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CHRISTIAN RELIEF AND DEVELOPMENT ASSOCIATION

TRAINING PROGRAMME ON COMMUNITY BASED WATER SUPPLY AND SANITATION

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1. INTRODUCTION TO LOW COST WATER SUPPLY AND SANITATION

1.1 DEFINING LOW COST OR APPROPRIATE TECHNOLOGY WATER SUPPLY & SANITATION SCHEMES

There is no concise and universally correct definition of technological appropriateness. Determination of Appropriate Technology varies with the variations of development goals and socio-economic situation of the environment. In this context, the definition to be used is the description of the process of determining which technology is appropriate in a particular case.

"An appropriate technology" is, therefore, defined as a method or technique that provides technically, socially and environmentally acceptable level of (water supply and sanitation) services with maximum health benefits, at low cost. This definition immediately provokes questions. How does one judge social and environmental acceptability? To answer one has to start investigation from the initiation of the project i.e. water supply and sanitation scheme. First let us deal with the water supply scheme. When a water supply project is initiated, it is important to know the following main informations:-

- The purpose of the water supply initiation
  - for drinking (domestic use)
  - for industrial
  - for commercial or
  - for agricultural use ...etc

  If it is for drinking purpose,
  - is it for rural areas or urban?

In both cases, to determine or select appropriate technology for water supply projects, a thorough feasibility study has to be conducted with the exception of variation in the level of detail studies.

During feasibility study, the following main points should be investigated in depth.

A) Physical and Social Conditions of the Project Area

- Physical description of the area
  - location and topography
  - climate
  - geology
  - hydrogeology and
  - hydrology

- Present Infrastructure of the project area
  - access
  - style of living and living standards

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- economic activities
- health conditions
- population
- existing water supply systems
- power availability
- available water resources
- ground water sources
  - spring
  - shallow well
  - deep well
- surface water sources
  - river
  - lake ..etc
- rain water quality

B) Present and Future Water Requirements /Demands

- design population
- per capita domestic water demand
- average day water demand
- maximum day water demand
- peak home water demand

C) Identification of Potential Sources

- spring water)
- shallow well) in case of rural
- infiltration gallery)
- deep well ...etc.)

- conceptual design
- cost comparison
  - investment cost
  - maintenance and
  - operation cost

D) Selection of a Scheme

- demand coverage , in terms of quantity and quality
- no or less negative environmental impact and more positive environmental impact
- easy construction, maintenance and operation of the scheme
- afordability of the users to sustain the scheme
- preference of the community

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- relatively low overall cost ...etc.

If the selected water supply scheme fulfills the above mentioned main points, it is considered to be technically, socially and environmentally acceptable. Therefore, the water supply scheme selected could be said to be low cost or appropriate technology water supply scheme.

Sanitation Scheme/Project

For this purpose, when we mean sanitation, we are limited to the proper deposal of human excreta in rural areas. The principle of selecting low cost or appropriate technology sanitation scheme/project is similar to that of water supply scheme/project. Therefore, a thorough feasibility study should be conducted to investigate the physical and socio-economic situation of the specific project area.

This has to include, but not limited to the following:-

- location and topography
- climate
- access
- settlement condition, style of living (culture)
- economic condition
- living standard
- water supply condition
- available sanitation facilities
  - open field
  - pit latrine
  - VIP latrine
  - bucket latrines
  - septic tanks
  - flush toilets
  - sewer line ...etc.

Taking into consideration the above mentioned physical and socio-economic situation of the project area, from the facilities mentioned above, possible technologies will be selected and conceptual design be made. From the conceptual design, the technical, social and economic acceptability of these different options shall be examined, and the one which is technically and socially accepted with relatively low cost will be selected. This scheme /project is considered to be "low cost or appropriate technology sanitation scheme/ project.

In order to maximize the health benefit of both water supply and sanitation schemes, the provided services should be supplemented with proper education of the users, how to use the facilities and why they use.

1.2 AN OVER VIEW OF CLEAN WATER SUPPLY & SANITATION IN ETHIOPIA

1.2.1. Water Supply in Urban Areas

Great emphasis was given to the provision of clean and safe water supply to urban areas in

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Ethiopia over the past 12 years. However, despite of the efforts made, the level of service rendered has not yet been found to be adequate. Water shortage has always been there, due to low production levels, inadequate distribution facilities, system losses... etc.

According to UNICEF report, "A Situation Analysis of Children and Women in Ethiopia", 1993, the clean and safe water supply coverage in 1990 was estimated to be about 80%. Ministry of Health, 1995, "Health and Health Related Indicators" publication, the 1994 water supply coverage in urban areas is reported to be about the same with UNICEF's figure of 1990, i.e 80%. The expectation is to meet the global goals of safe water for all by the year 2000, i.e 100% coverage.

1.2.2. Water Supply in Rural Areas

Over 27 years have been elapsed since the rural water supply activity started in Ethiopia. In the earlier years, the activity concentrated on boreholes. According to the information obtained from UNICEF, quoting WRC, the safe water supply coverage in 1974 in the rural areas of Ethiopia was estimated to be about 1% of the population existing at that time. The remaining 99% was dependent on traditional and often contaminated sources. However, since then, low cost technological approaches such as construction of hand dug wells and spring development were undertaken. Ten years later, 1984, the supply coverage was estimated to be about 5.5% of the population existing that time . In 1990 the coverage percentage was estimated to increase to 11.5% . If the water supply coverage in rural areas continues with this trend, it is anticipated that the coverage in year 2000 will reach to about 22%. This indicates that 78% of the rural population in Ethiopia will still be using unprotected sources by the year 2000, the time the global goal is safe water for all.

Currently, safe water supply coverage in urban areas is estimated to be about 80% whereas the rural coverage is estimated to be about 19%. The over all safe water supply coverage in the country is estimated to be about 26%.

1.2.3. Sanitation (Urban/Rural)

At present, accurate and recent country wide data on the coverage of adequate sanitation facilities or use for latrines is not available as required.

However, pit latrines are the most commonly used facilities for handling human excreta. Septic tanks are rarely available and sewer lines are non existent except for very few in the city of Addis Ababa.

As per UNICEF, 1993, report on the Situation of Children and Women in Ethiopia, there is a national shortfall of about 9 million latrines. This figure will grow at a rate proportional to that of population growth. According to the figure in the Health and Health Indicators publication of the Ministry of Health , 1995, the total sanitation coverage in the urban areas of Ethiopia in 1994 was estimated to be about 60%. Figures reported for the rural areas was about 1%, which is considered to be among the worst in the world. The current over all national sanitation coverage is estimated to be about 8%.

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1.3 RELATION BETWEEN WATER, HEALTH AND ENVIRONMENTAL SANITATION/WASTE

Safe water supply and proper sanitation practices play a major role in the maintenance of good health. Lack of access to safe water supply and sanitation are known to be among the major causes for mortality and morbidity in the developing countries specially among children.. According to WHO, about 80% of all diseases in the developing countries are attributed to inadequate water supply and sanitation.

Massive contamination of water sources, due to lack of proper sanitation management or open field defecation is a source for all water borne and water related diseases.

All communicable diseases, for their spread, require a source of infection, a transmission route and the exposure of a susceptible living organism.

Contaminated water is one of the major transmission routes for these diseases.

Diarrhoeal, intestinal infections, skin, eye, malaria and schistosomiasis are among water borne, water washed and water related diseases.

Therefore, to safeguard the health of the society, water should be free from pathogens (disease causing organisms), contain no compounds in concentration that have adverse effect on human health. To overcome this, water has to be protected from pollutants such as human excreta by providing appropriate sanitary facilities or it should undergo through proper treatment prior to consumption.

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2 BASIC HYDROLOGY

2.1 THE HYDROLOGICAL CYCLE

The cyclic movement of water from the sea to the atmosphere and then by precipitation to the earth, where it collects in streams and runs back to the sea, is referred to as the hydrological cycle. Such a cycle order or events does occur but it is not so simple as that. Firstly, the cycle may short-circuit at several stages, for example, the precipitation may fall directly into the sea, lakes or river courses. Secondly, there is no uniformity in the time a cycle takes. During drought it may appear to have stopped altogether, during floods it may seem to be continuous. Thirdly, the intensity and frequency of the cycle depends on geography and climate, since it operates as a results of solar radiation, which varies according to latitude and season of the year. Finally, the various parts of the cycle can be quite complicated and man exercise some control only on the last part, when the rain has fallen on the earth and is making its way back to the sea.

Although the concept of the hydrologic cycle is oversimplified, it affords a means of illustrating the most important processes that the hydrologist must understand.

Water in the sea evaporates under solar radiation, and clouds of the water vapor move over the land areas. Water begins to flow back to the sea in the form of precipitation. Some of it infiltrates into the soil and moves down or percolates into the saturated ground zone beneath the water table, or phreatic surface. The water in this zone flows slowly through aquifers to river channels or sometimes directly to the sea. The water that infiltrates also feeds the surface plant life and some gets drawn up into this vegetation where transpiration takes place from leafy plant surfaces.

The water remaining on the surface partially evaporates back to vapor, but the bulk of it coalesces into streamlets and runs as surface runoff to the river channels. The river and lake surfaces also evaporate, so still more is removed back at the sea via the river channels. The groundwater, moving much more slowly, either emerges into the stream channels or arrives at the coastline and seeps into the sea, and the whole cycle starts again.

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2.2 INVENTORY OF THE EARTH'S WATER

It is as well to have a clear idea of the scale of the events that are being discussed. Table 1 lists estimates of the amounts of water involved in the hydrological cycle and the proportion (in percentages) of the total water on the earth involved in each part of it.

Table 1 Estimated earth's water inventory

Location	Volume (cubic km)	Percentage total water
Fresh-water lakes	125,000	0.009
Rivers	1,250	0.0001
Soil moisture	65,000	0.005
Groundwater	8,250,000	0.606
Saline lakes and inland seas	105,000	0.008
Atmosphere	13,000	0.001

Polar ice-caps, glaciers and snow	29,200,000	2.1
Seas and oceans	1,320,000,000	97.25
Total	1,360,000,000	100.0

Of the 0.6 per cent of total water that is available as fresh water, but half is below a depth of 800 m and so is not practically available on the surface. This means that the stock of the earth's fresh water is obtainable one way or another for man's use is about 4 million cubic km and is mainly in the ground. Spread over the earth's land surface it would be about 30 m deep.

2.3 APPLIED HYDROLOGY

The four processes with which we are mainly concerned are precipitation, evaporation and transpiration, surface runoff or stream flow, and groundwater. We need to be able to interpret data about these processes and to predict from our studies the most likely quantities involved in the extreme cases of flood and drought. We must be able also to express our opinion about the likely frequency with which events will occur, since it is on the frequency of certain values of extreme events that much water resources engineering design is based.

For those who are concerned with the planning and building of hydraulic structures, hydrology is an indispensable tool. Suppose, for example, that a community wishes to increase or improve its water supply for domestic and/or irrigation purposes:- we first look for sources of supply; having perhaps found a clean mountain catchment area, we must make an estimate of its capability of supplying water. How much rain will fall on it? How long will dry periods be and what amount of storage will be necessary to even out the flow? How much of the runoff will be lost as evaporation and transpiration? Would a surface storage scheme be better than abstraction of the groundwater from wells near by.

The questions do not stop here. If a dam is to be built, what capacity must the spillway have? What diameter should the supply pipelines be? Would afforestation of the catchment area be beneficial to the scheme or not?

To all these questions, and many others that arise, we should give answers. Often the answers will be qualified, and often also they will be given as probable values, with likely deviations in certain length of time. This is because hydrology is not an exact science.

2.4 RIVER BASINS IN ETHIOPIA

In Ethiopia, the differences in altitude (-120 to 4600 m.a.s.l) and relief create a large variation in climate and rainfall in various regions of the country. Annual rainfall ranges from less than 200 mm along the northern and eastern lowlands to more than 2000 mm in the south-western part of the country. Different climates are found in Ethiopia, varying from very hot lowlands to cold mountain zones.

Ethiopia is the 'Water Tower' of the north-eastern Africa. The country forms the divide between the Mediterranean and the Indian Ocean basins. The western part of the country, because of its general inclination westward, drains into the Mediterranean Sea. The southern part, because of its general inclination south-east direction, drains into the Indian Ocean. Table 2 shows the major river drainage

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basins in Ethiopia.

Table 2 Major River Drainage Basins

Name of Basin	Area (sq.km)
Awash	113,700
Wabi Shebelle	205,000
Genale - Dawa	168,100
Rift Valley (Central Lakes)	54,900
Ghibe - Omo	77,200
Baro - Akobo	75,700
Abbay (Blue Nile)	198,000
Tekeze - Atbara	87,800

Baro - Akobo, Abbay and Tekeze basins are within the Nile River Basin. Genale - Dawa and Wabi Shebelle drain into the Indian Ocean passing through Somalia. Ghibe - Omo flows into Lake Turkana. Awash and Central Lakes are closed interior basins.

2.5. RAINFALL

2.5.1 Rainfall in Ethiopia

All available water supplies in Ethiopia, surface and groundwater are derived from rainfall. The knowledge about the quantity, the distribution and the frequency of rainfall is essential in all of the problems associated with water resources development.

Generally, the wet season (or KIREMT) in Ethiopia occurs mainly from July to September and the source of the moisture is from Gulf of Guinea. The Indian Ocean is also another moisture source specially for the south-eastern part of the country in March and April.

Up to five distinct rainfall zones can be recognized depending on the nature of rainfall distribution patterns. They are described as follows:

A. Strongly peaked unimodal profile with peak in July and August. This pattern covers the Tekeze-Atbara basin and the northern part of the Abay basin.

B. Strongly flattened unimodal profile with maximum from May to September. This covers mainly the southern part of the Abay basin, the Baro - Akobo basin and the western part of the Ghibe-Omo basin.

C. Skewed bimodal profile with absolute peak in August and relative peak in April, and covers the eastern part of the Awash basin.

D. Symmetric bimodal profile with peaks in May and August. This covers most of the Wabi Shebelle basin.

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E. Skewed bimodal profile with absolute peak in April and relative peak in October. This covers the southern part of Rift Valley and the Genale - Dawa basin.

Table 2. Regional monthly rainfall in percent of the annual

Reg.	J	F	M	A	M	J	J	A	S	O	N	D
A	0.2	0.4	1.2	2.6	6.3	13.1	29.5	27.4	12.5	5.1	1.5	0.4
B	1.5	1.8	4.0	6.2	12.3	15.0	15.5	14.8	14.0	9.9	3.8	1.3
C	3.2	5.4	7.6	9.4	6.0	4.0	21.2	25.0	10.8	3.8	3.0	1.9
D	2.1	3.3	6.3	12.7	13.8	9.4	13.7	15.5	13.0	6.3	2.9	1.0
E	1.8	3.0	7.0	24.2	21.6	3.0	1.9	2.1	5.9	19.8	8.0	1.7

2.5.2. Rainfall gauges

Measurement of rainfall amount and intensity are the most important. Any open receptacle with vertical sides is convenient rain gauge, but because of varying wind and splash effects the measurements are not comparable unless the receptacle are of the same size and shape and similarly exposed. The standard gauge of US National Weather Service has a collector (receiver) of 20.3 cm diameter. Rain passes from the collector into a cylindrical measuring tube inside the overflow can. The measuring tube has a cross-sectional area 1/10 that of the collector so that 1 mm of rainfall will fill the tube to a depth of 10 mm.

In order to determine rates of rainfall over short periods of time, recording rain gauges are used. The 'weighing rain gauge' has a bucket supported by a spring or lever balance. Movement of the bucket is transmitted to a pen which traces a record of the increasing weight of the bucket and its contents on a clock-driven chart. The 'tipping-bucket gauge' consists of a pair of bucket pivots under a funnel in such a way that when one bucket receives 0.25 mm or rainfall it tips, discharging its contents into a reservoir and bringing the other bucket under the funnel. A recording mechanism indicates the time of occurrence of each tip. The tipping-bucket gauge is well adapted to the measurement of rainfall intensity for short periods.

2.6. EVAPORATION

In studying a hydrologic balance for an area, one is usually concerned only with the total evaporation (or evapo-transpiration), the evaporation from all water, soil, vegetation, and other surfaces plus transpiration. An estimate of the actual evapo-transpiration from an area can be made by subtracting measured outflow from an area (surface or subsurface) from the total water supply (rainfall and subsurface inflow and imported water). Change in surface and underground water storage must be included when significant.

Direct measurements of evaporation are quite delicate and requires continuous care. For this reason, it is quite rare to find long-term series of direct evaporation data that covers many sites. In the absence of direct measurements it is possible to evaluate evaporation from local climatic data.

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Compared to other empirical methods the Penman method of estimating evaporation or evapo-transpiration is likely to provide the most satisfactory results. The Penman method requires the availability of data on temperature, humidity, wind and sunshine duration or radiation.

The Penman method can be written in the following form:

$$Eo = W*Rn + (1-W)*f(U)*(Ea-Ed)$$

where,

Eo = open water evaporation in mm/day
Rn = net radiation
W = temperature related weighing factor
Ea = saturation vapor pressure at mean air temperature in mbar
Ed = mean actual vapor pressure of the air in mbar
f(U) = wind related function.

Even though evaporation depends on both geographical coordinates and on the ground features such as wind velocity, temperature and radiation, in the case of Ethiopia, it can fairly be related with altitude. The relationship can be approximated as:

$$EVo = 3000 - 0.4*ALT$$

where,

EVo = mean annual open water evaporation in mm
ALT = altitude above sea level in meters

Table 2. Regional monthly evaporation in percent of the annual

Reg.	J	F	M	A	M	J	J	A	S	O	N	D
A	8.0	8.6	10.8	10.7	10.5	9.8	6.6	5.9	7.5	8.5	7.5	7.0
B	9.0	9.2	10.4	10.3	8.5	7.1	6.9	6.4	7.5	8.4	8.0	8.4
C	7.1	7.5	9.1	9.0	10.5	10.4	8.2	7.8	7.6	8.4	7.3	7.0
D	8.1	7.9	9.4	8.8	8.9	8.5	8.0	8.0	8.3	8.3	7.9	8.1
E	9.4	9.1	10.2	8.6	7.9	7.5	7.3	7.7	8.1	8.0	7.8	8.2

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2.7. STREAM FLOW

Gauging stations required for stream flow measurement are:

1. Primary or principal stations defined as permanent stations to measure all ranges of discharges and observations and records to be accurate and complete.

2. Secondary or subsidiary stations to operate for as long as necessary to obtain a satisfactory correlation with the record of a primary station.

3. Special stations are those serving particular needs, such as reservoir levels and dry weather flow stations for controlling abstractions; these may be permanent or temporary.

Stage

The water level at a gauging station, the most important measurement in hydrometry, is generally known as 'stage'. It is measured with respect to a datum.

The instruments and installations range from the most primitive to highly sophisticated, that can be grouped into few important categories: the staff gauges, crest gauges, autographic recorder, pressure gauges.

Discharge

The most direct method of estimating a discharge of a stream (river) is by velocity-area method in which flow velocities are measured at selected vertical of known depths across a measured selection of the stream (river).

It has been found be observation that a good estimate of the average velocity in the vertical is obtained by taking the mean velocity measurement at 0.2 and 0.8 depths; for shallow depths 0.6 times the depth is recommended.

Measurement of Velocity

The simplest method for determining a velocity of flow is by timing of a float over a known distance. A factor of 0.7 is recommended for a river of 1.0 m depth with a factor of 0.8 for 6.0m or greater.

The determination of discharge at a stream section is best made by measuring the flow velocities with a 'current meter'. There are two main types of meter; the cup type has an assembly of six cups revolving round a vertical axis, and the propeller type has a single propeller rotating on a horizontal axis. Both types of instrument need to be calibrated to obtain the relationship between the rate of revolution of the cups of propeller and the water velocity.

The sampling of velocities across a gauging section depends on the size of the river and its accessibility. Some of the means are wading, bridge, boat, cable car and cable way.

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Weirs

Weirs are used to measure the flow in channels or streams. In its simplest form a weir consists of a weir wall of concrete, timber or metal with a sheet metal weir plate fixed on to it. Weirs may be built as stationary structures or they may be made portable. Rectangular weirs and 90-degree V-notch weirs are commonly used. It is desirable to install the weir at a point where there is a drop in the elevation of the channel bed. This will produce free fall to the downstream.

The basic formula for calculating discharge through a weir is:

$$Q = C*L*(H\hat{}m)$$

where, Q = discharge in litres per second
L = length of crest in cm

H = head in cm
C = coefficient (dimensionless)

The discharge through specific weirs may be computed by:

(a) Suppressed rectangular weir
Q = 0.0184*L*(H^1.5)

(b) Contracted rectangular weir (with end contractions at both ends):
Q = 0.0184*(L-0.2H)*(H^1.5)

(c) 90-degree V-notch:
Q = 0.0138*(H^2.5)

Slope-Area Method of Estimating Stream flow

The slope-area method is primarily to determine the discharge of a stream from a specific field data. However, if the discharge is known, this method can be used to compute the roughness coefficient (i.e., Manning's n). Field procedures required to obtain needed data for the slope-area method include:

- selecting a representative reach of river channel,
- determining the channel cross-section at each end of the selected reach,
- measuring the water surface slopes from observed high water marks, and
- selecting a suitable roughness factor (Manning's n).

With these data, the discharge is determined by Manning's formula:

Q = (1/n)*A*(R^2/3)*(S^0.5)

where, Q = discharge
A = the area of the flow cross-section
R = the hydraulic radius = A/P
P = wetted perimeter
S = energy gradient (approx. slope of the water surface)
n = Manning's roughness coefficient.

Coefficient of Manning's roughness, n, for an average channel

0.016	Smoothest natural earth channels, free from growth, with straight alignment.
0.020	Smooth natural earth channels, free from growth, little curvature.
0.0225	Average, well-constructed, moderate-sized earth channels in good conditions.
0.025	Small earth channels in good conditions, or large earth channels with some growth on banks scattered cobbles in bed.
0.030	Earth channels with considerable growth. Natural streams with good alignment, fairly constant section. Large floodway channels, well maintained.
0.035	Earth channels considerably covered with small growth. Cleared but not continuously maintained flood ways.
0.045	Mountain streams in clear loose cobbles. Rivers with variable section and some vegetation growing in banks. Earth channels with thick aquatic growths.

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0.070	Rivers with fairly straight alignment and cross-section, badly obstructed by small trees, very little underbush or aquatic growths.
0.100	Rivers with irregular alignment and cross-section, moderately obstructed by small trees and underbush. Rivers with fairly regular alignment and cross-section, heavily obstructed by small trees and underbush.
0.150	Rivers with irregular alignment and cross-section, many root trees, bushes, large logs, and other drift on bottom, trees continually falling due to bank caving.

Rating equation

A continuous record of stream flow requires the establishment of a relation between rate of flow and water level in a channel. A stage-discharge relation, or rating curve, is constructed by plotting the measured discharge against stage (water surface elevation) at time of measurement.

If station is located just upstream from a rapid or other natural control which fixes a definite relation between stage and discharge, an accurate and permanent rating is obtained. An artificial control consisting of a low weir of concrete or masonry is sometimes constructed on small streams. It may be necessary to accept the rating curve fixed by the channel geometry of large streams, and erosion or deposition of sediment may change the rating from time to time. Under these conditions a satisfactory stream flow record can be obtained only by frequent current-meter measurements to fix the position of the rating curve at any time. Even where a good control exists, routine check measurements are considered desirable.

The most widely used form of equation that relates gauge height with discharge has the following form:

$$Q = C*\{(G-e)\hat{}n\}$$

where, G = stage reading in m

C and n are constants derived from the curve relating Q and (G-e)

e = height in m between zero on the gauge and the elevation of zero flow.

2.8. SEDIMENTATION PROBLEMS

Sediment yield of a Catchment

The average annual sediment production from a catchment is dependent on many factors such as climate, soil type, land use, topography, and the presence of reservoirs. Adequate data for a complete analysis of all factors are difficult to obtain.

Vegetation provides significant protection against erosion by absorbing the energy of the falling drops and generally reducing the drop sizes which reach the ground. Vegetation may also provide mechanical protection to the soil against gully erosion. In addition, a good vegetal cover generally improves infiltration capacity through the addition of organic matter to the soil. Higher infiltration capacity means less overland flow and consequently less erosion.

Sediment Rating Equation

Sediment measurements, like current-meter measurements, give only occasional samples of the sediment

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discharge. A sediment-rating equation relating suspended sediment discharge and water discharge is commonly used to estimate sediment load on days when no measurements are available. The equation has the form:

$$Qs = a*(Q\hat{}n)$$

where, Qs = suspended sediment discharge
Q = water discharge

Sediment rating equations should be used with caution and where possible applied to small and relatively homogeneous catchments.

Reservoir Sedimentation

The rate at which the capacity of a reservoir is reduced by sedimentation mainly depends on the quantity of sediment inflow and percentages of this inflow trapped in the reservoir. The quantity of sediment inflow may be estimated from suspended sediment data available.

2.9. RESERVOIRS

A water supply, irrigation, or hydro-power project drawing water directly from a stream may be unable to satisfy the demands of its consumers during extremely low flows. This stream, which may carry little or no water during portions of the year, often becomes a raging torrent after heavy rains and a hazard to all activities along its banks. A storage (or conservation) reservoir can retain such excess water from periods of high flow for use during low flow periods. In addition to conserving water for later use, the storage of flood water may also reduce flood damage below the reservoir. Because of the varying rate of demand for water during the day, it may be necessary to provide distribution reservoirs within a supply system.

Whatever the size of a reservoir or the ultimate use of the water, the main function of a reservoir is to stabilize the flow of water, either by regulating a varying supply or by satisfying a varying demand by the ultimate consumers.

Since the primary function of reservoirs is to provide storage, their most important physical characteristic is 'storage capacity'.

It is virtually impossible to locate a reservoir site having completely ideal characteristics. General rules for choice of reservoir sites are:

1. A suitable dam site must exist. The cost of the dam is often a controlling factor in selection of site.

2. The cost of real estate for the reservoir (including road, cemetery, and dwelling relocation) must not be excessive.

3. The reservoir site must have adequate capacity.

4. A deep reservoir is preferable to allow one because of lower land costs per unit of capacity, less

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evaporation loss, and less likelihood of weed growth.

5. Tributary areas which are unusually productive of sediment should be avoided if possible.

6. The quality of the stored water must be satisfactory for its intended use.

7. Sites from which a considerable quantity of leakage may occur should be avoided.

2.10. WATER AVAILABILITY

Hydrological Data Availability

Generally, rainfall and stream flow data acquisition in Ethiopia is of very recent origin. The rainfall and stream flow gauging stations, besides their short age, have uneven and less dense spatial distribution.

The uneven distribution is mainly due to lack of access. Almost all major towns are located on the highland areas and the roads that connect these towns are aligned almost through the divide lines of the river basins. There are only very few roads that cross big rivers and as a result only very few large catchments are gauged. More than 70% of the rainfall and stream flow gauging stations are located at the heads of big river basins.

As of 1990 the density of rainfall stations is about 1 station for 2000 sq.km area. This is much lower figure compared to figures that are recommended by different authors for mountainous countries like Ethiopia. There are only about 10 rainfall gauging stations that have records for more than 30 years, the average length is about 10 years.

Stream flow Regulation

For many rivers in Ethiopia, low flow period prevails for about 75% of the year. In most of the cases there are only three peak months that cover more than 75% of the annual flow. Therefore, it seems obvious that water should be stored at times of peak flow for use at times of low flow or no flow, if efficient use of water is required. The degree of storage requirement varies from place to place based on the situation of the low flow periods. In the Tekeze - Atbara basin the low flow duration is very long and there is no flow at all for many months in many streams. In regions where one long rainy season occurs like the Baro - Akobo, the Western Ghibe - Omo and south-western Abay, most of the rivers are perennial and the low flows are quite satisfactory for many uses even without storage facilities. Regions with two rainy seasons have the advantage of maintaining their low flows at a reasonable level.

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3. POSSIBLE SOURCE OF WATER SUPPLY AND SELECTION CRITERIA

Available water supply sources have to be identified first, and then depending on the following criteria possible water supply sources have to be listed in the order of priority.

1. The source should be able to cover the required demand, down stream requirements, if any , should also be taken in to consideration if the source is spring or surface water.

2. The source and its components should be simple to construct, easy to maintain and operate (relatively requires less investment, maintenance and operation costs),

3. The source and its components should involve no or less negative environmental impact

4. It is preferable if the source and its components construction, maintenance and operation can be achieved by locally available skill and materials.

5. The distance between the source and the user should be taken in to consideration

6. The raw water quality of the source should require no treatment facilities or low cost type treatment facilities

7. The source should be acceptable by the society ...etc

In the light of the above mentioned criteria, the possible sources for the rural water supply is listed as an example in the order of priority.

1. Gravity spring water

2. Shallow wells (Hand dug wells)

3. Infiltration gallery

4. Deep wells

5. Subsurface dams

6. Rain water harvesting

7. Ponds

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4. SPRING PROTECTION

4.1. INTRODUCTION

Spring water has been used as source of drinking water supply by communities since early times. If properly developed and protected from any potential pollutant, it is a reliable and safe water source and could be supplied to communities without further treatment. Spring water could be tapped and protected with locally available materials and most often it can be supplied by gravity without the involvement of pumping equipment. Hence, it could be reliable and economic water supply source for rural communities.

4.2. TYPE OF SPRINGS

A spring is an underground water which has come out to surface due to some obstruction to the underground flow of water. Spring water is pure and could be supplied to a community without further treatment, provided it is properly protected from external pollution. The protection of a spring could be done with stone masonry, brick masonry and concrete. There are several names given to springs depending on the shape of the opening through which they emanate to the surface.

If spring water comes out from a porous ground through many small openings, it is known as seepage or infiltration springs. Springs emanating from joints or fracture of solid rocks are called fracture springs and where the out flow opening is some what round in shape they are called tubular springs. Springs could be gravity or artesian flow depending on the confinement. The understanding of the distinction between gravity and artesian flow springs is of paramount importance in spring development work. Gravity and artesian springs could be further sub-divided into depression and over flow springs.

Gravity Depression Springs:- When the ground surface dips below the ground water table of an unconfined aquifer, the depression will be filled by water creating a gravity depression spring. Springs of this type usually have small yield and fluctuate seasonally to a great extent making such springs unreliable source for community water supply. However, the presence of such springs indicates availability of shallow ground water which could be withdrawn by development of hand dug well.

Gravity Overflow Springs:- This type of spring occurs when the ground water flow in an unconfined aquifer is intercepted by an outcropping impermeable material and forced to over flow. Mostly the yield from this type of spring is large and less variable since most of the water from the tributary recharge area is discharged at this point. Although the yield from this type of spring is large and less variable, appreciable fluctuation of the discharge may occur and during periods of draught some of them may cease to flow. Therefore, to have a reliable and continuous source of water, investigation on the yield and seasonal fluctuation of this type of springs must be conducted before any development work is started.

Artesian Depression Springs:- These are similar in appearance to gravity depression springs apart from higher yield and less fluctuation observation. The drop in ground water table in an artesian aquifer has little influence on the water flow. Artesian depression springs occur when the confining impermeable layer over the ground water table is intercepted by depressions.

Artesian Fissure Springs:- These are the other variance of depression springs and their occurrence is when the impermeable layer is intercepted by joints or fractures. This type of springs are good source of water supply for communities.

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Artesian Overflow Springs:- These springs occur where confined aquifers are exposed to the surface. The recharge area of these type of springs is usually large and their yield is considerably large too. The seasonal fluctuation of these springs is very low or non-existent. Artesian overflow springs are very good community water supply sources if available at reasonable proximity. They are also easy to develop.

In general, artesian springs are superior to gravity springs in that the impermeable layer over the aquifer prevents seepage of pollutant into the aquifer, less fluctuating and have higher yields. Hence, water withdrawn from these springs is bacteriologically safe provided external pollution is prevented.

4.3. BASIC POINTS IN SPRING TAPPING

It has been mentioned several times that spring water is safe drinking water source that could be supplied to communities without further treatment. Nevertheless, unless properly protected from external pollution, it is liable to contamination once it has emerged to the surface and becomes unsafe to drink. Therefore, consideration of the following four points are of great importance in the development of spring water for community water supply.

1. Appropriate sanitary protection to avoid entry of pollutants into the spring tapping structure.

2. Although springs are generally taken to be free from pathogenic organisms, care should be taken if the temperature of the spring water varies during day and night; in which case the quality of the water is in suspect. Therefore, if such variation occurs to a spring water, bacteriological examination of the water must be conducted so as to assure the quality before supplying to a community.

3. In granular aquifer, the outflow will vary little with distance along the contour. Tapping of this type of spring water could be done with infiltration galleries of considerable length without critically considering their location; since location is not critical to that extent. With fractured rock aquifers the outflow will be concentrated where water carrying fissures reach ground surface. Hence, small tapping structure will be probably adequate but the site must be located properly.

4. Proper assessment of the yield of the spring and seasonal variation are pertinent for reliable spring source development, as these are slightly influenced by the construction of spring water collection work. Hence, before tapping a spring for community water supply use, it should be assessed thoroughly for its yield and seasonal fluctuation.

4.4. SPRING WATER TAPPING

4.4.1 Tapping Gravity Springs

4.4.1.1 Gravity Depression Springs

These type of springs are not recommended as source of water supply for community use because of their small yield and the difficulty to construct appropriate sanitary protection structures. But, their presence indicate shallow ground water table that can be exploited with hand dug wells. Development of hand dug wells instead of springs is preferred for ease of protection from external pollution and provision of continuous and reliable water

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supply through out the year.

4.4.1.2 Gravity Overflow Springs

A. Springs in granular ground formation

Overflow spring from granular ground formation can be tapped with drains consisting pipes with open joints placed in gravel pack. Where the spring comes out from a hill side, it can be collected from drains with an open side spring box (fig. 2). The area around must be dug out up to the impermeable layer so that all available flow is withdrawn into the spring box. The dug out area from the entrance side to the spring box should be packed with selected gravel and above the aquifer it must be backfilled with clay puddle and compacted soil. Surface water diversion ditch about 8mt. from the spring box must be constructed to prevent pollution of the spring water by flood. The gravel pack prevents the spring water from washing away fine particles from the spring eye area and serves as a filter material to entrap fine particles before coming into the box.

If the spring eyes are two or more, water can be collected with separate spring boxes and could be gravitated to a common silt trap as shown in figure 3. When gravitating water from several springs through a pipe, there might be a danger of pressure build-up from one spring stopping water flow from another spring. Therefore, the pipes should be separately laid and must enter into the silt trap above the water level in the collection chamber.

B. Seepage or infiltration springs

Overflow seepage or infiltration springs are collected with infiltration ditch or perforated pipe packed with gravel. The collected water is channelled to a spring box from which it is gravitated to a collection point or a reservoir. The collectors are installed in the deepest part of the aquifer so that the storage capacity of the saturated zone above them is exploited during times of low ground water table.

The perforations in the collector pipes must be about 5mm in diameter to prevent fine particles from entering to the pipe. In sand aquifer, the perforated pipes must be packed with selected gravel to avoid sand particles from entering the pipe. Even under this condition finer particles will find their way in to the pipe and could clog it. Therefore, the pipe should be sized and must be laid in such a way that the water flow velocity inside the pipe is kept within the range of 0.5 to 1m/sec. to avoid clogging.

The water collection pipes must be laid across the entire width and length of the seepage area and should be perpendicular to the flow of water within the aquifer. The collector system has the advantage of guiding water into the central storage collection basin from a large seepage area very easily. To prevent escaping water, a cut of wing wall should be constructed deep into the impermeable layer so as to guide the water toward the collector pipes and prevent leakage (fig.4).

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and are not sustainable. Spring water could also escape underneath and /or the sides of the spring box if pressure builds up inside the structure due to improper positioning and size selection of the outlet and overflow pipes. Therefore, construction of spring protection structures should be done with maximum precaution to attain the primary objective of supplying safe and adequate drinking water to communities.

Below are given common mistakes encountered in spring development with their effects and possible solutions.

A. Spring surrounding not fenced.

* The structures are liable to abusal by animals and kids.
* The water could be easily polluted by animals and human excreta.
* The soil could be easily eroded due to over grazing of grasses by cattle.

Recommendation

- Fence the area properly.

B. Surface water drainage ditch not provided.

* Surface water can pollute the spring water.
* The area could be easily flooded and becomes muddy creating inconvenience for water collectors.
* The soil around the spring protection structure can be eroded.
* Water pool formation that could be potential area for insect breeding that causes health hazard such as malaria, yellow fever and elephantiasis.

Recommendation

- Provide adequate surface water drainage facility.

C. Loose and permeable backfill over spring drain.

* Polluted surface water can easily seep into the spring water.
* The spring water could get turbid by seeping rain water.
* The backfill could sink due to settlement thereby causing pool of water in the depression created by the settlement of the backfill.

Recommendation

- Backfill the excavated area with compacted and impermeable soil.

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H. No wire mesh covering the overflow pipe.

* Small creatures such as rats, birds ...etc. could enter the chamber and can pollute the water.

* Kids might throw debris through the opening into the chamber or could plug the overflow pipe causing problem to the flow of surplus water.

Recommendation

- Cap the outlet of the overflow pipe with appropriate wire mesh.

I. No strainer to the outlet pipe from the inlet side.

* Some floating materials are taken to the water intake point.

Recommendation

- Provide strainer to the inlet side of the outlet pipe.

J. No drainage pipe for the spring box.

* The water inside the chamber can not be drained for cleaning or maintenance purposes.

Recommendation

- Provide drainage pipe so as to drain the water inside the chamber in order to facilitate cleaning and maintaining the chamber.

K. Trees or weeds near the spring tapping structure.

* Roots of trees or weeds will find their way into the tapping structure and could clog the intake pipe.

Recommendation

- Remove trees and weeds from the spring eye area.

4.6. CHECK LIST

1. Community participation

* Is supply of clean water first priority to the community?

* Are they aware about the objective of the project?

* Have awareness programme through community participation promotion been carried to make them participate in all the project life cycle?

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2. Spring tapping

* Is the spring to be tapped perennial? Is there no suspect of possible external pollution?
* Is the spring catchment area properly fenced?
* Is the spring tapping structure protected from external pollution?
* Is the water collection chamber water tight? Are the outlet pipe, overflow and drainage pipes installed in the appropriate position?
* Have you provided inspection manhole for the collection chamber? Is it properly sealed to curtail surface water seepage?
* Is the spring area fenced? Is there flood water drainage ditch?
* Are there trees or other plants very near to the spring tapping structure?

3. Information recording

* Have you given project identification number?
* Is the project accomplished date and year registered?
* Have you determined the yield of the spring? Is it recorded? How many are benefited from the project? Is this properly recorded?
* Is there as built in drawing? How much does it cost you to build the scheme? What was the share of the community in terms of finance? Is it properly identified and registered?
* What was the deviation of the estimated cost with the actual cost?

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5. HAND DUG WELLS

5.1. GENERAL BACK GROUND.

Ground water withdrawal from shallow aquifer using hand dug well has been used since early times. In areas where fresh surface water or spring water is not readily available, hand dug wells are important sources of drinking water supply. Hand dug wells can be categorized into two groups i.e. traditional and modern hand dug wells. In Ethiopia, traditional dug wells have been used in many rural areas quite for a long time but development of shallow ground water using modern improved wells is practiced only recently.

5.2. INTRODUCTION TO GROUND WATER OCCURRENCE

As part of hydrological cycle water precipitates onto the ground in the form of snow, hail and rainfall. Out of the precipitated water some flow as run-off, lost by evapotranspiration and soil moisture deficit while the remaining percolates into the ground. Percolation of water into the ground depends on the permeability of the underground formation which inturn depends on the porosity, distribution of fissures and average pore size of the soil and rock formation. Infiltrated water through time accumulates in pores, voids and fissures of the ground formation causing occurrence of ground water. The formation in which water accumulates in the above manner is called an aquifer.

The ground water in the aquifer is not stagnant; like surface water it flows underground from higher to lower potential. This flowing underground water will emanate onto the surface either in the form of a spring or as ground water flow in a river or lake when intercepted by a barrier or weak point on the surface of the ground is encountered. Compared to surface water flow, ground water flow takes place very slowly due to constrictions to the flow of water in the underground formation. Hence, natural clarification due to filtration, sedimentation and absorption takes place in the movement of ground water both during percolation and flow due to hydraulic gradient. This phenomena makes ground water to be relatively of better quality than surface water. Hence, properly protected spring and ground water exploited in the form of a bore hole or a hand dug well could be supplied to a community without further treatment.

When percolating water reaches impermeable layer, it accumulates and forms a saturation zone. The upper boundary of the saturation zone is termed as the ground water table. Like surface water level, ground water table fluctuates in dry and wet season. It decreases in dry season since it escapes in the form of spring or ground water outflow in rivers and lakes and it increases during wet season due to recharge by infiltration of rain water. Moreover, ground water table could also decrease if water abstraction from a well is unbalanced with the recharge of the aquifer.

The water bearing formations (aquifer) are generally divided into two.

- Unconfined Aquifer - if the water bearing formation is a permeable bed partly filled with water and overlying a relatively impervious layer with free water table or phreatic level under atmospheric pressure.

- Confined Aquifer - if the water bearing formation is between impermeable layers and is completely saturated. If a well is drilled in confined aquifer, the water level will rise and possibly flow freely to the surface.

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If the aquifer contains high organic matter, the oxygen content of the water may be completely depleted and the ground water will become anaerobic (without oxygen). This type of water dissolves iron, manganese and heavy metals from the underground formations thereby causing the water objectionable for use. Water with high content of iron and manganese could be treated by aeration and filtration. Aeration will change soluble iron and manganese into insoluble form that could be removed by sedimentation and filtration. Besides, aeration could remove objectionable gases such as hydrogen sulphide and methane.

5.3. HAND DUG WELLS.

Hand dug wells could be divided into two groups; traditional and modern hand dug wells. The major difference being means of lifting water, method of well lining, well head cover and sanitary protection structures. Their method of construction and other differences are given below:-

5.3.1 Traditional Hand Dug Well

Traditional dug wells have been used since early civilization for domestic water supply and animal uses. They are still widely in use in Ethiopia and elsewhere for domestic water supply, animal watering and at some places even for small scale irrigations. In most of the places water lifting from traditional wells is with inner tubes or some other containers and ropes. At some other places, windlass is installed on top of the well to bail out water easily with a rope and a container.

Almost all traditional wells are unlined and have no proper well cover. Spilt over water and polluted surface water could easily enter the well carrying pathogenic organisms. These pathogenic organisms will multiply inside contaminating the water and making it unsafe to drink. Consuming water from such sources could cause out-break of diseases such as cholera and typhoid fever causing thousands of death. Therefore, traditional wells must be improved and should be well protected to avoid any health risk that could arise on benefitting community. The best way to improve a traditional well is to construct appropriate well head cover, drainage facility and to install a hand pump. If a hand pump is not available the well could be protected from pollution by improving the water lifting mechanism. This could be done using windlass, rope, bucket and flexible hose. The arrangement of this system is shown in fig(1).

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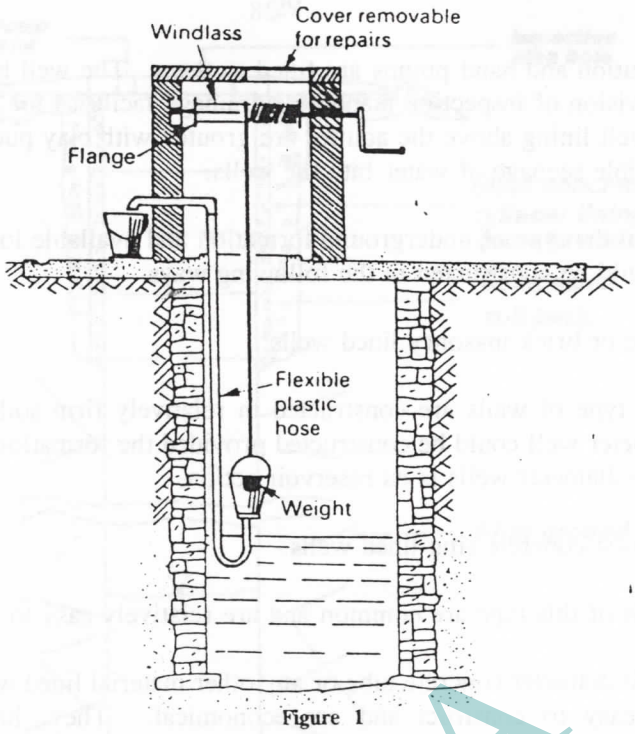


Figure 1
Windlass, Bucket and Flexible Hose Water Abstraction System

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5.3.1.1. Improvement of Traditional Hand Dug Wells.

Improving traditional wells is advantageous since there is a substantial saving in cost and in the time required to build a new well. Several methods could be used to improve traditional wells. To cite some:-

a) If the traditional well is sunk in a consolidated formation, line the well with blind concrete cylinder up to 3m. and grout the well properly with clay puddle. Construct well head and cover slab and finish the well apron to a required standard.

b) If the formation is unconsolidated, line the whole length of the well with concrete cylinders and finish the well head cover. But, if under such condition the lining of the well is not possible due to small well size and low yield, abandon it. However, if the well yield is found adequate for the intended use line with small diameter tubes.

c) In wells where only the loose top soil requires additional work, a masonry wall could be built leaving the lower stable portion unattained. Plaster the masonry structure and provide concrete seal and grout with clay puddle in the soil region. Construct well head cover and cover slab and finish the well apron to standard.

5.3.2. Modern Hand Dug Wells.

Modern hand dug wells differ from the traditional wells in that they are well protected from

external pollution and hand pumps are fitted to them. The well heads are properly constructed with the provision of inspection manholes, drainage facilities for spilt over water and the areas around the well lining above the aquifer are grouted with clay puddle or cement sand mortar to prevent possible seepage of water into the wells.

Depending on the type of underground formation and available local construction material hand dug wells could be constructed in the following ways.

a. Stone or brick masonry lined wells.

This type of wells are constructed in relatively firm soil. If stone is available a large diameter well could be constructed provided the formation is suitable. The advantage of large diameter wells is its reservoir action.

b. Pre-cast concrete ring lined wells.

Wells of this type are common and are relatively easy to construct.

c. Small diameter concrete tube or any other material lined wells. Wells of this sort are easy to construct and are economical. They, however, are with the disadvantage of difficulty of rehabilitation if silted or decreasing yield.

d. Concrete cast in situ lined wells.

This type of wells are time consuming and requires form work for casting the concrete. Besides, the well wall should be straight to minimize concrete wastage. This implies that digging must be done with at most care. All these make the cost of the well high and time consuming and therefore, are not recommended for frequent usage.

5.3.2.1. Large Diameter Concrete Lined Wells.

Large diameter concrete ring lined wells are those with inside diameter large enough for a person to work inside. The advantages of this type of wells is that it could be developed if silted and the depth could be increased if the water table decreases. Depending on the geologic formation, large diameter concrete cylinder wells are classified into three types.

1. Consolidated formation dug well:-

If the underground formation is consolidated throughout, the well is left unlined except for the top three meters which is lined for sanitary protection (fig.2.a.).

2. Partially unconsolidated formation dug wells:-

When the formation is only unconsolidated in the aquifer zone, line the top three meters with blind concrete cylinder and the aquifer zone with perforated concrete cylinder (fig. 2.b.).

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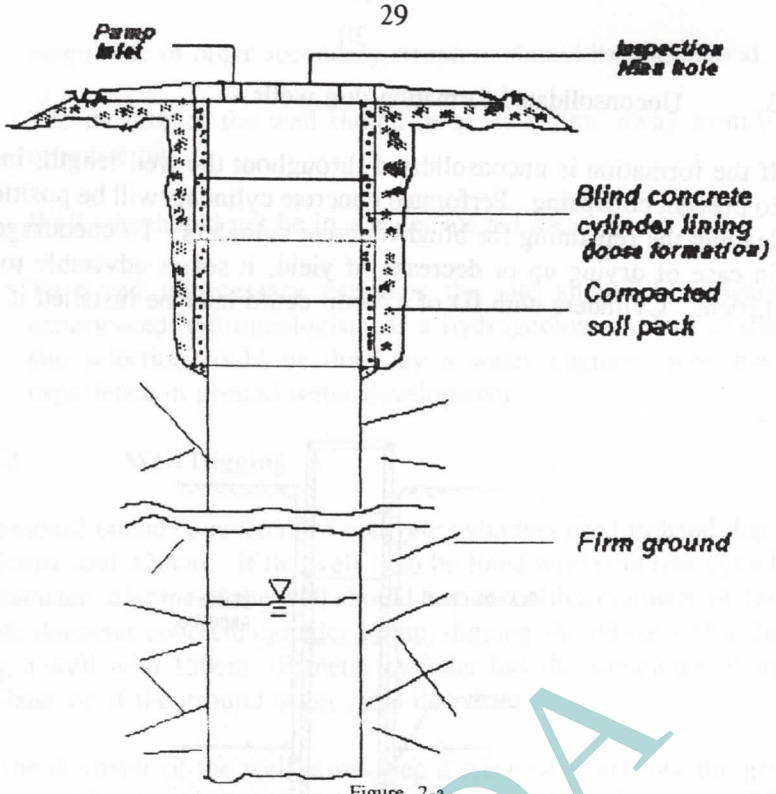


Figure 2-a
Well Lined the Top Loose Formation Only

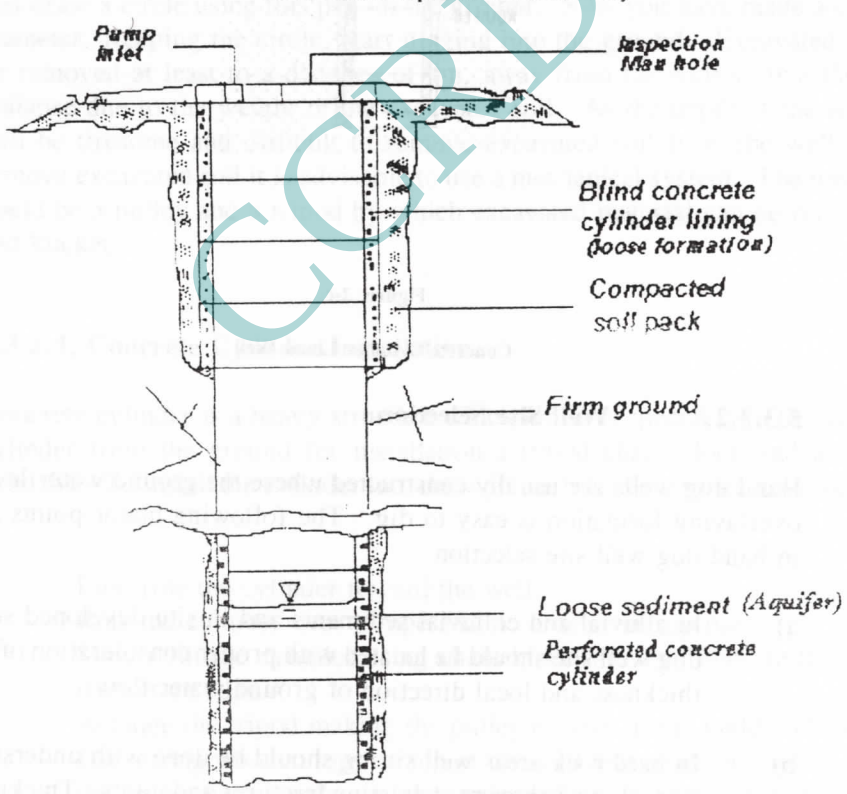


Figure 2-b
Well Lined the Top Loose Formation and Aquifer Zone

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3. Unconsolidated formation dug wells:-

If the formation is unconsolidated throughout the well length, install concrete cylinders to prevent collapsing. Perforated concrete cylinders will be positioned in the aquifer zone leaving the remaining for blind concrete cylinders. To encourage further depth increase in case of drying up or decrease of yield, it seems advisable to install cylinders of ID 130cm. Cylinders with ID of 120cm. could later be installed if need arises. (Fig. 2c)

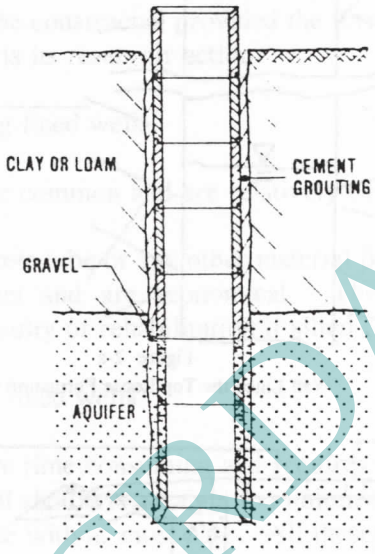


Figure 2-c

Concrete Cylinder Lined Well

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5.3.2.2. Well Site Selection.

Hand dug wells are usually constructed where the ground water level is shallow and the overlaying formation is easy to dig. The following major points should be considered in hand dug well site selection.

a) In alluvial and colluvial sediments and in situ developed soils, the hand dug well site should be located with proper consideration of aerial extent, thickness and local direction of ground water flow.

b) In hard rock areas well sitting should be done with understanding of the hydrologic behavior of existing fractures and joints. Thickness and aerial extent of the weathered sandy portion of the unit should be properly assessed. Geological parameters such as age sequence of faults and

magnitude of other secondary structure should be understood.

c) The location of the well should be at least 30m. away from pit latrines or waste pits.

d) Well site should not be in a water logged area.

e) To avoid unnecessary expenses the site should be selected by an experienced hydrogeologist. If a hydrogeologist is not available, well site selection could be done by a water engineer who has a sound experience in ground water development.

5.3.2.3 Well Digging

The standard outside diameters of concrete cylinders used in hand dug well construction are 150cm. and 120cm. If the well is to be lined with concrete cylinder of 150cm. out side diameter, digging of the well should be done with a diameter of 180cm. For 120cm. out side diameter concrete cylinder lining, digging should be with a diameter of 150cm. Lining a well with 150cm. diameter cylinder has the advantage of increasing the well depth later on if the ground water table decreases.

Once the diameter of the well is set, peg a piece of wood into the ground and attach a string to it. To the other end of the string tie a peg at a distance of 90cm. from the peg and draw a circle using this peg on the ground. Now you have made a circle of 180cm. diameter. Keeping the circle, start digging into the ground. Excavated material should be removed at least to a distance of 4m. away from the well so that the well does not collapse due to the weight of the excavated soil. As the depth of the well increases, it will be tiresome and difficult to remove excavated soil from the well. Therefore, to remove excavated soil it is advisable to use a mechanical system. The mechanical system could be a pulley and a tripod by which excavated material can be removed using rope and bucket.

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5.3.2.4. Concrete Cylinder Installation.

Concrete cylinder is a heavy structure which requires special care to install. To lift the cylinder from the ground for installation a tripod chain block and a cable should be available. To install the cylinder into the well the following procedures should be adhered to.

- First role the cylinder toward the well.
- Role the cylinder over a rope and tie it near the top part.
- Slowly lift the cylinder using chain block and put it beside the well by its bottom edge.
- Arrange the tripod making the pulley exactly in the middle of the well.
- Lay strong wooden logs on top of the well that could be used to support the concrete cylinder while arrangement is made for the proper installation of the cylinder.

- Tie a cable around the cylinder as shown in fig.3.
- Now lift the cylinder up carefully and check for proper lifting. If lifting is not in the proper way lower it onto the wooden pole and rearrange the system.
- Lift the cylinder and remove the wooden logs.
- Lower the cylinder into the bottom of the well and untie the cable.
- Check with spirit level for the proper alignment of the cylinders. If the cylinders are not aligned, the alignment could be adjusted by timing the soil beneath the edge of the concrete cylinder.
- Install the other cylinders in the same manner as digging progresses.

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N.B. :- Do not forget to install perforated cylinder in the aquifer zone unless the aquifer is of sand materials. In which case all the cylinders should be blind to avoid horizontal flow of water into the well. Pack the bottom portion of the well with graded gravel for about 20cm. thickness. Otherwise the outer periphery of the cylinder in the aquifer zone should be packed with gravel and the remaining should be blinded. This could be done immediately after installation of each cylinder and packing the outer periphery with clay puddle.

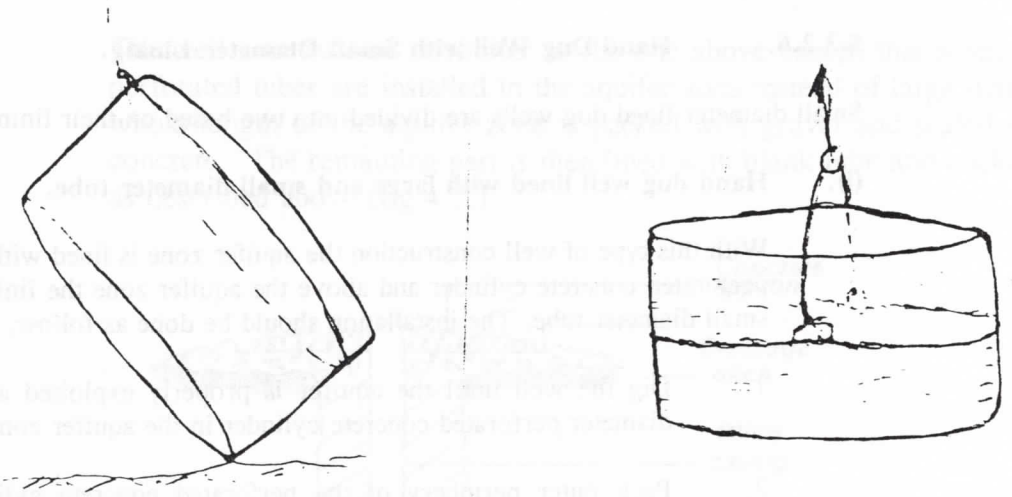


Figure 3
Concrete Cylinder Installation

5.3.2.5. Well Head Construction.

The concrete cylinder lining should extend to height of 20cm. above ground level. The well head should be constructed as follow.

1. Excavate the rings surrounding to a width of 150cm. and to a depth of 20cm.

2. Fill the excavated area with hard core and construct lean concrete standing platform on top.

3. The lean concrete should be constructed with sufficient slope that could allow all spilt over water to be drained easily.

4. Construct lined drainage ditch to take away drained water to a soak away pit.

5. The soak away pit must be filled with gravel and it should be at a reasonable distance from the well.

6. Cast 15cm. thick reinforced concrete cover slab equivalent to the outside diameter of the concrete cylinder.

7. The slab should be provided with a 50 x 50 cm. inspection manhole and about 15cm. diameter pump installation hole. Bolts to tie up the pump head should be casted into the slab.

8. Cover the well with the already casted cover slab and seal it properly with cement sand mortar of 1:4 mix.

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5.3.2.6. Hand Dug Well with Small Diameter Lining.

Small diameter lined dug wells are divided into two based on their lining.

(i). Hand dug well lined with large and small diameter tube.

With this type of well construction the aquifer zone is lined with large diameter perforated concrete cylinder and above the aquifer zone the lining is done with small diameter tube. The installation should be done as follow.

1. Dig the well until the aquifer is properly exploited and install large diameter perforated concrete cylinder in the aquifer zone.

2. Pack outer periphery of the perforated concrete cylinder with well rounded river gravel.

3. Cast reinforced concrete cover slab whose diameter is equivalent to out side diameter of the cylinder. A hole whose diameter is sufficient to install small diameter tube should be left in the middle of the slab while casting.

4. Install the small diameter tubes one after the other.

5. Back fill the remaining space of the well in 30cm. layer with an impermeable soil and compact it well by rinsing with water to avoid any possible crack due to settlement (Fig. 4.1).

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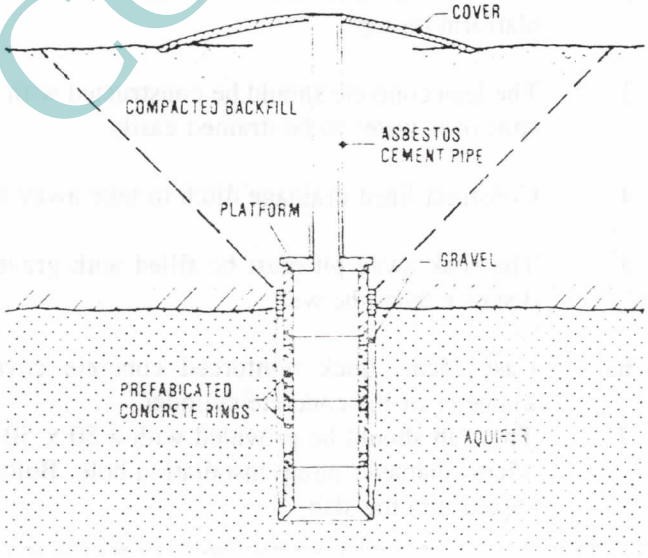


Figure 4.1
Combination Well Lining Method

(ii). Small Diameter Tube Lined Hand Dug Well.

The well construction is similar to the one above except that a small diameter perforated tubes are installed in the aquifer zone instead of large diameter. The whole length of the aquifer zone is packed with gravel and sealed on top with concrete. The remaining part is then lined with blank tube and packed with soil as described above (fig 4.2.).

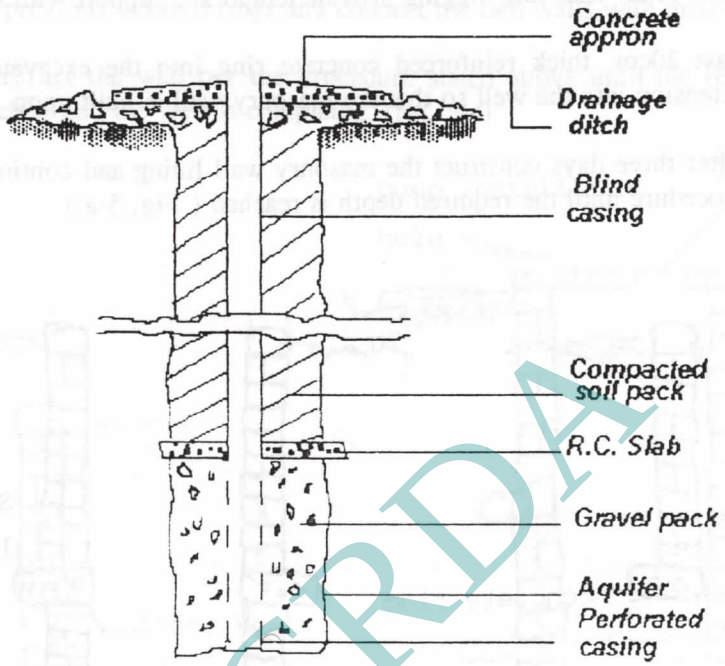


Figure 4.2
Well Lined with Small Diameter Casing

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5.4. MASONRY LINED HAND DUG WELL.

In the absence of equipment such as chain block, concrete cylinder mould and tripod, masonry lined wells could be alternative solutions to the construction of hand dug wells.

In masonry lined hand dug well construction:

- Check the problem of collapse. Avoid or take necessary engineering solutions while digging if the soil is expansive.
- Line the aquifer zone with dry stone masonry to allow horizontal flow of water to the well.
- Line above the aquifer zone with cement stone masonry and plaster it for sanitary purposes.
- Provide well head, well apron and cover slab to the structure.

Under collapsing ground formation (but not in expansive clay soil) follow the procedures given below.

Method 1. Supporting the masonry lining with reinforced concrete cylinder.

- Dig the well to a safe depth where there is no danger of collapsing.
- Level the flow and dig laterally into the ground along the circumference of the well. After finishing digging provide temporary support with stone.
- Cast 20cm. thick reinforced concrete ring into the excavated space and an extension into the well so that the masonry wall is built upon.
- After three days construct the masonry wall lining and continue with the same procedure until the required depth is reached (Fig. 5-a).

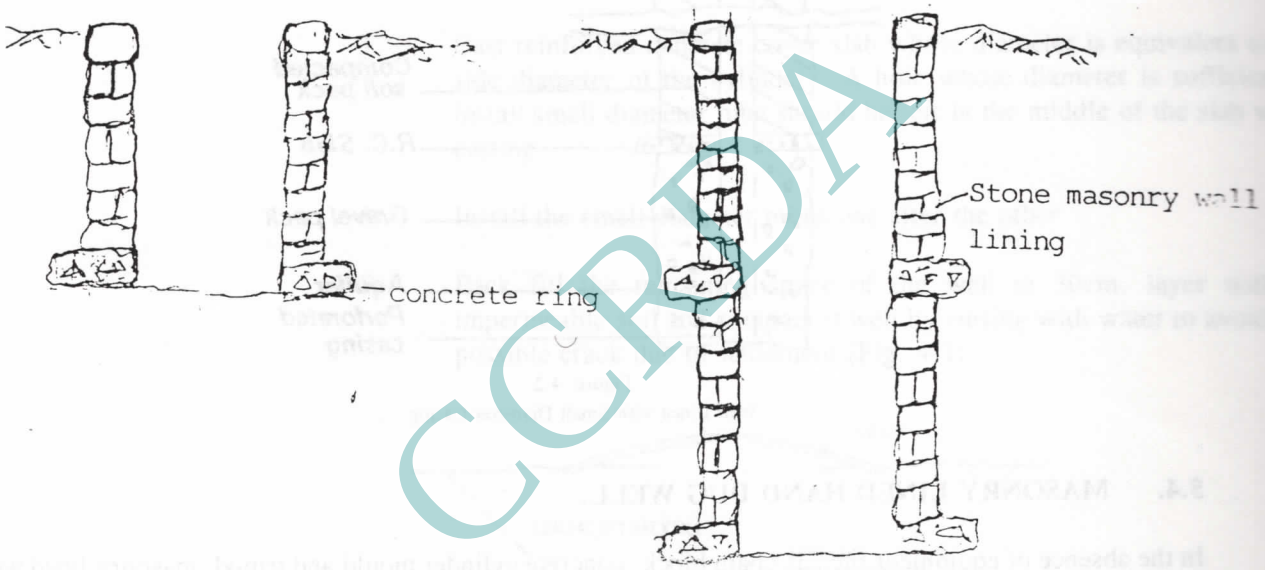


Figure 5-a

Stone Masonry Lined Well Supported on R.C. Ring

Method 2. Supporting the masonry lining with temporary scaffolding.

- Excavate the well in the same manner as described above.
- Excavate laterally for about 30cm. along the circumference of the well and support with pieces of wooden rings.
- Construct masonry wall starting from the excavated space.

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- Dig the well below the wooden ring to about two meter by decreasing the diameter to keep in place the soil above.
- Support the wooden ring with wooden scaffolding and dig the well to the previous diameter (Fig. 5-b).
- Following the same procedure as above, construct the masonry wall and pull out the previous wooden rings and connect the two walls with masonry work.
- Construct the well per the procedure stated above until the required depth is reached and the well is completed. (fig. 5-c)

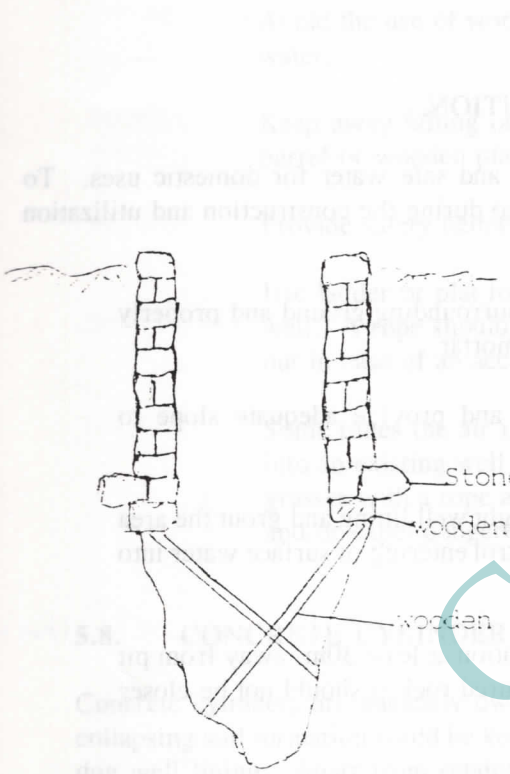


Figure 5-b Wooden Ring Supported Lining

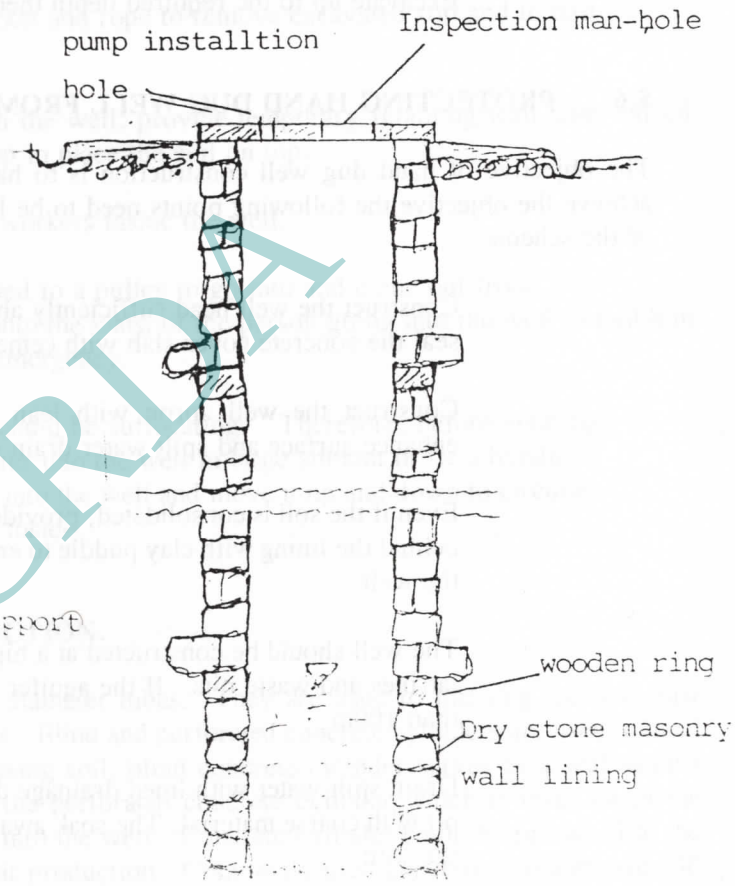


Figure 5-c Finished Stone Masonry Lined Well

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5.5. POSSIBLE PROBLEMS IN HAND DUG WELL CONSTRUCTION

5.5.1. Quick Sand (flowing sand)

Digging of hand dug wells in aquifers of fine sand could bring about inflow of the sandy materials resulting in possible caving in and collapse of the well. Attempts to control such happenings involves digging through inside of the concrete cylinder and making the cylinder sink by its own weight.

5.5.2. Collapsing Top Soil

In some area when developing a hand dug well the top soil collapses and could create problem for well sinking. This is particularly true in expansive clay soil. Such problems could be over come through:

- Digging the well in rectangular shape and providing temporary retaining wall with lumber if available or with wooden logs properly anchored.
- After completing digging, install blind concrete cylinder: remove the retaining wall and fill the area outside the concrete cylinder with compacted soil.
- Excavate up to the required depth there after.

5.6. PROTECTING HAND DUG WELL FROM POLLUTION.

The objective of hand dug well construction is to have clean and safe water for domestic uses. To achieve the objective the following points need to be looked into during the construction and utilization of the scheme.

- Construct the well head sufficiently above the surrounding ground and properly seal the concrete cover slab with cement sand mortar.
- Construct the well apron with lean concrete and provide adequate slope to enhance surface and spilt water drain easily.
- Even if the soil is consolidated, provide water tight well lining and grout the area behind the lining with clay puddle to enable control entering of surface water into the well.
- The well should be constructed at a higher elevation at least 30m. away from pit latrines and waste pits. If the aquifer is a fractured rock it should not be closer than 100m.
- Drain spilt water with lined drainage ditch to soak away pit. Fill the soak away pit with coarse material. The soak away pit should be at least 6 meter away from the well.
- Fence the well area to keep away children and animals.
- Disinfect the well before use. The simplest way to disinfect in rural conditions is to use bleaching fluid. Possible application of the bleaching fluid is as follows:-
  - Dilute two liters (2lt.) of fluid with 35lt. of clean water.
  - Rinse the inner part of the well lining with the diluted solution. But, if

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the lining is of small diameter tubes, pour the solution into the well and pump it continuously.

- Prepare another solution in the same way and pour into the well and leave it for about two days. Remove the poured in solution through continuous pumping until the smell of chlorine disappears.

5.7. SAFETY PRECAUTION IN HAND DUG WELL CONSTRUCTION

To safe guard the workers involved in hand dug well construction, the following major points should be taken care of:

- Avoid the use of worn out bucket and rope to remove excavated soil and to bail water.
- Keep away falling object from the well; provide temporary retaining wall with old oil barrel or wooden plank to keep in place the soil on top.
- Provide safety helmet for the workers inside the well.
- Use ladder or plat form attached to a pulley to go into and come out from well. A rope should be tied onto the waist of the person going into the well to pull him out in case of an accident or emergency.
- Some times the air in a well could be suffocating. Therefore, before entering into an existing well, pour water into the well in large amount or tie a bundle of grasses with a rope and insert into the well and move it up and down to circulate and/or expel dangerous gases inside.

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5.8. CONCRETE CYLINDER PRODUCTION.

Concrete cylinders are basically dwarf large diameter tubes. They are used to line dug wells so that collapsing soil formation could be kept in place. Blind and perforated concrete cylinders are used in hand dug well lining. Apart from retaining collapsing soil, blind concrete cylinder serves as a seal against seepage of polluted water into the well and the perforated concrete cylinder which is installed in the aquifer zone allows horizontal flow of water into the well. Concrete cylinder could be produced at the field. No skilled personnel is required for their production. Commonly used concrete cylinders are 130 and 100 cm. inside diameter and the height of the cylinders are 60cm. and 80cm. respectively with a thickness of 10cm.

The materials used in concrete cylinder production are cement, sand and gravel. The gravel size ranges from 6mm - 20mm and the mix ratio for blind concrete cylinder is 1:2:4 (cement,sand,gravel) and for perforated concrete cylinder it is 1:4 (cement, gravel). The amount of water used to mix the ingredient should be sufficient only to prepare a workable mix. If too much water is used, the cement will escape resulting in poor concrete quality. After the ingredients are mixed in accordance to the mix ratio, the mix product is casted in a circular steel mould. For a better strength the cylinder is reinforced with 8mm.

diameter reinforcement bar. The procedures that should be followed in the production process are:-

- Prepare two circular and four vertical 8mm. diameter reinforcement bar. Place the circular bar at 10cm. from each edge of the cylinder and the vertical bars at equal distance along the circumference of the cylinder. Tie the circular bar with soft wire on to the vertical bars.

- Arrange the concrete mould cylinder and paint it with used motor oil for smooth after casting. Place into this cylinder the already prepared reinforcement bars and pour fresh concrete mix which is prepared as per the ratio described above. Remove the entrapped air from the concrete by moving up and down a piece of wooden stick while pouring the mix into the cylinder. The cylinder could be removed after few hours. Two or more cylinders can be produced with one mould in a day.

- If the concrete edges are required to have groove, two metal ring forms must be used along with the cylinder mould. When casting this type of concrete cylinders, the lower edge ring should not be removed before 48 hours. Therefore, at least there should be seven ring forms for one cylinder mould to utilize the mould efficiently.

- In casting perforated cylinder, 15cm. from bottom and top casting should be done with mix ratio of 1:2:4. This will allow the edges to be strong.

- Rinse the cylinder after production for about three days for curing and the cylinder could be installed after one week.

5.9. CHECK LIST IN HAND DUG WELL CONSTRUCTION.

To have a sustainable and to standard hand dug wells for a community use attention should be given to the following check lists during the process of hand dug well construction and management.

5.9.1. Community Participation

* Do the beneficiaries understand the objective of the scheme ?
* Do the community participate in all phases of the project ? Are they aware about their involvement in operation and maintenance of the scheme ?
* Are there established water committees ?

5.9.2. Site Selection.

* Is location of the site appropriate ?
* Is it located sufficiently away from pit latrines and waste pits?

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* Is the well point protected from flood ?

* Is ground water fluctuation considered ?

* Is the location at reasonable distance for all the beneficiaries ?

5.9.3. Well Digging.

* Has the digging process cut enough through the aquifer thickness ?

* Is digging of the well conducted with consideration of deepening it ?

* Is the storage capacity of the well adequate for night storage ?

5.9.4. Sanitary Protection Measures.

* Is the well properly sealed at least up to 3m. ?

* Is the drainage facility properly done ?

* Are the man-hole cover and the pump head stand water tight ?

* Is it fenced ?

5.9.5. Workers' Safety.

* Do you take appropriate precautions so that certain objects or materials could not fall into the well while workers are on duty?

* Have you taken appropriate precautions for caving problem?

* Do workers use safety helmet while they are on work ?

* Do you take proper precautions to avoid accidents that might result due to negligence?

5.9.6. Data Collection.

* Is the well number or any other code to identify the well carved on the well head?

* The well depth, estimated yield, well type, ground water table, pump type and make, accomplishment date and number of beneficiaries properly registered ?

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5.10. LIST OF EQUIPMENT AND HAND TOOLS NEEDED FOR HAND DUG WELL CONSTRUCTION.

Ser. no.	Type of equipment and tools	Quantity
1	Tripod	1
2	Chain block	1
3	Pulley	1
4	Sludge type dewatering pump	1
5	Generator	1
6	Nylon rope 10mm dia.	50m.
7	Steel cable 12mm dia.	50m.
8	Spade	4
9	Shovel	2
10	Bucket	4
11	Wedge	4
12	Mattock	2
13	Crow bar	1
14	Sledge hammer	1
15	Mason hammer	2
16	carpenter hammer	1
17	Bow saw	1
18	Trawl	1
19	Plumb bob	1
20	Spirit level	1
21	Tape meter 50m.	1
22	Pincer	1
23	Adjustable wrench	1
24	Safety helmet	4
25	Cylinder mould 150/130	1
26	Cylinder mould 120/100	1
27	Ladder (made of nylon rope and 1/2" pipe)	30m.

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5.11. SPECIFICATION AND QUANTITY OF MATERIALS.

5.11.1. General specification.

* Water bearing zone shall be lined with perforated concrete cylinder. The concrete cylinder shall be constructed with 1:4 cement gravel mix and should be reinforced with 8mm diameter reinforcement bar. The thickness of the concrete cylinder shall be 10cm. while the height is 60cm. and 80cm. for 130cm and 100cm. inside diameter cylinders respectively.

* The perforated concrete cylinder shall be casted with 1:2:4 (cement, sand, gravel) mix for a height of 15cm from bottom and top edge. of the cylinder.

* The cylinder shall be reinforced vertically and along the circumference i.e. vertical and hoop reinforcement. The hoop reinforcement should be overlapped for 30cm.

* Above the water bearing zone the well shall be lined with blind concrete cylinder. The mix to construct the cylinder shall be 1:2:4 (cement, sand, gravel) and should be reinforced in the same manner as the perforated cylinders.

* Gravel size shall be 6 - 20mm. for both blind and perforated cylinders.

* Outer periphery of the concrete cylinder lining shall be packed with selected river gravel to a level of 3m. below ground level. The gravel shall be well rounded and sorted. The size shall not be greater than 10mm.

* Above the gravel pack the well shall be packed with clay puddle for about 2.5m. On top of the clay puddle the well must be grouted with 1:6 cement sand mortar for a better sanitary protection.

* The well head apron shall be constructed on properly compacted hard core of 40cm. thick and be provided with adequate slope to direct spilt water to a drainage ditch. The drainage ditch will direct the waste water to soak

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away pit.

* The well should be covered with concrete cover slab with inspection manhole. The manhole cover shall be sealed with cement mortar to make it water tight. After installing the pump, its inlet hole should be sealed properly.

* The well should be disinfected with chlorine before use and it should be well fenced.

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5.11.2. Quantity of materials for hand dug well (average depth 15mt.).

Ser. no.	Description	Unit	Qty.	Remark
1.	Perforated concrete cylinder (1:4). No. of cylinders = 4			
1.1	Cement	sack	4	
1.2	Aggregate	m^3	0.8	
2	Blind concrete cylinder (1:2:4). No. of cylinders = 26			
2.1	Cement	sack	26	
2.2	Sand	m^3	1.8	
2.3	Aggregate	m^3	3.6	
3	Concrete ring seal (1:2:4) (20x15 cm. around the cylinder)			
3.1	Cement	sack	1	
3.2	Sand	m^3	0.05	
3.3	Aggregate	m^3	0.1	
4	Cement grout (1:6) for sanitary protection			
4.1	Cement	sack	6	
4.2	Sand	m^3	1.3	
5	Lean concrete (1:4:8)			
5.1	Cement	sack	2	
5.2	Sand	m^3	0.24	
5.3	Aggregate	m^3	0.48	
6	Cover slab (1.6 * 1.6 * 0.15mt.) (1:2:4)			
6.1	Cement	sack	2	
6.2	Sand	m^3	1.5	
6.3	Aggregate	m^3	3	
7	Manhole cover (0.6*0.6*0.1mt.) (1:2:4)			
7.1	Cement	sack	0.25	
7.2	Sand	m^3	0.16	
7.3	Aggregate	m^3	0.32	
8	Hard core	m^3	5	
9	Reinforcement bar			
9.1	ϕ 8mm	kg	6.3	
9.2	ϕ 6mm	kg	66	
9.3	soft wire	kg	0.1	

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Major Material Summary.

NO	MATERIAL	UNIT	QUANTITY	Added for Wastage
1.	Cement	Sacs	45	2
2.	Sand	M3	8	3
3.	Aggregates	M3	10	4
4.	Hard Core	M3	4	1
5.	Reinforcement Bar			
	. 8mm	Kg	63	5.1
	. 6mm	Kg	66	5.2
	. Soft Wire	Kg	1	0.3

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6. ALTERNATIVE WATER SUPPLY SOURCES

6.1 MICRO DAMS

6.1.1 Types of dams

Dams are classified on the basis of the type and material of construction, as gravity, arch, buttress, and earth-fill. The first three types are usually constructed of concrete. A gravity dam depends on its own weight for stability and is usually straight in plan although some times slightly curved. Arch dams transmit most of the horizontal thrust of cross-sections than comparable gravity dam. Arch dams can be used only in narrow canyons where the walls are comparable of withstanding the thrust produced by the arch action. The simplest of the many types of buttress dams is the slab type, which consists of the sloping flat slabs supported at intervals by buttresses. Earth fill dams are embankments of rock or earth with some provision of controlling seepage by means of an impermeable core or upstream blanket. More than one type of dam may be included in a single structure.

The selection of the best type of dam for a given site is a problem in both engineering feasibility and cost. Feasibility is governed by topography, geology, and climate. The relative cost of the various types of dams depends mainly on the availability of construction materials near the site and the accessibility of transportation facilities.

The height of a dam is defined as the difference in elevation between the roadway or spillway crest and the lowest part of the excavated foundation. However, figures quoted for heights of dams are often determined in other ways. Frequently the height is taken as the net height above the old river bed.

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6.1.2 Approach to Design

In arriving at a design for a dam to meet a specific need, the following factors will need to be taken into account:

- pattern of reservoir use;
- overall topography and geology of the area;
- availability of materials;
- availability of labour, local construction sills;
- any local tradition relating to the arrangement of works or methods of construction.

In this field of construction, perhaps more than in any other, it is essential that these factors be

considered together from the outset of the planning stage are borne in mind throughout. The application of analytical techniques and detailed design of the various components of the work will take up a relatively small proportion of the total design input at a professional level.

The following notes refer only to fill dams which will be the type most often encountered.

6.1.3 Site Investigation and Testing

6.1.3.1 Boreholes/ Trial Pits/ Auger Holes

These are required to identify:-

- material, quality and water-tightness of foundation;
- quality and quantity of construction materials.

6.1.3.2 In-situ and Field Testing

- water testing (rock)
- point load testing (rock)
- penetration testing (soils)

6.1.3.3 Laboratory testing; (may not be practicable or economic for micro-dams).

Sampling to obtain at least one good depth profile in the foundation is preferable to spreading the sampling and testing over a larger number of shallow holes or trial excavations.

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6.1.4 Materials

Most soil and rock materials can be used as dam fill given appropriate design and methods of construction. The main exceptions are organic soils (peat) which should be removed from foundations and borrow areas. Black cotton soils are also problematical because of their excessive swelling and shrinkage. This problem can be minimized, with specialist advice, by mixing it with sand. Permeable (coarse grained) materials can be rendered satisfactorily impervious by mixing them with clay (fine grained) material. Mixing coarse material with silty or clayey soils to improve consistency (and reduce cracking).

6.1.5 Design of Embankment Cross-section

The two essential requirements of a dam are that it should:

- be structurally stable over the expected range of operating conditions;
- retain sufficient water to fulfil the required function.

For most fills, these objectives can be met by a suitable arrangement incorporating a core of membrane located either at the upstream face or centrally and such drainage as might be needed to prevent the phreatic surface from emerging on the downstream face.

Homogeneous embankments are not satisfactory for long-term storage but are generally quite adequate where storage is seasonal.

Where long-term storage is required, zoned fill embankments will generally prove most economic provided an adequate source of material for the impervious core can be obtained within easy reach of the site. The grading of core and shell materials should be checked to ensure that the core will not migrate into the voids of the shell and transition zones provide necessary.

Culverts, pipes or other structures passing through embankments are a great source of weakness which should be avoided where possible by locating such works beneath the abutments or around the ends of the dam. Where this can not be done, potential seepage paths can be lengthened by incorporating flanges or collars but these measures should only be adopted as a last resort.

6.1.6 Construction

It is desirable, during construction, to achieve a uniformly high fill density, since this will improve the soil properties controlling the permeability, stability and settlement of the dam.

The basic recommended construction technique is the "rolled fill" method, in which the required density is achieved by placing and compacting the fill in levers. The "dumped fill" method is used where wet weather makes the control of moisture content impossible and the consistency of the soil is such that it will consolidate effectively under its own weight to achieve a satisfactory final shear strength and low permeability.

The risk of slip failure is increased when excess pore pressures, which are induced in the foundation and dam, do not dissipate as construction proceeds. To limit pore pressure build up is therefore advisable to control the rate of construction.

This may be done by constructing the dam in stages and allowing sufficient time for consolidation and the associated shear strength increase of the foundation material before placing the next layer of fill.

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6.2 GROUND WATER DAMS

In areas where sandy seasonal rivers exist, people get drinking water in the dry seasons by digging pits in the saturated sandy valleys.

If a sort of a barrier is constructed across these permeable valleys to store the water below the ground level in the upstream reservoir, a dependable water supply system can be attained. These sort of barriers are called ground water dams.

Apart from the enormous cost differences, ground water dams have the following advantages over surface dams:-

a) simple to construct using locally available materials.

b) water treatment facilities are not necessary

c) less evaporation from the storage reservoir

d) little loss of land

e) no damage due to dam failure

f) reservoir is less exposed to act as breeding

g) less vulnerable to pollution by animals or human beings

There are mainly two techniques of damming ground water

1. Sub surface dams, which are dams constructed below ground level to store water of natural aquifer tin the reservoir upstream of the dam (see FIG.18)

2. Sand dams, these dams are constructed across valleys to make a reservoir filled with sand, gravel, or stone to make an artificial aquifer which will be replenished each year by the runoff in the valley (see FIG. 19)

The following points should be considered in the design and construction of ground water dams:-

1. Site identification:-the best sites are usually those valleys where villagers obtain their water supply by digging pits

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2. Topographic consideration:-in order to have adequate storage volume in the reservoir upstream of the dams; the cross section and plan area should be calculated. If the dam site is chosen upstream of the service area, gravitational flow can be achieved. This will avoid pump installation

3. Climatic consideration:-in order to avoid unexpected flooding and to minimize pumping from the construction sites, all construction works should commence and be completed at the driest month.

4. Hydrogeologic consideration:-Precaution should be taken in choosing the correct foundation of a dam. It has to be a water tight solid bed rock. An experimental sand dam constructed in Dire Dawa area has failed due to leakage through the bed rock.

5. Construction materials:-ground water dams can be construction from clay. In areas where clay is not available a mixture of red laterite soil and black cotton soil mixed in a dry 50:50 ration and compacted with water can be used. Masonry, concrete structures or ferrocement walls are all suitable materials for these constructions. If a gravity masonry or concrete dam is used, the following dimension are recommended

Crest width = 30cm

Width of dam = Height - 30cm

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6.3 INFILTRATION GALLERIES

Infiltration galleries are horizontal wells which collect water over their entire length (Fig.14). Where the construction of infiltration galleries are feasible a cheap and good quality of filtered water can be obtained.

The best sites for infiltration galleries are where beds or lake shores are sand or gravel. The galleries are constructed by digging a trench into the water bearing sand or gravel, then collecting the water in perforated pipe or tunnels which lead to the well here the filtrate is stored.

6.4 PONDS

Where ground water is difficult to obtain and other surface water sources are unavailable, ponds are usually be most important source of water for domestic and livestock use. Apart from natural self

purification, none of the ponds used in most parts of Ethiopia have any type of treatment facilities.

6.4.1 Design and Construction of Ponds

The quality of water from ponds require little treatment provided certain sanitary precautions are carefully observed. Such considerations include:-

a) Strict measures have to be taken to protect the watershed area by fencing

b) The submerged zone of all vegetation and decaying matter should be cleared.

c) Ample storage should be provided for the deposition of silt and reduction of bacteria by self purification.

d) All condition which favor the creation of suitable breeding places for disease carrying mosquitoes and bilharziasis carrying snails should be avoided.

Different type of ponds construction exist in practice, but basically ponds are one of the following three types

1. Pit or dugout ponds
2. Embankment ponds
3. Combination ponds

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1. Pit or Dugout Ponds

These ponds are developed by enlarging an already existing depression or simply by excavating a pit in flat areas. The sources of water can be spring, underground seepage or runoff to a small quantity. The shape can be made to fit any location. The side slopes should not be steeper than the angle of response of the soil or should have ratio of 1:1. If livestock are allowed to water directly from the pond at least one side should have slope of 4:1 or flatter and be protected with paved rock or other materials. The excavated materials can be stacked, spread, or removed (see Fig.15)

2. Embankment Ponds:-

Such ponds are constructed across small valleys by making an embankment from earth and/or

rock fill (see Fig.16).

The major design consideration is that the dam cross section has to be in a narrow valley which provides economic and deep storage to reduce water loss through evaporation.

3. Combination pond:-

These types are those constructed on sloping land by excavating uphill ponds area and placing cut materials on the down hill side to form an embankment (see Fig.17)

Soil bearing tests may be required before construction to estimate the permeability and bearing strength of the soil.

6.5 ROOF CATCHMENT FOR RAIN WATER HARVESTING

Most places in Ethiopia have adequate rainfall for the use of drinking water. But it is not a common practice to use roof catchment even where no other options are not available. The main constraint to exploit this resource is the nature of the roofing materials in the rural areas which is a thatched type. Such roofing is not suitable for rain water collecting owing to health hazards and problems in the installation of gutters. The best sites in the rural areas are in the institutions like schools, clinics...etc.

Storage facilities can be above or below ground. A tight cover should ensure dark storage conditions so as to prevent the growth of algae and breeding of mosquitoes. Advantages of underground tanks are the coolness of the water and prevention of losses through evaporation. Tanks can be constructed or brick, stone, ferrocement, metals, reinforced concrete, bamboo reinforced concrete...etc.

Storage may deteriorate the quality of rain water collected from roof catchment through the putrefaction of organic matter in the water, or through the growth of bacteria and other micro-organisms. Measures to protect the quality of the stored water include the exclusion of light from the stored water, cool storage conditions and regular cleaning.

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7. DISTRIBUTION NETWORK

7.1 SURVEYING PRINCIPLES

7.1.1. Contour Lines

Depressions and hills on the surface of the ground are shown on maps by means of contour lines. A contour or simply contour may be defined as a line of intersection of a level surface with the surface of the ground. The vertical distance between any two consecutive contours is called the contour interval and the horizontal distance between any two consecutive contours is called the horizontal equivalent. The contour interval depends upon the nature of ground, the purpose and nature of survey, the scale of the map and the time and expense required in its determination. For a given contour interval the horizontal equivalent depends on the steepness of the ground.

Contour line characteristics may be stated as follows:

a. Contour lines run close together near the top of hill, representing steep ground and wide apart at the foot of a hill indicating flat ground.

b. A uniform slope is indicated when contour lines are uniformly spaced while a plain surface is indicated when they are straight and equally spaced.

c. Contour lines cross ridge lines or valley lines at right angles. Valley contours are convex towards the stream.

d. Contour lines cannot cross one another on the map except in the case of over-hanging cliff and a vertical cliff is indicated when contour lines coincide, the horizontal equivalent being zero.

e. Contour lines close on themselves either within the limits of map or out side.

f. A series of closed contours on the map indicates a depression or a summit according as the lower or higher values are inside them.

The most important uses of contours are the following:

(a) By inspection of a contour map information concerning the nature of the area is obtained i.e., whether it is flat or undulating or mountainous.

(b) The most suitable site for engineering works can be selected.

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(c) Earth work quantities are computed from contour maps.

(d) Catchment areas can be determined for reservoirs and consequently the capacity of the reservoir.

(e) Ground profiles can be easily drawn in any direction from the contours.

(f) Inventory of two given points can be ascertained.

(g) The route of a given grade line can be traced on the map.

7.1.2 Marking Contour Lines with the Line Level

(a) Definition: Contour lines are horizontal lines across the slope joining points of the same elevation. Contour lines are used to map the topography of an area.

(b) Materials: The following items are needed:

- Water level
- Thin plastic rope, 11 m long
- 2 wooden poles (staff), marked every 10 cm
- Meter-band or meter-stick
- Short poles for marking on the ground

(c) Preparation:

Fix the thin rope with each end to one wooden pole so that exactly 10 m of rope are between the poles. Check length regularly. Mark the middle of the rope at 5 m with nod. Hang the small water level in the middle of the rope. Three to four people are needed to survey a level line and to mark it on the ground.

(d) Marking contour lines:

Proceed across the slope. Survey 10 m at a time, in difficult topography only 5 m (half the rope).

7.1.3 Measuring Slope Gradients

(a) Definition: Slope gradient is the steepness of a slope. It is given in percentage of length (%)

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or in degree.

(b) Materials: The following items are needed:

- Water level
- Thin plastic rope, 11 m long, meter band or meter stick
- 2 wooden poles (staff), marked every 10 cm
- Meter-band or meter-stick
- Short poles for marking on the ground

(c) Measuring slope gradients with the line level: The following steps are used to measure and calculate slopes.

- Select any distance so that the rope can be fixed on both poles and remains level. Measure the distance in meters.
- Measure vertical interval in centimeters.
- Calculate the slope. The slope in percent is calculated by dividing the vertical intervals (in centimeter) by horizontal distance (in meters).

7.2. HYDRAULICS OF PIPE FLOW

Two types of conduits are used to convey water, the open channel and the pressure conduit. The open channel may take the form of canal, flume, tunnel, or partly filled pipe. Open channels are characterized by free water surface, in contrast to pressure conduits, which always flow full.

If water is scarce, pressure conduits may be used to avoid loss of water by seepage and evaporation which might occur in open channels. Pressure conduits are preferable for public water supplies because of the reduced opportunity for pollution.

7.2.1 Energy Equation

Writing the energy equation between any two sections (a) and (b) gives:

$$Za + Pa + (Va^2)/2g = Zb + Pb + (Vb^2)/2g + Hl \quad (1)$$

in which Z is vertical distance above an arbitrary horizontal datum, P is pressure head, V is average velocity of flow, and Hl is total head between sections (a) and (b). The units are in meters or feet.

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7.2.2 Head loss due to pipe friction

The head loss due to pipe friction may be found by the Darcy-Weisbach equation

$$Hl = f.(L/D).(V^2)/2g \qquad (2)$$

in which L and D are the length and diameter of the pipe, respectively, and f is a friction factor. f ranges from 0.015 to 0.05 for common pipes of diameters ranging from 5.0 cm to 1.0 cm.

The Mannings Equation for velocity is expressed as:

$$V = (1/N).(R^2/3).(S^1/2) \qquad (3)$$

where V is the average velocity in meters per second, N is Mannings coefficient of roughness (N varies from 0.010 to 0.015 for most of the common pipes), R is the hydraulic radius (cross-sectional area divided by wetted perimeter, for circular pressure pipe R = D/4), and S is the slope of the energy grade line.

The main element of uncertainty is the selection of the roughness coefficient. Tests indicate that the absolute roughness of most metal pipes increases more or less linearly with the length of use. The rate of change of the hydraulic characteristics of a pipe depends on the pipe material and the quality of the water it conveys.

7.2.3 Minor losses

Minor losses in pipelines are caused by abrupt changes in flow geometry as a result of changes in pipe size, bends, valves, and fittings of all types. In long pipelines these minor losses can often be neglected without serious error, but they may be quite important in short pipes.

Minor losses vary approximately with the square of the velocity and are usually expressed as a function of velocity head.

(a) Enlargements

Angle (deg)*	10	20	45	60	90	120	180
D2/D1 =	0.17	0.40	0.86	1.02	1.06	1.04	1.00
D2/d1 =	1.5	0.17	0.40	1.06	1.21	1.14	1.07	1.00

* The angle is between the sides of the tapering degrees

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(b) Abrupt contraction

D2/D1	0.0	0.4	0.6	0.8	1.0
Kl	0.5	0.4	0.3	0.1	0.0

(c) Pipe entrance from reservoir

Bell mouth 0.04

Square-edge ... 0.5

(d) Bends (the head loss in excess of that in a straight pipe of equal length)

(D bend)/(D pipe)	1	2	4	6	8
90 deg	0.50	0.30	0.25	0.15	0.15
45 deg	0.37	0.22	0.19	0.11	0.11
22.5 deg	0.25	0.15	0.12	0.08	0.08

(e) Valves and fittings

Gate valve (wide open) 0.2

Gate valve (half open) 5.6

Standard T (tee) 1.8

Standard 90 degrees elbow 0.9

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7.3 TRANSMISSION AND DISTRIBUTION LINES

If topographic conditions are ideal, "gravity distribution " is used. This requires a reservoir at a sufficient elevation above the residence (or supply) area so that water can reach any part of the distribution system with adequate pressure without pumping. If pumping is necessary, water may be pumped directly into closed distribution lines, or it may be pumped into distribution reservoirs which serve to equalize pumping rates throughout the day and provide for peak use.

Faucet pressure of 2 to 4 m head are satisfactory for most domestic needs.

Distribution Reservoirs

Distribution reservoirs are used to provide storage to meet fluctuations in use and to stabilize pressures in distribution system. The reservoir should be located as close to the centre of use as possible. The water level in the reservoir must be high enough to permit gravity flow at satisfactory pressures to the system which it serves. Water is usually pumped into a distribution reservoir when the demand is low and withdrawn by gravity flow during periods of high demand.

Various types of distribution reservoirs are built to meet the topographic and structural conditions encountered. If hills of adequate elevation exist in or near the supply area, a surface reservoir, either below ground level or of the cut-and-fill type, is usually the best selection. The reservoirs may require concrete lining, with side walls designed as retaining walls to resist external soil loads with reservoir empty.

Surface reservoirs may or may not be covered. Covering a reservoir will prevent contamination by animals, birds, and human beings. Reservoir roofs may be of wood, concrete, or steel. Precast slabs of lightweight concrete are widely used. An open distribution reservoir should have a high fence around it to keep out trespassers.

If the topography does not permit sufficient head from a surface reservoir, an elevated tank may be used to gain the necessary height.

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8. WATER LIFTING DEVICES (HAND PUMPS)

8.1. INTRODUCTION

Lifting of water to the proximity of the end users could either be through usage of natural forces such as gravity or mechanical devices where there are no positive head between the sources of supply or reservoir and the collection point.

The mechanical devices involved in water lifting ranges from surface or horizontal centrifugal pumps through hand pumps for relatively shallow depth water extraction and deep well submersible and vertical shaft pumps. In this section we will be dealing with the water lifting devices mainly used in the rural areas, hand pumps.

8.2. AN OVER VIEW OF MAJOR HAND PUMPS

Hand pumps can be classified in a variety of ways: the way the handle is used (direct action or lever); the type of motion (reciprocating or rotary); the action of the piston (suction or force). Other lesser known pumps are inertia and diaphragm types. Reciprocating (piston) pumps are the most common because they are the easiest for manufacture and maintenance. Rotary (progressing cavity), and diaphragm pumps are difficult to manufacture. Suction pumps are liable to pollution as they are not self priming. That leaves us with reciprocating hand pumps - in direct action and lever mode - with the piston down at the water level.

Direct action pumps don't have a lever, bearings ..etc. and are employed for shallow wells and pumping is like in bicycle pumps. They are also less expensive. Their development locally has been beset by raw material shortages. But, because of the relatively few drilled wells anticipated in this head range and the as yet unpublished specifications for direct action pumps, further discussions will concentrate only on the traditional hand pump with a mechanical advantage given by a pedal, a flywheel or usually by a lever mechanism.

8.3. HAND PUMP SELECTION

Selection of pumps is done on various criteria: Operating conditions, maintenance system, corrosion resistance, abrasion resistance, local manufacture and price. The questions of maintenance and local manufacture are probably the most crucial in the case of Ethiopia.

Two hand pump depths are generally recognized: for shallow wells (0 to 10m) and deep wells (10 - 45m). Design of pumps for extra deep wells (upto 70 meters or more) are also available. A survey of wells dug between 1983 - 89 for hand pumps in Ethiopia showed more than 95% to be shallower than 45m. There is, therefore, no express need to go into extra-deep wells presently.

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The pump selected is the Afridev (Ibex) in whose development researchers from Ethiopia participated. It is unique because it is the first hand pump designed for maintenance. Its design features are given in 8.2.2. below.

The use of some Afridev derivatives has caused many problems in the field. Therefore, a detailed specification is released by SKAT and is revised every two years. Purchases should be per the specifications in order to avoid problems. Other related issues by SKAT include guidelines for Packaging and Rubber Working. R&D work is still continuing to find detachable coupling for pvc riser and other user friendly pump rod designs.

8.3.1. Maintenance

As hand pumps are scattered in rural areas, it is difficult for any centrally based organization to do effective maintenance. There is not enough human and material resources to cover the whole countryside either. In many cases, the down time of a deep well hand pump was several months. Hence a hand pump design that fully relies on the user community for maintenance is mandatory. There was no such community pump in the early eighties and the AFRIDEV had to be designed.

8.3.2. Local Manufacture

Ethiopia has a weak manufacturing base and almost everything is imported. In fact, metal related items account for over 50% of all imports. This situation has to change. Local manufacture of hand pumps is one important item because rural water supply is also another very weak sector in Ethiopia.

Local manufacture is seen as an opportunity to secure the availability of spares. It creates job opportunities.

The large rural population is a reliable market base. It reduce transport costs and import formalities. The opportunity of using the available large engineering industries has grown tremendously. It offers the potential for self reliance and therefore carries with it benefits that reach beyond financial gains alone.

8.4. AFRIDEV DESIGN

Village Level Operation and Maintenance (VLOM) is the most recent concept in hand pump systems. Here, the availability of a hand pump is more important than its reliability. Although hand pumps are available in both Direct Action and Lever formats, only the latter is relatively widely used. Below is described the VLOM features of one such pump: the Afridev.

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8.4.1. Components

A. There is only one single set of below-ground components. The pump rod, piston, cylinder, foot-valve, riser are all identical in any Afridev pump. Stock is minimized and there is less confusion for the user technicians.

B. Further, there is no need to pull out the riser in order to service the piston and foot-valve. Both are easily reached at for maintenance and (re) installation.

C. All wearing parts are easily replaced, about once a year.

D. Most of the pump components are easily manufactured in a developing country.

- Steel parts are usually off-the-self materials.
- Most parts are of mild steel and hot-dip galvanized for corrosion protection. Only a relatively small amount of stainless steel components are routinely used.
- There is the option to use stainless components in aggressive ground waters.

E. All wearing parts are of plastic or rubber and generally inexpensive:

- Designs make use of easily fabricated but long lasting engineering plastics.
- Parts are injection moulded in a relatively small machine. Quality control problems during manufacture are also minimal.
- The foot-valve and piston body and valves are identical.
- Plastic bushes (instead of ball bearing) are inexpensive and easy to replace in the field.
- The riser pipe is in PVC, which is also corrosion resistant.
- Rubber parts have the same nitrile composition and are made on simple transfer moulds

F. The design also employs a relatively small diameter piston/cylinder, ~ 50mm, thereby reducing the force on the pump rod assembly - without sacrificing the amount of water drawn per stroke.

8.4.2 Ease of Maintenance

A. The pump rod is assembled or disassembled manually in hook and eye

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connections.

B. There are no threads that make village level maintenance a nightmare or installation difficult even for the technicians as it could involve threading at site.

C. There is only one size (M16) and one tool for routine maintenance: size 24 spanner. A fishing tool (to fetch broken pump rods) is also another tool; but it is used in the cases where the hook and eye rod has broken.

8.4.3. Installation

Afridev installation is in three main steps: preparation in the office, and below ground and final component assembly in the field. Office preparation is for choosing direct action or lever pump and to determine pump setting. Hand pump caretakers should assist in hand pump installation, thereby learning the routine maintenance procedures.

The main item to look for in the installation is solvent cementing PVC pipes. Precautions should be taken to use appropriate cleaning fluid and PVC cement which has not expired. The pipe should be fully inserted in the bell end. The cemented joints should not be loaded with the pipe weight until after 5 minutes or so. The whole riser assembly is then left overnight suspended on the nylon rope, and the pump rod and elements installed the next day. The care takers' training is mainly on the second day as the first day's exercise is normally a one-time standard lengths of bell-end only. Shorter lengths are risky because the riser assembly could be heavy or the cement not hardened enough to pull some pipes a few centimeters out of the bell ends.

8.5. Operation & Maintenance

Hand pump operation is reasonably simple for users to learn in a few minutes. However, the caretaker should train the users so that the handle bar does not knock on the pump head. The handle should be pulled straight up for direct action pumping. The water collection jar should have a wide mouth so that spillage is minimal. Hygiene education should stress on the cleanliness of water collection and storing before consumption.

Maintenance activities are limited to changing wearing parts: u-seal, valve bobbins and bearing bushes and, to a lesser extent, rod centralizers and foot-valve o-ring. Occasional tightening of the fulcrum and rod-hanger pins will prevent serious pump head wear.

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8.5.1. Unavailability of Spares

Wearing parts need to be changed very year. However, if these parts are not readily available with the user, then the whole concept of user maintenance is at stake.

An interim solution here is that WRM/WSSA should see to it that sufficient stock of parts and tools are available on the local market. UNICEF and other sector partners, in cooperation with RADD (WSSA) should be able to muster the necessary parts. Another possibility is the availability of spares through a local manufacturer. Akaki Pump Factory - although in deep financial trouble - are embarking strongly on hand pumps manufacture. Distributing the spares (and tools, below) to where it is needed is an exercise that should be approached in a commercial manner. There should be more options now than some years ago on how to go about such distributions.

8.5.2. Tools

Pump rods fail during operation, are severed off the assembly in the riser. A fishing tool is not widely available in order to take out such pump rod when they break. However, the pump rods should be routinely inspected and replaced if worn down. That way the pump down-time is reduced; but, then spare pump rods would be required on hand, especially for the deeper settings.

A lasting solution for the pump rod failures is the glass fiber pump rod. This rod is joined by threaded connections; but, once installed, the whole assembly is flexible enough to be withdrawn and reinstalled in one piece. This type of rod is at an advanced stage of field testing for inclusion in the next revision of the Afridev specifications.

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8.5.3. Riser Connection

The riser pipe sometimes needs to be cut and changed if a leak occurs due to wear or poor cementing procedure. This is a difficult exercise.

Threading on PVC is not allowed as it will fail by fatigue. A lasting solution is jointing by special threaded adaptors in plastics. Such adaptors are being field tested before inclusion in the Afridev Specifications.

8.5.4. Hand Dug Wells

The Afridev is not well suited for installation in a hand dug well.

The pump is primarily designed for installation in a borehole or tube wells. However , as the

number of hand dug wells is substantial in Ethiopia, we need to find suitable mechanisms to successfully install it there in. Some exercise has been done at RADD but is not considered enough at the moment.

8.6. FOLLOW-UP

In order to assure the smooth functioning of the system, follow-up activities on all elements are of paramount importance. Maintenance and follow-up activity on the hand pump is a relatively straight forward affair. The handle should not touch any part of the pump head or wobble from side to side. No part of the pump head should be worn. No squeaking should be heard during operation. The discharge should be monitored such that seals are replaced before they are completely worn.

Fencing around the apron and the cleanliness for the area are indications of quality of "house-keeping". The concrete pedestal sometimes segregates from the pump. If this happens, it is a serious problem; and the caretaker should mobilize resources to effectively maintain the civil works. Grouting around the well cover or man-hole should be intact.

Failure of the aquifer to recharge the well sometimes is wrongly ascribed to pump failure. Water level should be monitored in the dry season and especially if the pump is delivering water intermittently. Well deepening measures should be undertaken if there is not enough water. A telescoping arrangement is possible if the original well has a relatively large diameter. The bacteriological quality of the well water should be routinely monitored or curative doses of chlorine injected regularly.

CPP activities should continue to monitor if the WATSAN committee is managing the water point as originally planned. Members which do not actively participate should be prompted to do so, or be replaced . Tariff collection should be done regularly as should payment to the caretakers. Financial records should be audited regularly, especially if there are tendencies of embezzlement. The relation between the WATSAN committee and the care-takers should be smooth.

The caretakers are easily evaluated by the number of hand pumps which are in working order in the village. They should demonstrate skills in foot valve removal and piston seal replacement. Further, the cleanliness for the pump area is an indication of how much the sanitation message has got across. The realization of the link between health and clean water is crucial. The community as a whole is aware of this if traditional sources are not used (eg unlined wells are blocked). Evaluation through interviews or questionnaires could give revealing information on water related habits. Finally, if there are requests for more installations elsewhere in the area by a group of people during an unplanned tour, then people are generally satisfied, and the next hand pump system is bound to succeed.

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9. SOME FACTORS AFFECTING SCHEME SUSTAINABILITY

Sustainability is the ability of projects to continue providing acceptable levels of services over a prolonged period or estimated life time. Attainment of such services revolves around the ability of projects to endure sustenance institutionally, financially and environmentally.

9.1 INSTITUTIONAL SUSTAINABILITY

Under institutional sustainability is grouped all activities related to capability and capacity of all the parties involved in the formulation, implementation and management of projects. The parties involved usually include the beneficiaries or end users of the schemes, the supervising authorities or the Government bodies and external supporting agencies, ESA, covering multi-lateral, bilateral and NGO's. Their institutional strength which is reflected through their interaction starting the initiation of the project followed by planning, implementation and operation and management has a direct bearing on the sustainability of projects. Harmonious on time interactive move based on a known and shared responsibilities benefit the economic accomplishment of the scheme and smooth managing after completion. A number of institutional functions to be accomplished by the parties involved contribute towards project sustainability. Some of the major ones are the following:-

a) Degree of Community Involvement

The degree of community involvement and the method used to enhance community participation play a big role in scheme sustainability. Unless the community is made to get involved in all stages of the project life, the project will lack appreciation and attention of the main component - end users. Social and cultural views and norms of the communities for which the project is designed to serve need to be respected if effective use is anticipated. The involvement of the communities in the various stages of the project life also develops the sense of ownership and better fosters the management of the scheme after take over. Hence, community's involvement from the stage of project initiation all through operation and management is vital for project sustainability.

b) Degree of Supervising Authority Involvement

Formal involvement of the supervising authority, responsible government agencies, in all the project life enhances:-

- better organizing the community to take over the scheme at its completion
- giving financial and material supports whenever required

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- controlling standard of structures constructed to give services
- controlling of finance utilization of the project
- assisting in major maintenance works after the community has taken over
- performing of monitoring & evaluation on the projects
- giving or arranging appropriate training to the community members as required

c) Degree of External Supporting Agencies (ESA) Involvement

Generating a project finance and having the project constructed can not be an end by themselves. The sustainability of the project, among others, also requires systematic involvement and follow-up by ESA. To observe scheme sustainability, the External Supporting Agencies are required to:-

- understand in depth the interest and intent of both the beneficiaries and the Government in the project to be implemented
- enter into formal agreement with the other parties involved in the project execution
- encourage and advocate participatory approach
- work out systematic withdrawal from the project through strengthening of capacity at the community and supervising authority levels. Sudden and untimely withdrawal will lead to project disruption.
- have detail project study including base line survey to assist in measuring future socio-economic benefit
- evaluate the project after some years of operation and find remedial solution with those concerned if problems are identified.

D) Training

Project sustainability could be enhanced through giving proper training for the end users and the supervisory authority. The training could be on job training at the time of project execution and/or organized short term training at an appropriate location. The training develops sense of

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self-reliance interms of project handling and management and contributes to its sustainability.

E) Choice of Technology

To have community's appreciation and to be sustainable, schemes require to be technologically fit. In the Ethiopian context, especially in the rural areas, the structures to be constructed have to be sturdy but usable by elders and children, and affordable to be managed and maintained by the users. Moreover, the material source for construction is preferred to be of local origin.

The structures to be constructed should be acceptable by the community with respect to culture and other social taboos.

Uniformity and simplicity of structures and attempts to standardize construction material usage will assist on each maintenance work.

F) Quality of Workmanship

The quality of materials and skills invested on the project have bearing on the life of the project. Scheme constructed with poor cement mixes, for instance, crack or disintegrate without giving required services. Lag on project completion time due to poor controlling mechanism and supply management will reduce confidence of the beneficiaries on the other parties involved and the project as a whole.

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9.2 FINANCIAL SUSTAINABILITY

Project overall sustainability is also dependant on its financial sustainability. The ability of projects to generate or acquire finance to cover cost of maintenances including spares and manpower involved and to pay for scheme care takers and related expenses is indicative of schemes financial strength. In financially viable schemes, it could be planned for expansion of similar activities within their domain for more and better services to the community. Financial dependency on the other hand retards effective maintenance, replicability and hampers continuity of scheme usage.

9.3 ENVIRONMENTAL SUSTAINABILITY

A project is categorized as sustainable if it could positively respond to the environment. In water supply projects for instance, over-grazing due to search of water for animals or regionally polluting of water sources because of misuse, is introducing negative environmental impact to the existing natural environment. Hence, any project design and implementation require minimizing or stopping negative environmental impact to remain sustainable.

10. WATER TREATMENT

10.1 WATER QUALITY STANDARDS

Water borne diseases virtually do not exist in developed countries and the attention of quality control focuses towards the public health effects of chronic diseases resulting from the presence of organic chemicals. In developing countries on the other hand, as enteric diseases are predominant, standards for water quality should concentrate on microbiological quality. Further more, the removal of many unwanted chemicals from drinking water requires sophisticated treatment processes that are beyond the technical and financial capabilities of most of the communities in developing countries. In places like Mojo, Awassa ...etc, where excessive fluoride exists and in other places with above normal nitrates in their water supply sources (which can cause infant cyanosis) are known, it is advisable to change the sources rather than attempting to solve the problem through deployment of sophisticated treatment plants.

A safe and potable drinking water should possess the following basic qualities.

1. Free from pathogenic organisms
2. Low concentration of compounds and elements such as lead that are toxic or have serious long term effects on human health.
3. Clear
4. Not saline
5. Free from compounds that cause offensive taste and odor
6. Non corrosive and should not cause incrustation on pipes and staining clothes (see WHO guide lines for drinking water quality). These guide lines are mostly adopted by developing countries while in the industrialized countries a relatively tighter criteria are used.

10.2 THE NEED FOR WATER TREATMENT

The purpose of water treatment is to convert the water taken from underground and the surface (the raw water) for domestic use. Most important is the removal of pathogenic organisms and toxic substances such as heavy metals causing health hazards. This includes:-

- suspended solids causing turbidity

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- iron and manganese compounds imparting a bitter taste or staining clothes
- excessive carbon dioxide corroding concrete and metal works

For small communities characteristics like hardness, TDS and organic contents are less important.

Any water treatment system designed for small communities has to full fill the following requirements:-

1. Construction and operation should be out of the locally available skill, labor and materials.
2. Low cost
3. Easy to operate and construct
4. Need minimum mechanical and electrical equipment
5. Do not require chemicals

10.3 SOURCE IDENTIFICATION

The selection of the source is based on the adequacy, reliability and quality of the water supply. The raw water quality dictates the treatment requirements. For instance, most ground water that are free from objectionable mineralization are safe for drinking without treatment. Surface water on the other hand is exposed to direct pollution and usually needs treatment. The location of the source also affects the need for energy requirements.

Ground water is mostly preferred for community water supply because it generally does not require extensive treatment and operation is limited to pumping and possibly chlorination. If surface water which needs treatment is to be considered, pre-treatment may be provided by plain sedimentation or roughing filtration prior to slow sand filtration. Only as last resort should sources that require chemical coagulation, rapid sand filtration and disinfection, be considered.

Ground water may need treatment when the water comes from an aquifer containing organic matters, in which case oxygen will be consumed with the formation of high carbon dioxide content. Such water will be corrosive unless calcium carbonate in one form or another is either present or injected to the water supply. The water containing no oxygen will also dissolve iron, manganese and heavy metals making the water toxic. Problems of this sort could be tackled through addition of oxygen by aeration.

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10.4 TYPES OF WATER TREATMENT

A treatment plant may consist of many processes including pre-treatment, chemical coagulation, rapid mixing flocculation, filtration and disinfection which are arranged as shown in the following diagram.

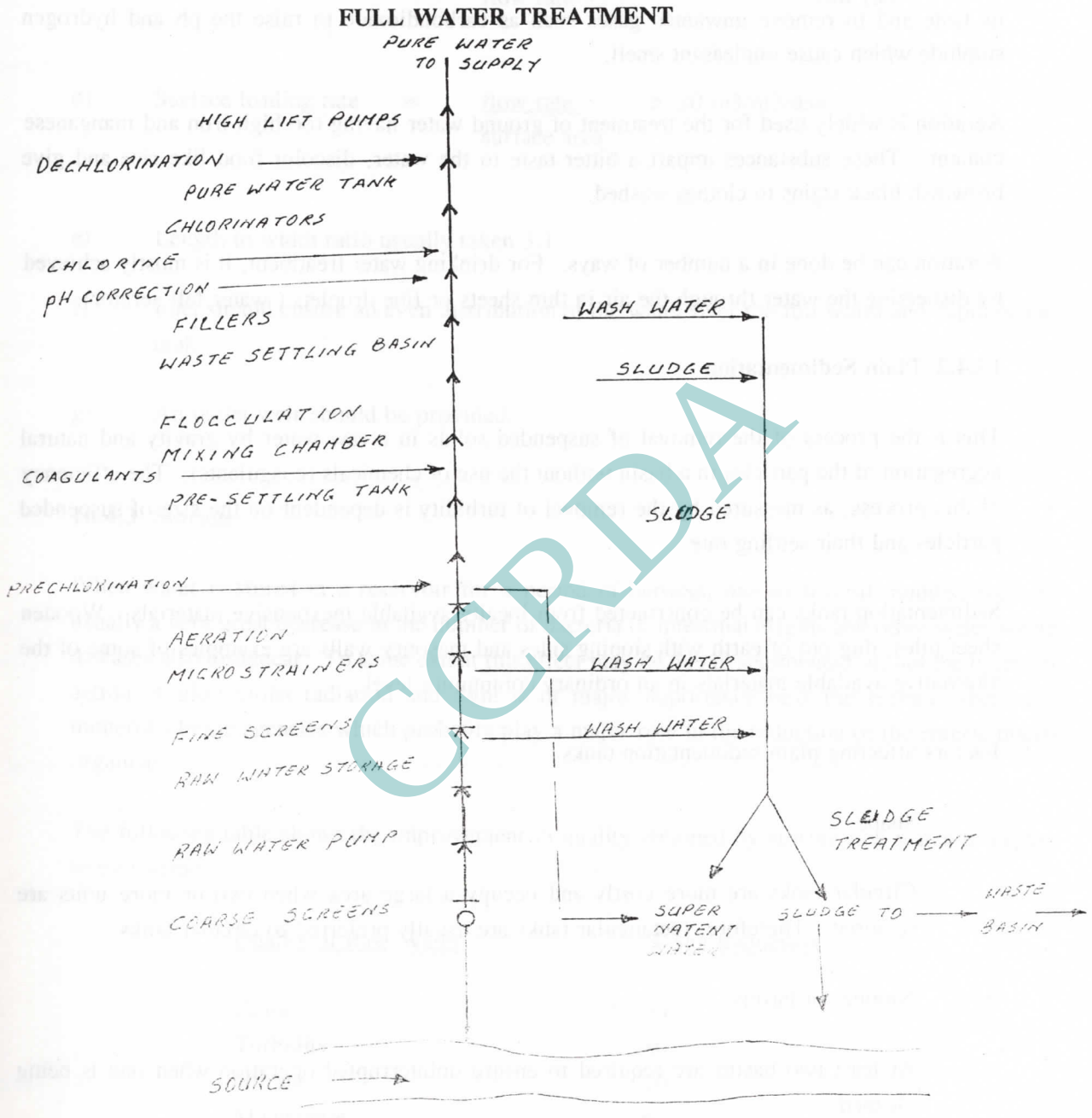


DIAGRAM SHOWING POSSIBLE TREATMENT STAGES

FIG. 1

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The most used and appropriate treatment systems in developing countries are briefly discussed as follows.

10.4.1 Aeration

Aeration is the process where-by water is brought into intimate contact with oxygen to improve its taste and to remove unwanted gases such as carbondioxide to raise the ph and hydrogen sulphide which cause unpleasant smell.

Aeration is widely used for the treatment of ground water having too high iron and manganese content. These substances impart a bitter taste to the water, discolor food like rice and give brownish black stains to clothes washed.

Aeration can be done in a number of ways. For drinking water treatment, it is mostly achieved by dispersing the water through the air in thin sheets or fine droplets (water fall aerator).

10.4.2 Plain Sedimentation

This is the process of the removal of suspended solids in a raw water by gravity and natural aggregation of the particles in a basin without the use of chemicals (coagulants). The efficiency of this process, as measured by the removal of turbidity is dependent on the size of suspended particles and their settling rate.

Sedimentation tanks can be constructed from locally available inexpensive materials. Wooden sheet piles, dug out of earth with sloping sides and masonry walls are examples of some of the alternative available materials in an ordinary community level.

Factors affecting plain sedimentation tanks

a) Shape

Circular tanks are more costly and occupy a large area when two or more units are required. Therefore, rectangular tanks are usually preferred to circular tanks.

b) Number of basins

At least two basins are required to ensure uninterrupted operation when one is being cleaned.

c) Detention time

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In order to provide sufficient time for the settlement of suspended solids, a detention period of four hours is considered for surface water treatment. The detention time can be calculated as follows:-

$$DT = \frac{\text{Volume}}{\text{flow rate}} = \frac{\text{Surface area x depth}}{\text{flow rate}}$$

d) Surface loading rate $= \frac{\text{flow rate}}{\text{surface area}} > 20$ m3/m2/day

e) Length to width ratio usually taken 3:1

f) Inlet should ensure an even distribution of the water over the full width and depth of the tank.

g) An outlet weir should be provided.

10.4.3 Storage

When water is stored in a reservoir for a period of between one to several months, there is usually a very great decrease in the number of bacteria of intestinal origins and other water borne diseases also disappear. To some extent this effect may be due to sedimentation, but the bacterial action of ultra violet radiation and light is of major importance near the surface; there are numerous biotic agencies which probably play a major role in the reduction of the enteric micro organism.

The following table shows the improvement in quality obtained by storing raw water from one to two weeks.

Quality of Raw Water	% age Reduction
Color	50
Turbidity	80
Nitrate	20
Manganese	60
Colony count	88

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10.4.4 Roughing Filters

Roughing filters can be used for pre-treatment before filtration where gravel is easily available (though crushed stone can also be used). Horizontal roughing filters tried in some parts of Ethiopia are showing excellent performance.

The principal treatment process involves sedimentation in the pore space, adhesion, filtration and biochemical degradation of the particles captured.

The solid materials retained by the filters are removed by flushing and digging out the pebbles at approximate intervals of five years.

10.4.5 Slow Sand Filters

Slow sand filtration is an excellent method of water treatment for rural water supplies. It can give good results and requires minimum operation and maintenance. The turbidity of the raw water to be treated, however, must not exceed certain limits.

Slow sand filters are not only limited in rural communities, but, are being used in big cities like London. In Ethiopia the towns of Metu, Goba, Yirgalem, Guder, Shakisso ...etc. are using slow sand filters.

The main problems associated with this system are the high turbidity loads, the growth of algae that reduce the interval between cleaning and its inability to remove color. Despite these problems, slow sand filters have the following advantages:-

a) They are extremely effective in the removal of pathogens; it can reduce up to 99% of bacterial count depending on the initial load.

b) Slow sand filters do not require chemicals for pre-treatment.

c) Simplicity of design and construction.

d) Highly skilled operators and sophisticated equipment are not required.

e) Locally available sand and other construction materials can be used for their construction.

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Factors affecting the design and construction of SSF

a) Number of filters

At least two, but, preferably more units should be provided in order to have a continuous water treatment when one is cleaned.

b) Filtration rate

The recommended filtration rate is between 0.1 - 2m/hr

c) Supernatant water

In order to provide sufficient head of water head to make filtration, an operation depth of about 1m should be considered.

d) Filter beds

It consists of sand and gravel grains with uniformity coefficient of the sand 2 - 3 and effective size 0.15 - 0.35

Suggested configuration of the filter materials:-

filter sand (ESO 0.15 - 0.3mm)	1 - 1.2m
coarse sand (1 - 4mm)	0.1m
gravel (4.5 - 6mm)	0.1m
gravel (15 - 20mm)	0.2m

e) Under drainage system

The filter bed should consist of a good under drainage system which provides the passage for the collection of treated water. It has to ensure a uniform filtration rate over the entire filter area and firm support to the total medium.

f) Filter control

Appropriate valves should be incorporated to control the flow.

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10.4.6 Conventional Water Systems

Conventional treatment systems include the type of treatment facilities indicated in FIG. Such systems are not appropriate for developing countries. This is because of the fact that they require highly trained professionals to design, construct and operate. In addition, as they work with the support of chemicals and electrical and mechanical equipment which are imported from developed countries, their installation and operation costs are very high.

Rapid sand filters are the most common means of water filtration mechanisms. Rapid sand filters work with filtration rates ranging from 4 to 21m/hr. The sand used has effective sizes of 0.55 and higher with uniformity coefficient of 1.5 and lower. The dirts from the sand are normally cleaned by back washing while in slow sand filters cleaning is done by scraping the top 5 to 10 cm of the filter medium.

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11. BASIC CONCEPT ON BILL OF QUANTITY PREPARATION

It is clear that Bill of Quantities are prepared from detail designs. Therefore, in order to prepare bill of quantities, detail design and specification of the project/scheme have to be made ready. The time, when the completion of the project is required, should be known. Based on the time required for completion, detail construction work schedule of the project has to be prepared. The detail design also provides information on the different components or activities involved in the overall project execution which could be grouped into different bill items. To understand the subject matter clearly, considering in detail a typical rural water supply scheme seems vital.

Below is analyzed a water supply scheme for a rural community based on gravity spring with distribution system including some water points. The scheme is assumed to be completed in 1/2 year time . The major activities in the scheme implementation are divided in to different components as follows:-

A) spring cupping

B) collection chamber

C) pipe laying

D) water points construction ...etc

After dividing scheme implementation activities in to different components, detail design and specification of each components shall be prepared. Each component is again sub divided in to major categories of work as follows:-

A. Spring cupping (RC)

As per the detail design work to be performed for cupping, the spring cupping shall be categorized in to:-

1. Earth work
   - clearing
   - excavation and back fill
   - cutaway ...etc.
2. Rock excavation
   - soft
   - hard

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3. Concrete Work
   - in foundation
   - sub structure
   - supper structure

4. Material Required (as per the design)
   - sand)
   - gravel (aggregate)) Quantity depends on the size of the tank & specification.
   - cement)
   - reinforcing bar)
   - stone (if masonry work is involved))

5. Manpower Required
   - supervisor (design engineer)
   - foreman
   - mason
   - carpenter
   - bar bender
   - daily laborer ...etc

6. Equipment /Machinery Required
   - mixer
   - vibrator
   - loader (optional)
   - dump truck

B. Collection Chamber

The approach is similar to spring cupping for collection chamber.

C. Pipe Laying

1. Earth work
   - cleaning

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. excavation
. back fill

2. Rock excavation

. soft rock
. hard rock

3. Construction of trust blocks and ditch crossings

4. Pressure testing and disinfection work

5. Material required

. pipe and fittings

6. Manpower required

. plumbers
. daily laborers

7. Equipment /machinery required

. pipe dice
. " cutter
. Trencher (optimal)

D. Water Points Construction

Similar to that of A

Depending on the volume of work to be done and the time required to complete, detail work schedule shall be prepared, and the number of manpower and equipment required be determined, or having known the volume of work to be done and examining the manpower and equipment capacity of the executing agency, the over all completion time can be set.

The project management should develop in the office as well as on each site record keeping for all materials, labour and machinery requirement of the project. This could be achieved through establishing daily site record books and formats in two or three copies and keep one copy at the site and the vest in the office as required, and summarize record files up to the end of the project.

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12. COMMUNITY PARTICIPATION IN WATER SUPPLY AND SANITATION PROJECT

12.1 INTRODUCTION

CP is the involvement of beneficiaries in project development with emphasis of participation by the intended target users rather than external inputs. This is well elaborated and clearly defined by the World Bank as "an active process whereby beneficiaries influence the direction and execution of development projects rather than merely receive a share of project benefits" (Paul 1986).

CP has become a favored development strategy, because it involves community users in planning, implementing, O&M as well as monitoring and evaluation of WATSAN projects.

The main objectives of CP in development process as a whole and in WATSAN Projects in particular are the following:-

- **sharing project costs** - beneficiaries contribute money & labour or locally available materials.
- **increasing project efficiency** - users genuinely involve and assist at all stages of project life i.e. planning, implementation and management.
- **promoting project effectiveness** - enabling beneficiaries to have a say in project design and implementation so as to inculcate sense of ownership.
- **building beneficiary capacity** - helping users to share in management tasks such as operation and maintenance responsibilities.
- **increasing community empowerment** - creating awareness in users to share power and to increase their political, economical, social and cultural influence over developmental outcomes.

Among developmental efforts to improve health, education and living standard of people, WATER SUPPLY AND SANITATION (WSS) PROJECT is crucial. But, installation of water and sanitation facilities is not an end in itself unless it involves the beneficiary communities in the project implementation, operation and maintenance. The involvement of the intended beneficiary communities in the whole process of WSS project is of paramount importance and decisive factor to achieve improved health, productivity and a better living environment.

12.2. CONCEPT OF COMMUNITY PARTICIPATION

Individuals could have diversified views and opinions on the concept of CP. Proper understanding

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depends on how close they are to projects being implemented. Attempts to answer the key questions for the concept of CP could help in formulating common understanding on the subject. The key questions for the concept of CP are:-

- What do you mean by CP ?
- What kind of participation are we talking about ? Participation by whom ? In what form ? At what level ? In which roles ? Participation for what purpose ?
- Who will benefit from CP ? In what way ?
- What would be done in order to get that kind of CP ?
- What indicators will tell us that the process of CP has been effective ?

You may have different answers to these questions. An engineer's perception and answer may be different from that of a health officer, a doctor, an economist or a sociologist. The extension agents, field technicians and community promoters perceptions on CP concept may differ from a central office manager who is concerned with costs of installation and maintenance. Even if the answers to the questions are not uniform, there is a great value in people hearing each other's ideas. The ideal is to clarify and refine concepts, reconcile differences and combine ideas into coherent conceptual understanding. However, there are common concept of understanding on CP as that:-

- CP involves people in decision-making process and planning of action programme to solve their problems.
- CP engages people in an assessment of situations, defining of problems and setting up of priorities.
- CP involves target people in the acceptance of responsibilities for implementing WSS programme.
- CP manifests in the beneficiary communities member through the contributions of labour force, materials, financial resources to WSS programme implementation, operation and maintenance of systems.

In a nut shell CP implies development to be achieved with and by the people, but not just for the people as a gift. In practical terms, CP rely on the massive use of auxiliaries chosen by the community and plans of action based on needs and elaborated, implemented, monitored and evaluated with local population. With this concept, let us define CP.

CP can be defined in many ways, for example, **COMMUNITY** refers to a group of people living in a geographically defined areas, or to people that interact, because of common social, economical and political interest, while **PARTICIPATION** means involvement, taking or sharing parts of common issues. Hence, CP refers to community involvement in development projects which has become a favored

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development strategy, because it involves people in decision making and actions affecting their welfare. The concept of CP was originated during community development endeavors by the colonial administration in Africa and Asia to improve local welfare through training people and extending government control through local self-help activities. At present, the concept of CP is taken to mean that the community plays an active role in its own affairs by sharing and exercising social, economical and political power.

In WSS projects, we can discuss the concept of CP from different points of views as:-

1. The **Cheap Labour Concept** of CP - the community is considered to have participated when it provides free labour for construction and donates raw materials in the spirit of self-help. Community's role is to carry pipes, dig trenches and perform unskill construction works, while the technical parts are done by engineers and technical personnel. Obviously, this will lower the costs of projects. The labour contribution increases people's identification with the system being built and enhances sense of pride in the possession of the project which ultimately assist in maintaining and keeping the scheme in good order. On the other hand, this assumption is contested. It might be pointed out that pride of ownership depends on what the people's priority might be . Therefore, if the constructed project is not a priority for the majority of community members, labour may be contributed under duress i.e unwillingly or not voluntarily. The interest in using and sustaining the facility may, therefore, die after a while.

2. The **Cost Sharing Concept** of CP - indicates people's willingness to invest a part of their meager resources in maintaining the system e.g. to pay the local mechanic, is taken as indication that they value the WSS service and are, therefore, committed to keep it in a good working order with the development of the sense of ownership of the project. However, some believe that agreements to maintain a system may not in themselves be a reliable indictor of local commitment. For instance, if average community members in particular women have not been involved in decisions concerning the system, they may revert and go back to their old traditional water sources when the pump breaks down rather than contributing towards the cost of repair.

3. The **Contractual Obligation Concept of CP** - this focuses on :-

   a. Local leadership to legitimize the project

   b. Water committees to promote, manage and monitor local contributions and water usage

   c. Voluntarily trained mechanics, pump attendants, operators and other local technicians to help transferring technology to the community. To make these requirements more formal and binding a contract is often drawn up. The contract spell out in detail, what roles and responsibilities apply to each partner in the project i.e. Gov't, NGO's and communities.

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It is assumed that by assigning management roles to local water committees and by training local mechanics there is greater assurance that the terms of the contract will be fulfilled. However, others question whether this approach sufficiently involves the average villager. They feel that contracts that have been negotiated primarily with village leadership and presented at large village meetings may not be fully understood by the community at large resulting after a while to a decline in contribution in labour, cash and /or in kind.

Setting up local committees immediately following the first village meeting also runs the risk that the best or the representative people may not be nominated. Similarly pump caretakers who have been hastily selected may drop out for lack of commitment and accountability to the community at large.

4. **The Community Discussion Making Concept** of Participation - involves a broad base of the mass in decision making of the whole project cycle and contribute their own ideas, views and scarce resources. In doing so communities will develop a sense of ownership of the project and feel responsibility for using the improved water and sustain it in a good order. The decision making requirements should apply not only to the male leadership, but also to village women. Women should also feel equal responsibility with their male counter part for the contractual obligation, cost-sharing and resources contributions, since women are the main carriers and principal drawers of water. It should be noted that women's lack of schooling and literacy skills shouldn't prevent females from making valuable contributions to community decision making.

12.3. FACTORS ENABLING COMMUNITY PARTICIPATION

In the past CP was conceptualized as an effort of individuals to assist in the implementation of the plans already made and imposed by the government or other development agencies as the "top-down" approaches through didactic method which was a traditional type. This kind of CP prescribes passive acceptance which results in the failure of the project. The present and new type of CP is the participatory approach which involves the target beneficiaries at the initial discussions, project identification, planning, design, implementation, construction, operation, maintenance, monitoring and evaluation of the project at all stages.

The most commonly accepted factors enabling CP on the basis of participatory techniques for the promotion of WSS programme are enumerated below:-

1. More people can be served with CP. Services can be provided at low costs to each community.

2. More will be accomplished at relatively low cost if communities are genuinely motivated to participated in the decision-making.

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3. Participation encourages adaption to local knowledge, needs and circumstances. Community has an intrinsic value for participation. CP is more instrumental and has advantages as a means to achieve the ends which enable communities to participate actively in the process that affect them.

4. Cp is catalyst for further development efforts since popular participation will lead to a more united community. The organizations created i.e. committees arrangements for voluntary labour and enthusiasm generated by success will provide the means and stimulus for further efforts to tackle the other needs by strengthening their sense of ownership and responsibilities towards the projects, particularly WSS programme.

5. CP guarantees that a felt need is involved. Communities have demonstrated their needs and willingness to support the project. They have shown collective efforts to organize and participate in the projects.

6. CP ensures that things are done in the right way. If communities take an active role in planning, design and site selection of WSS project, they will use it confidentially and presumably be better adapt to their needs than others.

7. CP enables the use of indigenous knowledge and experiences. Some indigenous rural people possess local access and valuable experiences that might help their WSS project activities . CP will facilitate the usage of their skill.

8. CP leads to freedom of rural people from the dependence on professionals. A radical approach to CP envisages the prospects of freeing the communities from dependence on professionals and experts.

9. CP develops consciousness among people, enabling them to know the structural cause of their situations and rights under the existing law.

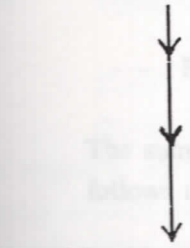
10. Through CP, villagers will better understand the nature of the constraints which are hindering their escape from poverty. They learn how to make more effective demands on Gov't, NGO's and acquire a method of resolving their problems by collective efforts through the genuine CP.

The summary of the reasons /factors/ for CP in WSS project, written by white, 1981, will help as supplementary clarification as illustrated below:-

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TABLE 1 : Reasons /factors/ for CP in WSS projects:-

narrow short term benefit



broad long-term benefit

- Participation reduces the cost of improved facilities
- With participation more people can be served,
- Participation encourages adaption to local knowledge needs and circumstances;
- Participation increases the chance of proper use and continuous functioning of the system
- Participation can be a catalyst for long-term benefits further socio-economic development.

12.4. AREAS AND SCOPE OF COMMUNITY PARTICIPATION

It is fundamental to any successful WSS project that the people concerned are involved in as many stages as possible throughout the various phases of the project life cycle. In principle, limiting the areas and scopes of CP is undesirable. However, the ideal areas and scope of CP in WSS project is illustrated as follows:-

1. **Pre-planning and planning stages:-**

Areas and scopes of CP varies from country to country in pre-planning and planning stages. In countries which pursue participatory developments approach, local people are involved in the initial discussions and decision making concerning their project. Although there is no model of CP suitable for all situation, community involvement scope, integration with other development sector, setting facilities decision on types and design of technology, selection of water sources are given a due consideration during the pre-planning and planning stages of WSS project.

2. **Implementation and construction stages of WSS project;-**

The scope of CP at these stages may be expressed in two areas:-

a. Preparation for construction i.e. site selection, land preparation, cleaning and fencing project site, collecting and stocking materials for construction and provision of houses for project technicians living and stores.

b. Provision of free labour, if possible money in cash and materials kind and supervision through the local committees.

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3. Operation and Maintenance /O&M/ stages of WSS project:-

The areas and scope of CP in the O&M phases includes the following responsibilities:-

- Selection and paying pump operators salaries,
- Cover lubricant and fuel costs,
- Cover minor repair and maintenance cost,
- Contribute fund, if possible for maintenance costs,
- Establish village water committees and supervise the system, - Ensure sites are cleaned fenced and protected from vandalism and mis-use

4. Monitoring and Evaluation M&E stages of WSS projects:-

M&E is carried out in order not to repeat mistakes and adjust the appropriate approach where possible. Consequently, it is recommended that M&E should be included in WSS project and be designed at the very beginning of the project. Therefore M&E programme should mainly concentrate on the following informations;-

- Users satisfaction or dis-satisfaction on project,
- How far improved water supply has reached the most disadvantaged groups i.e. poor women and the remote communities,
- Cost effectiveness of CP in construction, management and O&M,
- Impact of the improve WSS project on health, knowledge adoption of improved facilities and communities attitude changes,
- Socio-economic impact of the project i.e. redistribution of income, reduction of burden, benefits and increased productivity,
- Users complaints on project i.e. number, duration and type of breakdown, amount of water lost through leakage,
- Conditions and hygiene around water supply points,
- Benefits of self-development experience, co-cooperativeness and community spirit,

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- Appropriateness and transfer of technology e.g VLOM types of pumps,
- Project influence and adaption of self-reliance,
- Reduction of water borne and water related diseases and vector breading places

The summary of areas, scope and level of CP in the majority of WSS project is described as follows on Table 2.

TABLE 2. SUMMARY OF AREA, SCOPE AND LEVEL OF CP IN WSS PROJECT

PROJECT		LEVEL AND SCOPE OF CP	
STAGE	AREAS	WATER SUPPLY	SANITATION
I.	Pre -planning	Low	Low
II.	Planning		
1.	a) Data collection, needs assessment	Low	Low
	b) Identify technical opinions	Low	Low
	c) Community Organization	Medium	Low
	d) Select goals, systems technology	Low	Low
	e) Decide on time table	Low	Low
	f) Determine man-power needs and resources	Medium	Low
	g) Identify local hygiene education needs and strategies	Low	Low
2.	Implementation & Construction	Medium	Low
	a) designs	High	Medium
	b) construction	Low	Low
	c) information,education,communication	Medium	Medium
4.	Operation & Maintenance	Low	Low
5.	Monitoring & Evaluation		

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12.5. HOW TO MOTIVATE COMMUNITIES' INVOLVEMENT (Methods & Tools)

It is well understood that local communities, particularly the water needy people are eager and accept any one positively to achieve their end goal of getting safe drinking water through working with them. But still to coherently approach and motivate communities involvement, the following points have to be emphasized and performed subsequently:-

1. **Community Mobilization and Organization:-**

CP means involving as many community members as possible by providing an institutional vehicle through which they can act, motivating communities to participate genuinely.

2. **Project Negotiations:-**

Communities need to communicate their preferences and have a say in the type of project to be considered. Their input may be acquired through consultation between community leaders and agency officials or in public discussions within committee meetings. It may consist formal bargaining on issues such as WSS project design, community contributions and external assistance.

3. **Committee Operations:-**

Community organization e.g water and sanitation committees are usually elected or appointed by the beneficiaries. Their potential operating effectiveness depends on the degree to which they are allowed to function in WSS project activities.

4. **Training:-**

It is necessary for the system manager's committee members and other involved in WSS project implementation, construction, O&M.

5. **Hygiene and user education:-**

Help to develop responsibility for the system and feelings of control over the environment in the mind of the community members. Such training should be participatory and practical type, rather than didactic and theoretical and it should encourage a behavioral change to maximize health benefits.

6. **Community contributions:-**

Communities must contribute to WSS projects development and operations, if they are to feel that they own the system. Contribution should include monetary investments, materials, equipment, labour, committee membership and general participation in the project.

7. **Cost recovery:-**

The community should take cost recovery as an obligation to meet its share of the cost of WSS

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project. It should respect its cost recovery obligation to impress external agencies for their genuine assistance.

8. **Operations and Maintenance:-**

Communities should accept and exercise responsibility for O&M. Care-takers, repair crews should be well trained and responsible to the community based WSS projects.

With the understanding of these CP activities, we shall go to the needy people, as Chinese development leaders say " Go to the people, living among them, love and learn from them, and start working with what they know, build with what they have, bout of the leaders when the task is accomplished, the people all remark, we have done it ourselves". Hence, the effective means of motivating communities is approaching and working with them as partnership.

12.6 PARTICIPATION OBSTACLES AND POSSIBLE SOLUTIONS

There are many CP obstacles. The major ones are briefly discussed below.

1. **Mis-conceptual problem:-**

Decision-making bodies of Gov't, NGO's and local authorities mis-understood or mis-interpreted the basic concept of CP considering it as hinderance to WSS programme causing delay in the project activities. One of the mis-conception is considering CP's contributions merely to reduce construction costs. But CP is more than that and its main objectives is to create and promote sense of ownership and responsibilities among the intended beneficiaries. The possible solution to over-come this problem is to enlighten all.

2. **Lack of Socio-Economic Base Line Data:-**

Shortage of the socio-economic base line data ignoring the traditional beliefs, customs, needs, interests and practices of the target beneficiary communities is the major hinderance for the development of WSS project. For instance, drinking water from a borehole drilled in a grave-yard is considered as a taboo. The solution is to approach, consult and fully involve the target community throughout the project cycle.

3. **Appropriate Choice of Technology:-**

This is often introduced without local consultation; consequently, it lacks appreciations and acceptance by the users. The applied technology should correspond to the knowledge, skill and living standard of the beneficiaries. The use of different types of pumps is also another set-back. For instance, it is reported by Mr.Wood that "there are 400 Moyno hand pumps in the Southern Region of Ethiopia which are beyond the maintenance capability of local technicians". Here, the mitigation measure and possible

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solution is to introduce a village-level-operated maintained (VLOM) types of pumps and provide training for the locally selected individuals. The other is to substitute the most complex pumps by the more simpler type and there must be a continuous effort to standardize the existing pumps.

4. Local Integrated Approach:-

Integrated approach to project execution by the parties involved i.e. the Gov't, NGO's, local leaders and target beneficiaries is vital for the smooth running and sustainability of the project. Projects designed and implemented individually always carry risks of poor management and sustenance. It is, therefore, appropriate to prepare ground for group action of all parties involved through establishment of committee.

5. Resource constraint:-

Lack of resource (finance, material and skilled manpower is the major problem which hinders the development of WSS project. CP field agent and technicians are also not equipped with the necessary logistic support. Hence, the allocation of an adequate resource is a decisive solution to mitigate the problem.

6. Limited Involvement of Women:-

Although women are the most users and carriers of water, their involvements are still too limited: husbands won't let their wives and daughters to participate in WSS projects. The possible solution to this problem is to conduct workshop to create awareness and promote consciousness.

7. Lack of Training:-

There is a lack of training at all levels of Gov't, NGO's, local authorities and target communities who are involved in WSS projects. Even those trained lack basic O&M tools to work with. The solution is to provide the necessary O&M tools and extend comprehensive training to WSS programs.

8. Lack of Community Management:-

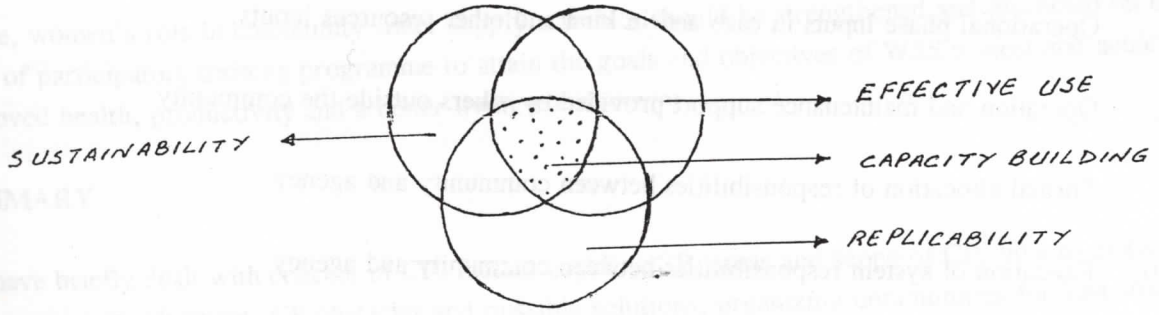
Communities have been denied access to necessary information concerning their own WSS project and they were not given the chance to decide on development issues affect their lives. The solution to this constraint is to strength and promote community management including decision-making authority and control over the WSS project.

12.7. ORGANIZING THE COMMUNITY FOR SUSTAINABLE WATER SUPPLY

The basic and fundamental goals and objective of WSS project are SUSTAINABILITY, EFFECTIVE

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USE, and REPLICABILITY . These goals and objectives are illustrated below as:-



SUSTAINABILITY is an effective utilization of project output without a notable frequent break-down. Sustainability refers to maintain efforts and drive benefits at the community and agency levels, even after external assistance has been phased out. It can be achieved by building problem-solving capacities in communities and partnership agencies to solve problems as they arise by adjusting with changing environment.

Nowadays, **PARTICIPATORY APPROACH,** in which people are centrally involved in decision-making is becoming important to achieve sustainable project. Therefore, organizing communities for sustainable WSS project could be attained through building capacity and confidence in communities and agencies, management knowledge generation and technical skills, facilitating leadership shared vision, arranging system for two ways knowledge generation, resource recovery and conflict resolution. Organizing community according to WHO draft guidelines for sustainable WSS projects will be a fundamental base for sustained WSS projects.

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The ten WHO draft guidelines for water project **SUSTAINABILITY** are:-

1. Community institutions and administrative mechanisms i.e.water committees, women's groups, accounting systems ...etc.

2. All technical and non-technical skills required to implement community-based projects.

3. Supportive attitudes, understanding, motivation , choice, willingness to assume ownership, etc.

4. Community extension services provided by agencies

5. Community acceptance of level of service and related costs

6. Appropriate technology, sustainable to community needs

7. Operational phase inputs in cash and in kind and other resources inputs.

8. Operation and maintenance support provided by others outside the community

9. Formal allocation of responsibilities between community and agency

10. Execution of system responsibilities between community and agency

12.8. WOMEN'S ROLE IN COMMUNITY WATER SUPPLY ACTIVITIES (Gender Issues)

Women have often been regarded primary as beneficiaries from WSS projects, which would reduce their water hauling work load. Women are expected to provide free labour for construction works and perform routine works of WSS project. Experiences have proved that rural women with modest training can make a highly significant contributions to WSS project as it has been demonstrated at Dodotta /Arsi/ and Mio-Grassers /Bale/ WSS projects, where women have taken the leading role in the project activities. Women have shown themselves that they are capable of fulfilling intelligent and responsible roles in community level planning, management, needs assessment, site selection, pump maintenance and fund raising. They have exercised initiative role to increase project effectiveness and support at the local level. As it has been explained earlier, women are main carriers of water for domestic needs and custodians of family hygiene, Although the UN Decade of women, 1976-1985, and the UN IDWSS, 1980-1990, have drawn worldwide attentions to promote women's roll in WSS projects, not much recognition is yet given to women's involvement. As home managers and mothers, women make important decision on family, choice of water for cooking, drinking, laundrying and bathing. In this respect training women as water technicians, care-takers, pump attendants and operators in WSS project is not only ensure projects success and sustainability, but also eliminate the myths of female inferiority.

Therefore, to promote women's role in communities water supply activities, the following suggestions should be considered:-

- Make women aware of new information about how they can improve the quality of their lives and families.
- Identify women's needs and choice during WSS project cycle and consult community members to promote women's role in communities WSS service.
- Encourage efforts among researchers, planners and administrators to seek out women's view on WSS project.

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- Start a pilot project in areas where women's role is already acknowledged.

Hence, women's role in community water supply activities should be strengthened and promoted on the basis of participatory training programme to attain the goals and objectives of WSS project and achieve improved health, productivity and a better living environment.

SUMMARY

We have briefly dealt with concept of CP, factors enabling CP, areas and scope of CP, how to motivate communities involvement, CP obstacles and possible solutions, organizing communities for sustainable WSS project and women's role in WSS programme. However, the overriding goal of CP in WSS sector is not simply to ensure the effective applications of the above mentioned themes and attain sustainability of system by teaching people how to function in a committee or how to fix pumps. Rather, it is to help people develop the outlook, competence, self-confidence and commitment which will ensure a sustained and responsible community efforts in water resources development sector and beyond. If a project comes up against fears, doubts, suspicion, lack of self-change, a participatory approach can be vital. The **participatory approach,** often know as leaner centre, has involve over the past decade as a means of helping leaners take greater control of their lives and their environment by developing their skills in problem-solving and resource management unlike **traditional teaching methods** which have emphasized the transfer knowledge, message or content pre-selected by outside specialists or authorities; the participatory training focuses more on the development and take initiatives. These skills can then be spilt over to many other aspects of the person's life and community to promote **PARTICIPATION.**

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13. MAINTAINING RURAL WATER SUPPLY SCHEME

Maintenance of rural water supply scheme depends, in general, on the complexity of the scheme and the financial, skilled manpower and equipment capability of the concerned Authority or Community. Therefore, the role of beneficiaries, supervising authority and donor organizations in maintaining rural water supply scheme will be discussed in the view of the above mentioned considerations.

13.1 Role of Beneficiaries

- Participate in all stages of the project life to enhance smooth take over at its completion. Participation during construction and installation will assist selected community members to get trained which could be vital for en-suing maintenance work.

- Cover maintenance costs whenever the maintenance skill required is beyond that is available within the community.

- Provide unskilled labour to assist the maintenance work in order to reduce cost

- Inform concerned Supervising Authorities to get a helping hand whenever maintenance works are beyond their capacity.

- Pay service charges for pump care takers and water system attendants who look after the scheme regularly.

- Organize into water committee with the participation of women to look after the management of the scheme including maintenances.

- Fence and also look after the cleanness of the water collection area.

13.2 Role of Supervising Authority

- Provide skill manpower, spare parts and equipment required for all maintenances beyond the capacity of the beneficiaries. Charge for the service rendered if found could afford.

- Make an arrangement to get spare parts and equipment for maintenance from donor organizations.

- Assist the community to establish water management body including the maintenance crew and give them on job training to improve their skills.

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- Regularly monitors schemes for better management and maintenance…etc.

13.3 Role of Donor Organization

- Assist the community by supplying major spare parts and equipment
- Assist the community in establishing water management system which maintenance of the scheme is a part.
- Assist the community by training the water management staff to improve their skill in maintaining the scheme, and financial management, which inturn contributes for better maintenance and operation of the system.
- Assist in the evaluation and monitoring of the scheme maintenance and operation to observe the weakness area and take corrective measures …etc.

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14. TECHNIQUES OF PROJECT PLANNING & FOLLOW-UP

14.1 GENERAL PLANNING PRINCIPLE

Planning is a primary function of management that enhances development of proper and sound organizational structure, staffing and directing and controlling of an organization. To have an economic and coordinated implementation of activities and to achieve the organizational objectives and goals concise but, comprehensive and purpose full planning is a vital tool. Planning enables visualize future trends and coordinated moves to achieving targets. In a broad form planning could be defined as an orderly consideration of a project from the original statement of purpose through the evaluation of alternatives to the final decision on the course of action. In a nut shell, planning is preparing for tomorrow, today.

Basically, there are two types of planning; namely

1. Long Term or Strategic Planning

2. Short Term or Operational Planning

A) STRATEGIC PLANNING (LONG TERM PLAN)

Strategic planning is normally worked out by top management of an organization having clearly identified the objectives and goals of the firm they are leading. Systematic analysis of the working environment shall be conducted in the setting of the Long term plan. Such environs cover both **internal** - all capacities, capabilities and handicaps within the firm - and **external** - those related to outside influences beyond the jurisdictional control of the organization - national and international interactions. Strategic plans requiring details from intermediate and lower echelon of the organization.

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B) OPERATIONAL PLANNING (SHORT TERM PLAN)

Operational planning is detailed but of short duration. It bases itself on the strategic plan prepared by higher hierarchy. The whole operational or activity plan starts and finishes at the lower level of the organization which confronts the direct project execution.

The above planning activities are analyzed and expressed with planning tools such as PERT, GANNT Diagram, LFA (Logical Framework Approach), ZOPP (Objective Oriented Project Planning)...etc.

There exist always barriers to the planning process. Planning activity is often observed suffering from:-

a) problems arising from difficulties related to attitudinal change among the people required to plan

b) lack or insufficiency of information required for planning purpose

c) hasty preparation of plans without allocating enough time for its development

d) poor research base to enable uncover many alternatives during planning

e) preparation of a complicated plan which is not easy to understand and measure.

f) being fix and ridge without leaving room for modification and changes whenever required.

Viable and strong plans are those having good information base, of a participatory nature with ideas and opinions sharing from employees working at all levels and with qualitative goals distilled to measurable goals.

14.2 WATER RESOURCES PLANNING AND REPORTING

14.2.1 WATER RESOURCES PLANNING

Water resource planning includes all the work associated with the design of a project. It is the basis for the decision to proceed with (or to abandon) a proposed project and is clearly a most important aspect of the total engineering for the project. Because each water-development project is unique in its physical and economic setting, it is impossible to describe a simple process which will inevitably lead to the best decision. There is no substitute for "**engineering judgment**" in the selection of the method of approach to project planning even though each individual step toward the final decision should be supported by quantitative analysis rather than estimates or judgment.

The following sections outline steps required to prepare comprehensive plan for water resources development.

1. Statement of Objective

An essential preliminary to project planning is a clear statement of objectives.

2. Data Needed for Planning

Reliable decision on water development must be based on facts if emotion, supposition or political ambition are to be prevented from governing the decisions.

The following outlines show the required data for planning.

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General,

a. Water resources
. Hydrology - rainfall, stream flow, evapotranspiration, water quality, sediment
. Geology - groundwater, soil survey, erosion
. Cartographic - maps

b. Other basic resources
. Geologic - minerals
. Ecologic - vegetation, fish and wild life
. Demographic - people and institutions
. Economic - industry, transportation, markets, tourism, recreation, land, taxes

c. Constraints
. Law - water rights, pollution control, land zoning, land ownership, administrative patterns
. Public opinion
. Existing projects

Special Data,

a. Irrigation
. Land classification
. Crop water requirements - quantity and quality
. Climatic limitations

b. Water supply
. Population water uses - quantity and quality
. Industrial water needs - quantity and quality

c. Hydro power
. Projected needs
. Alternative sources

d. Flood control
. Extent of past flooding and damages
. Local storm drainage requirements

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e. Recreation
   . Natural attraction
   . Present recreation patterns - types, place, time

f. Pollution control
   . Existing waste discharges - location, time, character of waste
   . Water pollution regulations or quality standards

Note that this goes far beyond the hydrologic and site data required for engineering design. A substantial body of economic, social, and resource data are required and the services of specialists in many fields are needed to collect and interpret these data.

3 Projections for Planning

The historical and current data collected for project planning have only one purpose - to serve as a base for projection of future conditions. All the projects are for the future and must be planned to meet future needs. The projections should be more than a simple extrapolation of past growth curves, for social, economic, and technological developments may cause significant changes in trends.

The following items are to be considered in projections for planning.

General,

a. Population - place and time
b. Land use - place and time
c. Economic - markets, tourism, etc.

Specific,

a. Irrigation
   . Markets
   . Crops
   . Technical development
   . water demand
b. Water supply
   . Domestic water demand
   . Industrial water demand
   . Technological changes
c. Power
   . Market and demand
   . Growth of alternative sources

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. Technological improvements

d. Flood Control
. Zoning possibilities
. Projected flood damage - place and frequency
. Possibilities of flood warning

e. Recreation
. Growth of demand
. Changes in recreation preferences

f. Pollution
. Anticipated quantities and characteristics of waste
. Technological advances

Unrealistic values for "water needs" lead to over design and excessive costs and, if the supply is limited, to the diversion of water from other uses which are also economic but of lower priority. When excessive allowances are accepted as values of the real need, conservation of water is discouraged.

It will be evident that accurate long-range projections are difficult, if not impossible. The planning process must allow for this by retaining flexibility so that the plans can be adjusted to meet changing condition. Stage construction should be given careful consideration in the planning process. Differing flexibility of alternate plans may be an intangible factor of importance in the final decision.

4. Project Formulation

Once the basic data and the projections of future conditions are assembled, actual formulation of the project can commence. This is a phase of planning where imagination and skill are required. The important first consideration is the compilation of a list of alternatives. Such a list should be comprehensive. Often a preliminary project plan is in hand as the first phase of the planning operation and the operation is reduced to attempting to justify this plan. This approach is wrong. The planning process should be an evaluation of all possible alternatives with respect to project features and water use. It is not even sufficient to start with the assumption that a specified quantity of water is required at point X and to evaluate the merits of two or more plans for supplying this quantity. Planning should consider alternative and competing uses for water as well as the various possibilities for control and delivery of the water. The planning process may involve considerable feedback. As project formulation proceeds, it may be evident that new data or projections are required or that some revision of background data is needed.

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The following are some of the basic steps in project formulation.

a. Defining boundary conditions

b. Listing all possible land use plans and their water requirements

c. Listing all possible projects which could meet the needs as projected under 3 and 4b

d. Preparing preliminary designs and cost estimates for projects listed under 4c

e. Estimating benefits for all projects

f. Rejecting all projects which do not appear to be individually economic.

g. Forming of all combinations of projects which are not mutually exclusive and totalling the costs and benefits of all combinations.

h. Selecting the two or three combinations which offer prospect of maximum return for detailed consideration and reanalyzing costs and benefits - selecting the "final alternative plans."

i. Preparing reports on final alternatives showing costs, benefits, staging, financing, and intangible factors for review by appropriate authority.

5 Project Analysis

The procedure outlined in the previous section leads to the listing of a large number of individual alternatives and their associated costs. From this list the planner must select the unit or combination of units which is economically most efficient. If this most efficient unit (or units) meets the established standards, i.e., benefit-cost ratio above a specified minimum value, the unit or units may be recommended for construction.

An occasional unit will be completely independent both physically and economically of all other units and may be tested alone. To be physically independent, there can be no other units either upstream or downstream of the unit in question which would affect the inflows to the unit or be affected by the outflows from it. In addition, no other unit can contribute to the same end purpose. Thus, two reservoirs on different streams but both providing flood control for a single downstream point are physically interdependent. To be economically independent, a unit must have no economic interconnection with any other unit. Thus, two power plants on different streams might have no physical interrelation as far as stream flow is concerned, but if they serve the same power system, they are economically interdependent in that their power production must be integrated into the system. The comments above apply also to the

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case of a group of mutually exclusive units at a given site provided all of the mutually exclusive units would be independent if constructed.

For an independent, single-purpose unit the testing is relatively simple. One need only establish a sufficient number of points on a curve of benefits vs. costs to determine the level of project development which produces the largest net benefits.

After the optimum level of development for the total system is defined, computations should be performed deleting each separable unit from the optimum combination to verify that the increment of benefits from each unit warrants its cost.

6 Some Common Pitfalls in Project Planning

A study of project reports by various agencies indicates that there are many pitfalls which may substantially negate an otherwise excellent effort to make a sound economic analysis. Some of the most common pitfalls are discussed in the following paragraphs. In general, the only protection against these difficulties is to be constantly alert against incorporating them in the analysis.

The Survey report: Because of the large number of possible project it is fairly common practice to prepare a survey of preliminary report on a project as the first phase of its analysis. If this report is unfavorable, the project can be dropped without excessive expenditure of funds. If it is favorable, the decision to proceed on more through studies is made. In theory, the project can be rejected even after a favorable survey report, but for public projects political considerations may work to avoid any such rejection. Consequently the survey report becomes a very important step in the economic analysis of projects, and it is important that the survey report not be based on approximations and short-cut procedure.

In particular the study of hydrology and those factors related to expected water use should be carried to the level of refinement appropriate for final design. Anything less may incur the hazard of a serious error. While this may increase the cost of preliminary studies, it should reduce the cost of the final design for projects which reach that phase.

Agency standards: Many agencies have developed standards of design as the result of tradition or administrative rule. These may not, however, always be appropriate to the particular problems of a given project. For example, a spillway which will flow only once in 50 year might profitably be built of soil cement or other similar construction since repair or replacement on the average of once every 50 years might be less costly than more permanent construction. Many agencies would not, however, consider anything less than massive or strongly reinforced concrete for such construction.

Early construction: Assuming that the economy is functioning fully, $1.00 investment postponed for

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10 years at 5 percent interest is equivalent to $1.63. Construction of a project substantially before it is needed constitutes a waste of funds which might profitably be employed gainfully in the interim period. Even increased construction costs over the 10-year period need not necessarily represent a loss of profit resulting from the delay, since increased costs will be at least partially offset by a relative increase in benefits.

Stage construction or investment may be appropriate. If a project is known to be needed 10 year hence it may be quite desirable to buy right-of-way at once to prevent development that would greatly increase cost. There are numerous examples of dams which have been planned for stage construction as growing water requirements increase the required reservoir size. In some cases where a water supply is required immediately, it may be prudent to install conduits designed to meet anticipated future demands and perhaps, even, a dam large enough for the long-range future. In each case, however, this need should be demonstrated by analysis and not assumed a priority.

The practice of building flood-control works on the basis of anticipated future growth of the area to be protected is especially erroneous. Flood control should not be provided until it is justified by existing values.

A priori decisions: Decisions regarding certain features of a project are sometimes made before economic analysis and are never checked. Thus in one flood control project the decision was made to limit maximum flows to 300 cu.m/s in the protected reach to prevent bank erosion although flood damage did not begin until flows of over 400 cu.m/s occurred. No study was made of the incremental cost of the additional 100 cu.m/s reduction in peak flows to determine whether the cost was justified by the relatively small losses incurred by bank erosion. A priori decisions of this type can lead to incorporation of uneconomic increments in many projects. No such decisions should stand until its incremental benefit-cost ratio justifies it.

Failure to consider all alternatives: Probably the most pitfall is the failure to consider all alternatives. In particular, non-engineering alternatives such as flood-plain zoning may be overlooked by the engineering designer, but simple engineering alternatives are often overlooked especially when they depart from the traditional solutions. When it became necessary to reduce the seepage through a small earth dam, consulting soils engineers recommended construction of a clay cutoff wall and blanket on the upstream face. While successful, this precluded the possibility of relief wells on the downstream side which, in this instance, would have been a useful source of filtered water as well as a seepage control measure. In the same vein, one rarely hears water conservation suggested as a solution to a water shortage when it is feasible to construct works to provide an additional supply.

Use of market prices: Market prices of water do not always reflect its real value. Hence, market prices are not necessarily a satisfactory basis for computing benefits. Whenever possible, the real benefit should be estimated and utilized in the economic analysis.

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Use of next best alternatives: In lieu of any other estimate of the benefits of a project, it is not uncommon to use the next best alternative as a measure of benefits. By judicious selection of the next best alternative, the benefits can be made very large indeed.

7. Multi-purpose Projects

Many water resources projects can serve more than one of the basic purposes - water supply, irrigation, hydroelectric power, flood control, recreation, sanitation, and wildlife conservation. Multiple use of facilities may increase benefits without a proportional increase in cost and thus enhance the economic justification for the project. A project which is designed for single purpose but which produces incidental benefits for other purposes should not, however, be considered a multi-purpose project. Only those projects which are designed and operated to serve two or more purposes should be described as multiple-purpose.

It is imperative that maximum use be made of our water resources and the concept of multiple use is essential to such maximum use. Indeed, with the best project sites already utilized, many projects cannot be justified economically without multi-purpose goals. Multiple-use planning involves substantially more than the simple combination of single-purpose elements. Non of the possible uses of a reservoir are entirely compatible with any other use, although under many circumstances it is possible to bring some uses into good arrangement.

The basic factor in multi-purpose design is **compromise**. A working plan must be devised which permits reasonably efficient operation for each purpose although maximum efficiency is not necessarily attained for any single purpose. The physical elements of a multi-purpose project (dam, spillway, sluiceway, gates, power plant, etc.) differ in no way from those for a single-purpose project. The unique feature in multi-purpose design is the selection of physical works and an operation plan which is an effective compromise among the various uses.

Two extremes in allocation of reservoir storage are (1) to assume that no storage is jointly used and (2) to assume that all storage is jointly used. In the first instance storage requirements for all functions are pyramided to create a large total storage requirement which can be economically attained only when unit cost of storage is constant or decreases as total storage increases. The other extreme results in maximum economy since the required storage is no longer than that necessary for any one of the several purposes. In this case the problem is one of physical feasibility, i.e., the water requirements of the several uses must be the same. Such a situation is relatively rare, and the usual multi-purpose project is designed to fall somewhere between these two extremes.

8. Functional Requirements in Multi-purpose Projects

The success which can be obtained in achieving joint use of storage space is a multi-purpose project

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depends upon the extent to which the various purposes are compatible. It is helpful, therefore, to review the requirements of the various uses and to consider the ways in which these uses may be coordinated.

Irrigation: Water requirements for irrigation are usually seasonal, with maximum during the dry months and little or no demand during the wet months. Water requirements do not vary greatly from year to year, although low-rainfall years usually create a greater irrigation demand than high-rainfall years. Unless the project area is increased, the average annual demand will remain nearly constant. Since irrigation storage is insurance against drought, it is desirable to maintain as much reserve storage as possible consistent with current demands.

Water supply: Requirements for domestic water are more nearly constant throughout the year than are irrigation requirements, but a seasonal maximum is usually experienced in the dry season. The demand normally increases slowly from year to year, and provision must be made for this increase. Maintenance of an adequate reserve to avoid water shortage during droughts is necessary. Sanitary precautions may preclude use of the reservoirs for recreational purposes.

Hydroelectric power: Power demand usually has a marked seasonal variation depending on the type of area served. Most power plants are parts of an interconnected system, and considerable flexibility is possible in coordinating power needs with other uses of water. Power production is not a consumptive use of water and is therefore more compatible with other uses. Water released from a reservoir for irrigation use downstream may be passed through the turbine to produce power as well.

Flood control: The basic requirement of flood control is sufficient empty storage space to permit withholding of flood water during the flood season.

Fish and wildlife: The problems of fish and wildlife in large reservoirs are mainly ones of protection. Reservoir construction results in a major change in habitat for existing wildlife and may result in a decrease in one species of fish or other wild life and perhaps an increase in other species. Protection of existing fisheries may require the provision of fish ladders or other arrangements permitting migratory fish to travel upstream. Large and rapid fluctuations in water level are harmful to fish, particularly at critical periods such as the spawning period. Complete stoppage of flow below the dam is also destructive of fish and wildlife.

Sanitation: The maintenance of adequate flows downstream is the main sanitary function of a reservoir. Usually this is easily fitted into the pattern of releases required by other functions.

9. Compatibility of Multi-purpose Uses

Irrigation and water supply require a volume of water which cannot be jointly used, and hence a project combining these functions must provide a clear of storage space to each. Since power development is not

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consumptive use, any water released for the other purposes may be used for power.

10 Cost Allocation for Multi-purpose Projects

Because a multipurpose project serves several different groups of beneficiaries, it is often necessary to allocate the cost among the several uses to fix the prices of water or power or to determine the contribution required of flood-control beneficiaries.

There is no really satisfactory method of cost allocation in the sense that such a method would be equally applicable to all projects and would yield allocations which are unquestionable correct. Any method of allocation must first set aside the **separable costs** which are clearly chargeable to a single project function, such as the cost of powerhouse. The separable costs for a single function are usually estimated by computing the cost of the project with that function omitted. The separable cost of the function is the total project cost less the estimated cost of that function omitted. The real problem in cost allocation is the division of the **joint costs** (total cost less the sum of the separable costs) among the project functions. The two methods which seem most applicable to a multipurpose water project are the **remaining-benefits method** and the **alternative justifiable-expenditure method**. The application of these methods is illustrated by Table 1. The first line of the table represents the separable costs, which total $1,180,000. Since the total cost allocated is $1,765,000, the joint cost is $585,000.

Table 1. Cost Allocation for a Multipurpose Project
(All costs in thousands of dollars)

Line	Item	Flood	Power	Irrigation	Navigation	Total
1	Separable costs	380	600	150	50	1180
2	Estimated benefits	500	1500	350	100	2450
3	Alternative single purpose cost	400	1000	600	80	2080
	Remaining-benefits Method					
4	Benefits limited by alternative cost ...	400	1000	350	80	1830
5	Remaining benefits ...	20	400	200	30	650
6	Allocated joint costs ..	18	360	180	27	585
7	Total allocation:					
	Dollars ...	398	960	330	77	1765
	Per cent ...	22.6	54.6	18.7	4.4	100

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Alternative Justifiable-expenditure Method

8	Alternative cost less separable cost ...	20	400	450	30	900
9	Allocated joint costs ..	13	260	292	20	585
10	Total allocation:					
	Dollars	393	860	442	70	1765
	Per cent	22.2	48.7	25.0	4.0	100

In the remaining-benefits method, the joint cost are assumed to be distributed in accordance with the differences between the separable costs (line 1) and the estimated benefits of each function (line 2). In no case, however, are the benefits assumed to be greater than the cost of an alternative single-purpose project which would provide equivalent benefits. Thus the remaining benefits (line 5) are the differences between the lesser value of lines 2 or 3 and the separable costs in line 1. The joint costs are distributed in proportion to these remaining benefits and added to the corresponding separable costs to obtain the total allocation (line 7).

Under the alternative justifiable-expenditure method the joint costs are assumed to distributed in accordance with the differences between the separable costs and the estimated cost of a single-purpose project which would provide equivalent services and would itself be economically justifiable. These costs (line 8) are the differences between line 1 and 3. The distributed joint costs (line 9) are added to the separable costs to obtain the total allocated costs (line 10). It should be noted that a large percentage difference in the allocation of joint costs is only a moderately small percentage difference in the allocated total cost because the separable costs are normally a large part of the total. The greatest difficulty with both methods is that of estimating the benefits of alternative costs. From a practical viewpoint both methods give results which are within the probable limits of accuracy obtainable in any allocation.

In order to establish a pricing policy it is sometimes necessary to allocate costs between several classes of users. When a long pipeline is constructed, it may be proper to charge users near the head of the line less for water than is charged to users at the far end of the line. In this case the allocation is often based on the proportional use of facilities.

No single method of cost allocation can properly be described as the "best" method. For establishing prices or allocating charges to various beneficiaries, any method which is agreeable to all concerned can be considered acceptable. Because of the arbitrary nature of cost allocation, it must be viewed as an accounting device totally unrelated to the economic evaluation of a project. Cost allocated to a specific project purpose should not be compared with expected benefits to justify the inclusion of the particular purpose in the project plans. If the remaining-benefits method is used, it will automatically make each

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purpose appear to have a benefit-cost ratio in excess of one (Table 1).

14.2.2. GENERAL OUTLINE OF PROJECT REPORT

Three different types of reports are expected to appear in the process of water resources planning. They are:

1. The reconnaissance (pre-feasibility) report;
2. the feasibility report; and
3. the definite plan report.

The reconnaissance report presents the findings of the first preliminary studies of alternative water resources plans. One of the reconnaissance investigation is to determine whether or not worthwhile to conduct a more detailed investigation. If this is not the case, then that is the end of the studies. If the findings are affirmative, then the reconnaissance report should contain recommendations regarding how to proceed with a more detailed investigations: What type of data should be collected; which alternative plans should be further investigated; and what professional manpower, time and cost will likely be involved.

The feasibility report is the end of the planning process. Sufficient data has been collected; the alternative plans have been adequately studied; the socio-economic analysis has been completed; and the most desirable plan has been selected.

The definite plan report provides the basis for the construction of engineering works. The feasibility report only contained preliminary designs and cost estimates with such accuracy as was required to decide between alternative plans and to justify the selected plan. Normally such drawings are inadequate to proceed with construction. Moreover, considerable time may have elapsed between the preparation of the feasibility report and the authorization and financing of the project. Therefore, it is necessary to obtain up-to-date and complete information, and to prepare detailed design drawings, before the actual construction of the project can began.

The writer of a feasibility report must realize that the most essential requirements of the report are:

- Careful documentation of all the steps that have led to the final recommendation;

- clarity in the presentation of all material so that someone who is not familiar with the project can readily understand the trend of the thought;

- an unbiased evaluation of the reliability of the basic data, the validity of the different assumptions that had to be made, and the degree of uncertainty of the final cost and benefit figures, upon which the recommendations are based.

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In presenting the technical plans it is important not only to discuss the project selected, but also the alternatives that were rejected; and the reasons why.

The following are the detailed outline of a feasibility report for a water resources project.

1. Title Page

The cover of the report as well as the following title page should contain: the name of the project; the name of the location (Kebele, Woreda, Zone, Kilil, Country, etc.); the name of the organization for whom the report is prepared; the name of the organization who prepared the report; the name of the type of the report; and the date when the report was completed.

2. Letter of Transmittal

This is the formal presentation of the report by the person who is responsible for its preparation to the person who has authorized the study.

3. Table of Contents

Following the Letter of Transmittal should come an explicit Table of Contents of the entire report containing chapter headings, section headings, and perhaps subheadings. A well organized Table of Contents will give the reader the best possible review of how the material of the report is organized. The Table of Contents of the text should be followed by a List of Figures and List of Tables.

4. Summary

This chapter should be a brief view of the highlights of the whole report. It should begin by defining the objectives of the development plan. It should show how different components are related to each other; and what alternative plans have been investigated. It may end with a brief statement of how the financing and implementation of the project can take place.

The summary should enable any one who has no knowledge of the project familiarize himself with the most important aspects in the shortest possible time.

5. Introduction

This chapter introduces the reader the problem at hand. One should avoid making this chapter another "Summary" of the report and only discuss as why the study was carried out, what were its objectives, and how it was done. This chapter may include:

- Previous investigations that have some bearing upon the present. Findings and recommendations

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of these earlier investigations should be reviewed.

- Comprehensive statement regarding the objectives that the proposed project attempts to reach.

- Scope of the investigation reviewing the manner in which the investigation was conducted; the total amount of manpower, time and costs that were involved; the nature of field surveys; and the nature of the office studies.

- The staff that have participated in various phases and part of the study; and all assistance and help received from other organizations, and individual persons should be acknowledged.

6. General Description

This chapter gives a description of the physical and cultural setting in which the project is placed. It presents the basic data upon which the study is based. If necessary, these data may have to be analyzed and interpreted. An opinion may be expressed regarding the reliability of the data and the need for additional data. The following are some of the points that should be included in this chapter.

- Description of the pertinent geographical and geological features of the project area should be provided. Maps should be provided showing the rivers, lakes, topography, settlement areas, and geological formations that have some bearing on the water resources. The written part can be very short. The maps should be well prepared and perhaps provided with explanatory notes to enable quick familiarization.

- Data regarding rainfall and other climatic variables distribution in time should be provided. Nearly all these data should be presented in the form of convenient maps, diagrams and tables. This takes less space and easier to review.

- A comprehensive but condensed water inventory of the region, including surface and ground water availability (with its distribution in space and time) and data on water quality.

- Economic and social conditions must be taken into consideration. Pertinent data may be presented regarding income distribution, land ownership, living and working conditions, unemployment, education, social services, population growth,...etc.

7. Domestic Water Supply

This chapter deals with the supply of clean drinking water.

7.1 Water requirements: This section presents the water demand interms of quality and quantity for

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the present and the future. This demand should be shown as a function of the cost.

7.2 Alternative sources of supply: This section presents the different possibilities of supplying the quantities and quality of water, specified in the foregoing section. Plans of the required engineering works with pertinent cost estimates for various levels of supply, should be presented.

7.3 Standards of water quality: Before methods of water treatment can be determined, there should be a decision regarding the desirable level of quality. Once the tolerable water quality is set, various methods of water treatment can be considered.

8. Multi-purpose Projects

This chapter reviews to what extent various water development components (domestic water supply, irrigation, water power, flood control, recreation, fishing, etc.) may affect one another. There may be areas of conflict, such as competing use of available water supplies, or available reservoir space. These should be clearly spelled out, and principles for resolving these conflicts should be established. There may also be opportunities for sharing the same facilities.

9. Selection of Plan

In this chapter costs and benefits of different alternatives shall be established. Having considered the alternative plans from a viewpoint of economic, social welfare, etc. different views, the best plans in ranked order should be presented. One should keep in mind that political considerations or the judgement of higher authorities may alter the selection of plan.

10. Project Implementation

This chapter discusses what steps will have to be taken to bring the proposed development plan into reality. It is important that all essential elements for a balanced social and economic development are included in the proposed program, and that the time element is realistic and in accordance with the with the benefit estimates.

10.1 Time table of construction: This section presents the proposed construction schedule of the engineering works included in the development plan. The starting date of the schedule could be the authorization and financing of the project. The first activity would be the final design and the site preparation of the engineering works. The terminal date would be the testing, approval and acceptance of those works by the project authority.

10.2 Demonstration and education: A detailed and realistic plan for demonstration and education will considerably enhance the acceptance of a proposed project. It should be kept in mind that users should be able to participate in the planning, construction, operation and maintenance of the proposed project.

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11. Conclusions and Recommendations

This final chapter of the report presents first of all the factual findings of the study in a number of conclusions. These may deal with the availability of water, the feasibility and estimated cost of constructing certain engineering works, and the estimated benefits of alternative water development projects. Thereafter, this chapter presents a number of recommendations. The first one may be that a certain project be adopted for implementation. The may follow recommendations regarding financing of the project, the additional field surveys and studies that have to be made before the final designs of the engineering works can be prepared, and the measures that have to be taken to bring the project into full development at the earliest possible date.

14.3 ESSENCE OF MONITORING & EVALUATION

Monitoring and evaluation works enable to visualize the progresses made and the targets achieved including their sustainability in terms of finance, institution and environmental impact. They provide status reports with analysis on problems encountered and suggestions of solution and recommendations.

Through regular monitoring the ability of the project to meet the desired target will be checked and followed-up . It enables the benevolent to work closely with the communities and local concerned government responsible bodies involved towards the well being of the society.

Carrying out of evaluation mainly assists in the understanding of project sustainability and impact assessment. It provides the external supporting agencies a good ground to learn lessons from past activities and better plan or formulate similar projects in the future.

Monitoring and evaluation are not ends in themselves but, are basic tools to planners and implementors at community level and agencies involved in WATSAN projects achieve successful projects and programs. It, therefore, means that monitoring and evaluation assists in the provision of information for subsequent performance improvement at the project level, assessment of the outcomes of costs and providing feed backs for improving and designing future project development.

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15. SANITATION

15.1. HEALTH ASPECT OF WATER AND SANITATION

Improved community health is generally considered the major benefit of improved water supply and sanitation. As safe water is important for supporting human health it also affects human life, if contaminated by wastes or not adequately available for drinking and the use of personal hygiene. Insufficient quantities of water could result in diseases such as skin and eye ; and contaminated water causes water borne diseases, such as diarrhoea, cholera, typhoid and hepatitis.

Waste water contains human excreta, industrial wastes, which may be hazardous, and other wastes which are produced as a result of human activities and carried by water. Human excreta, which constitutes most of waste water is a critical path for the transmission and spread of communicable diseases. The most obvious route is direct, whereby playing children are in contact with faecal contaminated wastes and then places their contaminated hands in their mouths or on their food.

A less direct route occurs when vectors such as flies and cockroaches transport disease carrying agents in their intestinal tracts and subsequently contaminating food they come in contact with. In the view of the above discussion it worth to mentioned the Ethiopian situation.

About 81% of rural and 20% urban population in Ethiopia have no access to protected water sources and more than 40% have no access to sanitation facilities/latrine use. They depend on traditional water sources and open field defecation. Traditional water sources are often polluted or contaminated due to un-treated domestic and industrial waste water discharged into them as a result of inadequate waste management. This has left the health and well-being of the society at great risk.

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15.2. WATER BORNE DISEASES

Below are given some of the common water borne diseases:

1. Typhoid Fever

   a) An infectious disease characterized by fever
   b) Agent: Bacilus Typhosus
   C) Mode of transmission : through contaminated food and water by faeces

2. Dysentery

   a) Ulceration of the large intestine, characterized by pain
   b) Agent: Amoebic Dysentery and Bacillary Dysentery

c) Mode of transmission: through contaminated food and water

3. Cholera

a) A fatal disease characterized by diarrhea, vomiting, Dehydration ...etc
b) Agent Vibriochmma
c) Mode of transmission: By contaminated water.

4. Para-typhoid Fever

a) Resembles 1 above
b) Agent: Salmonella
c) Mode of transmission: by direct contact (man to man) through urine, faces ...etc and indirectly by water.

5. Infectious Hepatitis

a) An acute infection characterized by fever, nausea and abdominal discomfort, followed by Jaundice (Yellow-ness of the skin and urine)
b) Agent: Virus of Infectious Hepatitis
c) Mode of transmission: person to person contact and through unsanitary food and water ...etc.

In addition to water borne diseases, major water related diseases are mentioned below:

6. Skin Disease -) can be prevented by personal hygiene, including frequent
7. Eye Disease (Trachoma)) bathing and laundering.
8. Schistosomiasis Chemical control for avoiding the spread of snails.
9. Malaria Preventing spread of mosquitos.

15.3. HYGIENE EDUCATION

In addition to the provision of safe water supply and appropriate sanitation facilities, improving people's understanding about proper utilization of the facilities and clean environment, through proper education it is believed to supplement the maintenance of better health.

The anticipated hygiene education programme should be able to disseminate the following main issues.

- the importance of clean and safe water
- the problem of using unprotected water, not only for drinking but when using it for washing

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dishes, glasses, hands ...etc.
- the importance of clean environment - clean house, clothes, house utensils ...etc.
- the role of flies and other diseases transmission vectors
- proper disposal of wastes (the importance of use of latrines)
- the importance of avoiding flies attracting media
- the problem of open field defecation ...etc

Giving education could be done at public gatherings, schools, through radio ...etc.

15.3. ON-SITE SANITATION DESIGN AND CONSTRUCTION

Different on site sanitation facilities are available; however, the most widely accepted and used by the Ethiopian Communities are pit latrines.

Therefore, design and construction of pit latrines will be discussed below.

Design Considerations

1. Latrine location

a)	of minimum distance from dwelling (living quarter)	
	. Urban densities	6m
	. Rural "	15m
b)	from household well, water point...etc.	15m
c)	from public well	15m
d)	from spring (down hill)	15m
e)	from spring (approx. level)	15m
f)	from (up hill in homogenous soil)	50m
g)	elevation of pit bottom above the ground water table (if water is to be used for water supply)	
	. minimum	1m
	. recommended	3m

2. Minimum depth (D) of a single vertical pit — 2.5m

3. Maximum level of excreta (below ground surface) — 0.5m

4. Minimum floor elevation (above ground surface) — 0.2m

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5. The pit should not penetrate the ground water table

6. The floor must be fly tight and light impervious

7. The maximum distance from the dwelling should not discourage the latrine use at night by children or disabled person ...etc.

8. The pathway from house to latrine should be free of obstacles and as straight as possible

9. Service life for single pit (family size) is 6 - 10 years

10. Service life for Twin pit (family size) is normally 3 years

2. Pit geometry

V = effective pit capacity /volume (m3)
L = service life (years)
H' = effective pit depth (m)
H = total pit depth (m)
W = width of the pit (m)
M = Unit length of the pit (m)

Effective pit capacity for an average family of five

$V = 0.4L$

- Vertical single pit (fig 3-1)
  - Lmin = 6years
  - Lmax = 10years
  - W = 1.3m (recommended as standard)
  - M = 0.9m (recommended as standard)

$V_{min} = 0.4 \times 6 = 2.4m^3$

$V_{max} = 0.4 \times 10 = 4.0m^3$

$H' = \frac{V}{WM} \quad H = H' + 0.5$

$H_{min} = \frac{V_{min}}{W \times M} + 0.5 = \frac{2.4}{1.3 \times 0.9} + 0.5 = 2.55m \text{ ^ } 2.5m$

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$$H_{max} = \frac{V_{max}}{WxM} + 0.5 = \frac{4}{1.3 \times 0.9} + 0.5 = 3.92 \hat{} 4.m$$

In areas where the ground water table is high or where excavation is extremely difficult (as in rocky grounds ... etc.), for the construction of vertical pits, a horizontal or twin pit latrines can be used. A horizontal pit is not often recommendable to substitute the vertical although given in Figure 3-2 for educational purposes.

- Twin pit (fig 3 - 3)

. V = 0.4L V = 0.4 x 3 = 1.2m3
. L = 3 years (recommended)
. M = 0.9m (recommended)
. H' = 1.0m (recommended)

$$W_{twin} = \frac{V}{MH'} = 0.5H' = \frac{1.2}{0.9 \times 1} + 0.5 \times 1 = 1.8m3$$

$$H = H' + 0.5 = 1 + 0.5 = 1.5m$$

Construction of Pits

Affordability and preference of the community and local conditions determine the type of construction of pits. However, for this particular case , the construction of, recommended on site sanitation facilities, ie. single and twin pit latrines are based exclusively on the local skill available in rural areas of the country. Materials are also of local origin; but, some special materials and pre-cast elements could also be used.

- Wooden logs 12 to 18 cm in diameter laced together with poles stuck in the ground and stones are used for base construction of pits.

- Chika, mainly a mixture of soil and teff straw is used as a mortar and wall plaster. It can also be used for the construction of vent in places of vent pipe if pipe is not available or not affordable.

- Wooden poles can be used for wall construction

- Corrugated iron sheet, split bamboo, woven mats and screen ...etc can be used for roof construction

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- Wooden poles for gates and wooden lid for pit hole cover...etc

- Depending on the affordability, for more sophisticated construction of pit latrines the following can be used.

  . pre-cast concrete slab for base construction
  . bricks or hollow blocks for wall construction
  . corrugated iron sheet for roof construction and gates.

- The super structure floor area has to be between 1 - 2 m2

- Ventilation is necessary (the simple way in is to leave an open space between the top of the door or of side walls and the roof). Ventilation of pit plays an important role in reducing not only odor but also fly and mosquito breeding. If affordable, better ventilation is recommended to be provided through the installation of 100mm diameter PVC pipe preferably black and extending 30cm above the roof.

- Natural light should be available with the floor sufficiently shaded to discourage flies.

- the door if provided should open out-wards.

15.4 SANITATION MONITORING TECHNIQUES

Sanitation is a wide topic; however, if we restrict it to mean the use of latrines and personal hygiene the common monitoring system could be taken as make visual inspection of areas of interest within some fixed time limit based on the manpower, finance and equipment,...etc adequacy of the concerned and responsible authority.

During the visit the following main observations are of interest.

- if the latrines provided are properly used or not
- if open fields are still used for defecation or not
- personal hygiene of individuals and house holds
- visiting health service institutions such as clinics to obtain information about the causes of diseases in the area ...etc.

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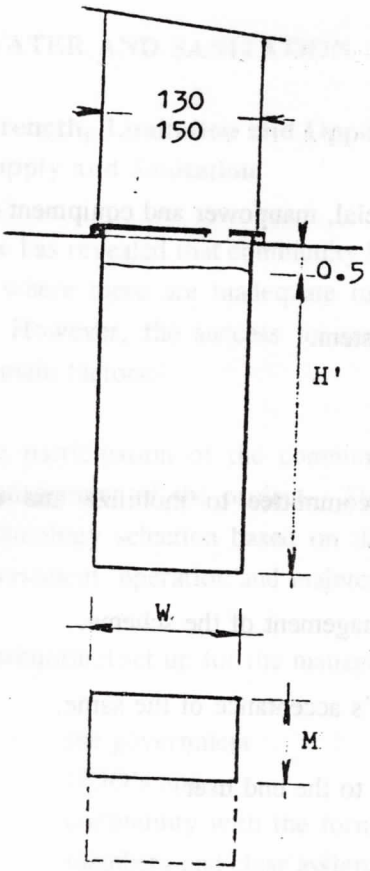


Fig. 3-1

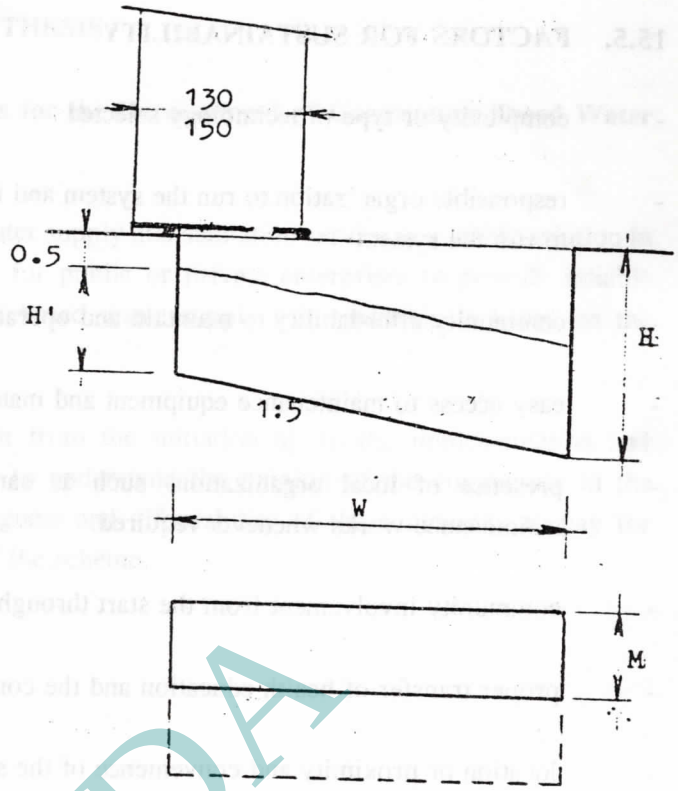


Fig. 3-2

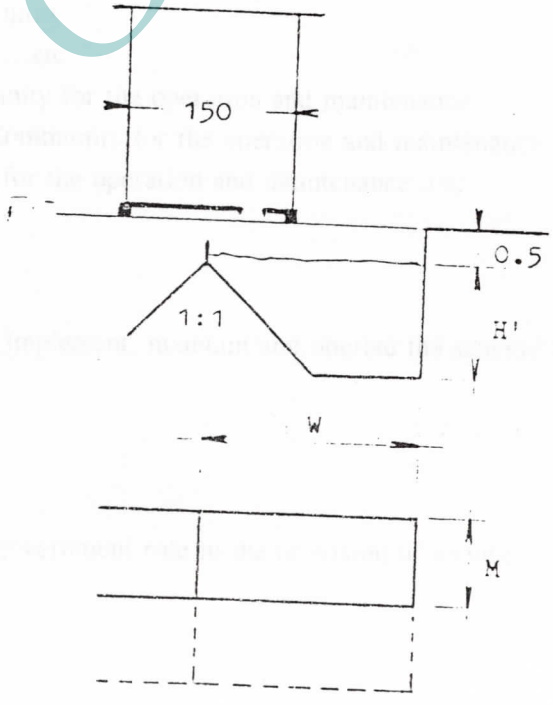


Fig. 3-3

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15.5. FACTORS FOR SUSTAINABILITY

- complexity or type of technology selected
- responsible organization to run the system and its financial, manpower and equipment capability to run the system
- community affordability to maintain and operate the system.
- easy access to maintenance equipment and material etc.
- presence of local organizations such as sanitation committee to mobilize and coordinate maintenance works whenever required.
- community involvement from the start through the management of the scheme.
- proper transfer of health education and the community's acceptance of the same.
- location or proximity and convenience of the structure to the end user.

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16. WATER AND SANITATION : A SYNTHESIS

16.1. Strength, Limitation and Opportunities for the Development of Community Based Water Supply and Sanitation

Experience has revealed that community based water supply and sanitation service is a viable solution in situations where there are inadequate incentives for public or private enterprises to provide reliable services. However, the success for community based water supply and sanitation is based on the following main factors:-

- the participation of the community right from the initiation up to the implementation and management of the project. This helps to understand the opinion of the community in the technology selection based on the willingness and affordability of the community to pay for investment, operation and maintenance of the scheme.

- Institutional set up for the management

  - the government
  - NGO's and
  - community with the formation of appropriate committees from among the community members and clear assignment of responsibilities and work relationship with government bodies and NGO's and legality of their operation.

- Financial Resource, for the investment, operation and maintenance

  - NGO's + Government + Community (Investment)
  - NGO's + Community "
  - Community only ...etc "
  - NGOs + Community for the operation and maintenance
  - Government + Community for the operation and maintenance
  - Community only for the operation and maintenance..etc

- Availability of sources

- Community skill to plan, implement, maintain and operate the scheme or only maintenance and operation

- Available Policies

  - to clearly define government role in the provision of services ...etc

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. the promotion of service giving agencies
. encouraging the development of community management
. involvement of private sector
. generation, usage and management of resources
. source area utilization and management

- Public education on safe water and sanitation
  . the effect of fetching water from traditional or protected sources on health
  . the importance of clean environment and how to make the environment clean
  . the role of flies, their causes and how to avoid them ...etc
  . importance of sanitation facilities and how best to use them.
  . keeping personal hygiene and its benefits ...etc.

- The effect of availability of traditional water sources and cost of potable water

- Availability of sufficient potable water supply

- Availability of training opportunities to up grade the community management skill in the area of :-

  . technical staff for planning, maintenance and operation
  . financial administration ...etc

The above mentioned main factors are the opportunities to be full filled for the development of community based water supply and sanitation and if these are not full-filled they are the limitations for the development of community based water supply and sanitation.

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16.2. Possible Recommendations including future direction

- Participation of the community from the initiation up to the implementation and management of the project plays a significant role in selecting appropriate technology, which the community prefers and willing to pay for investment, operation and maintenance. This inturn guarantees the sustainability of the system.

- Public Education about safe water supply and sanitation has to be given in a wide spectrum

- Appropriate sector policies have to be drawn
  . to clearly define the responsibility, coordination and cooperation or relation of government institutions, private sector and communities ...etc
  . to develop water supply and sanitation standards

. identify proper usage and management of resources ...etc.

- Depending on the understanding of the community about safe water and sanitation and their affordability, free water policy has to be changed gradually

- Understand, analyze and plan resources acquisition for all stages of the project
  . implementation, operation and maintenance
  . human skilled resources
  . finance resource and
  . equipment

- Avail training opportunities to update the community water supply and sanitation management staff skill in the area of financial management, operation and maintenance and planning and scheme administration.

- Encourage involvement of external supporting agencies in community based water supply and sanitation systems provision for some years to come.

- The government should give proper attention and allocate enough resources to the development of these basic services.

16.3 Trouble shooting mechanisms

Trouble shooting mechanisms depend on the level of detail design, availability of operation and maintenance manual and the knowledge and skill of the operator. As built drawing or a map showing the scheme including detail controlling points should be prepared. In addition to the map an operation manual which explains each component of the scheme, ie. the equipment, the pipe line, intake, reservoirs, controlling systems... etc. and possible problems and their tracing mechanisms should be prepared and well known to the operators through training.

To make it more clear an example is given below.

Assume gravity scheme of a spring source with a distribution system having four water points. If water is not available at one water point and there is flow at the other three water points, the first approach to diagnose trouble shooting is be to take the distribution map and check the condition of the pipe line between the junction point to the water point. This depends on the judgement of the operator. If water is available in the rest of the water points except one, the operator should not anticipate the problem at he source or from the distribution reservoir. He should focus on areas between the mal-functioning point and the junction. Therefore, trouble shooting mechanisms generally depends on the type of scheme complexity, available facilities and understanding of the function of the scheme by the operator.

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16.4 Project Sustainability

Sustainability of the scheme depends on so many factors, however, the followings are considered to be the main influencing factors:-

- Appropriateness of the technology selected
- Participation and willingness of the community to pay for the project implementation, operation and maintenance.
- Availability of institutional set-up to manage the project
- Availability or source of resource to manage the project
  - financial
  - human (skilled)
  - equipment etc
- Socio-economic situation of the project area
- The level of understanding of the community about the importance of the project.
- Availability of unprotected traditional sources and cost of the protected scheme
- Availability of monitoring and evaluation systems
- Impact on the environment because of service provision.
- Strength in up-grading and building of capacity and capability at the grass-root and supervisory authority levels through constant training...etc.

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