rods. At each point of contact, the wire is welded to the rods. Another type of metal screen is made from well casing which has short vertical slots cut into expanded bridges around the pipe barrel. Plastic screens have slots cut horizontally around part of the circumference of the pipe, some pipes are ribbed for additional strength other pipes are ribbed only over the slotted area. Another type of plastic pipe screen has relatively large perforations with a plastic coated metal spiral-wound screen of desired slot size bonded to the original pipe. For small diameter wells, using galvanized steel pipe with relatively strong drive point and heavily constructed spiral wound galvanized wire screen is commonly used. Other types of drive point screens are those with wire mesh inside the drive point tube located opposite staggered apertures and spiral- wound wire around the outside of a perforated pipe.

e. Gravel Packing

When the natural-bearing sand does not contain any relatively coarse material to permit development and the formation of a natural gravel pack around the screen, it is sometimes desirable to place the necessary artificial coarse materials around the screen. Artificial gravel packing is of great value where the water-bearing formation is composed of fine sand in which the individual grains are uniform in size.

In a gravel packed well, the zone immediately surrounding the well screen is made more permeable by removing the formation material and replacing it with artificially-graded, coarser gravel pack two (2) to four (4) inches thick (Refer to Fig. 6-06). A gravel size that will retain essentially all of the formation materials should be chosen. Then a well screen opening is selected of a size that will retain the gravel.

In fine, uniform sand, gravel packing should be considered because larger slot openings in the screen may be used.

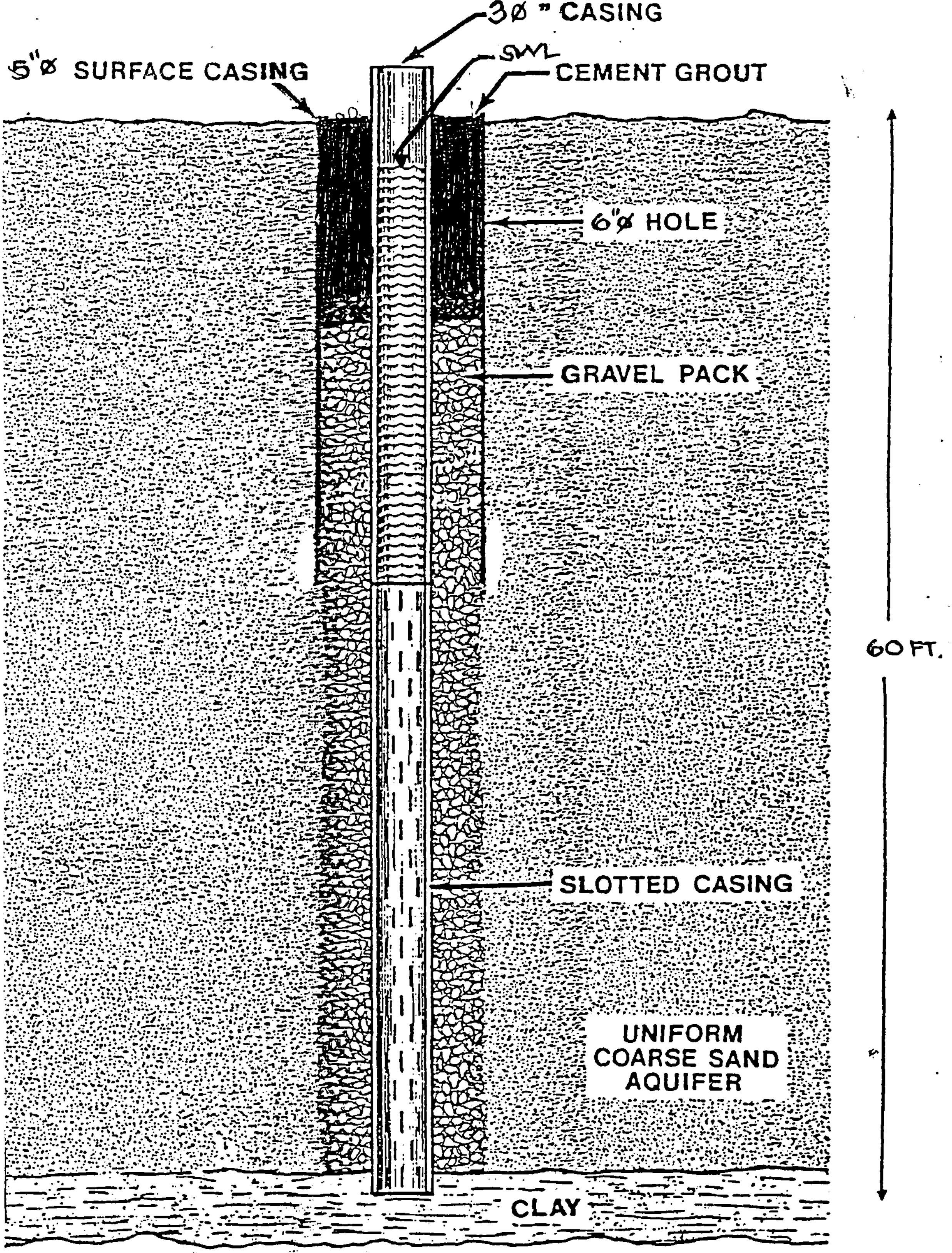
In a thick artesian aquifer a long screen would be required and the pump set above the screened section of the well, a small diameter well screen can be centered on the borehole and the similar space filled with gravel. This is preferable to using a shorter diameter about the same as that of the borehole.

In a loosely cemented sandstone, some sand particles slough from the walls of the hole and this results in a sand pumping well. Because most sandstones are fine drained, screen openings of 0.005 inch or smaller may be required to screen them correctly. For such formations, it is usually better to provide an artificially graded gravel or sand envelope so that larger screen openings may be used.

Another reason for gravel packing a well is to provide lateral support for a partly cemented sandstone which will otherwise fret if not supported, or to support formations in which layers of clay or silty clay.

The most important feature of artificial gravel packing is the selection of the correct sizes of the gravel and screen slot openings. The grading of the gravel should be in proper relation to the grading of the sand making up the water-bearing formation. The use of gravel that is too coarse can cause trouble. Fine sand may fill the voids in a coarse gravel pack and reduce the yield of the well. Another result may be that sand will pass through the gravel pack when the well is pumped, making the well a sand-pumped. Coarse, uniformly graded gravel, of about 1/8 inch maximum size, makes the best gravel pack for most fine sand formations. Fine gravel up to 1/4 inch maximum size should be used to pack a forma-

FIG. 6-06 GRAVEL PACKED WITH SLOTTED CASING



tion consisting of coarse sand. The screen to be used should have openings that will retain from 75 to 90% of the gravel.

The length of gravel pack material should extend at a distance equal to 2.5 times the largest diameter of the well above any screen. Sand, cement, clay or other additional filter material should be placed between the gravel pack material and the lower limit of the sanitary seal. The size of additional filter materials should be such that it will not infiltrate into the gravel packing materials.

f. Well Development

The aim of all water well development is to remove the finer material from the aquifer and thereby open up and re-arrange the formation sands to allow the water to freely enter the well. Proper development of a well brings it to its maximum capacity. There are several beneficial results obtained from the development procedure, such as: - Development re-arranges the sand grains by drawing the fine material through the screen and corrects any damage to, or clogging of the water bearing formation caused during construction,

- Development increases the porosity and permeability of the natural formation adjacent to the well,

- Development stabilizes the sand, builds up an envelope of coarse sand around the screen well, and results in a sand-free yield.

- The mechanical means employed in the development will depend on what is known about the well, i.e. the type and slot opening of the screen, the outside diameter, the position of the screen and the type of strata above the aquifer.

The following is a list of the most common techniques used for well development:

<u>Overpumping</u> - This is simplest and most common method of development. Meaning pumping the well at a higher capacity than it will be pumped when in regular service, there are several objectives to this method of development:

- it tends to cause the sand to bridge in the formation,

- one direction flow,

- limited development in poor aquifer,

- Requires use of larger pumping equipment than what is conveniently available.

<u>Backwashing and Rawhiding</u> - Backwashing is based on the principle of agitating the formation at the well end, for the

purpose of preventing bridging of the sand particles and removing a large portion of the finer material, accomplishing this result by a backflow of water. One effective means of backwashing is called rawhiding the well. This is done by starting and stopping the pump intermittently to produce relatively rapid changes in the pressure heads in the well.

Mechanical Surging - Mechanical surging is done by the use of a surge plunger which operates like a piston and a cylinder that goes up and down. There are two general types of surge plungers:

- Solid Surge Plunger - it may be operated at the string of percussion drilling tools with a subjoint. Some drillers run the plunger on a continuous string of pipe or a partial string with a cable adaptor at the top.

- Valved Surge Plunger - This is operated in the manner the solid surge plunger is operated but its main difference is in the principle of operation. In a solid plunger, you force the water gradually out of the well and back into the formation. In a weak yield type of aquifer your head of water drops rapidlly. In a valved plunger, it produces a surging or an in and out movement of the water through the screen and the formation around the screen with a greater in-rush than out-rush of water. When a valved-type plunger is operated in the well, the water is pulled into the well on the up stroke of the plungers, there being no check valve in the well. The w. ter recedes as the plunger drops on the down-stroke thus backwashing the well. The friction of the rapidly moving plunger with its relatively small valve parts will exert a downward pressure on the receding water and give more force to the backwashing action.

Developing Wells ·th Compressed Air - the principle through which deve nent is accomplished is a combination of surging and pumpin 3y means of sudden release of large volumes of air a stro g surge is produced by virtue of the resistance of · ate head, friction and inertia. Pumping is done as with · ·inary airlift. It is upon the skillful application of this alternate surging and pumping that the success of work depends.

There are two recognized methods of using compressed air to ·elop a well - the open casing method and backwashing. In wells equipped with sand screens, many drillers do all their development with the use of compressed air. Of the two above mentioned methods, the open casing or back blow is the more widely used. In shallow screened wells, the open casing method of air surgi·· is very ef ive, but in deep wells the backwashing ie screen · the closed well head can be equally useful · development work.

In the open casing method, before running a pipe into the well, the bailer should be operated for a short period of time to make sure water is entering the well from the aquifer. This ensures there is no build-up of differential pressure across the screen when large volumes of air are released during the surging operation. The well should be slowly air-lifted or pumped at the start and continued until the water being discharged is clear of sand. When no further sand is entering through the screen and the water is clear, the surging of the well can be commenced.

In backwashing or closed well-head method, after preliminary bailing, the top of the casing is sealed with a tighthead, tapped with a small and large hole, one for the pipe and the other for the rising main. Through the large hole, the rising main is extended down into the well until at least 60% and preferably 70% of its length is submerged in water. In operation, air is forced down the air line and returns to the surface through the rising main, and bringing a stream of water to the surface.

Air development should only be used in wells which have the screen set in a good depth of sand, with an impervious clay or cap rock above the sand. Wells with a thin, sandy aquifer and overlaid with a soft clay, may result in sand cavities into which the overburden collapses behind the screen and can result in the complete loss of the well.

<u>High Velocity Jetting</u> - Since the availability of large capacity pressure pumps became available, it became possible to effectively develop a sound screen by the forceful action of high velocity jets of water washing out through the screen openings. This method has a number of important advantages:

- It is easy to apply and there is very little danger of over development with the resulting collapse of the strata above the aquifer,
- the modern stainless steel, wire-wound screen with its closely spaced openings is readily operational and allows a deep and relatively uniform penetration of the jet stream,
- the action of the jets breaks down any clay particles or mud cakes on the outside of the screen,
- Bringing in these fine sands and re-arranging the close particles improves permeability.

The equipment required for jet development consists of a pressure pump capable of producing 120 GPM and a variable pressure of 100 psi to 300 psi. Selection of pipe size will depend on the depth of the well and the amount of water to be delivered at the nozzles. To keep friction losses to a minimum, the generally used sizes are as follows:

TABLE 6-03 Generally Used Pipe Sizes

| Size of Pipe | lpm | gpm | To Depth |
|---|---|---|---|
| 38.1mm I.D. | 227.3 | 50 | 100 (30.48m) |
| 38.1MM I.D. | 159.1 | 35 | 200 (60.96m) |
| 50.8MM I.D. | 454.6 | 100 | 100 (30.48m) |
| 50.8MM I.D. | 345.9 | 75 | 200 (60.96m) |

With increased depth the pipe size must be enlarged to hold friction losses within acceptable limits.

A three nozzle jetting tool has the nozzles interchangeable in sizes 0.47 cm., 0.6 cm and 0.95 cm. spaced 120 degrees apart to balance the unit during operation. Other equipments used are pressure hose, water shivel or other connection, a string of pipe and a supply of water at the bore head.

After lowering the jetting tool to the bottom of the screen and having commenced to pump water down through the equipment, the jetting tool should be slowly rotated, raised and lowered until the surface of the screen has been completely covered.

Due to the high velocity jets working on the formation, the turbulence created by the jets will bring fine sands, silt and mud into the screen.

In artesian wells this is not a problem as the flow from the well ensures that materials brought in by jetting will be washed from the well. However, in non-artesian wells, provision can be made to pump or air lift the water from the well while jetting is in progress.

Chemical Means of Development

There are two (2) types of chemicals that are normally used in well development. Calgon (Sodium Hexametaphosphate) has proved to be one of the most effective agents in removing accumulations of clay or fine silt, as well as deposits of iron oxide and calcium carbonate when the screen and/or water bearing sand has become clogged. Dry ice has been used to a limited extent in producing a surging action and also as a means of obtaining back pressure with the closed well head, but although inexpensive, has been out-moded by more effective means of development.

The ultimate results of the treatment are the restoration of the original well capacity in the case of an old well, and an increase in yield and reduced draw down in a new well.

g. Sanitary Seal (Grouting)

Due to unavoidable irregularities in the size of the borehole, and because the hole must necessarily be somewhat larger than the pipe used for well casing, it must be assumed that some openings are left around the outside of the casing. Whatever may be the method of installation, polluted water from the surface drainage or from formations other than the aquifer once the well is completed can move downward to the spaces. This can result in contamination of the water being pumped from the well.

Cement grouting of the cased portion of a well should be carried with an impervious subsurface formation above the aquifer, or in a homogeneous formation. (Refer to Fig. 6-07) It should be carried to a safe depth below the anticipated pumping level. The reasons for grouting are:

- protection of the aquifer(s), including the prevention of water movement between aquifers, for purposes of maintaining quality or preserving the hydraulic response of the producing zone(s).

- protecting the well against the entry of unwanted water from the surface or a subsurface zone,

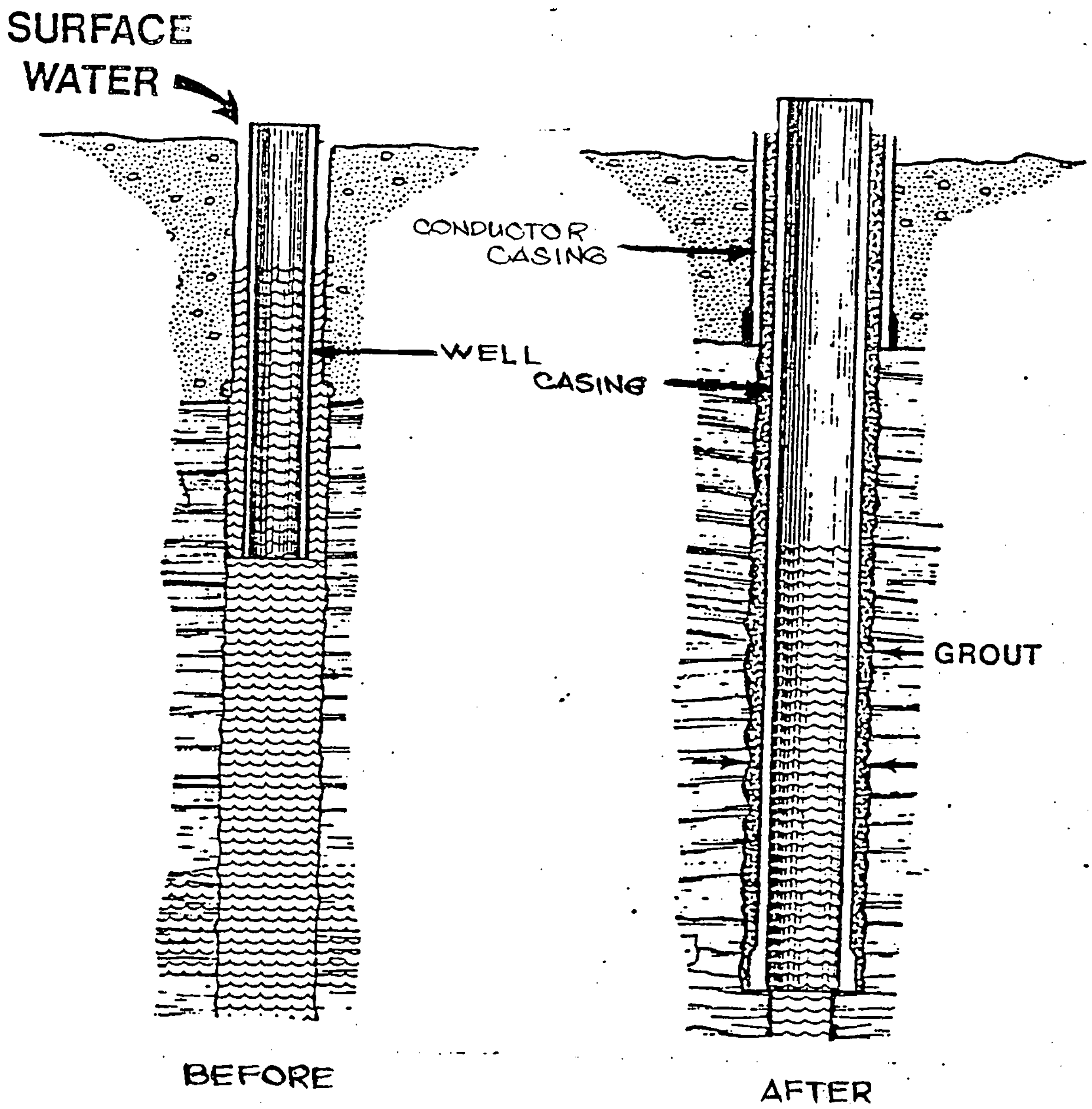
- to make the casing tight in the hole and protect it against attack by corrossive water.

In determining the specific grouting requirements of a well at a designated site, consideration must be given to existing surface conditions, especially the location of sources of pollution, and to subsurface geologic and hydrologic conditions. To protect against contamination or pollution by surface waters or shallow subsurface water (such as effluent from septic tank), the annular space should be sealed to whatever depth is necessary to protect the well. This may be as little as 10 feet or more than 100 feet, depending on conditions.

Formations which yield polluted water or water of an undesirable quality must be adequately sealed off to prevent pollution or contamination of the overlying or underlying water-bearing zones. To accomplish this, the annular space should be grouted from at least 10 feet above to 10 feet below the interval from which such polluted or mineralized water is being produced.

Grouting materials maybe either one of the following combinations:

Concrete Grout - a mixture of portland cement, sand, coarse aggregate and water in the proportion of at least




# FIG. 6-07 WELL POLLUTION

one (1) bag per 0.15 cubic meter of concrete to not more than seven (7) gallons of clean water per bag of cement (94 pounds per bag) should be used.

Sand Cement Grout - a mixture of portland cement, sand and water in the proportion of not more than two parts by weight of sand to one part of cement with not more than seven (7) gallons of clean water per bag of cement should be used.

Neat Cement Grout - a mixture of portland cement and not more than seven (7) gallons of clean water per bag of cement shall be used.

Special cements, bentonite to reduce shrinkage, or other admixtures to reduce permeability, increase fluidity, and/or control time of set. may be used.

Sometimes grout materials may be poured into the annular space by gravity. However, this method should be employed only where the interval to be grouted is clearly visible from the surface and is dry. Maximum allowable depth to bottom of grout interval should be 30 feet. Grout material may also be poured into the annular space by pumping or air pressure injection through the grout pipe (tremie pipe) installed either outside or inside the casing after water or other drilling fluids has been circulated in the annular space sufficient to clear obstructions. Curing time before any construction may be resumed ranges from 36 hours to 72 hours.

Pressure testing of the grout seal should be employed following the appropriate time for curing of the grout. A pressure of 7 to 10 PSI air should be maintained within the well, without the addition of more air, for a period of not less than one hour. Any loss of air should be construed as indicating a defective seal.

h. Pumping Test

In testing the well for capacity, it is necessary to measure the pump discharge and the depth of the water. Pump discharge (Q) is measured by dividing the volume of water that has been pumped out of the well per unit time (T) since the start of pumping while taking measurement until the container is filled of water. There are two kinds of water level while conducting a pumping test. The first one is what we call static water level (SWL) and it is the vertical distance from the center line of the discharge to the water surface in the well when there is no pumping. The second one the pumping water level, is the vertical distance from the center line of the discharge to the water surface in the well while pumping. The difference between the static water level and the pumping water level is called drawdown (dd). The specific capacity of a well is volume of water produced or pumped per minute for each foot of drawdown. There are two methods of conducting a pumping test for large diameter deepwells, 1) constant rate drawdown test (CROT) and 2) Step drawdown test (SDT). Pumps used are either centrifugal, submersible or line shaft turbine and pumps depending on the required demand, water level and pump setting.

For small diameter, shallow and deepwell hand pumps, the most common method of taking the discharge of the well is by volumetric method. This is done by recording the average volume per unit of time using the handpump. If the water level is low, centrifugal pump can be use to test pump the well. However, if the water level is very high (beyond the lifting capacity of a centrifugal pump) a deepwell handpump (cylinder type) is to be used. The discharge is dependent on the number of strokes made per minute or depending on the model of the cylinder pump installed.

i. Disinfection of Wells

In its natural state, chlorine is a gas; for chlorination of water supplies chlorine is used either as a liquid (gas under pressure), or in a solid or powder form of sodium or calcium hypochlorite. The solid or powder form of chlorine are most suitable for rural water supplies.

An effective and economical method of disinfecting wells is by the use of calcium hypochloride (chlorinated lime) containing approximately 25% available chlorine. This can be purchased at most drug stores and in large quantities at chemical supply houses. A fresh supply should be used, since the chemical deteriorates when standing in air.

TABLE 6-04

<u>Percent Available Chlorine Of Various Chlorine Compounds</u>

| Materials | Percent Available Chlorine |
|---|---|
| 1. Chlorine, CL | 100 |
| 2. Calcium Hypochlorine (HTH) | 70 - 74 |
| 3. Bleaching Powder | 35 - 37 |
| 4. Sodium Hypochlorite | 12 - 15 |

<u>Factors Affecting The Effectiveness Of Chlorination</u>

1. Time of contact
2. Nature and Concentration of Pathogenic Bacteria
3. Chlorine Dosage
4. Temperature of water to be disinfected.

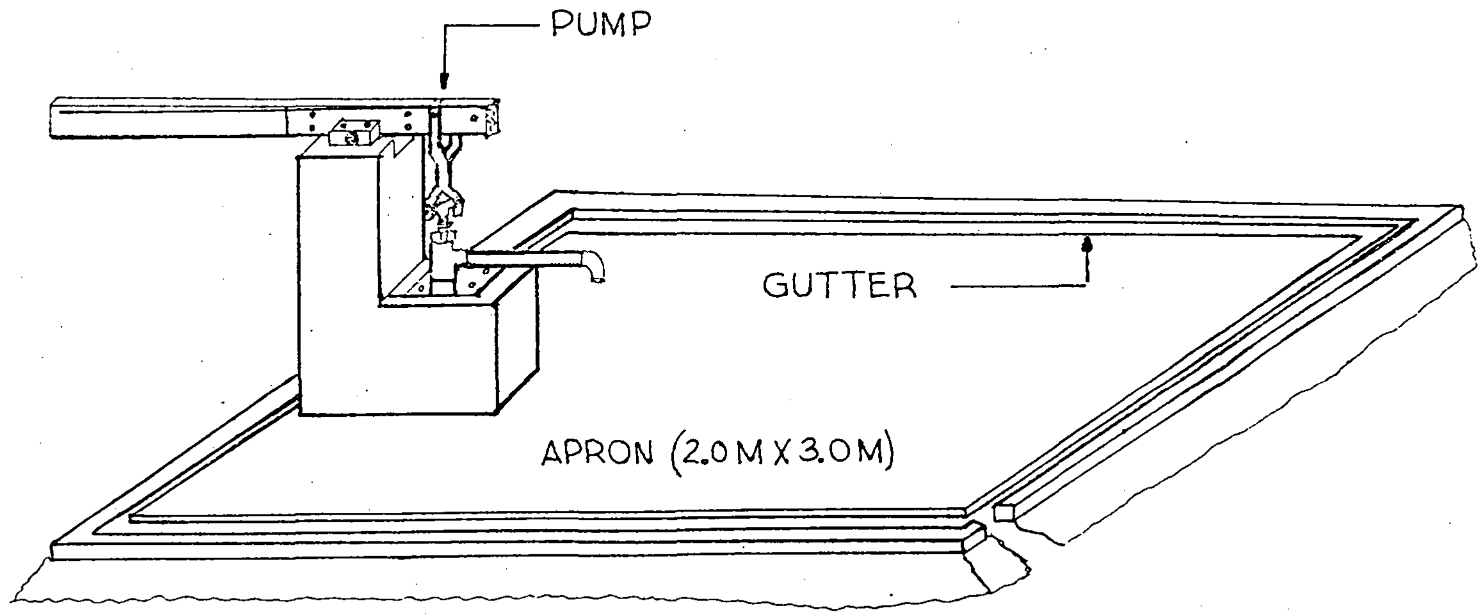
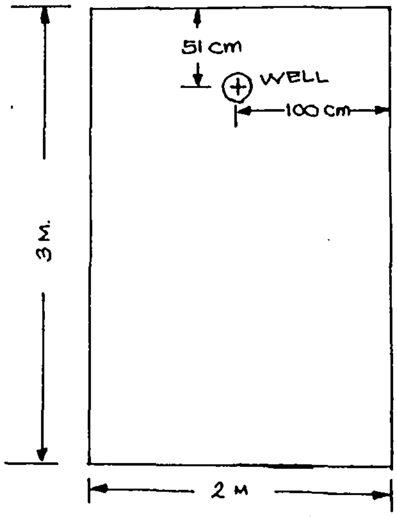



FIG. 6.08 LAYOUT OF PUMP SITE




LAY-OUT OF DRILLED WELL

STAKING OUT OF THE APRON

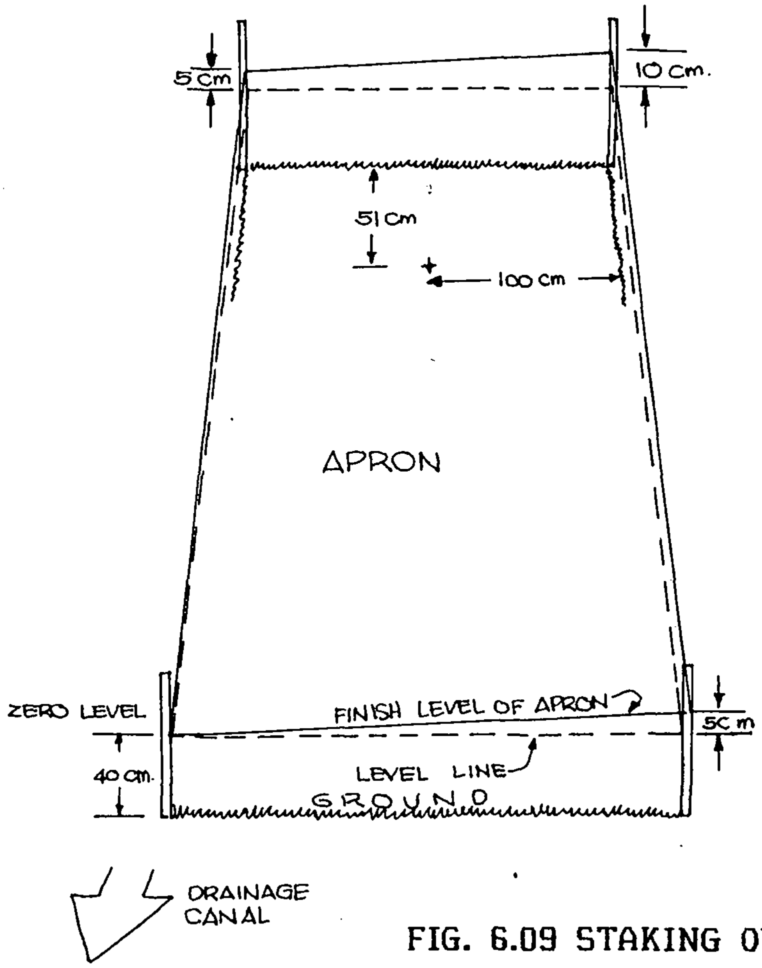
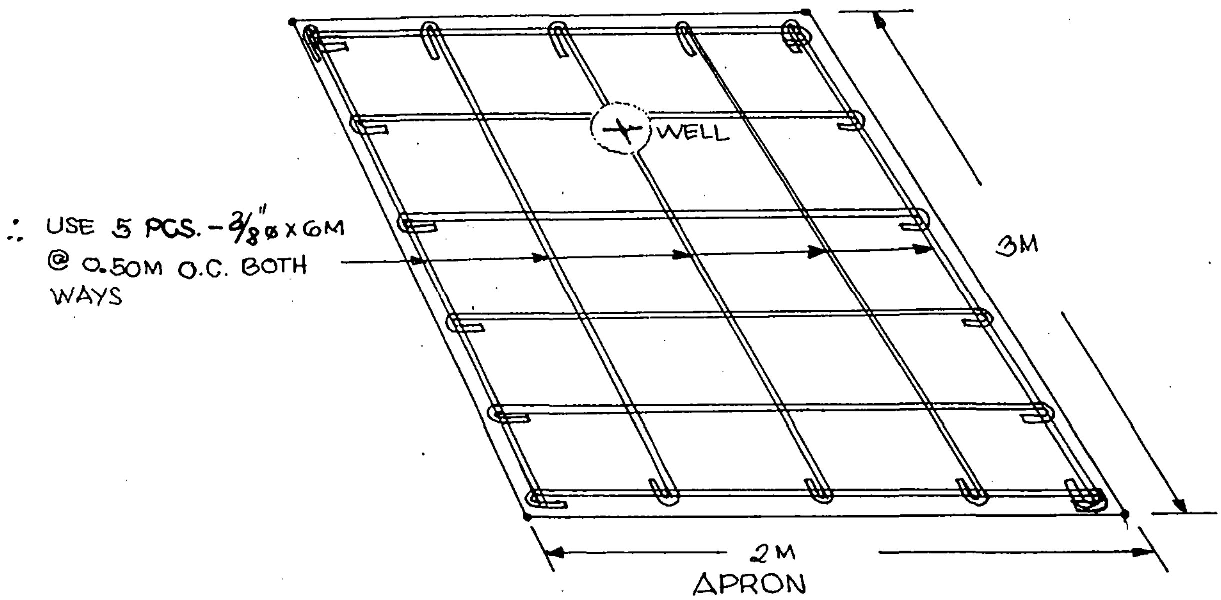



FIG. 6.09 STAKING OUT OF THE APRON



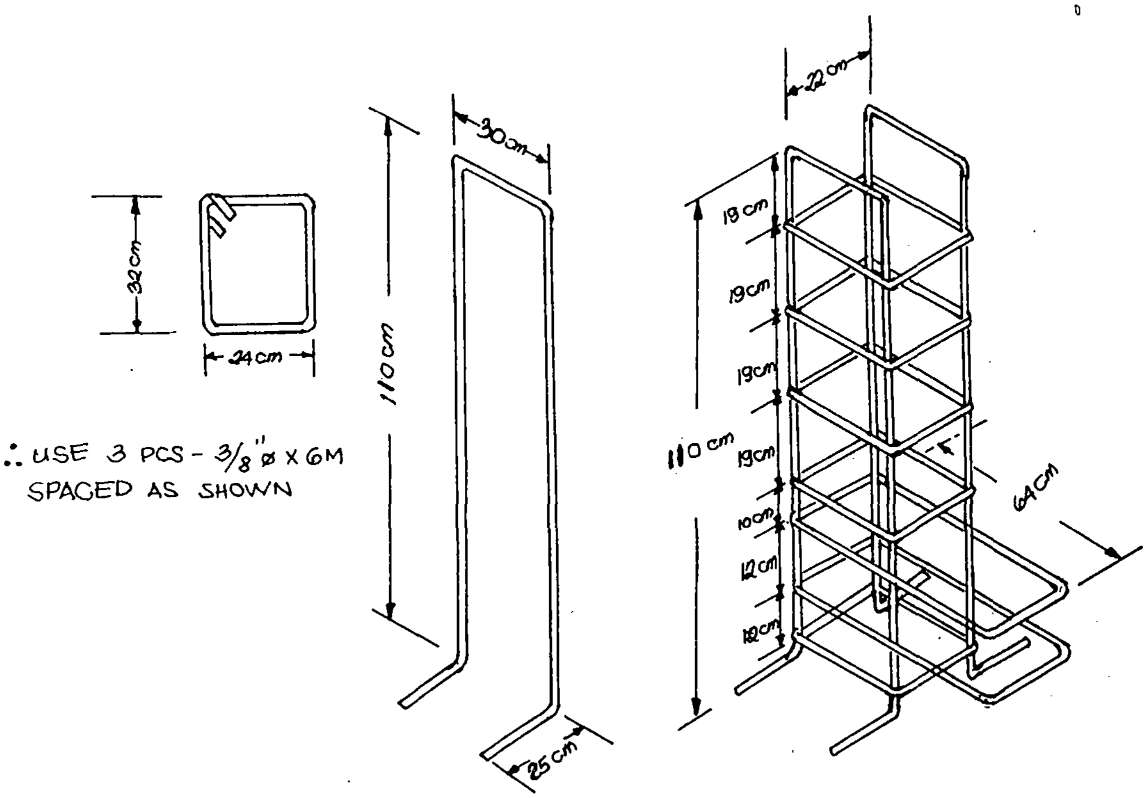




FIG. 6.10 REINFORCEMENT BARS OF COLUMN & APRON

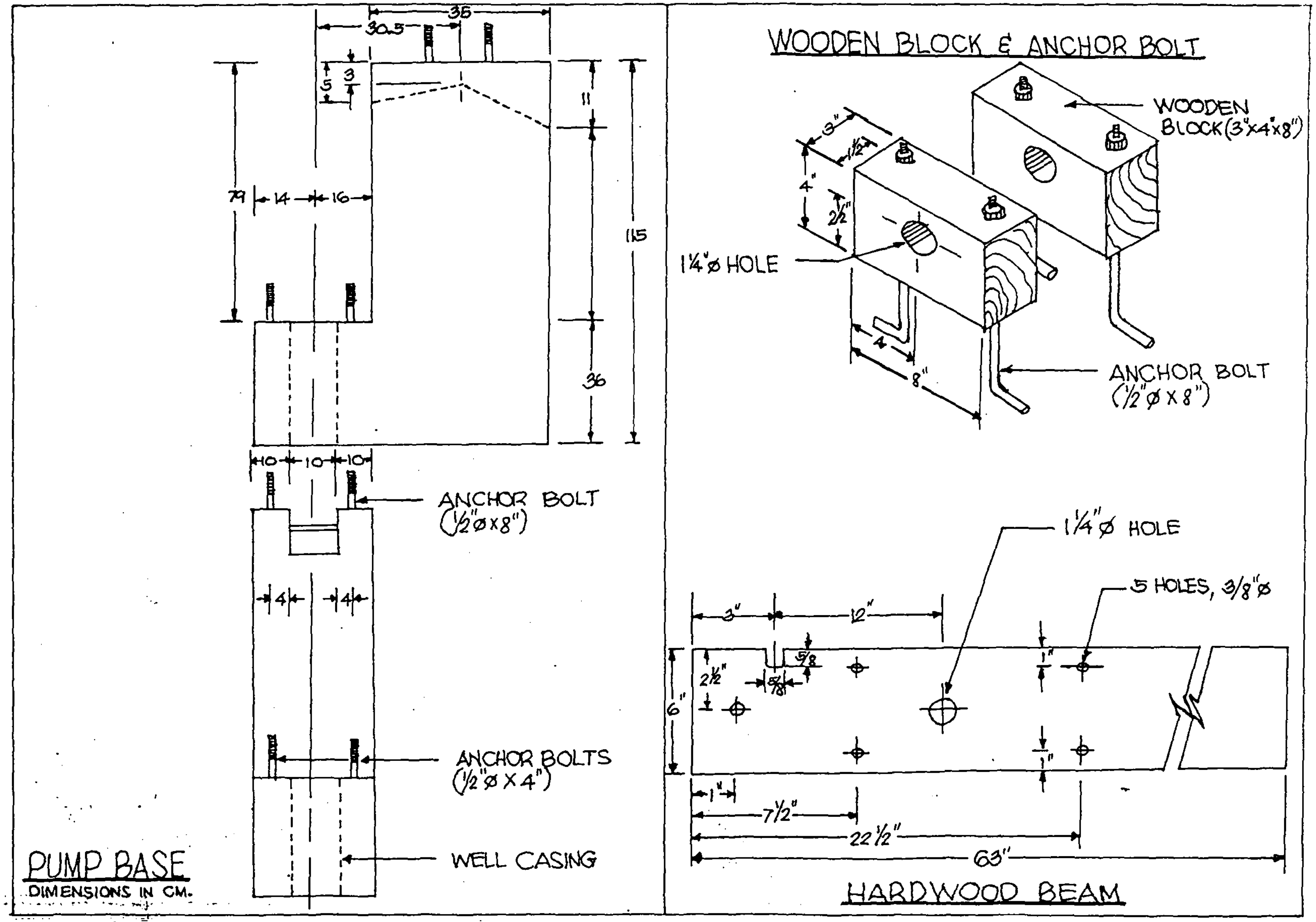



FIG. 6.11 DETAILS OF COLUMN, WOODEN BLOCK & BEAM

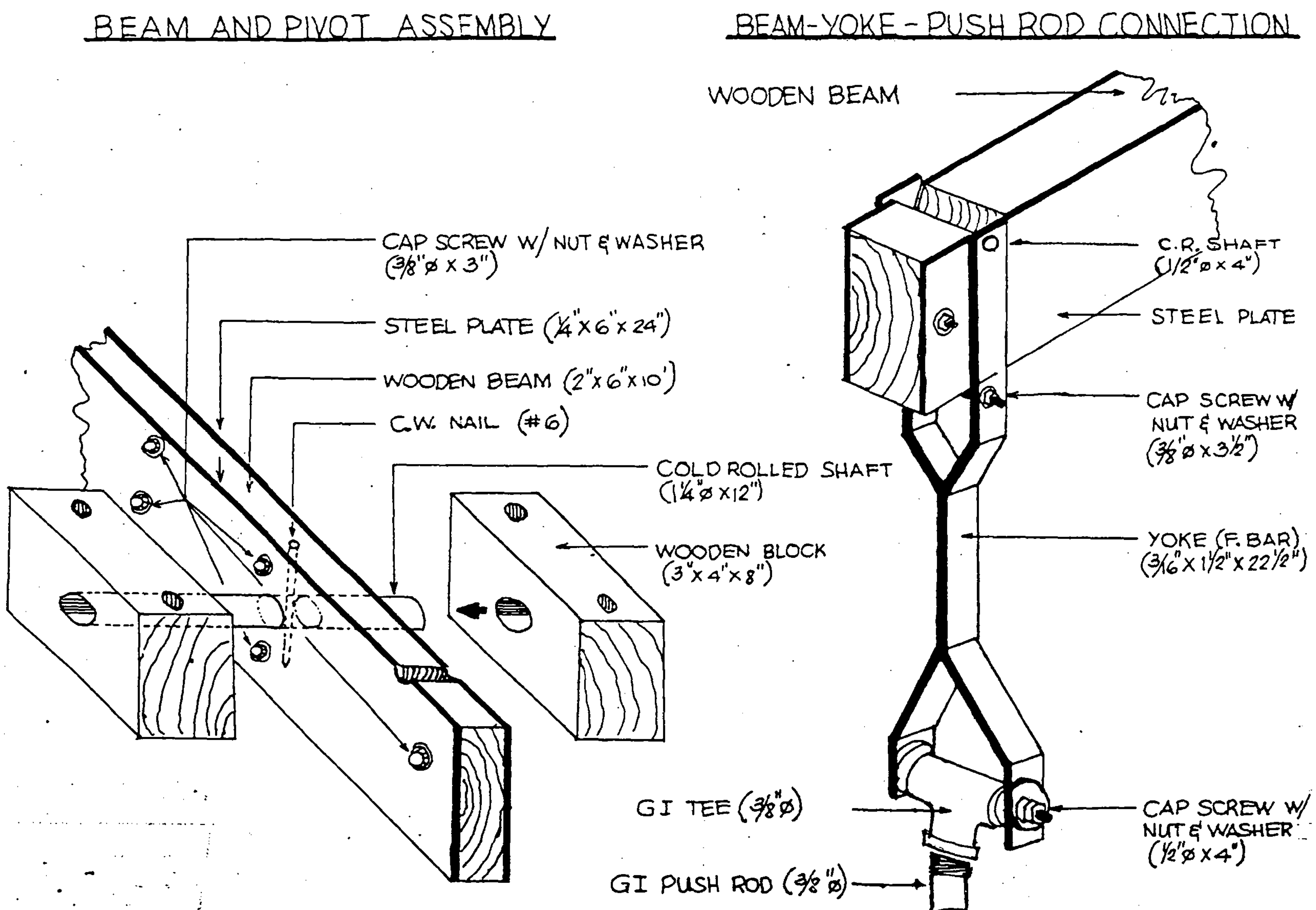



FIG. 6.12 DETAILS OF BEAM, PIVOT & BEAM-YOKE PUSH ROD CONNECTION

Chlorine Dosages For Newly Constructed/Repaired Well

1. Dosage : 50 mg/l
   Contact time : 24 hours

2. Dosage : 300 mg/l
   Contact time : 1 hour

The amount of chlorine compounds to be used in disinfecting a newly constructed or rehabilitated well is based on the following data or information needed.

a) Diameter of well
b) Static water level
c) Total depth of well
d) Dosage
e) Contact time

Based of the above information, calculate the volume of water in the well.

where V= Volume of water in liter
D= Diameter of well,in meter
H= Height of water column inside the well,in meter
1 cu.m = 1,000 liters

Then calculate the amount of chlorine compounds to be applied.

$$A = \frac{V \times D}{\text{Available Chlorine (\%)}}$$

where A=amount of chlorine,in grams
V=Volume of water,in liters
D=Dosage, mgl

Steps to follow in disinfecting a newly drilled or repaired well.

1. The pumps (either hand or motor pump) should be operated until the water is clear and free from turbidity as much as possible.

2. After pulling out the pump, pour the required amount of chlorine compound into the well slowly. Mixing of the solution may be done with use of a hose or pipe or by using dry ice.

3. Wash the outside and inside of the pump cylinder and the drop pipe as they are lowered into the well.

4. After the pump is set into position, operate it intermittently for very short periods to further mix the solution in the well.

6. After 24 hours have elapsed, the well should be cleaned by pumping. Operate the pump until the water is free from the odor of chlorine.

j. Pumping Facilities

Pumps are devices used in transferring water or other liquids from one place to another through pipes. The transfer is effected by the addition of energy. An understanding of the different types of pumps, their applications, their design differences, and procedures to operate and maintain them is important in planning a water supply system.

There are a variety of pumps available for water supply projects, and the selection will be based on required performance and site conditions, such as water quality, depth of water below ground, and safe yield or discharge. Each type of pumps has its own advantages and disadvantages. It also has its own limit of application.

Operation, maintenance and repair are the major considerations for rural water supply projects. These functions are likely to be entrusted to personnel with minimum of training, and hence, all equipment should be sturdy and simple.

A further important consideration is the cost of the above functions. With limited funds likely to be available, the cheapest but efficient and reliable source of prime mover should be selected. Consideration must always be given to such types of prime movers already tested for its good performance. The availability of spare parts for maintenance purposes should also be considered.

DESIGN OF PUMPS

- Data Needed to Purchase a Pump
  1. Pump Discharge, Q, (in liters per sec.or gals. per min.)
  2. Total Dynamic Head ,TDH, (in ft. or meter)
  3. Well Casing Diameter, (in inches or millimeter)
  4. Pump Setting in case of submersible or turbine pumps (in ft. or meters)
- Pump Discharge or Capacity, Q
  1. If the pump is used directly to supply water, the capacity must be equal to the maximum hour demand.
  2. If the water distribution system has a reservoir, the pump capacity must be equal to the maximum day demand.
- Pump Selection
  1. In the absence of electric power and in case of

isolated population, hand pumps are recommended because diesel or gasoline engine driven pumps require higher capital, maintenance and operating costs.

2. If the water level is 6 meters or less use centrifugal pump if the well is capable of supplying the required demand.
3. If the water level is 6-20m, use jet pumps.
4. If the water level is more than 20M, use submersible or vertical line shaft turbine pumps.

Pumps Operating Time- At least 8-12 hours.

CLASSIFICATION OF PUMPS

a. Hand Pumps

Hand pumps are installed over dug wells or tube wells, this method of supplying water is most suitable for scattered population, when water bearing ground exists near the service area and where there is an absence of electric power.

There are two basic types of hand pumps. The shallow well pump with the cylinder above the ground, and the deepwell pump with the cylinder below the ground (always below the water level).

The term shallow well does not refer to the total depth of the well, but rather to the depth of the water level below the ground (SWL). A well may be 100 ft. in depth before it hits or strikes an aquifer, but once the aquifer is hit, the water may rise to within 10 ft. of the ground level or even overflow, this would have a shallow well pump. However, in case the water level is 30 ft. or more below the ground, a deep well pump is needed.

The discharge per stroke will depend on the cylinder's diameter and its effective length, there are obviously many variations in these dimension combinations to give the required output. Cylinders are normally made of cast iron, and to avoid excessive wear on the cups, have a brass or PVC liner for shallow well hand pumps while for deep well hand pumps, cylinders are made from brass materials. There are two basic types of deep well hand pumps: the "closed type" and the "open type", the former is tapped to receive the drop pipe, while the latter can be screened directly to the well casing so that this becomes the drop pipes. Cylinders with 1-15/16" O.D. (1-13/16" I.D.) can be used for 2"dia. casing using 1-1/4" diameter as the drop pipe, and is an example of the closed type cylinder. Another example of the closed type cylinders is a cylinder having a 2-3/16"O.D. (2"I.D.) and can be used for 2-1/2" diameter casing and using 1- 1/4" diameter as the drop pipe. Example of open type cylinder is a cylinder having a 1-15/16"O.D. (1-13/16"I.D.) with spring dog and rubber expander to protect the cylinder from dropping into the well. This type of cylinder needs a 2"diameter casing and 3/8" diameter riser pipe. Both shallow and deep well hand pumps uses leather cups; the former uses only one set while with the latter, the number varies from one to four set depending on the cylinder diameter. Obviously the greater the number of leather cups, the less the effective length of the cylinder.

b. Centrifugal Pumps

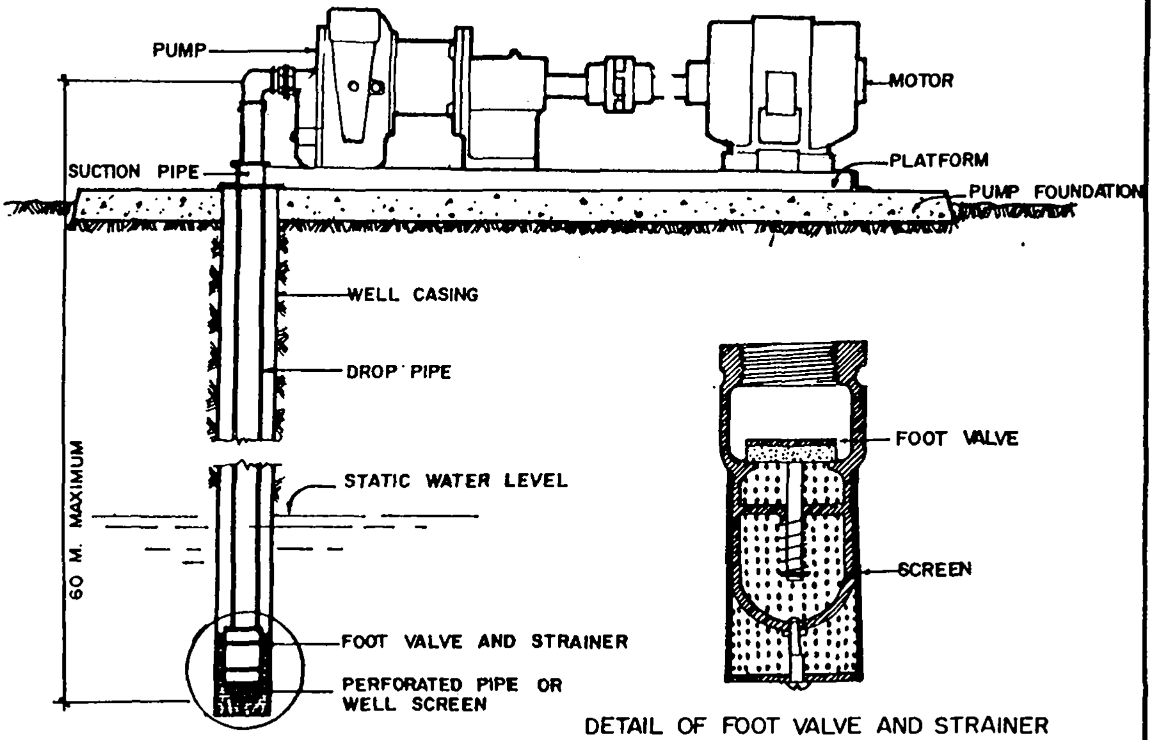
Centrifugal pumps raise liquids by centrifugal force created by a wheel, called an impeller, rotating within a pump case. Water enters at the center of the impeller. When the impeller is rotated, water in the pump is forced out by centrifugal force. This causes a vacuum condition at the center or eye which provides the necessary force to move or lift the water. Water is continuously drawn toward the vacuum and, at the same time is discharged by centrifugal force of the impeller, thereby providing a smooth and continuous flow of water. (Refer to Fig. 6-13)

Centrifugal pumps come in many different designs, arrangements and types, although they all operate on the same principles. The volute-design centrifugal pump has an impeller which discharges into a progressively expanding spiral casing. The proportions of the casing are designed to produce equal velocity of the water all around its circumference. The velocity of the water is gradually reduced as it flows from the impeller to the discharge pipe resulting in the energy of the pump being converted from a velocity head to a pressure head.

Turbine pumps are also considered a type of centrifugal pump. This pump does not rely solely upon centrifugal action to do the necessary pumping. In turbine pumps, the water does not flow freely from impeller vanes but is held in the pump until the water has rotated about the pump. The water, when released at the discharge, has a higher pressure than the common centrifugal pump.

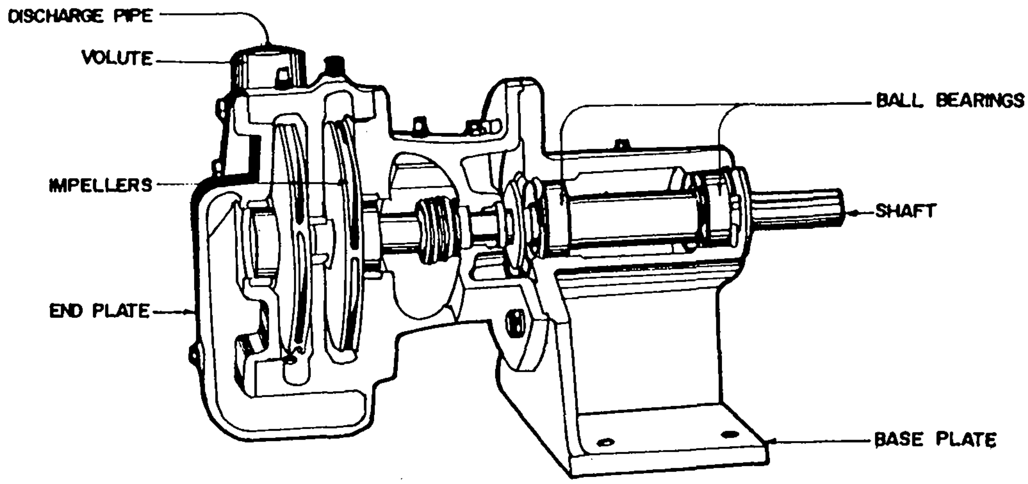
Mixed-flow pumps are a type of centrifugal pump which produce the necessary water pressure by a combination of centrifugal force and the lift of vanes on the impeller. Axial-flow or propeller pumps may or may not be considered centrifugal pumps since they rely almost solely upon the lift of the impeller vanes to produce the flow of water.

Centrifugal pumps may have a single suction inlet, where water is admitted on one side of the impeller, or a double suction inlet if water is admitted on both sides of the impeller. A centrifugal pump cannot operate unless the pump casing is full of water. For the pump to begin




DETAIL OF FOOT VALVE AND STRAINER

INSTALLED CENTRIFUGAL PUMP IN A WELL




DETAIL OF CENTRIFUGAL PUMP

FIGURE 6.13

CENTRIFUGAL PUMP

developing a suction at the eye of the pump, the casing will have to be filled with water, or "primed".

c. Jet Pumps

A Jet pump (Refer to Fig. 6-14) consist of a nozzle which discharges the water into a constricted throat much like a venturi. This throat leads from a suction pipe. This arrangement permits energy of a high pressure fluid to be converted into a high velocity fluid.

Jet pumps are usually selected when the suction lift required is greater than that of centrifugal pumps and the volume of water needed is relatively small. Jet pumps are suitable for 50 mm diameter wells. Jet pumps are easy to maintain and repair for its moving parts are installed above the ground. However, its distinct disadvantage is that there is an appreciable reduction in its capacity as the depth down to water level increases.

Jet pumps are oftentimes employed in shallow and deep wells. The maximum depth down to water level to which it can operate normally is 30.5- 36.5 meters with a corresponding discharge of about 0.21 liters per second.

Jet pump units are usually run by electric motors.

d. Submersible Pumps

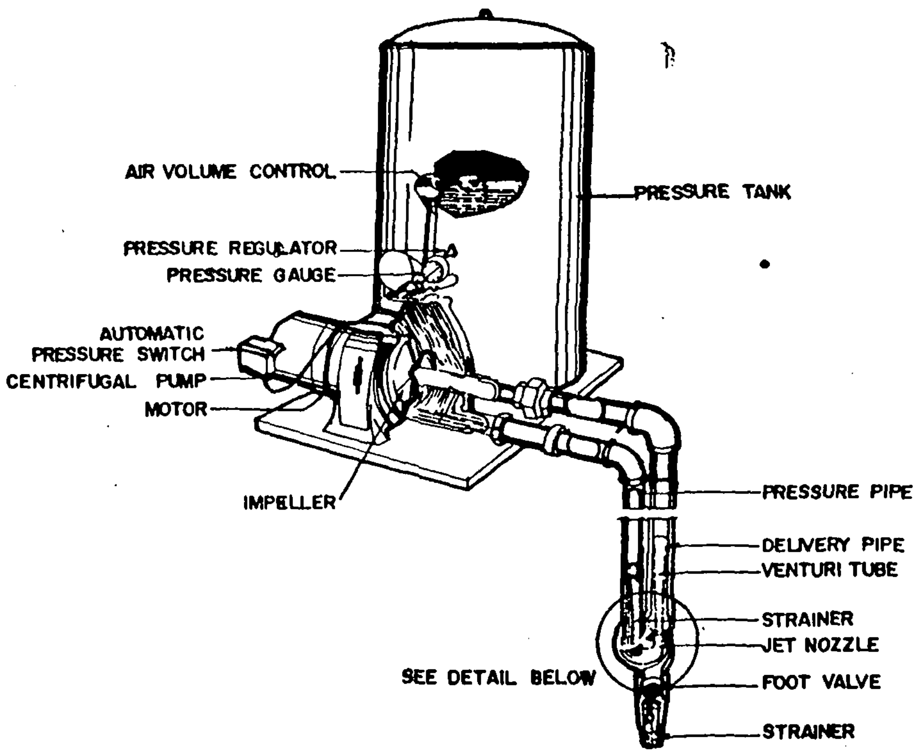
Submersible pumps (Refer to Fig. 6-15) are suitable for wells where the depth to water exceeds the capability of centrifugal pumps; and where the required discharge exceeds the capability of jet (ejector) pumps; these pumps have electric motors directly coupled to the pump, which is usually a centrifugal type, though some manufacturers have units which incorporate the helical rotor. Both pump and motor are installed down the well below water level; no power is thus lost in driving a long shaft as in the case of the deep well turbine pump.

Their range of performance is considerable: it can be as low as 10 gal/min. or over 1000 gal/min.; pumping heads can exceed 1000 ft.

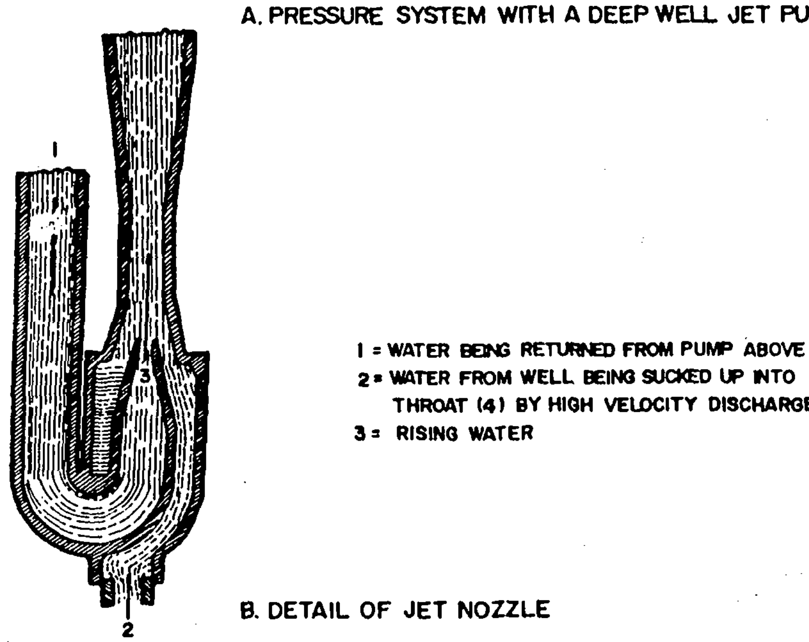
The greater the head, the greater the number of stages in the pumps; pumps of up to 35 stages are produced.

These pumps can be installed in wells as small as 4" (100 mm) internal diameter.

It is more usual to pump to an elevated storage tank though these pumps can be connected to ground level pressure tanks or direct to the distribution system.




A. PRESSURE SYSTEM WITH A DEEP WELL JET PUMP




B. DETAIL OF JET NOZZLE

FIGURE 6-14

JET PUMP

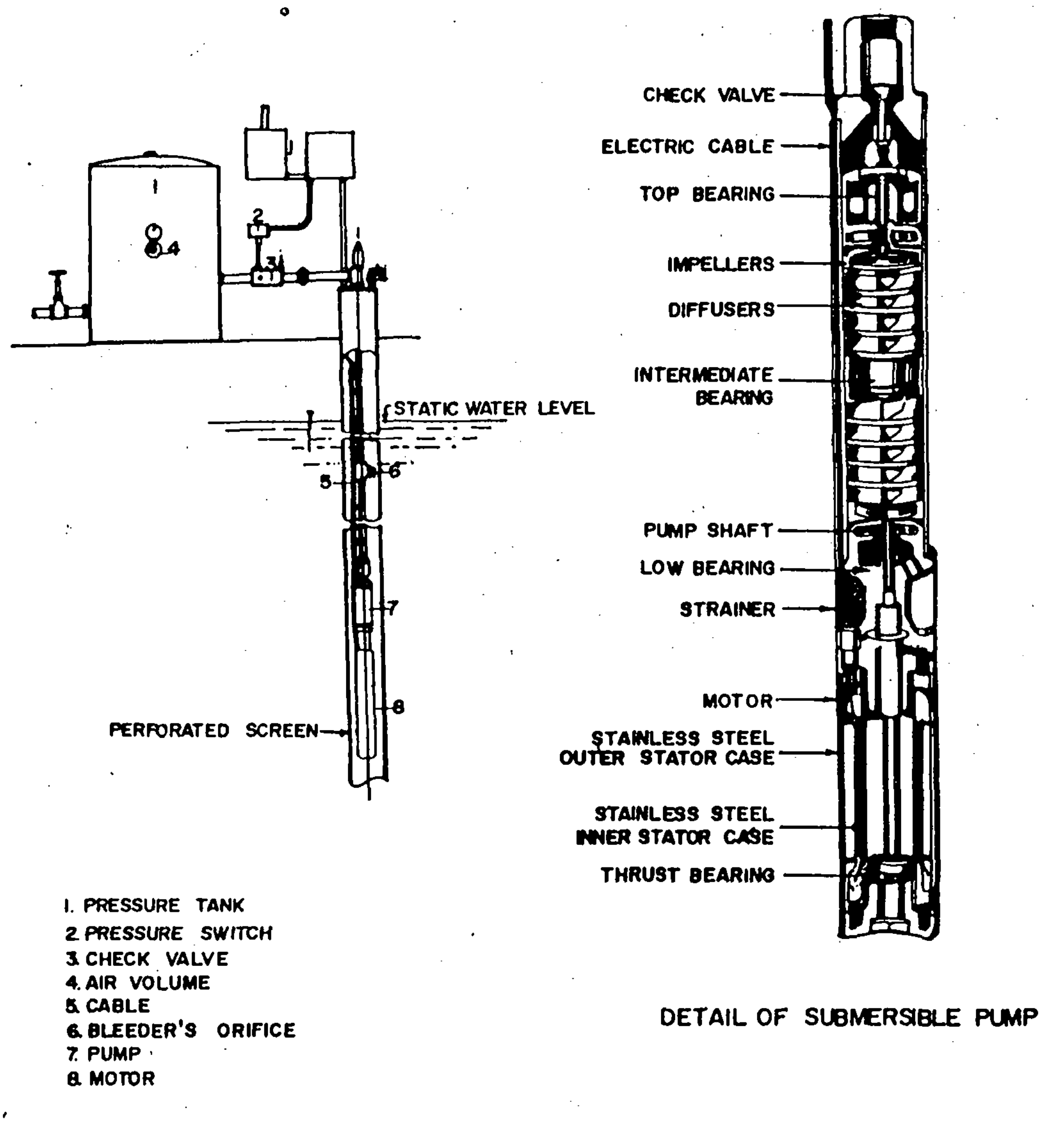



FIGURE 6-15

SUBMERSIBLE PUMP

The electric motors may be as small as 1/3 HP; small HP electric motors are single phase, while the larger units are 3 phase. These motors are hermetically sealed. The smaller units (about 3 HP) are usually of the capacitor type; this motor is normally the oil filled type and lubricated for life.

The discharge pipe from the pump is relatively small and will be in the range of 1" to 2" (25 to 50 mm) for 4" (100 mm) pumps, while a 3" (80 mm) pipe is usual with the 6" size pump.

Water containing sand is harmful to submersible pumps as this causes excessive wear and could cause binding. The safe upper limit of sand content in the water is generally taken as 25 grams per cubic meter of water.

2. Springs

Because of limited resources, it is often difficult for rural communities to afford frequent repair cost, so that as much as possible, all constructed system parts should be durable enough to withstand rough handling and the elements of nature. This can be achieved through proper construction methods and materials and close supervision during construction.

Construction of water supply projects under the spring development category involves installation of transmission and distribution lines with public taps, developing spring(s) and construction of spring box, putting up of reservoir and other structures that would be deemed necessary to provide beneficiaries an effective water system.

Developing Springs

High yielding springs can be tapped as a source of domestic water supply for a small community. However, before it can be used as a source, it must first be developed to obtain its maximum potential flow.

Herewith are step-by-step procedures in developing a spring:

- Clean the site of weeds and all undesirable vegetation.

- Using a crowbar and/or pick-axe, enlarge the "eye" of the spring by excavating the area around the hole down to the impervious water-bearing layer. Remove the silt, rocks and other excavated materials. During the excavation, care must be exercised to avoid distributing the undergorund rocks formation as this may deflect the spring to another direction or rock formation.

- Pile loose stones against the eye of the spring to prevent the spring from washing the soil around the eye and also to serve as foundation for the spring box.

Spring Box Construction

Spring boxes are installed in a water system primarily to protect the spring water from contamination.

Design and construction of spring boxes depends on the kind of spring(s) to be protected. This can be constructed as follows:

- Construct the spring box using reinforced concrete, with a minimum wall thickness of 0.15m.

- Provide an access manhole covered with a removable concrete cover. The manhole should have a raised edge to prevent surface water from entering the box. The top of the box should be at least 0.3 meter above the highest ground elevation in the vicinity.

- Provide an outlet pipe above the bottom of the spring box, but below the eye of the spring. The end of the outlet pipe inside the box should be screened to prevent stones, rubbish and sometimes frogs from blocking the pipes.

- Provide an overflow pipe fitted with a screen to prevent the entrance of insects. The pipe must be sufficient to carry the maximum flow of the spring during the wet season. A pipe 50mm in diameter is recommended. Overflow pipes must be installed at eye spring level to prevent a possible backflow on the spring. Most of the defects of old constructed spring boxes could be accounted to faulty construction of the spring box and overflow installation.

After constructing the spring box, it is advise that a drainage ditch at least 8.0m uphill and around the spring box to intercept surface water and prevent it from entering the spring box should be constructed. To prevent any stray animals and maybe people from destroying and contaminating the spring water, fence the area around the spring box.

Construction of Reservoir

Reservoirs as we have said in the previous chapter, may be classified according to their function or manner of operation, relative position with respect to the earth's surface, and as to type of materials of construction. In this chapter we will concentrate our discussion on the construction of reinforced concrete reservoir.

Reinforced concrete reservoirs are made of concrete reinforced with steel bars. The process consists of preparing the formwork to serve as mold for concrete, the positioning of steel bars and construction joints or water stops, the pouring of freshly prepared concrete mix into the forms, curing of concrete, removal of forms, installation of the necessary appurtenances, finishing and water proofing.

The procedure of construction is as follows:

a. Foundation Works

  - Mark the location of t eservoir as specified in the plans. Clear th :.

  - Determine the beari :apacity of soil (SBP) to know whether it is capable of supporti ie weight of reservoir and its water content when it is full. If nd incapable look for a new location of reservoir.

  - Start the excava until loose g d formation is removed. When the structu o be constr d is located in a side-hill, benching sh extensiv gh to insure stable formation. This is usually accomplished by cutting into the sidehill to a depth of 1.2 meters.

Before the bottom slab or footing of the structures is constructed on the soil foundation, it is necessary to even up the trench bottom. Also, to ensure a good bond between the soil foundation and concrete, soil surface should be stripped of top soil to a depth of about 15 cm and watered to the approximate optimum moisture content before construction.

Prepare the underdrain. It consists of perforated PVC, PE or AC pipe surrounded by a gravel blanket. For small tanks, pipes could be deleted and the underdrain will consist only of a gravel layer properly compacted to support the imposed load on it. The underdrain is necessary for draining water at the base of the reservoir to take care of the uplift pressure when empty and the water table is above the base of the reservoir.

b. Fabrication and Re-bar Installation

Start the bar fabrication following the detailed design of the reservoir. Bar bending and cutting Schedule will not only ease bar fabrication but will also save rebar, as well as minimize mistakes in the fabrication.

After fabrication, place the rebar according to the detailed design plan. Weld all reservoir appurtenances to reinforcing bars such as overflow pipes, distribution pipe, drain pipe, etc., to insure that it will have a good bind in the concrete. Formworks installation followed.

c. Formwork

Forms are used to mold concrete to desired shapes and smoothness as specified in the plans. They are constructed so that concrete slabs, walls and other materials will be of correct size, dimension, shape, alignment, elevation and position.

Brace the forms properly so that it will be capable of holding the concrete mix weight during the pouring and curing period.

Placing of Concrete

a. Factors to be Considered during Placing of Concrete

Placement and consolidation of concrete affect the appearance, durability and strength of a concrete structure to a large extent. Presented below are the factors to be considered during placement:

- Fresh concrete mix should be of good quality, as determined in terms of water-cement ratio, slump and homogeneity. Separation or clusters of coarse aggregate are objectionable and should be scattered prior to placing of concrete to prevent rock pockets and honeycomb in the completed work.

- The concrete mix should be deposited at or near its final position during placement to eliminate the tendency of the coarse aggregate to separate.

  On sloping surfaces, concrete should be placed at the lower portion of the slope, and progressing upwards from these (Figure 6-16).

- When concreting starts, placing should be continuous until a definite section is completed. High velocity discharge should be avoided because it may cause segregation and formation of laitance. Laitance is a whitish, chalky substance composed of cement particles, silt, and clay that gathers on the surface of wet concrete mixture. Excess water and laitance should be drained off.

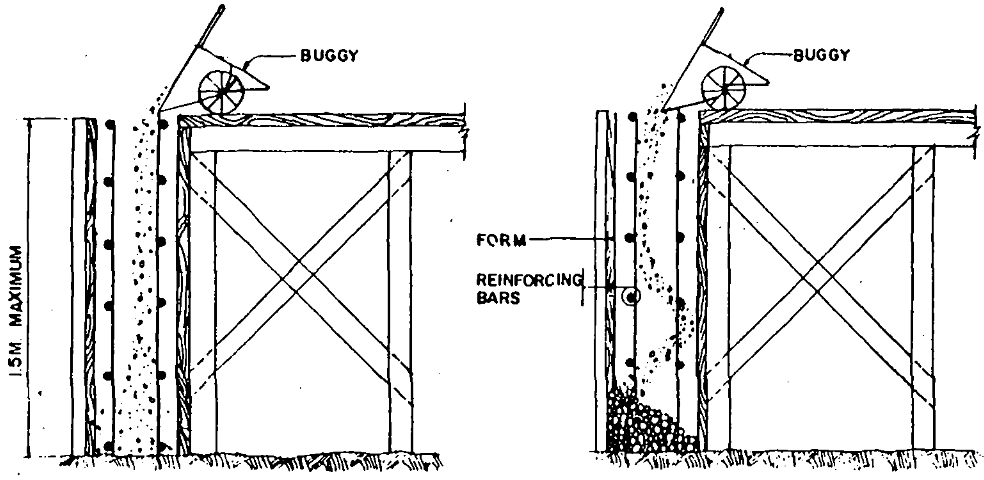
- Concrete mix should be placed in horizontal layers not exceeding 60 cm. (2 feet) in depth. Each concrete layer should be placed while the underlying layer is still responsive to consolidation, and layers should be sufficiently shallow to permit the knitting of the two layers together through proper tamping or rodding, or vibration.

b. Preparation of Surface to be Concreted

- Clean up subgrade steel reinforcements and forms from embedded items, dirt and other debris. Reinforcing steel should be clean, in its correct position, and well supported and secured prior to the start of concrete placement. It is not necessary to remove tightly adherent rust and mortar from the reinforcing steel but loose adhering materials should be removed.

- Check all bracing. Forms should be strong and tight to prevent loss of mortar.

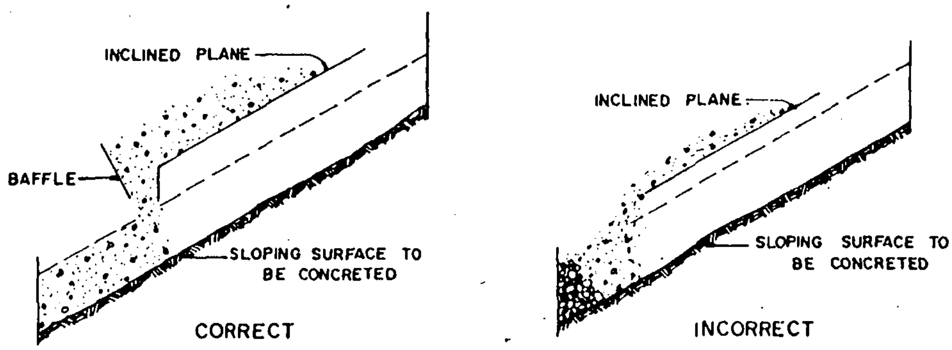
- Wet subgrade and forms to minimize their tendency to absorb water from the mix. Subgrade should be moistened up to a depth of about 15 cm (6 in.).




CORRECT INCORRECT

WHEN PLACING CONCRETE, AVOID THE CONTACT OF CONCRETE WITH FORMS OR REINFORCING BARS.

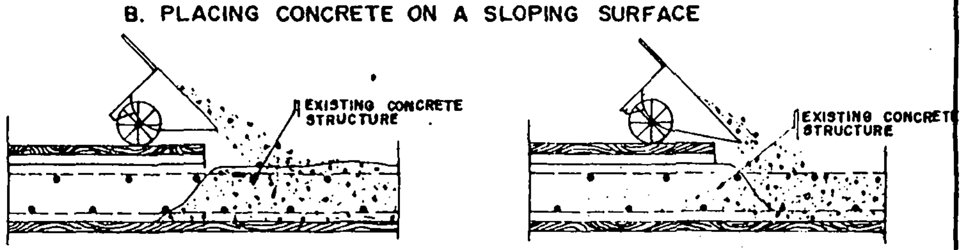
A. PLACING CONCRETE ON TOP OF NARROW FORM




CORRECT INCORRECT

START PLACING CONCRETE AT THE BOTTOM OF THE SLOPE.

B. PLACING CONCRETE ON A SLOPING SURFACE




CORRECT INCORRECT

START PLACING CONCRETE NEAR THE EXISTING CONCRETE STRUCTURE AND NOT AWAY FROM IT.

C. PLACING SLAB CONCRETE

FIGURE 6.16

PLACING OF CONCRETE

c. Preparation of Concrete Slabs

Place concrete mix as close as possible to its final position. If there is an existing concrete structure, place new concrete against previously placed concrete and not away from it (Figure 6-16). As each batch of concrete is placed in the forms, consolidate and work it into all corners and around the steel by hand spading, rodding or vibrating.

d. Preparation of Concrete Walls and Other Vertical Structures

Start placement of concrete at the opposite ends and proceed to the middle to prevent water from forming in corners. When placing concrete, the mix should be directed as close to its final location as possible.

Do not allow mix to bounce off from the reinforcement or forms. As the desired thickness is reached, consolidate the concrete by rodding, tamping or vibrating.

e. Bonding of Fresh Concrete to Existing Concrete Structure

In joining fresh concrete to existing concrete structure the old surface should be roughened with a pick or cold chisel and all loose materials and dirt should be removed. The cleaned surface is moistened, then a coat of water-cement mixture about 13 mm thick is applied and then cover carefully with a layer of concrete. Placing of fresh concrete may then be resumed.

f. Consolidation of Concrete

Consolidation of concrete is necessary to bring the concrete particles together to produce a homogenous and high strength concrete structure. Consolidation can be effected through vibration or rodding.

1. Consolidation by Vibration

Vibration is the most effective method of consolidating concrete, permitting the placement of concrete containing less water than required when concrete is not vibrated. In addition to improved quality and economy resulting from these mix proportioning changes, superior appearance and workmanship are obtained.

Procedure:

- Insert the vibrator vertically into the newly placed concrete (Figure 6-17) layer allowing it to penetrate through the entire layer of the newly placed concrete and through the previously placed concrete to have an effective blending of the two layers. When consolidating concrete in a sloping surface always start the consolidation from the bottom of the

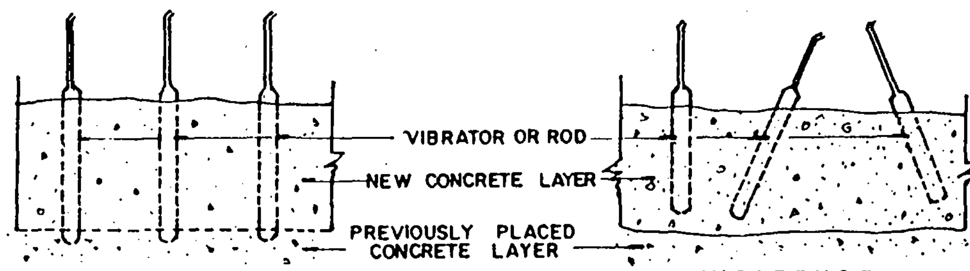

CORRECT

START PLACING AT BOTTOM OF SLOPE SO THAT COMPACTION IS INCREASED BY WEIGHT OF NEWLY ADDED CONCRETE. VIBRATION CONSOLIDATES.

INCORRECT

TO BEGIN PLACING AT TOP OF SLOPE. UPPER CONCRETE TENDS TO PULL APART ESPECIALLY WHEN VIBRATED BELOW AS VIBRATION STARTS FLOW AND REMOVES SUPPORT FROM CONCRETE ABOVE.

WHEN CONCRETE MUST BE PLACED IN A SLOPING LIFT



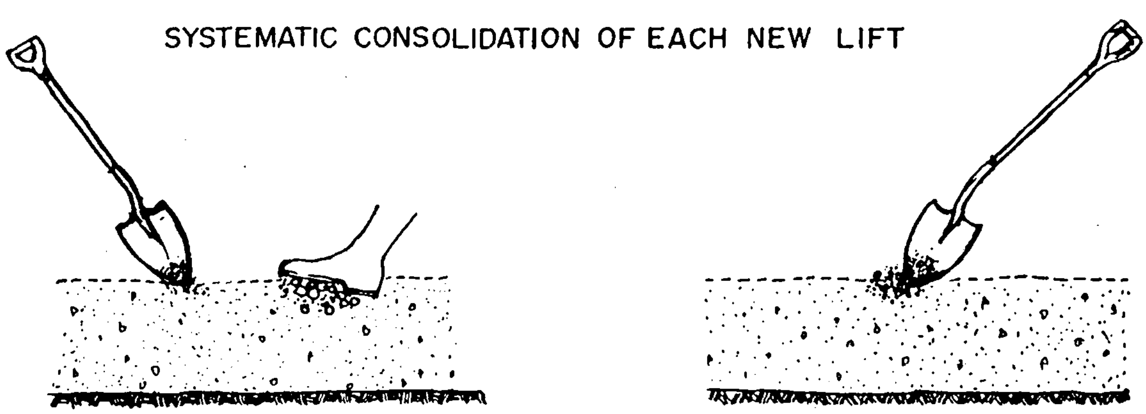

CORRECT

VERTICAL PENETRATION OF VIBRATOR A FEW INCHES INTO PREVIOUS LIFT (WHICH SHOULD NOT YET BE RIGID) AT SYSTEMATIC REGULAR INTERVALS FOUND TO GIVE ADEQUATE CONSOLIDATION.

INCORRECT

HAPHAZARD RANDOM PENETRATION OF THE VIBRATOR AT ALL ANGLES AND SPACINGS WITHOUT SUFFICIENT DEPTH TO ASSURE MONOLITHIC COMBINATION OF THE TWO LAYERS.

SYSTEMATIC CONSOLIDATION OF EACH NEW LIFT



CORRECT

SHOVEL ROCKS FROM ROCK POCKET ONTO SOFTER, AMPLY SANDED AREA AND TRAMP OR VIBRATE.

INCORRECT

ATTEMPTING TO CORRECT ROCK POCKET BY SHOVELLING MORTAR AND SOFT CONCRETE ON IT.

TREATMENT OF ROCK POCKET WHEN PLACING CONCRETE

FIGURE 6.47

CONSOLIDATION OF CONCRETE

slope. Vibration is usually indicated by vibrator resuming normal speed after an initial slowdown.

- Withdraw the vibrator slowly and reinsert it into concrete 40 to 70 cm away from the previous point. Avoid dragging it through the concrete during the withdrawal and transfer. Continue the above process until the entire area is consolidated. Vibration is completed when the surface of concrete has a glistening appearance, the rise of entrapped air indicated by bubbles on concrete surface ceases and the coarse aggregate blends with the surface but does not disappear. Avoid over-vibrating the concrete mix.

2. Consolidation by Rodding

Consolidation by rodding is effected by raising a rod up and down through the layer of newly placed concrete until the entire area being concreted is covered. The rod should at least penetrate a few centimeters into the previouly placed concrete to produce a monolithic concrete structure.

g. Curing of Concrete

1. General

Curing is necessary to insure the availability of water for the hydration of cement and to maintain a temperature within the concrete that will result in the desired strength. Curing can be accomplished by application of water through ponding or spraying or by providing a moist environment with the use of saturated cover materials such as burlaps, cotton mats, rags, earth or hay or by preventing the loss of mixing water from concrete by means of sealing materials such as impervious sheets of plastic or by application of a membrane forming curing compound to the freshly placed concrete.

2. Curing by Direct Application of Water or by Providing Moist Environment

Curing by direct application of water or by providing a moist environment is generally considered to be the ideal method. However, these methods are satisfactory only as long as the presence of water is continuous and there is no opportunity for the concrete to dry to such degree that the hydration of the cement ceases. Intermittent wetting and drying especially after an initial 2 or 3 days of satisfactory curing will allow continued gain of strength although not as rapid as continuous curing. Inetermittent curing reduced service durability.

3. Curing Period

Curing period and materials are dependent upon cost of labor and materials, the need for early accessibility or protection of a surface during subsequent construction operations and the desired concrete quality. In no case should the curing period be less than 14 days. Normally, strength is used to measure the relative quality of concrete. A specified strength will be attained in the shortest time by continuous curing. Whenever curing is interrupted before the desired strength is attained, subsequent curing whether from natural source such as rain or artificial application of water will result in further gain in strength but at a much slower rate.

h. Finishing of Concrete Surfaces

Immediately after the stripping of forms, concrete surfaces must be inspected and any poor joints, voids, rock pockets and other areas must be repaired and all form tie fastener holes must be filled. Stripping of forms is usually done after 14 days of curing.

Procedure:

- Prepare a grout by mixing one part portland cement and one part fine sand which pass a No. 16 sieve with sufficient water to give a consistency of a thick paste.

- Wet the concrete surface to be grouted.

- Apply the freshly prepared mortar into the concrete surface with a wood float filling all small air holes.

- Keep the surface moist for an hour or more until the grout hardens sufficiently and it can be scraped from the surface with the edge of a steel trowel without distributing mortar into the air holes.

- Remove all surface grout using a steel trowel and allow the surface to dry. After drying, rub it with burlap or cotton rag to remove all surface grout so that there is no visible paint-like grout on the concrete. The entire cleaning operation for any area must be completed the day it is started and no grout must be left on the concrete surface overnight.

i. Treatment of Surface Defects

1. General

After the removal of forms, all exposed concrete surfaces must be examined for defects and any irregularities must be immediately rubbed or ground in a satisfactory manner with carborundum bricks in order to secure a smooth, uniform and continuous surface. Plastering or coating surfaces to be smoothened usually do not produce a good result, hence, they are not recommended. Also, concrete containing voids, holes, honeycombs or similar depression defects must be completely removed and replaced with a cement mortar. In no case should extensive patching of honeycombed concrete be permitted because the bonding of cement mortar to existing concrete will not be strong and durable.

2. Preparation of Concrete Surfaces to be Repaired

- Make a thorough examination of the imperfections.

- Remove all concrete of questionable quality and clean hole thoroughly. Edges of hole should be cut as straight as possible at right angles to surface or slightly undercut to provide a key for the patch. For holes left by the tie rods of forms, ream and clean them to make them clean and rough.

- Wet the surfaces within the trimmed holes for several hours prior to placing new concrete. Best method is to pack hole with wet burlap or cotton rag.

- Immediatedly before placing the cement mortar, clean the hole again so as to leave the surface completely free of chipping dust, dried grout and all other foreign materials.

3. Treatment of Surface Defects Using a Dry Pack

Dry pack is employed to plug holes with depths equal to or greater than the least surface dimension such as form tie holes. It is usually not employed in filling holes wherein lateral restraint cannot be obtained and for filling in back of considerable lengths of exposed reinforcement.

Application Procedure

- Brush off with stiff mortar or grout the surfaces of the holes to be filled. The grout will serve as the bonding agent between the dry pack and the existing concrete surfaces. The grout is prepared by mixing one part cement and one part fine sand by volume with sufficient water to form a consistency of a thick paste. It is not recommended to paint the surfaces of the holes with neat cement grout as this would make the dry pack too wet and cause high shrinkage.

- Prepare a dry pack by mixing one part portland cement to 2-1/2 parts of sand that will pass Sieve No. 16. A trial mix should be prepared to determine the amount of white cement needed if matching of the color of the existing concrete is necessary.

- Place immediately the dry pack into the hole before the bonding grout has dried. Dry pack should be placed and packed in layers having a compacted thickness not greater than 9-1/2 mm. Thicker layers will not be well compacted at the bottom. After placement of each layer, pack it in using of a hardwood stick and a hammer. Much of the tamping should be directed at a slight angle toward the sides of the hole.

- Finishing is completed by laying the flat side of a hardwood piece against the pack and striking it with several good blows. A few light strokes with a rag may improve the appearance.

j. Treatment of Surface Defects by Concrete Replacement

This method of repairing concrete defects is applicable when holes in unreinforced concrete are more than 0.10 square meter (1 square foot) in area and 100 mm (4 in.) or more in depth or when holes in reinforced concrete are more than 0.05 square meter (0.5 square foot) in area and deeper than the reinforcing steel.

1. Preparation of Concrete Surfaces

Before starting the replacement of concrete, the existing concrete surfaces should have the following features:

- Top edge of hole should be cut fairly horizontal with a 1:3 slope from back to front. This is essential to eliminate air pockets.

- The bottom and sides should be cut straight and at right angles to the face. All interior corners should be rounded.

- Clearance should be 25 mm around reinforcing bars.

2. Procedure of Repair

Construct a form if it is necessary to prevent concrete mortar from escaping from holes being repaired.

Prepare the concrete mix to be applied. The composition of the mix should be similar to the mix used for the original structure. Low slump should be used to minimize shrinkage.

Place the prepared mix into the hole and consolidate it by tamping. When placing in layers, placement should not be continuous. A minimum period of 30 minutes should elapse between lifts.

Remove the forms the day after casting. After removal, scrape the bulging edges and level the surface by use of steel trowels.

k. Treatment of Surface Defects by Mortar Replacement

This method is used if the holes are too wide to dry pack or too shallow for concrete replacement, and for all comparatively shallow depressions, large or small which extend no deeper than the far side of the reinforcing bars nearest the surface.

1. Preparation of Concrete Surfaces to be Repaired

- Flare holes outward at 1:1 slope and round all corners.
- Remove all loose concrete and other foreign materials.
- Moist the surfaces to be repaired.

2. Application Procedure

- Mix one part cement to three parts sand by volume which is well graded and passes sieve no. 16 with sufficient water to make a consistency of a thick paste.
- Fill the hole with cement mortar slightly more than full. The mortar should be applied in layers not more than 19 mm to avoid sagging and loss of bond. Allow the mortar to harden.
- Shave off the excess material with a steel trowel to produce a uniform surface.

Another way of constructing a reservoir is by using a ferrocement structure. Its construction is much easier and simplier than the conventional reinforced concrete discussed herewith. Refer to Chapter V.

l. Installation of Pipelines

Pipeline installation is compose of laying of transmission and distribution lines plus its controls. These transmission and distribution line could be laid simultaneously.

Procedure in laying the transmission line:

- Conduct the construction survey, following the traverse set on plan and stake the route of pipelines.
- Clean and grub the area.
- Excavate portion where pipes will be buried. Galvanized iron steel pipes can be used for areas with rocky or hard soil and need not be buried. But in projects using PVC, PB, PE and other non-metalic pipes, the minimum depth of excavation is 60 cm. Sand cushion can also be provided for additional pipe protection.

- Joint the pipes one by one and having one union patente, for every 60 m length. Valves are also to be placed according to plan. For ease of installation, start pipe laying works from the water source down to the reservoir.

Basically, the same procedure is followed in laying the distribution pipes. The only difference is that no heavy cleaning and laying the distribution pipes have to be done. Construction survey could also be omitted. The procedure will be as follows:

- Lay-out the system on ground.

- Excavate the route of pipes. Pipe trench is usually .30-.40 cm in width and .40-.50 cm in depth.

- Stake the position of public taps

- Lay the pipelines from water source to service area.

No PVC pipes shall be exposed to elements. All exposed pipes should be G.I. pipes. Exception are those pipes installed along bridge, culverts crossing, and to other areas where excavation is not possible.

m. Partial Backfill

Pipelaid portion if possible should have a partial backfill leaving the joints open before the end of the day. This will prevent the pipes from dislocation during floods. It will also protect the pipes from damage caused by stray animals, playing children or falling sharp objects like stone. Laid pipes end should at no time leave open. Open end pipes will alow entry of soils, gravel, sand, debris, etc. that may cause clogged pipes.

n. Pressure Test

After completion of the laying of pipelines the system is now ready for a pressure test. First clean the pipelines by passing water from the source, leaving all taps open for quite sometime. When the water coming out of taps and drains becomes already clean and there is no presence of sand or soil then you may start pressure testing the system. In spring development projects where the flow of water is by gravity, pressure test could be done by feeding the water from the spring box and closing the valve at end lines when the pipes being tested are transmission lines. Note that for wet spots along the transmission pipes, when testing the distribution pipes with feed water from reservoir, let the tap open for a while leaving trapped air to flow, then close all taps and observe if there will be wet spots along distribution line. Let the water stay inside the pipes without opening faucets and observe again. If there is no indication of leakage, backfill the pipes completely.

o. Backfilling of Pipeline Trenches

After the pipelines have been laid and tested for pressure and leakage they should be backfilled immediately to completely protect them from falling boulders and to prevent dislocation due to heavy flooding of open trenches and cave-in should there be rain. The backfilling process consist of shovelling backfill good materials (free of sharp objects) into the trench and then compacting it, every 10 to 15 cm. layers.

## 3. RAINWATER CATCHMENTS

Well contructed cisterns play an important role in providing families with an accessible supply of potable water. Cisterns and storage jars constructed of locally available materials offer improved access to water supply in many areas where good supplies are limited. They also provide a means of controlling the water quality.

The steps discussed here are offered as guidelines and can be altered to fit local needs and situations. Before attempting the contruction of any cistern, seek advice and assistance from people with work experienced in concrete and ferrocement construction.

### Materials Needed

Before beginning the construction process, be sure to have the following items:

- A plan of the cistern showing the design and dimensions

- A list of materials, tools and other supplies needed to complete the job. All materials should be available before construction begins in order to avoid delays.

### Construction Steps for a Reinforced Concrete Cistern

Follow the construction steps below. Refer to the appropriate diagrams during the construction process.

a. Find the best location near the house to build the cistern. It should be located on high ground for good drainage and should not be located closer than 15m to the nearest waste disposal site. Once the site is located, mark it out using a measuring tape, wooden stakes and cord.

b. Dig out a base in the ground to fit the dimensions of the cistern. The hole should be only 50-100mm deep. This will allow installation of an outlet near the bottom of the cistern to take advantage of the entire volume of the cistern. Level the excavated area using flat-nosed shovels and scrapers made from wood.

c. Prepare the forms for the structure. Use plywood sheets, if available, for the faces and small pieces of wood for bracing. All form-work for the cistern should be completed before any concrete is poured.

  - Nail all forms together to the design size of the cistern. Walls should be 200mm thick.

  - Brace the forms well. Place small holes in the forms and slide wire through them. At the end of each piece of wire, attach a stick to hold the wire in place. Then tighten the wire to create enough pressure to withstand the force of the poured concrete.

(See Figure 6-18.) Dirt should also be piled up against the outside of the walls to give them support against the weight of the concrete.

- Place reinforcing rods in the forms. For best results, lay the rod on the floor in a grid pattern as shown in Figure 6-19. The cross bars should be long enough to cross the entire length of width of the floor and extend at least 300mm into the wall. The reinforcing rods should be bent to fit into the wall forms to a height of 300mm. Other lengths may be used to complete the installation of the reinforcing rod.

  This technique is recommended to provide a solid connection between the wall and the floor. Figure 6-19. demonstrates the placement of reinforcing bars in concrete. The steel bars should be separated 150mm with the first cross bar laid 75mm from the edge of the pour. The bars should be placed one third of the distance from the outside or, as in the example given, about 70mm from the outside edge.

d. Make holes in the form for placement of the overflow and outlet pipes. The pipes should be placed directly in the forms when pouring the concrete to ensure a good pipe installation.

e. Oil all forms before pouring concrete. Use old motor oil or other available lubricant to prevent the concrete from sticking to the forms.

f. Formwork and steel bar placement for the cover follow the same procedures as outlined above. After all forms are complete, mix the cement, sand and gravel in a 1:2:3 ratio adding 23 liters of water for each bag of cement. These proportions will ensure a thick paste.

Pour the floor and about 200mm up the side of the wall in the first pour. Tamp down the cement with steel rods and shovels to make sure that all voids are filled. Once all reinforcing rods are attached, finish the pour, tamp the mixture well and smooth all surfaces.

Cover the concrete with canvas, burlap, empty cement bags, plastic or other protective material to prevent loss of moisture. Keep the covering wet so the concrete does not become dry and cracked. When pouring the cover, be sure to leave an opening for access to the cistern. The opening should be fitted with a cover either can be locked or is difficult to remove.

Reinforced concrete cisterns can be built underground. They are usually equipped with hand pumps for extraction of the stored water. To build an underground cistern, follow the same basic construction steps for above ground cisterns. Make sure that the walls extend at least 300mm above the ground surface. A tight fitting cover with an access opening and a small base for a hand pump should be cast.

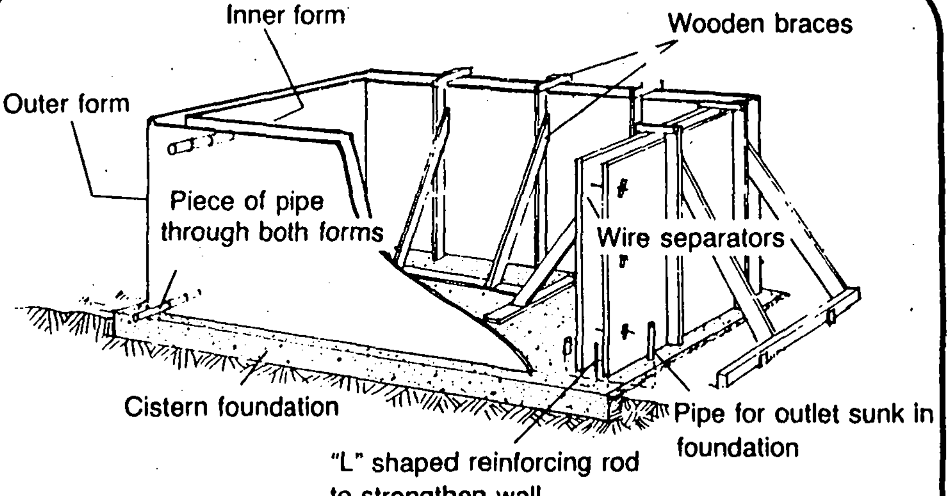



**Fig.6.18 Forms for Cistern Walls**

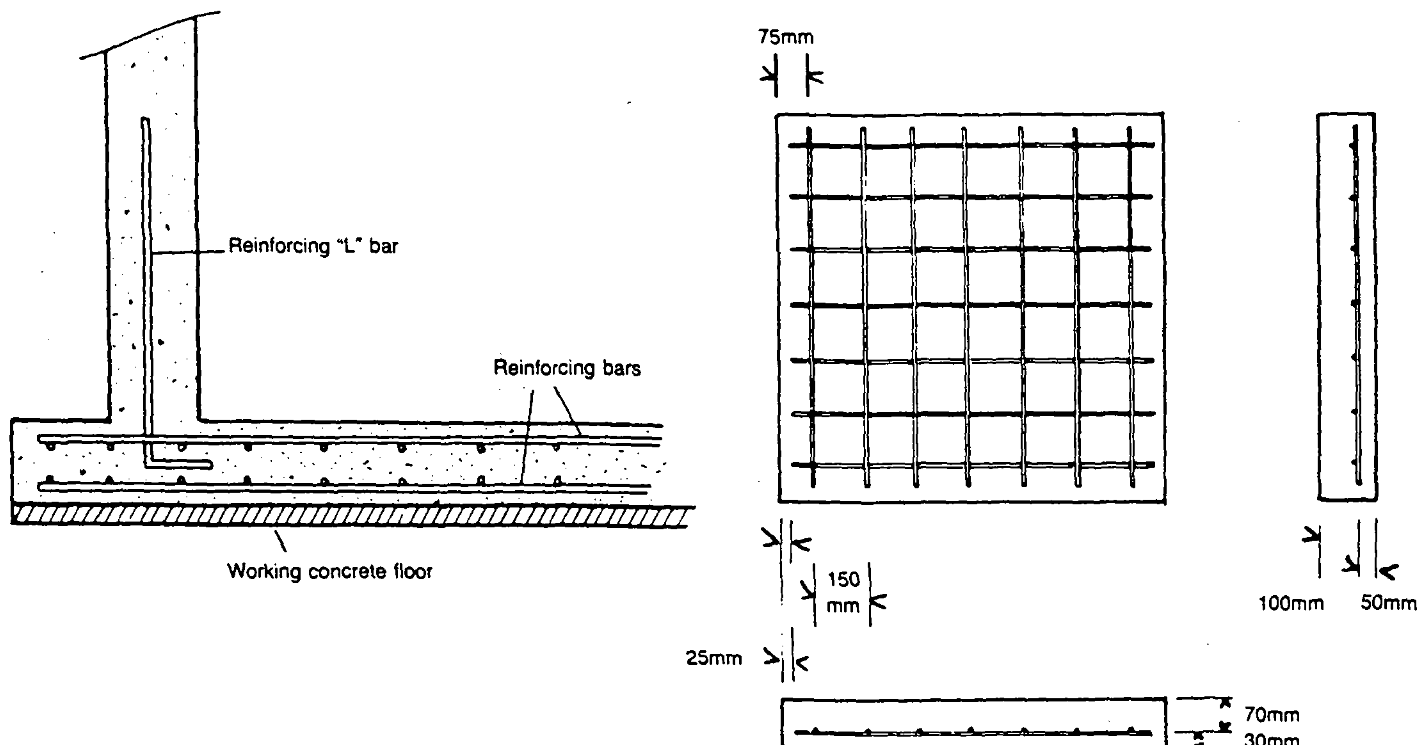



**Fig 6.19 Placement of Rebar in Foundation and Walls**

Other Types of Cisterns

Brick and masonry tanks can be used for rainwater storage. Skilled workers should construct them. Keep the following points in mind when constructing a masonry or brick tank:

- Make all walls at least 300mm thick.

- For shallow tanks, the walls can be built on the floor. For deep tanks over 1.5m, a concrete footing or foundation built below the base should be constructed.

- Line the inside of the cistern with two 10mm thick layers of mortar to prevent leaks. The mortar, and all mortar used in the construction process, should contain cement and sand in the proportion 1:3.

Ferrocement cisterns are generally circular in shape and made with locally available materials. Some experience and skill are needed. The construction steps described below are for relatively large capacity cisterns, about $10m^3$. Both smaller and larger cisterns can be constructed following the general construction guidelines.

a. Measure and stake out a circular area 2.8m in diameter. An easy way is to drive a stake into the ground at the center and attach to it a length of rope 1.4m, the radius. Tie a stick or pointed object to the other end and trace the circle on the ground. Dig out a base 300mm in the ground.

b. Place a 100mm layer of sand and gravel over the excavated area, and then a 75mm layer of concrete on top of this. Use a concrete mix of 1:2:4, cement: sand: gravel.

c. Before the concrete sets, cast a 1m length of 20 mm steel pipe into the foundation, as shown in Figure 6-20. This will be the outlet. The pipe should extend 80-100mm above the tank floor, high enough above the ground on the outside of the tank to allow a bucket or ceramic container to sit underneath. A tap will be placed on the pipe when construction is completed.

d. When the floor hardens, build the formwork for the tank. Use 16 sheets of plain G.I sheet iron 0.6mm thick. Place four sheets together to form four sections. Bolt the sections, angling iron verticals so they form a circle. The steel angle iron, 40mm x 40mm x 5m , is bolted vertically on the inside face at the ends of each set sheets. Place a wedge between the ends of each section. The wedge can be pulled out to dismantle the forms. Wood can be used for forms.

e. Clean the forms, removing any dirt, and oil them. Then wrap a 50mm wire mesh, (chicken wire), around the forms. The netting should be wound around to a single thickness and tucked underneath

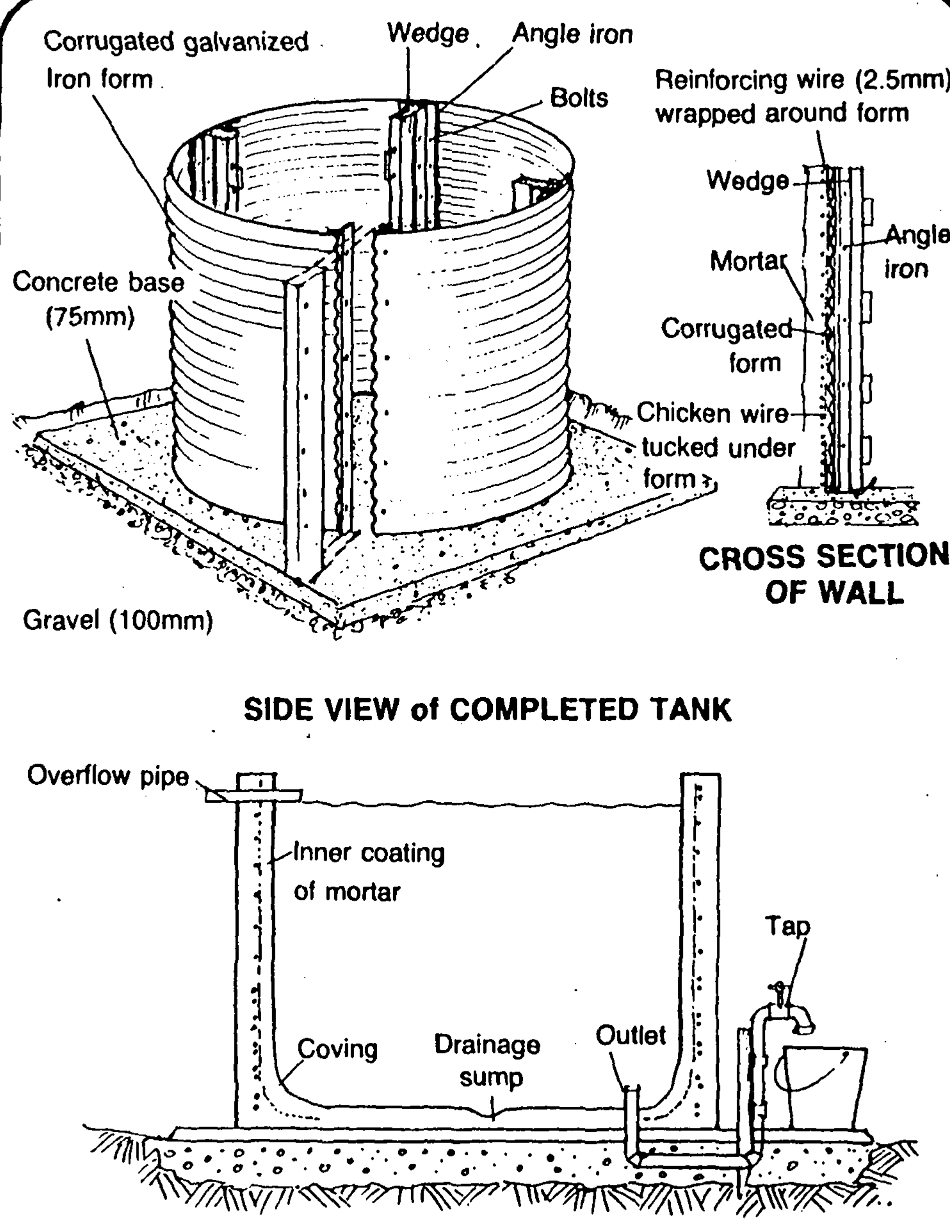



**Fig. 6.20 Ferrocement Cistern Construction**

the forms to hold it in place. The mesh provided vertical reinforcement and keeps the straight wire out of the corrugation.

f. Wrap 2.5mm straight galvanized iron wires tightly around the formwork starting at the base and using the following spacings:

- two wires in each of the first eight corrugations from the bottom,

- one wire in each remaining corrugation except for the top one,

- two wires in the top corrugation.

g. Plaster the outside of the forms with a layer of mortar that covers the wire. The mortar mix should be 1:3, cement:sand. When this layer begins to harden, trowel on a 15mm thick layer mortar to cover the wire. Give the mortar a smooth finish.

h. Take the forms apart after the mortar has set for two or three days. Remove the holding bolts and wedges so that the forms are easily removed.

i. Place an overflow pipe 200mm long and about 80mm in diameter at the top of the tank. Then to finish the cistern, plaster the inside to fill in the corrugations. When this mortar dries, trowel on a final coat. Before the mortar stiffens, make a shallow depression in the middle of the floor to act as a sediment trap for tank cleaning. Sediment can be swept into the sump and removed with a cup.

Roof Structure

Install a roof on the cistern to prevent the evaporation of water, the growth of algae and contamination by rubbish, insects or rodents. A choice between two roof structures is possible as shown in Figure 6-21. The structure is cast continuously with the walls. After the tank has dried for two days, lay mortar onto shaped formwork made with two layers of wire mesh supported from below by boards. Tie wire mesh onto the mesh extending from the walls. Install an iron frame to form an access opening in the roof. Remove the frame after construction is completed. Trowel in a layer of mortar and allow three days for curing. After three days, or when the roof is strong enough, take off the formwork and trowel a layer of mortar onto the underside of the tank. Let the roof cure for at least seven days. Keep the surfaces moist during the curing process.

Attach lightweight roofing such as aluminum sheet or galvanized iron with wire. Screen any open areas between the tank and the roof to prevent the entrance of insects and debris.

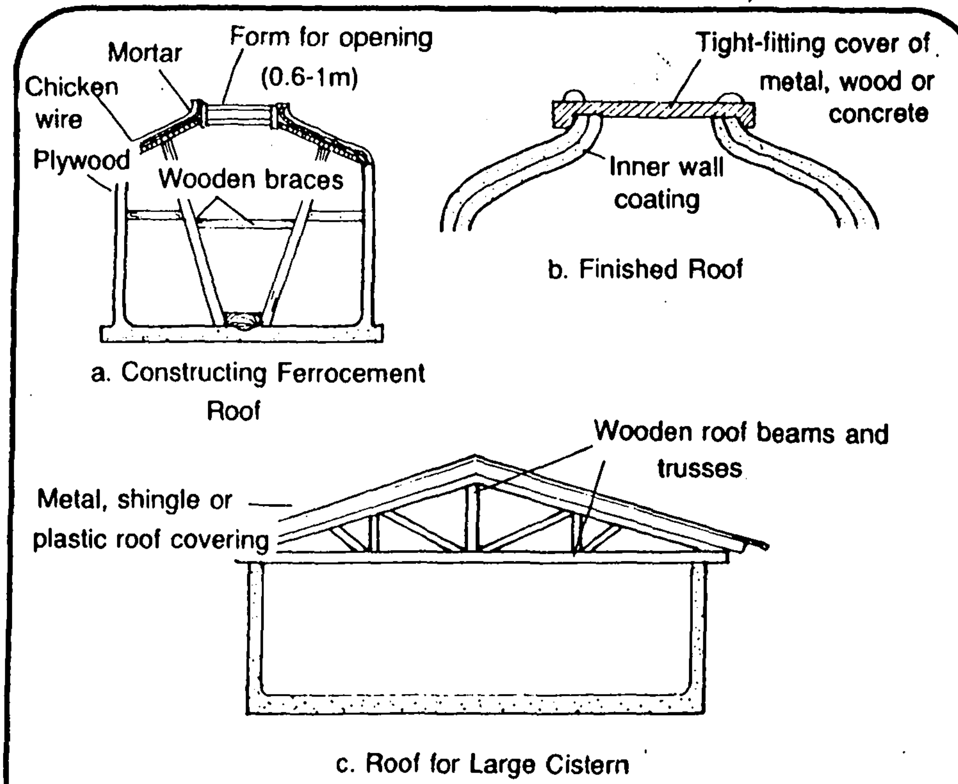



**Figure** 6.21 Cistern Roofs

Unreinforced Mortar Storage Jars

Unreinforced mortar storage jars can be constructed by people with little or no previous experience. The jars are inexpensive and relatively easy way to store rainwater in for drinking. Small 25m$^3$ capacities, as well as larger 4m$^3$ containers can be built following the basic construction steps given below. This example is for a 4m$^3$, (4,000-liter storage jar).

a. The first step in the construction process involves preparation of the mold. Place two pieces of gunny cloth together and mark them out. The bottom width should be marked at 1.2m and the top width at 2.0m. Draw a curved line along the sides connecting the top and the bottom and sew the sack together with heavy thread or twine. The sack height should be 1.7m.

b. Make a precast mortar bottom plate 1m in diameter and 15mm thick. To make forms for the plate, mark out a circle on the ground using a nail as a midpoint and a piece of twine 0.5m long. Trace the circle and lay half bricks or other suitable materials around the outside of the circle to act as a form. Place a paper, an empty cement bag or other material on the ground within the circle so the mortar does not stick to the ground. Make a mortar mixture of 1:2 cement:sand ratio.

c. Once the bottom plate dries, place the sack narrow end down on the plate and begin filling it with sand, sawdust or rice husks. The weight of the filling material will hold the sack on the plate. Make sure the mortar base sticks out from under the sack.

d. Completely fill the sack, then fold the top and tie it into the desired shape. With a piece of wood, smooth and round out the jar. When the jar is in the final form spray it with water to completely dampen it.

e. Place a circular ring on the top of the sack to make an opening for the jar. The ring can be made from wood, precast mortar or other suitable material.

f. Begin placing a layer of mortar on the jar. The mortar should be about 5mm thick. Apply another 5mm layer of mortar, checking the thickness by pushing a sharp object like a nail into the side. Be sure to build up any thin spots and add mortar to weak places. Finally, build up the jar thickness and shape. Place a small tap neat the bottom of the jar.

g. Twenty-four hours after the jar is constructed, remove the contents of the sack. This operation is easier for small jars. When the jar is empty, check for defects and make any necessary repairs. Paint the inside with a wet mortar mix and then cure the jar outside for two weeks. For best results, cover the jar with damp sacks or plastic sheeting during the curing process.

# CHAPTER VII - PROJECT OPERATIONS

## A. Repair and Maintenance

### 1. Water Facilities

#### a. Wells

The water source is the heart of the water supply system. To insure that the whole community has sufficient water at all times, it must be properly maintained. This can be done by periodically checking the water yield and if a defect is detected, this should be examined and corrected at the earliest possible time.

Groundwater is one of the most widely used water source in the Philippines. Water is usually drawn through wells from the aquifer by pumping. A properly designed and constructed well will give many years of trouble free service. However, if the system fails, the cause of the failure should be determined and corrected immediately. The causes of the malfunction of the system may be due to over-pumping, defective or damaged well casing and/or screen, and incrustation of well screen. These failures are usually indicated by reduced or no pump discharge and/or poor quality of water delivered.

1.1 Common Causes of Well Failures

- Overpumping - Overpumping is the pumping of water more than the capacity of the well. Overpumping will result in the pumping of sand and eventually in the clogging of the screen, lowering of the water level in the well and the surrounding groundwater table, consequently reducing well yield or capacity. This problem can be solved by deepening the well or by reducing the pump discharge.

- Corroded Well Casing - A well casing is employed to prevent the collapse of the hole, entrance of undesirable water and escape of good water from the well. A well casing could be damaged if corrosive gases are present in water, corrosion could also be brought about by the direct reaction between water and casing material.

  When the casing is damaged, the following can be done:

  a. If the diameter of the casing is of minimum size, build a new well in the vicinity.

  b. If the diameter of the old casing is oversized, insert a new casing (diameter is two sizes smaller than the original) inside the damaged casing.

- Corroded Well Screen - A screen or perforated pipe is required at the bottom of the well to prevent the walls from caving in, to exclude fine sand and to permit entrance of water. In case the well screen or perforated pipe is completely damaged, no water can be pumped from the well. In this situation, the following solutions may be applied:

  a. If the casing is still in good condition, pull it out from the hole and charge the screen with a new one.

  b. If both the casing and screen are corroded, either drill a new well or insert a new casing and screen (diameter two sizes smaller than the original casing inside diameter - see sub- section B: Corroded Well Casing) into the old one.

- Incrustation or Clogging of Well Screen - These may be caused by direct deposition of suspended matter or fine sand, formation and desposition of calcium carbonate on the screen and deposition of slimy matter resulting from the biological activity of bacteria. Calcium carbonate is the principal encrustant which forms scales on the screen and cement deposited particles. Incrustation caused by the deposition of suspended matter and/or scale could be corrected by surging or by muriatic acid treatment. Clogging due to bacteria can be corrected by chlorination.

- Deterioration of Water Quality - deterioration of water quality in the well is due to leaks in the casing or infiltration of surface water. This is the result of improper pouring of concrete materials into the well during the grouting process or it may be that the well was not grouted at all. A possible remedy is to grout the well to prevent the entry of undesirable water. If grouting is not possible, another remedy is to chlorinate or disinfect the well.

1.2 Pumping Facilities

Pumps, when used in the water supply system should be properly operated and maintained to insure that water is delivered to users at all times. Generally, pumping facilities can be maintained in good condition if the guidelines presented below are followed.

- Follow recommendation of the manufacturers on the manner of operating and maintaining the pumps. These recommendations are indicated in the manual which always accompany the purchased pumps.

- Follow the maintenance schedule. Maintenance operations include greasing, oiling inspection, checking of voltage at power source (if electric motor driven), adjustment and repairs. If during inspection a defect is detected, it should be repaired immediately. The operator should not wait for this defect to become worse and cause other parts or the whole unit to fail.

- Schedule the running and stopping of well pumps. The desirable schedule can be made by referring the pump capacity to the daily records of the water demand and water levels of the reservoir.

The operation and maintenance of common pumps used in small water supply systems is discussed in detail in succeeding sections.

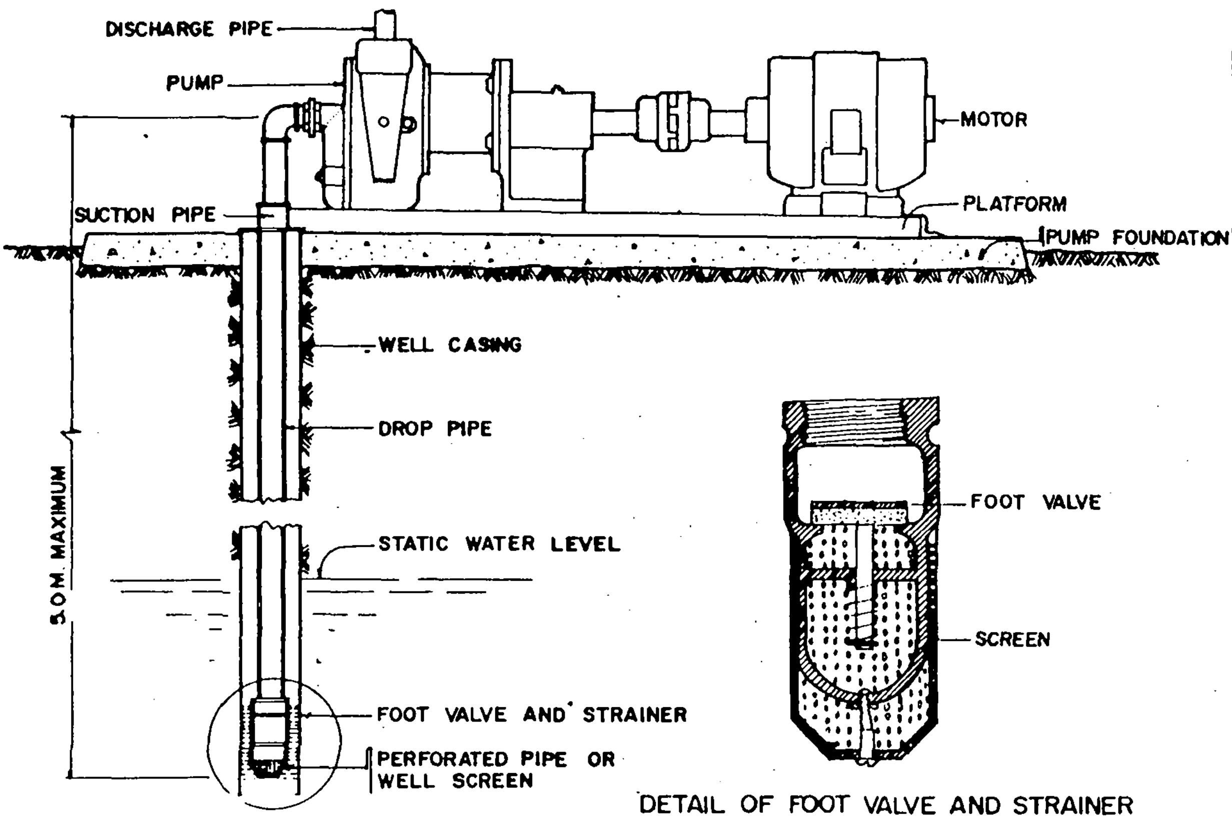
<u>Centrifugal Pumps</u>

A centrifugal pump is a device which employs centrifugal force created by the revolving impeller to convey water from one point to another. Shown in Figure 7-01 are the details of an installed centrifugal pump and its appurtenances. Water enters the pump at the center of the impeller and is thrown into the channel between the rim of the impeller and its casing by centrifugal force. Water is then discharged at high velocity and pressure.

- Manual Operation of Electric-Motor-Driven Centrifugal Pumps

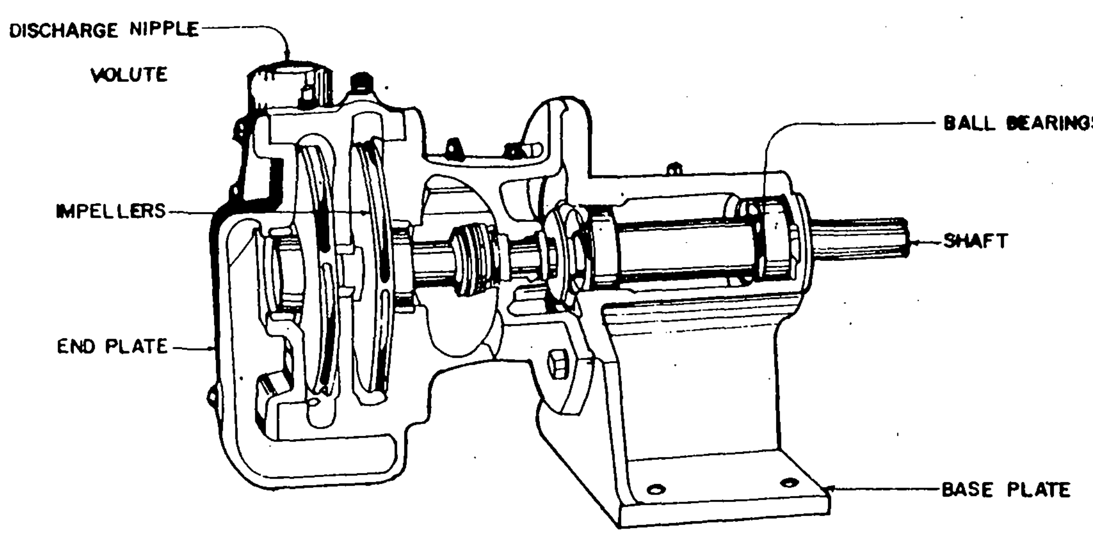
  * Bearing, gears and other pump moving parts should be properly and regularly lubricated by lubricants recommended by the equipment supplier.
  * If pump is not self priming (or self priming pumps with defective suction line or foot valve), add priming water. Before starting the motor, make sure that the discharge gate valve is closed.
  * Start the pump motor.
  * Allow the pressure to build up; then slowly open the discharge gate valve. This is to avoid water hammer or sudden surge of water which might destroy the valves and pipes (especially the pipe joints). In case pump has been primed with water, waste the water pumped during the first 1-2 minutes by opening the drain valve.
  * Once the pump has started running, make a routine check for faults in the operation of the system. This includes observing and noting down pump pressures and output, excessive or abnormal noise, vibration, heat and odor.

  Should the operator observe any fault in the operation, he should immediately find the cause of




DETAIL OF FOOT VALVE AND STRAINER

INSTALLED CENTRIFUGAL PUMP IN A WELL




DETAIL OF CENTRIFUGAL PUMP

FIGURE 7-01

DETAIL OF INSTALLED CENTRIFUGAL PUMP AND APPURTENANCES the malfunction and then carry out appropriate and necessary actions.

- Maintenance and Repair of Centrifugal Pumps

Table 7-01

COMMON TROUBLES IN OPERATING CENTRIFUGAL PUMPS AND THE REMEDIES

| Pump Trouble | Likely Cause of Trouble | Remedy |
|---|---|---|
| Pump motor fails to start | Blown fuse or open circuit breaker. | Replace blown fuse or reset circuit breaker. |
| | Motor or starting switch out of order. | Inspect & repair motor or starting switch. Call equipment supplier or an experienced mechanic or electrician. |
| | Break in wiring. | Repair the circuit wire. |
| | Stuffing box may be binding or tightly packed (in horizontal types). | Check the packing by manually turning the shaft. |
| | | Loosen the packing nut just enough to allow a slow seepage of water past the packing; and free the shaft. Water will serve as lubricant. |
| | Scale or sand in the impeller housing. | Open the pump and remove the scale by acid treatment to scraping. |
| Pump runs but delivers no water | Pump lost first priming | Repeat priming of the pump and follow the manufacturer's instructions |

| | | |
|---|---|---|
| | Pump repeatedly loses priming due to leaky drop pipe or suction line | Pull the drop pipe out from the well and seal the leak |
| | No water at source due to overpumping | Reduction of pumping rate |
| | Collapse of well casing and screen | If the diameter of the old casing is of minimum size, drill a new well |
| | | If the diameter of the old casing is large, insert a new casing, with diameter two sizes smaller than the original, inside the damaged casing |
| | Complete clogging of well screen | Surging or acid treatment |
| Pump runs but delivers only a small amount of water | Well not yielding enough water | Deepening of the well or by reducing the pumping rate |
| | Air leaks in suction line | Pull the drop pipe out from the well and seal the leak |
| | Incrustation or partial clogging of screen | Surging or acid treatment |
| | Impeller is worn out or plugged with scale or trash. | Open the pump and clean/replace impeller. |
| | Foot valve may be obstructed. | Clean the foot valve. |
| Leaky Stuffing Box (in horizontal type) | Packing is worn out or loose. | Replace or tighten the packing. Leave the packing nut loose enough to allow a slow drip of water which serves as a lubricant |

| | | |
|---|---|---|
| Pump is noisy. | Bearing and/or other working parts of pump are loose. | Tighten and/or replace defective parts. |
| | Pump motor is loosely mounted. | Tighten mountings. |
| | Presence of air in the suction line due to leaks and/or the water level in the well is very low. | Repair air leak and/or avoid pumping well too low. |

## Jet Pumps

A jet pump consists of a centrifugal pump and other jetting equipment. Shown in Figure 7-02 are the details of an installed jet pump and its appurtenances. The centrifugal pump draws the water while the jetting equipment raises the water from the well to within the suction level of the centrifugal pump. Described below are the mechanics of drawing water by jet pumps.

1. Water is drawn to the top by the centrifugal pump.

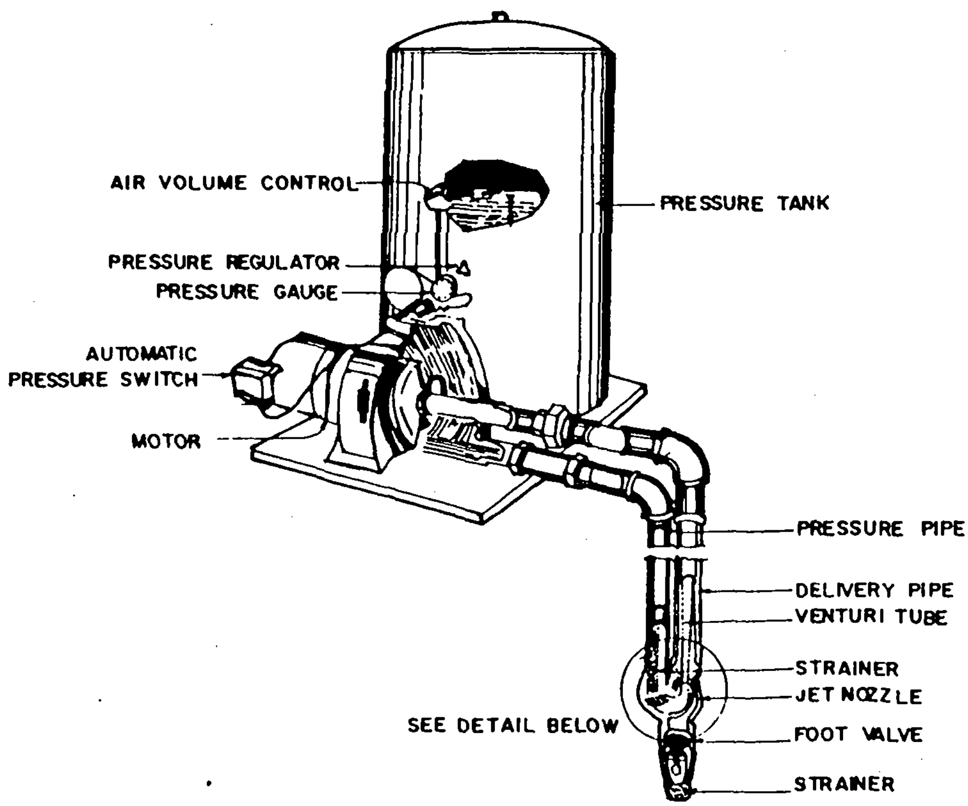
2. Part of the water drawn is returned to the bottom of the well at high pressure by the jetting equipment. The high pressure water injected causes the rising of a larger volume of water at low pressure to within the suction level of the pump. The process is then repeated.

Considering the water drawing process outlined above, it can be noted that the useful delivery of a jet pump is the difference between the quantity of water pumped and the amount of water recirculated.

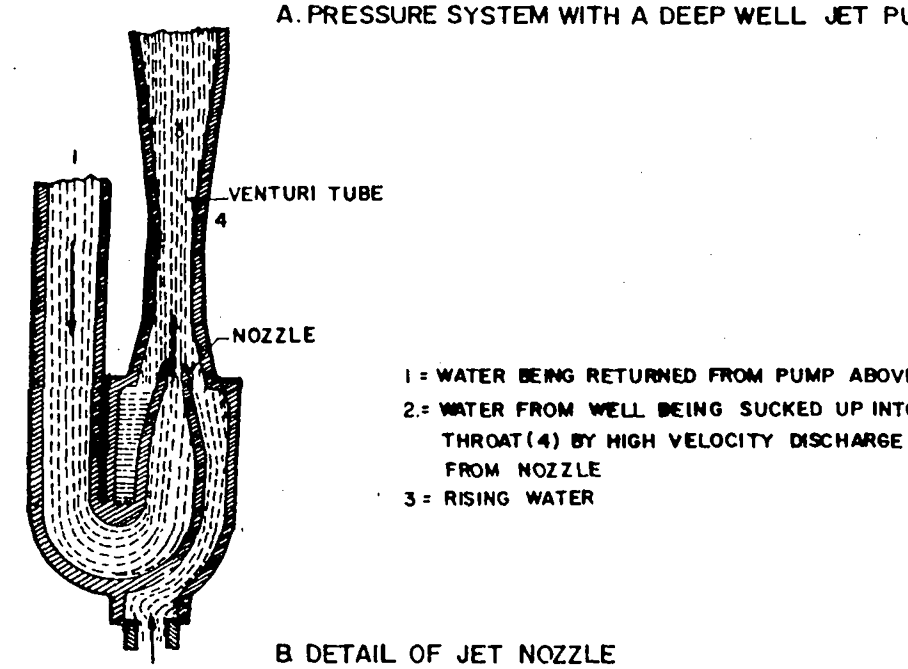
Table 7-02

COMMON TROUBLES IN OPERATING JET PUMP AND THE REMEDIES

| Pump Troubles | Likely Cause of Trouble | Remedy |
|---|---|---|
| Pump motor fails to start | Similar to centrifugal pumps. | Pls. see Table 7-01 |
| Pump runs but delivers no water. | No water at source due to overpumping | Reduction of pumping rate |
| | Collapse of well casing and screen | Drill a new well or overhaul the casing |
| | Complete clogging of well | Surging or |




A. PRESSURE SYSTEM WITH A DEEP WELL JET PUMP




B. DETAIL OF JET NOZZLE

FIGURE 7-02

DETAIL OF INSTALLED JET PUMP AND APPURTENANCES

| | | |
|---|---|---|
| | screen | acid treatment |
| | Pump lost first priming | Repeat the priming of the pump. Follow the manufacturer's instruction for priming |
| | Pump repeatedly loses priming due to leaky drop pipe or suction line | Pull the drop pipe out from the well and seal the well |
| | Impeller housing may be filled with scales or sand | Open the pump and remove the scale by acid treatment to scraping |
| | The nozzle-diffuser or jet may be plugged with scale or trash. | Remove jet & clean |
| Pump runs but delivers only a small amount of water | Well not yielding enough water | Deepening of the well or reducing pumping rate |
| | Air leaks in suction line | Pull the drop pipe from the well and seal the leak |
| | Incrustration or partial clogging of screen | By surging or acid treatment |
| | Impeller is worn out or plugged with scale or trash | Open the pump and clean/replace impeller |
| | Foot valve may have obstruction. | Clean foot valve. |
| | Nozzle-diffuser or jet may be partially plugged with scale or trash. | Remove & clean. |
| | Pressure regulator for jet may be set too low for existing water level. | Set regulator for higher pressure. |
| Leaky stuffing Box | Packing is worn out or loose | Replace or tighten the packing. Leave the packing nut loose enough to allow a slow drip |

| | | |
|---|---|---|
| | | of water to serve as lubricant |
| Pump is noisy. | Bearing and/or other working parts of pump is loose. | Tighten and/or replace defective parts. |
| | Pump motor is loosely mounted. | Tighten mountings. |
| | Presence of air in the suction line due to leaks and/or the water level in the well is very low. | Repair air leak and/or avoid pumping well too low. |
| Pump fails to pump up to full pressure and shuts off. | Jet pressure regulator is too low. | Set regulator for higher pressure. |
| | Jet nozzle is plugged with scale or trash. | Remove & clean jet |
| | Water level in well has dropped too low. | Reduce pumping rate, lower jet or find a new source. |

Submersible Pumps

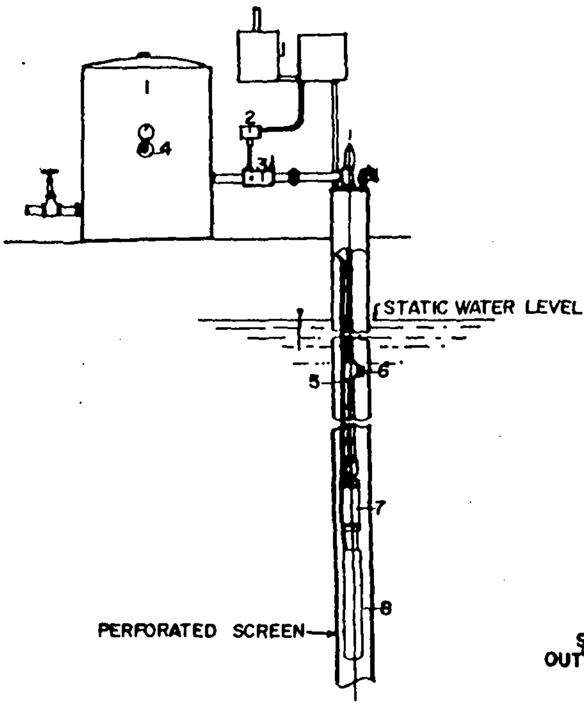
The pump and motor of a submersible pump are installed in the well below the water level. Shown in Figure 7-03 are the details of an installed submersible pump and its appurtenances. The pump usually employed is of the centrifugal or helical motor type. The motor is hermetically sealed to protect it from corrosion and is lubricated for life. Submersible pumps are always self priming.

1. Operation of Submersible Pumps

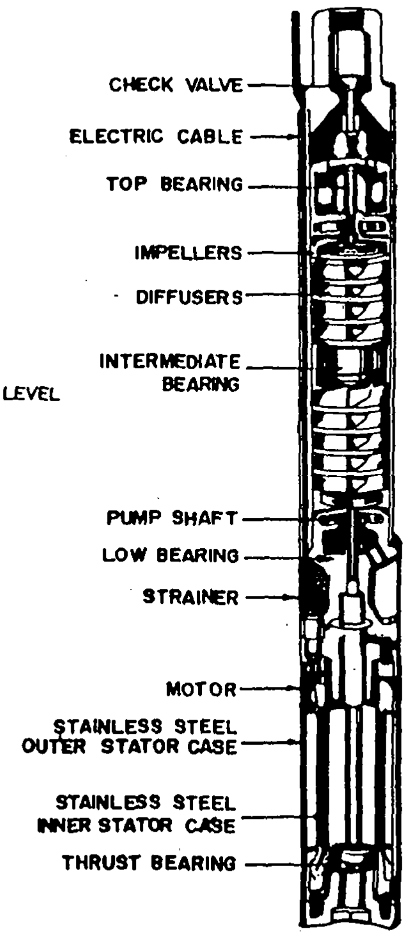
   Submersible pumps may be operated manually or automatically. It can be manually started by turning a switch located above ground level or automatically by the use of a pressure switch, electrodes or float control devices.

2. Maintenance and Repair of Submersible Pumps

   Familiarity with the most common problems which occur during operation of submersible pumps will enable the operator to immediately located trouble. The basic information required to begin a job analysis are as follows:




1. PRESSURE TANK
2. PRESSURE SWITCH
3. CHECK VALVE
4. AIR VOLUME
5. CABLE
6. BLEEDER'S ORIFICE
7. PUMP
8. MOTOR




DETAIL OF SUBMERSIBLE PUMP

FIGURE 7-03

**DETAIL OF INSTALLED SUBMERSIBLE PUMP & APPURTENANCES**

- Pump/Motor Unit Size and Type
- Pumping Level and static water level in well.
- Size of drop pipe.
- Pump setting.
- Discharge pressure required (line or tank pressure).
- Capacity pumped.
- Line voltage.
- Operating instruction.

Listed in Table 7-03 are the common trouble and the remedies when operating a submersible pump..

Table 7-03

COMMON TROUBLES IN OPERATING SUBMERSIBLE PUMPS AND THE REMEDIES

| Trouble | Cause of Trouble | Remedy |
|---|---|---|
| Pump motor fails to start. | Overload of motor causing the protection contacts to open. | Overload contacts will close automatically in a short time; check cause of overload. |
| | Low voltage. | Check voltage. |
| | Blown fuse, broken or loose electric connections | Check fuses, relays, condensers, and all electrical connections. |
| | Motor control box not in proper position. | Make sure box is in right position. |
| | Damaged cable insulation. | Locate & repair the damaged cable. |
| | Cable, splice or motor windings may be grounded or wet. | Check the ground by using ohmmeter. If grounded, pull out the unit and inspect cable and splice. Cut the unit loose from the cable and check part separately using an ohmmeter. |

| | | |
|---|---|---|
| | Pump struck by corrosion or abrasives. | Pull out pump, examine & remove the foreign matter |
| Pump runs but delivers little or no water | Pump not submerged. | Lower the unit into the wall or reduce pumping rate by replacing smaller capacity pump. |
| | Discharge pipe may be leaking. | Examine discharge line by pulling out one joint at a time. |
| | Check valve in pump if clogged or corroded. | Pull pump & clean. If badly worn, replace check valve. |
| | Pump badly worn by sand or abrasives. | Pull out pump and install new unit. Do not install new pump until well is thoroughly clean of abrasive. |
| | Strainers or impellers clogged with sand or scale. | Pull out pump unit & remove the scale by sand. |
| | Scale or corroded discharge pipe. | Replace pipe or remove scale by acid treatment. |
| Pressure switch fails to shut. | Pressure switch may be defective or out of adjustment. | Adjust or replace pressure switch. |
| | Discharge pipe may be leaking. | Raise unit one joint of a pipe at a time until leak is found. Repair leaks. |

b. Spring

Spring structures are easy to operate and maintain. One of the main advantages of springs as water source is that they are inexpensive to develop. The structures needed to protect them require little attention after installation. No structure, however, is completely maintenance free. Even the most simply designed spring structure need periodic maintenance to ensure that it provides good quality water in sufficient quantities.

1. Maintenance of Spring Boxes

The maintenance of spring boxes requires that a check be made to ensure that the structure adequately protects the water collected. Examine the spring box periodically to ensure that there is no silt build-up and that the water quality is good: Study the following conditions at the site to ensure that the spring is well-protected and free from any operating problems.

Determine whether the diversion drainage ditch above the spring is doing an adequate job of removing surface water from the area. If not, the trench should be improved. The diversion ditch should be lined with gravel or stones to increase flow and to prevent erosion of the sides. Grass can be planted in the trench to prevent erosion, but heavy growth will block flow. Be sure that grass is not too high and that no other obstructions will block water flow.

If there is a fence above the spring, make sure it is in good condition and is effectively keeping animals away from the spring.

Check the unslope wall to be sure it is solid and erosion is not wearing it away. If there are signs of heavy erosion or settling, add additional backfill of top soil, clay or gravel. Build up the hill with stones and plant grass to help control erosion around the spring box.

Check the water. If there is an increase in turbidity or flow after a rainstorm, surface run-off is reaching the source and contaminating it. Identify the source of the run-off and improve the protection of the spring.

Take periodic samples of the water and have them analyzed to check for evidence of fecal contamination.

Check the cover to be sure the box is watertight. Make sure that the cover is not removed by the users and that contamination is not being introduced by people dipping buckets and other utensils into the spring box.

Determine that all available water is being collected by the system. Watch out for water seeping from the sides or from underneath the spring box. If water seeps out, seal the leak with clay or concrete so that all flow is diverted into the spring box.

Ensure that the system is cleaned adequately. Once a year disinfect the system and clean the sediment out of the spring box. To clean the sytem, remove the cover. Allow the water to drain from the spring box by opening the valve on the outlet pipe. If the box has only one pipe for outlet and overflow, use a bucket to empty the spring box. Then use a small shovel to clean out the sediment collected on the bottom of the tank. Sediment removal will prevent clogging and build-up which causes the tank to fill up more quickly.

If pump is built into the spring box to collect sediment, a drain pipe can be installed to carry sediment away. The drain pipe should have a valve. This type of installation is especially useful when tapping a fast flowing spring.

All walls of the spring box should be washed with a chlorine solution and chlorine should be put directly into the water. If possible, the chlorine should be allowed to stand for 24 hours. If the chlorine cannot stand that long, apply two doses of chlorine twelve hours apart to ensure complete disinfection.

Check the screening on the pipes to see if cleaning is necessary. If screens are clogged or very dirty, they should be either cleaned or changed. Always use copper or plastic screens to prevent rust.

2. Maintenance of Seep Collection Systems

Operating and maintaining seep collection systems is similar to spring boxes except that extra care must be taken in the maintenance of the collection pipes. Although connections are lined with gravel to filter out sediment, the pipes can still clog.

If clogging occurs, substantially less water will reach the collection box. If water flow decreases, suspect that the collection system is clogged.

To clean the clogged pipes, remove the cap from the clean-out pipe and pour water into it. Use either a hose or a bucket so that sufficient force is available to break up the sediment.

3. Maintenance of water storage tank

The maintenance of water storage tanks is necessary to ensure the quality of the water stored. Maintenance of tanks basically involves two important procedures: prevention of contamination and cleaning the tank periodically to ensure that water is fresh.

General Maintenance

Water quality in storage tanks should be preserved. All storage tanks should be checked monthly to ensure that all necessary maintenance is done when needed. Never delay in attending to any problems that arise.

When looking at the tank, make sure to check on the following:

- Covers - make sure the cover fits tightly over the cistern. There should be no space for dust or leaves to enter the cistern or storage tank. The cover should fit tightly enough to prevent the entry of light. Light stimulates the growth of algae in the tank.

- Potential Sources of Contamination - check the area around the cistern or storage tank to make sure that no contaminants have been introduced to the area. No waste disposal or garbage disposal sites should be near the cistern or storage tank, especially when they are located below ground. Under no circumstances should any disposal sites or animal pen be placed on ground above the cistern. Contaminants can flow downhill and destroy the quality of water. A ditch should be dug near the cistern or storage area. Keep animals out of the drainage area.

- Screen - check screens covering pipe ends to make sure they are in good condition. Broken screens on outlet and overflow pipes are easy entry points for mosquitoes and small animals. All damaged screens should be replaced.

- Pipes - check all pipe connections to ensure that there are no leaks in the systems. When leaks occur, pipes should be tightened or repaired. Check all valves for proper functioning.

- Structure - repair any damage that may occur to the cistern or storage tank. Add concrete to repair any chip, broken edges or cracks.

Cleaning the Tank

No matter how much prevention is practiced, a storage tank requires disinfecting and cleaning. Where a cistern which collects rainwater from a roof is the only water source, there may be some difficulty in emptying the tank to clean it. The difficulty is especially great because the supply of water depends on rainfall. The use of a pot chlorinator can solve the problem of quality of water in the cistern. If a special filter or a foul flush run-off device is installed and a chlorinator is used, the quality of water in the tank will be satisfactory.

Ground level and elevated storage tanks are much less difficult to empty and clean. Because the source of the constant flow is a spring, well or surface source, the tank can be emptied, cleaned and refilled again. Users should be notified of any decision to close off the flow of water. The cleaning process should not take more than half a day. The tank should be cleaned between peak demand periods. To clean and disinfect the tank, do the following:

- Drain all water out of the storage tank. Usually, this is easily accomplished by letting the supply in the tank fall over time and draining the last bit.

- After the tank is drained, sweep and scrub it until all dirt and loose material are removed.

  Then choose the most appropriate tank disinfection.

- Fill the tank to overflowing with clean water and enough chlorine to make a 50mg/l solution. Add the chlorine to the tank as it is filling to get sufficient mixing. After the tank is filled, allow it to stand for at least six hours, preferably longer. After sufficient time has passed, drain the tank and allow it to refill for regular use.

- A second and faster method can be used when little time is available. Directly apply a very strong, 200mg/l chlorine solution to the inner surfaces of the tank. For best results, brush the walls with the solution and allow the chlorine to stay on the walls for at least 30 minutes before the tank is refilled.

- Another method can be used but it does not disinfect the upper walls of the tank. Feed water with a chlorine solution of 50mg/l into the tank at a volume that makes the chlorine concentration only 2mg/l when the tank is full. Keep the chlorinated water in the tank for 24 hours before new water is added. With this method, there is no need to drain the tank.

To avoid some of the problems involved with the cleaning of tanks, a tank with two compartments can be used. One compartment can be shut down for cleaning while the other is used. There is no problem of an interruption of the water supply. Both small and large storage tanks can use this technique.

Whenever a system must be temporarily closed for cleaning, the users should be forewarned. This allows storage of extra water and should lead each person to use less water during the time the supply is cut down. Cleaning should be limited to two or three times annually.

c. Rainwater Catchment

Rooftop catchment surfaces collect dust, organic matter and bird droppings which can clog channels, cause sediments build-up on the tank bottom and contaminate the stored water. Gutters and tanks must be cleaned frequently to prevent overflowing during heavy rains. Another problem is consistently discharging the "first flush" which would otherwise contaminate the tank. A device for keeping the first flush out of the tank is necessary; this is discussed in the Engineering Design section of this manual.

The maintenance requirements of the tank will eventually depend on the effectiveness of the first flush system and the frequency of roof and gutter cleaning. Another factor is the quality of the tank cover and screening on any inlet and outlet holes. Sunlight reaching the water will promote algae growth. Unprotected openings will also encourage mosquito breeding. The inside of all tanks require periodic cleaning, regardless of the quality of water collected. Sediments should be removed and walls should be scrubbed annually. Vinegar, baking soda and chlorine beach solutions are commonly used as cleaning agents. Care must be taken not to contaminate the next volume of incoming storage water. If cracks in the tank wall are observed, they should be replastered after each cleaning of the tank surface.

It is good idea to set up a program of inspection and repair of systems. This should include education for the user and training of local technicians to carry out repairs.

2. Sanitation Facilities

a. Level I - Pit Latrine

Disinfection

The aforementioned type of level I toilet facilities are very easy to maintain.

Where standing water in the latrine pit is unavoidable and mosquitoes are breeding, other actions should be taken.

Small quantities of special oil, kerosene, old engine oil and even expanded polysterene balls can be added to the pit. These prevent the mosquito larvae from breeding at the water surface.

Chemical larvicides can be used, but these are expensive and require careful supervision in use because they are usually very toxic to people as well as to mosquito larvae.

Most of these latrines are very easy to maintain and apart from regular cleaning and repairs, need no other attention until the pit is nearly full.

Use a little bleach or disinfectant to wash the floor slab, but large quantities of strong chemicals should not be put directly into the pit because they interfere with the important biological digestion of the excreta and cause the pit to fill up more quickly.

Some of the toilet facilities have the following parts which need extra care - fly screen and the foundation. The fly screen at the top of the vent should be kept clean of blockages and quickly replaced if it has any holes. Any sign of erosion of the foundation around the edge of the slab should be filled in immediately. If this is neglected, the whole structure may collapse, and that is why the superstructure is built using local house building materials and traditional skill, because then the households can be properly maintained and repair the structure.

b. Level II - Pour-Flush Toilet

Very little maintenance is necessary to keep the pour-flush toilet in good order. However, the toilet bowl and the floor should be regularly washed, using a mild disinfectant and the latrine superstructure should be kept in good repair.

No sullage water should be disposed of in the toilet because the pit may fold. No solid waste should be put down the toilet because this is likely to block the pipes.

Although blockages are unlikely to occur in normal use, to clearing them should be covered in user-educational program. These program should emphasize the necessity of using flexible materials for the rod because rigid rods are likely to break the trap.

In the case of the double pit latrine, when the pit in use fills with the effluent, it will "block up" the pipe and it becomes neccessary to bring the second pit into use. The branch that was blocked off in the junction chamber is then unblocked and the branch to the full pit is sealed. The full pit should be kept sealed for two (2) years if possible, it should be emptied before the pit that is in use fills completely. This gives the surrounding soil more chance to recover its infiltrative capacity before it is returned to use.

After two (2) years, the pathogens in the sludge of the unused pit will be dead and the sludge can be removed by a long-handled shovel. The pit material is useful as the soil conditioner. However, fresh excreta are dangerous to health and should be handled with great care. If possible contents should be removed by a pump flush. Further treatment of pit contents can be done using waste stabilization ponds, or composting.

Relocating Latrine

The latrine should not be used after the level of solid in the pit reaches within 0.5 m if the underside of the slab. When this occur, the remaining space in the pit should be field in with soil.

When digging a new latrine pit, it should be sited at least 2 meters away. This is because the soil may be contaminated with disease causing organism and because the pit is more likely to collapse since the soil structure will have been weakened by the digging of the original latrine.

Many of the materials from the old latrine can be used when building a new one, particularly the vent pipe and the cover slab.

Sludge Disposal

The sludge in the pit can be disposed of in one of these ways.

In the case of VIP latrine which can not be emptied, the pit serves as a final repository for the waste. The waste is abandoned in the pit and the latrine is rebuilt in a different manner, the walls with concrete and other heavy materials. The roof is normally made in that way for rural structures.

c. Level III - Flush Toilets

Sludge and scum must be removed from the tank when they occupy 2/3 tank capacity. This operation usually accumulates at a rate of 0.03 to 0.04 m/person/year, so given the number of users and the volume of tank, the interval between successive desludging operations can be easily calculated. Because survival of pathogens is highly variable, sludge disposal should be done with caution. The most satisfactory method of sludge removal is to use a tanker equipped with a pump and suction hose. When a tanker is unavailable, it can be removed manually. Anaerobic digestion of the septic tank sludge has been carried out in some tropical areas to produce methane for household uses, and the digested matter can be used as a soil conditioner and as a fertilizer for fish ponds. Inspect the effluents from septic tanks periodically to ensure that neither scum nor suspended solids are leaving the system.

B. Supervision of Water Association

The ultimate responsibility for the continuous functioning of water supply and sanitation systems rests on the active involvement of the community. Operation and maintenance of the facility/system through the water association must be a lasting commitment. It is imperative that the water subscribers who are members of the water association understands and internalize the need to effectively repair and maintain the water supply and sanitation projects.

The project becomes a collective responsibility of the Water Task Force composed of technical staff of implementing line agencies, Community Development Workers, Community Development Volunteers and most especially the water committee or water association. These people who are directly involved in the implementation of the water supply and sanitation projects are creatively involved in a teaching and learning process of enabling the officers and members of the water association to perform their functions throughout the operation of the project. The individual members, both women and men, learn trades or technical skills which will benefit the community for other future projects.

Supervision of the water association includes the support or assistance and guidance extended to the subscribers to ensure that all activities are coordinated and that the project moves smoothly towards its goal.

- Strengthening the organizations (water task force, water committee/association); operationalization of association structure, organization-building trainings, program management, membership expansion is always an on-going concern.

- Continuous training of subcribers to be able to perform their duties and functions well and meet whatever obligations there will be;

- Maintaining and sustaining linkages and alliances among agencies and communities with water supply and sanitation projects, and other related projects/activities;

- Assisting the water association in identifying better options to take in solving water problems ,including community responsibilities with each alternatives;

- Maintaining the collection of the water supply and sanitation project fees and relative systems and procedures agreed upon by the association for a smooth project implementation.

# CHAPTER VIII - MONITORING AND EVALUATION

Water supply and sanitation programs have economic and social as well as health implications. That's why reliable information on the importance of water supply and sanitation programs for health is often necessary in decision-making.

Aside from the actual construction of water supply and sanitation system, it is also a concern to ensure that the beneficiary organizations managing the system would effectively deliver their services. In view of these concerns, a monitoring and evaluation (M & E) scheme is designed to look into the program implementation and assess the program impact.

There are two major phases in the monitoring process - the progress monitoring and terminal assessment.

## A. Progress Monitoring

Progress monitoring is the continuous surveillance of the activities as well as the water systems installed in a locality. It aims to identify progress and impact indicators as they relate to the attainment of program goals and objectives. It also tends to assess whether the inputs are being delivered, are being used as intended and are having the initial effects as planned.

### 1. Design

Information through the M & E serves as basis for planning, reprogramming as well as assessment. Specifically the scheme seeks to:

- document project experiences, strategies and learnings
- identify program and impact indicator as they relate to the attainment of program goals and objectives
- formulate procedure on reporting and evaluating project program and impact on targetted beneficiaries

Project Indicators

| Objectives | Impact | Output | Effect | Impact |
|---|---|---|---|---|
| region/province/ municipality/barangay with improved supply system and sanitation facilities | -number & type of of potable water supply system<br>-number & type of sanitation facilities | -installed & functional potable water supply system & sanitation facilities with the following information<br>-number & type of | -number & type of functional potable water supply and sanitation facilities ; status of each potable | improved quality of life as seen in better health and sanitation condition in the targetted area<br>-number of beneficiaries |

| | | | | |
|---|---|---|---|---|
| | -amount of financial assistance<br>-quality type of manpower/labor<br>-description of installation equipment<br>-site | system<br>-sites<br>-number of users<br>-nature/frequency of breakdown<br>-technical efficiency | water supply system/sanitation facilities | -quality of water |
| LGUs, Proponents/water agencies & community group managing potable water supply and sanitation project & responding to other community related concerns | -nature, type of training<br>-nature, type of technical assistance | -LGU's proponent, water agencies & organized community groups<br>-KAS acquired<br>-number of individuals<br>-frequency of technical assistance | -LGUs, proponent water agencies efficiently and effectively managing potable water supply & sanitation projects.<br>-number/type of groups managing the systems | decrease occurrence of water-related diseases<br>-usage of water |

2. Tools/Materials

- Daily Log Book - This is a written record of daily activities throughout the duration of the program or project.

  Monthly Time Plan Organizer (MTPO)- This is a written plan for a certain activity that includes objectives for the month.

  Monthly Activity Report (MAR)- This is the summary of daily activities for the month including problems encountered, results of the activities, remarks, recommendations and evaluation of the activities vis-a- vis objectives.

  Special Activity Report (SAR)- A report on special activities undertaken during the project duration.

- Training Design - This is a framework of training activities that includes objectives, content areas, methodology, expected output, resource persons involved, venue of the training and the schedule. This is prepared before the conduct of the training.

- Training Report - This is a blow by blow account of the training highlights which included assessment of training vis-a-vis the objectives, some recommendations, list of actual participants and resource persons. This is submitted after the training.

- Minutes of the Meeting

- Field Visit Plan (FVP) - This is a definite set of objectives and expected outputs to be carried out in a given time in a specific project site.

- Field Visit Report (FVR) - A detailed report of the field visit.

- Quarterly Status Report - A regular report on the accomplishment of the program/project based on the target activities that included project site, total project cost, summary assessment, assessment of operations per objectives, project strengths and weaknesses, learnings/insights, problems encountered/ actions taken and plans of action.

- Bi-Annual Status Report/Annual Status Report - An in-depth discussion of the project activities, accomplishments, assessments and learnings of the implementing group as well as the beneficiaries.

- Annual Review - This is conducted regularly to review progress of the program implementation in order to pinpoint difficulties and problem areas as well as to recommend steps to improve project operations. The extent of attainment of objectives is also discussed.

- Case Studies - These are in-depth studies of a community group or local government unit (LGU) as they implement the project. This looks into the factors affecting success or failures of the projects.

- Terminal Report - Upon project completion, a project assessment is conducted to determine the extent of program objectives. Insights gained in program implementation are cited.

- Community Profile - These are data that will show the present status of the beneficiaries in terms of health and sanitation conditions.

3. Reporting Flow

The reports reviewed are not solely for the perusal of the people in charge of the project but it is also intended for the whole province. With this situation a basic reporting flow is thereby formulated. (Fig. 8-01).

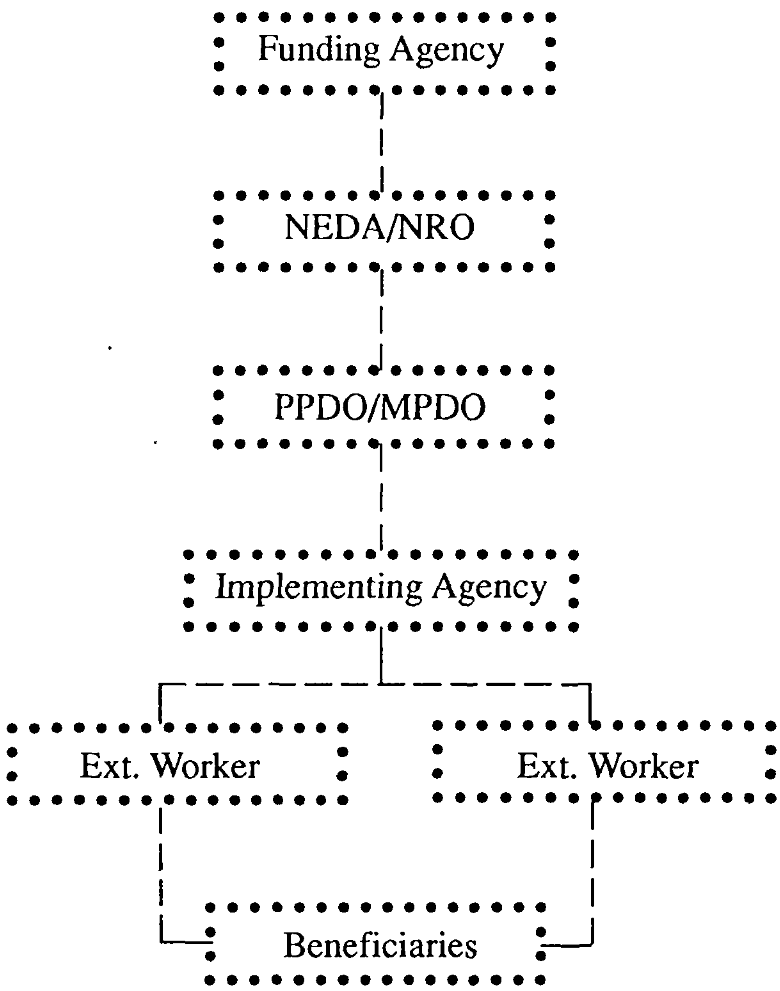



Fig. 8-01

Usually, the final submission of the reports are handed over to the funding agency, if any. This reporting flow can be altered to suit the needs, source of project funds and organizational structures of the province.

B. Terminal Assessment

The terminalassessment review or assessment of water supply and sanitation project operations is an evaluation procedure conducted yearly to determine end of the project status on target groups and communications as a whole. It is an integration of various associations and the representatives and technical staff of the implementing line agencies. Project objectives set in terms of expected outputs and effects sre checked if carried out as planned and in accordance with what were agreed upon. It includes results achieved, diffculties and problems encountered and the lessons to be drawn for future improvements.

This over-all assessment of the water supply and sanitation project is facilitated through workshops with the people who had been directly involved in project implementation at all levels, the community representatives and technical staff of implementing agencies.

1. Design

The terminal review or assessment workshop aims to achieve the following objectives:

- to assess the program after one year of implementation in terms of accomplishments and results, staff performance, problems encountered and actions taken;

- to assess whether inputs provided on the project decision-makers and/or implementors are able to produce the desired project outputs;

- to identify suggestions/recommendations on the improvement of the operations of the program.

The methodologies to be used during the workshop involves individual assessments and the team workshop, team presentation and group discussions. Initial plans to improve project implementation may be gathered and collated in preparation for planning workshop.

It is necessary that prior to the actual workshop, the project decision-makers/implementors at the different levels are able to facilitate its own assessment procedure. The process includes review of records, water association assessment or core group assessment and project implementation review.

a. Review of Records (RR) - the evaluation officer and the people directly involved in the project determine and maximize the use of records required by the project. Such records include community organization recordings, minutes of meetings, financial statement with quarterly, bi-annual and annual status report.

b. Water Association Assessment/Core Group Formation (CGA) - the process of determining the beneficiary community's level of awareness of the goals and operations of the water supply and sanitation project. It is through this assessment that the extent of the subcribers support and the participation in the project implementation is determined.

   This may be implemented either through the conduction of individual interviews of some community residents or through attendance at community meetings, dialogues and other related activities.

c. Project Implementation Review (PIR) - the process involves a com prehensive review or assessment of the significance results or management operations of the water supply and sanitation project with the representatives and technical staff of the different implementing line agencies. It includes difficulties encountered in managing the project, how these affected their activities, changes in plans and timetable, measures taken to overcome and prevent their recurrence. Equally important are the results of the use of major resources, how they were obtained and their cost effectiveness.

This assessment may be facilitated through individual interviews, workshops, meetings and dialogues with the representatives and technical staff of the implementing agencies.

2. Instruments/Tools

- Project reports/records
  Quarterly Status Report
  Bi-annual Status Report
  Annual Status Report
- Core Group Assessment Guidelines
- Project Implementation Review Guidelines
- Terminal Review or Assessment Workshop Design

# BASELINE DATA

## I. Demographic Characteristics

Total number of HHs
Population
Ave. Family Size
Religion
Civil Status
Number of School children

## II. Economic Status

Occupation
Ave. Income
Ave. Family Income
Other sources of Income
Existing resources
Savings (if any)
Household Possessions/Type of House

## III. Health and Sanitation

Source of Water, type of their status/
volume of water emitted
Type of Toilet & their status
Common illnesses/diseases
(water-borne or water-related diseases)
Where they go for treatment
Frequency of medical check-up
Drainage system
Garbage disposal

## IV. Community Participation and Leadership Perception

Existing Organizations
How long, how many members
Contributions offered:

Monetary
Manpower
Attendance in meetings

Past/existing projects/activities
Whom they perceive as leaders/reasons

## V. Perceived/Felt Community Problems/Needs

Family Problems
Community Problems
Actions Taken
Recommendations

<u>Data Essential To Be Gathered</u>

A. Water Supply

- Location of sources
- Distance to sources from households
- Conditions of preferred sources
- Sector who fetches water the most drinking water
- Amounts of water used for various purposes: working, washing, cooking, drinking, gardening, bathing, livestock watering.

B. Sanitation

- Presence & number of latrines/type & condition of latrines
- Defecation habits
- Use of latrines
- General care of latrines
- Other ways of defecating

C. General Health and personal Hygiene

- General hygiene conditions in the community
- Presence of files and other possible disease-spreading agents
- Personal washing habits
- Water storage
- General hygiene around the home
- Availability of water for personal hygiene

D. Principal Disease

- Presence of diseases related to water supply and sanitation

E. Community Resources

- Level of living of the people
- Borrowing and savings customs
- Money arrangement practices
- Work patterns
- Possessed/acquired and desired skills of the people in the community
- Availability of raw materials/other resources in and around the community

F. General Community Information

- Evidence of user cooperation
- Formal leadership and community organizations.
- Evidence of community participation
- Presence of informal leader and influential people?
- Presence of sub-groups, disputes or feuds in the community
- Literary levels
- Communication in the community

<u>Other Data Sources</u>

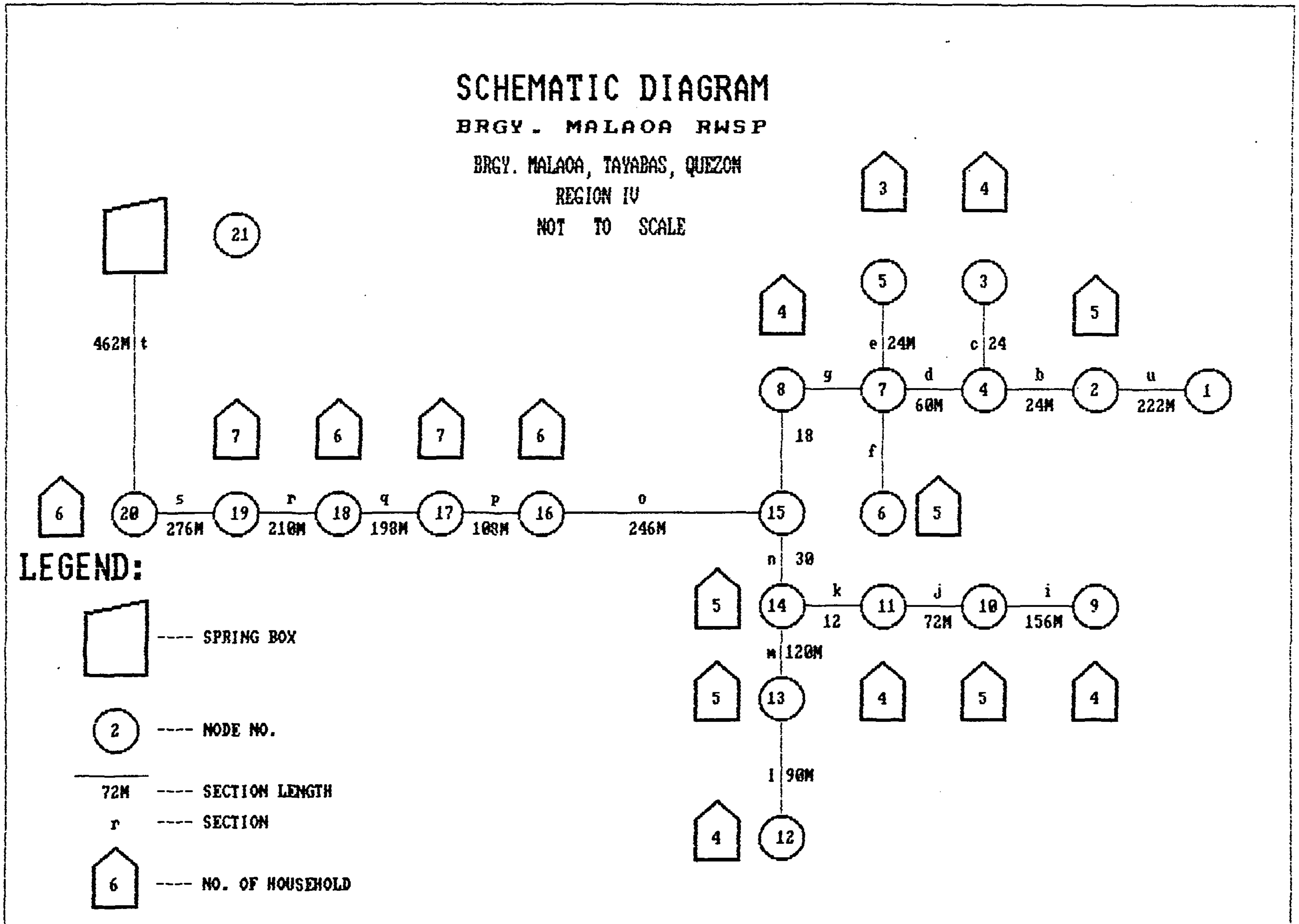
In addition, important information may be available from government and other agency sources. Discussions with outside people that have come in contact with the community can be helpful.

Benefits from the User Participation:

The benefits in initiating promoting and sustaining community participation include:

- lower costs
- better care of facilities
- community-level maintenance
- the use of socially acceptable and appropriate technologies
- improved fee collection
- technical training for some users
- and the building or strengthening of community organizations which can be used in other development projects.

APPENDIX B



SCHEMATIC DIAGRAM
BRGY. MALAOA RWSP
BRGY. MALAOA, TAYABAS, QUEZON
REGION IV
NOT TO SCALE
462M t
s 276M
r 210M
q 198M
p 108M
o 246M
18
n 30
m 120M
l 90M
k 12
j 72M
i 156M
g
d 60M
b 24M
u 222M
e 24M
c 24
f
LEGEND:
---- SPRING BOX
---- NODE NO.
72M ---- SECTION LENGTH
r ---- SECTION
---- NO. OF HOUSEHOLD

APPENDIX C

# PROJECT PROPOSAL
(Format)

## I. IDENTIFYING INFORMATION

| | | |
|---|---|---|
| Project Title | : | (town/implementing group - technology) |
| Project Site | : | (specific barangay, municipality, province) |
| Project Type/No. | : | (shallow well, deepwell, rainwater catchment, spring development, others) |
| Duration | : | (project life span) |
| No. of Beneficiaries | : | (persons, families, barangays) |
| Implementing Agency/ Contact Person | : | (name and complete address) |
| Total Project Cost | : | (assistance plus other counterparts) |
| Assistance Requested | : | (grant assistance from Tulungan sa Tubigan Foundation) |
| Proponent Counterpart | : | (implementation & training expenses) |
| Beneficiary Counterpart | : | (unskilled labor, minimal local materials) |

## II. RATIONALE

State exhaustively the existing situation in the area in relation to the needs and problems. What is the relevance of the project in responding to the need? What is the present source of water supply? What are the other resources and opportunities present?

## III. PROJECT DESCRIPTION

Describe the project as a whole, its location, methodology, concept, type & technology used. Use technical drawings/sketches if necessary.

## IV. BENEFICIARY AND AREA DESCRIPTION

More specific on socio-economic background, per capita and sources of income; previous assistance/projects. Geographical location, topography, climate, socio-demographic characteristics.

## V. DESCRIPTION OF IMPLEMENTING AGENCY

What is the nature and goal of the group; date organized, its officers, work experiences; status & cost of past, present and future projects.

VI. PROJECT GOALS & OBJECTIVES

The objectives must be specific, realistic, can be measured, can be attained within the resources & time frame given.

VII. PLAN OF ACTION

Organizational structure of the project (chart); functions & responsibilities of various person in chart (unit, partner, beneficiary), Schedule of Activities (gantt chart, S-curve or PERT-CPM), and Financial Requirement of the project showing the sources and usage of Funds.

APPENDICES

TECHNICAL DATA, DESIGN & DRAWING

A. GENERAL

1. Vicinity & location map of the area showing existing & proposed water supply.
2. Target population to be served by each system.
3. Canvass of materials (at least three suppliers)
4. Detailed Bill of Materials.
5. Construction/Drilling schedule (activity x time graph or PERT-CPM).
6. Bio-data of proposed technical person who will supervise the construction of the project.
7. Photograph of proposed spring box, reservoir and existing source of water in the area.

B. Technical Data Requirement for Spring Development

1. Spring flow at source (dry & wet season)
2. Status of existing water system, if any
3. Design water requirement
4. Structural design computation of proposed reservoir and spring intake box.
5. Hydraulic design computation of required pipes (transmission and distribution)
6. Engineering plans and drawings with appropriate scale to include: Vicinity and location map; Plan of existing system, if any; Location plan of proposed intake box; Details and sections of proposed intake box; Location plan of proposed reservoir; Details and section of proposed reservoir; Plan and profile of proposed transmission pipeline; Details of proposed public standpost.

C. Technical Data Requirement for Wells

1. Status of existing water system, or handpump for rehabilitation works

2. Depth of water table (specify source of data)
3. Length and diameter of casing to be used.
4. Method, cost and availability of drilling equipment.
5. Sectional drawing of proposed well showing method of installation of the deepwell pump cylinder.

D. <u>Technical Data Requirement for Rainwater Catchment</u>

1. Size of roof/catchment area.
2. Condition/type of the catchment area.
3. Daily/monthly rainfall data for at least 5 years.
4. Average daily Requirement per person/user.
5. Type of Storage tank to be used.

Appendix D

# WELL DRILLING QUOTATION

## A. PROJECT SITE

Sitio/Barangay ______________________________
Municipality of ______________________________
Province ______________________________

## B. WELL SPECIFICATION

| | | |
|---|---|---|
| Well Depth | ____________ | m |
| Well Casing Type | ____________ | |
| Borehole Diameter | ____________ | mm |
| Type/Length of Screen | ____________ | m |
| Type of Screen | ____________ | |
| Depth of Cement Grout | ____________ | m |
| Type/Length Gravel Pack | ____________ | m |
| Method of Drilling | ____________ | |

## C. SCOPE OF WORK

| LABOR ONLY | Unit Cost | Total Cost |
|---|---|---|
| 1. Mobilization of equipments and tools to the project site. | Lump Sum | P________ |
| 2. Drilling of borehole | P____/ft. | ________ |
| 3. Installation of casing, cylinder, well screen, and gravel packing. | Lump Sum | ________ |
| 4. Well development by continuous pumping. | Lump Sum | ________ |
| 5. Cement grouting. | Lump Sum | ________ |
| * 6. Supervise construction of platform and pump base. | Lump Sum | ________ |
| 7. Demobilzation of equipments. | Lump Sum | ________ |
| TOTAL COST | | P________ |

* Optional

## D. TERMS OF PAYMENT

- 30% Upon mobilization of equipments
- 30% Upon installation of casing and cylinder
- Balance upon completion and inspection and acceptance of the beneficiaries.

E. COMPLETION TIME ____________Working Days

F. OTHER CONDITIONS

1. The contractor shall provide all the necessary tools and equipments, skilled and unskilled personnel needed for the completion of the contract;

2. Pipes, handpumps and its accessories, and cement shall be provided by Tulungan sa Tubigan Foundation, Inc.

3. Tulungan sa Tubigan Foundation, Inc. or the Proponent shall not be liable for any sickness or injury to any laborer or personnel hired by the contractor;

4. The contractor guarantees the job against faulty workmanship and shall make good all defect which may be discovered at his own expense;

5. Upon failure of the contractor to complete the work herein contracted within the stipulated period, the contractor shall pay to Tulungan sa Tubigan Foundation, Inc. or Proponent the amount equal to one -tenth ( 1/10 ) of one percent (1%) for each day of delay as liquidated damages which may be deducted from any sum due to the contractor. However, delays caused by force majeure shall not be charged to the contractor.

Submitted By;

______________________________
Name and Signature

______________________________
Position

______________________________
Name of Company

CONFORME:

______________________________
Name and Signature

______________________________
Position

______________________________
Date

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