IMPROVED WATER SUPPLY OPTIONS FOR RURAL AREAS (A CASE STUDY OF APONMU VILLAGE, AKURE SOUTH LOCAL GOVERNMENT AREA, ONDO STATE, NIGERIA)

BY

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CERTIFICATION

This is to certify that this research was carried out by Akinroluyo Nelson Kehinde (CVE/98/6946) and Submitted through the Department of Civil Engineering to the School of Postgraduate Studies, Federal University of Technology, Akure, Ondo State. In partial fulfillment of the award of the degree of Master's of Engineering (M. Eng) in Civil Engineering.

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DEDICATION

This research work is dedicated to the Almighty God for His faithfulness.

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Firstly, my sincere appreciation goes to the Almighty God who has seen me through in life and who has sustained me in my academic pursuits.

I also appreciate the effort of my Supervisor, Dr. A. M. Oguntuase who made sure that this project became a reality. I thank all my lecturers, colleague, for their wonderful assistance before, during and after this programme. I also appreciate the effort of Dr. Babatola J. O. and Dr. Alatise M. O. for their kind assistance during the course of this thesis.

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ABSTRACT

Aponmu, in Akure South Local Government Area of Ondo State, Nigeria, is a typical village, which since historic times was sited near perennial springs, characteristic of most rural settlements. The water supply to the village from the State Water Corporation has stopped functioning after a new pipeline transmitting water from Owena Water Works to Akure was reconstructed along the express road cutting off the village.

Field survey of waters sources, requirements and uses were carried out at Aponmu village. The major water sources were identified as spring, hand- dug wells, rainwater and stream, which could be combined on a conjunctive use basis. This study was therefore directed towards the area of improvement of water supply that will meet all year requirements of the community in the next 10 years.

With a population growth rate of 5% in Ondo State (small areas), the design of water supply systems was projected for a 10 year. The identified spring source was found to be adequate for the water supply. A treatment plant was designed to discharge the total daily demand (265m^3/day) within the normal eight working hours. Designed parameters were evaluated from the chemical and biological analysis of the raw water samples obtained from the spring, hand dug wells and rain water. Results obtained, were compared with EEC (European Economic Commission) and WHO (World Health Organization) water quality

guidelines. The results were found to be desirable, requiring only a simple physical and chemical treatment and disinfections, using rapid sand filter, Sodium hypochlorite, and Aluminum sulphate. Analysis showed that the estimated discharge of 330m^3/day of the spring source would meet the present and future water requirement of the community (Aponmu).

The protection of the spring required the construction of a protective structure around the catchments, consisting of sandcrete block fence at the base with a height of 600mm above ground surface super imposed by wire-mesh, 1500mm high. From the topography and geographical condition of the spring, a maximum distance of 5metres from the source was recommended for the catchments tank.

The economic analysis of the project was also carried out based on the current market prices. The project was found to viable and beneficial.

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CHAPTER 1

INTRODUCTION

1.1 General Background

Water is used for a wide variety of purposes among which are domestic, industrial (including mineral extraction and processing), irrigation, hydroelectric power generation, navigation, recreation and fishery development. The extent of water use for any single purpose varies from one country to another, and is dependent on a variety of factors such as the state of economic development, standard of living, extent and level of industrial and agricultural development. This is also influenced by the efficiency of water use, socio - cultural practices etc. For example, for two industrially advanced countries namely Japan and U.S.A, industrial water use in terms of per capital per day are 4,500L to 9,600L respectively (Azit, 1983). The total agricultural and industrial water demands are somewhat similar, being approximately 40% of the total water requirements with that of US being about twice the usage of Japan. Agriculture is the largest user of water and account for nearly 80% of total consumption (Azit, 1983). In Nigeria, the above consumption figures are not easily estimated both for urban and rural water supply.

Water is a renewable resource and unlike nonrenewable resources such as oil or natural gas, there is no danger that the total world is going to run out of water, if properly managed. The major problem with water is that its distribution varies widely both with respect to time and space, and accordingly its rational management is of paramount importance for the welfare of mankind.

Unlike many other raw materials, there is no substitute for water in many of its uses. Water plays a vital role in the development of communities since a reliable supply of water is an essential prerequisite for the establishment of a permanent community. Hence, the development of water sources is to provide an ample supply of water of wholesome quantity, i.e., water free from visible suspended matter, taste and odour, excessive colour, objectionable dissolved matter, aggressive constituents and bacteria indicative of faecal pollution. For drinking water supply, the water must obviously be fit for human consumption i.e. potable, and it should also be aesthetically attractive. In addition, as far as is feasible, it should be suitable for other domestic uses.

With increasing global population, more and more water will be required for different purposes. Furthermore, current evidence indicates that water per capita requirement increases with improvements in the standard of living. It is however; extremely difficult to make meaningful projections for future global water requirement since efficiency of use is the most important consideration. The level of water consumption is on the increase with the increase in population and development of new buildings in both urban and rural communities. Without major improvement in efficiency for water use, a larger quantity will be required to sustain and improve present rate of growth in the population.

1.2 Objectives of the Study

The general objective of this research work is to develop appropriate method for harnessing the water resources within the rural community of Aponmu village, for its water supply.

The specific objectives are to:

(i) determine the water resource potential of the area and establish the possibility of using them for water supply for the community;

(ii) identify the appropriate water source that will meet the demand of the community on conjunctive use basis.

(iii) determine the quality and quantity of sourced water and use the data to design suitable storage and conveyance facilities; and

(iv) access the economic viability of the proposed water supply system.

1.3 Scope of the Project

The work was carried out in phases. Phase I involves reconnaissance survey of the existing water supply sources to the village and the design of a spring system and associated storage facilities, based on water quality data obtained from samples collected. Phase II deals with detail design of each components identified, and preparation of appropriate tender documents for experienced contractors in water works.

CHAPTER 2

LITERATURE REVIEW

2.1 Historical Background

The entire history of mankind could be written in terms of the need for water. From the very beginning, man realized that water was essential for survival, and hence early civilization flourished on lands made productive by the great rivers of Tigris and Euphrates in Mesopotamia, the Nile in Egypt, the Hindus in India, and the Huangho in China. By 3200 B.C, the Egyptians had already developed intricate water resources networks. For example, the historian Herodotus mentioned that king Menes, the first king of Egypt, dammed the Nile and diverted its course. He also mentioned that during the middle kingdom (2160 – 1788 B.C) artificial lakes were used to store and control the high flood waters of the Nile. Later, the Persians used karait systems extensively to develop their underground channel that carries water over a long distance either from a spring or from water – bearing strata. During the Roman civilization, the Romans built magnificent aqueducts to supply their capital city with millions of litres of water daily. (Resources Development Consultant, 1986).

The truly remarkable aspect of the water resource development works is that they were built on very little theoretical knowledge of hydraulics and hydrology. For example, Sextus Julius Frontinus (A.D 35 – 104), the famous Commissioner of Water Works of Rome, considered that discharge was equal to the cross- sectional area of a stream, irrespective of its velocity. The Roman Engineers were practical, and used empirical methods for construction, without much understanding of the physical principles involved. However, when we consider that not only did these structures admirably serve the purposes for which they were built but that some of them are also still in use, these are undoubtedly very remarkable achievements (Biswas, 1980)

The science of hydrology which is concerned with the management of the hydrological cycle and its water resources plays an important role in satisfying ever increasing demands for water throughout the developing world. It must therefore be appreciated that in considerations of water resources, it is essential to asses both the quality and the quantity of the source.

Having provided a suitable quality and quantity of water by development of a source and construction of treatment processes, the treated water must be delivered to the consumer via a distribution system. The transmission of water from the source up to disposal is schematically illustrated in figure 2.1 below.

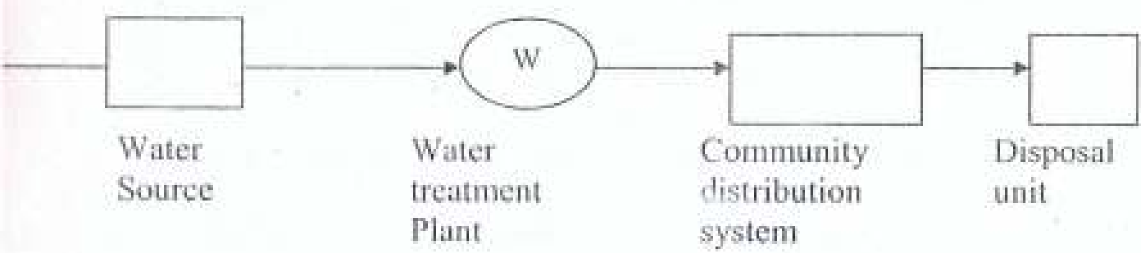


Fig. 2.1 Basic element of a water resources system.

2.2. Small Community Water Storage And Supply

When people began to establish settled communities, they nearly always chose a location near to a water source, usually a river, but sometimes a spring, well, oasis or lake. For a small population, a river is capable of supplying fresh water for drinking, cooking, washing and irrigation and at the same time removing waste from the neighbourhood. If washing was practiced downstream of the watering place, added impurities would not interfere with drinking supply but would be slowly removed by the natural purification process in the river. These time processes depend primarily on the presence of certain organisms (such as bacteria) together with a sufficient supply of dissolved oxygen. As long as there was no one in close proximity downstream who required clean water, this biological self-purification by the river was accomplished without hazard to health. With a simple water system such as this, there is often little necessity to pre-treat drinking water or to spend time and energy purifying water. Once the settlement has become well established, its water demand tended to rise and might exceed the natural supply, which must therefore be artificially augmented. This usually came through a pipe line from a large source or streams. It was important to note that as communities expanded towards one another, a town's water supply quickly become at least a part of the supply for its downstream neighbour. If the distance between the towns is insufficient for the natural processes to render the waters innocuous during the time of their journey, then the health and safety of the second town may be in jeopardy unless sufficient precautions were taken. Treatment of the water is then necessary to eliminate waterborne diseases such as typhoid, poliomyelitis, dysentery etc (Community water supply (WHO) 1987).

2.3 Water Requirement and Uses

Water is supplied to a community for many purposes, including:

(i) domestic uses;

(ii) heating;

(iii) watering lawn and garden;

(iv) sprinkling and cleaning streets;

(v) filling swimming and wading pools;

(vi) displaying in fountains and cascades;

(vii) producing hydraulic and stream power;

(viii) employment in numerous and varied industrial processes; and

(ix) protecting life and property against fire and hazardous waste from household (sewage) and industry (industrial wastewater).

Table 2.1 summarizes the quantity of the uses in hot climate. To provide for the various domestic uses, the supply of water must be satisfactory in quality and adequate in quantity, readily available to the user, relatively cheap, and easily disposed off after it had served its many purposes (Gordon and John ,1983).

Table 2.1 – Net domestic demand in hot climates

	Usage	Mean measured consumption in 63 households in a hot climate (lcd).
a	Sanitation use flushing toilets plus anal cleaning	28
b	Drinking food preparation and cooking	14
c	Dish- washing cleaning house etc.	13
d	Ablution, by showers and under running taps	58
e	Clothes washing	35
f	Miscellaneous :yard washing car cleaning, plant watering	Included above
	Total	175

Source (Twort et al; 1985)

Table 2.1 shows the proportion of the various domestic water uses.

2.3.1 Total water consumption: Total water consumption for all purposes vary widely, and there is no discernible relationship between size of population served and consumption per capita (Twort, et al: 1985). The range of total water demand is given in table 2.2

Table 2.2 **Range of total water demand**

Location	Typical total daily demand per capita (Lcpd)
(a) Small towns with little industrial demand areas with low standards of housing settlement area.	90 - 150
(b) Low standard housing and a high proportion of stand pipe supplies	70 - 90
(c) Rural areas with mainly stand pipe supplies	20 - 60

Source: Twort, et. al: (1985)

Standpipe demand depends upon the number of standpipe provided, the distance over which consumers must fetch water, the usages permitted from the standpipe and the daily hours of supply allowed. At a WHO. Conference in 1978, (Developing World Water, 1978) standpipe consumption of 20 to 60 Lcpd was reported from various parts of the world.

When water has been "consumed", the end product is simply dirty water. It is possible to remove the waste from this, resulting in relatively clean water. Water consumption therefore implies temporary removal of water from its natural (hydrological) cycle. This is the cycle in which rainwater flows down the hill in streams and river to the sea. Evaporation permits water to enter the atmosphere, condense as clouds and eventually returns as rain, thus completing the cycle.

If the total amount of water used by a population is divided by the number of people responsible for its use, then we can derive some idea of the amount of water consumed, on average, by each person (that is, per head). This is known as the per capita consumption. (Twort et al;, 1985). If this calculation is done for the total amount of water used in the home, then the domestic per capita consumption results. Figure 2.2 gives the daily consumption per capital under various categories.

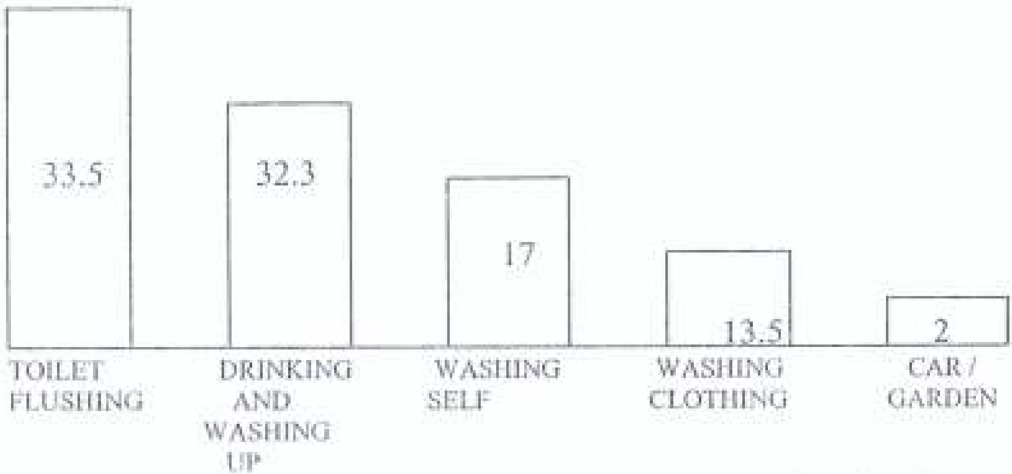


Fig. 2.2 The average daily per capita water consumption (litres)

(Source Twort, et. al: 1985.)

2.3.2 Water Demand

A person's basic physiological requirement for water is about 2.5 l/day, although work load and climate condition scan greatly increase this figure mainly because of the need to replace water lost by perspiration. As the standard of living increase so does the need for water.

In addition to the water requirement for survival, other domestic uses of water are highly desirable: e.g. for personal hygiene, washing of utensils and clothes, etc. The amount of water used for these other domestic purposes will be governed by the availability of water in the community. In a typical local village water demand of about 2.5 l/person/day has been recorded based on the total volume of water and cost of production; but as life style develop pipe water supply from longer distances increase the demand. The provision of a central standpipe supply in a community would probably increase the water demand to about 25L/person/day and the demand with an individual house tap in a low community was likely to be 50L/person/day. In developed countries and the high-valued urban housing area of developing countries, the provision of multiple taps, flush toilets, washing machines and dish washers would greatly increase water demand for domestic purposes up to several hundred litres per person per day as indicated for a country such as U.K, in Table 2.3 and Table 2.4.

Livestock also demanded a considerable amount of water in developed countries (table 2.4). This must also be considered in the total demand for a community

Table 2.3 Typical water usage in the U. K.

Use	Consumption l/d
Toilet flushing.	32
Drinking, cooking and washing	33
Baths and showers	17
Cloth washing	12
Garden watering	1
Car washing	1
Total	96

(Source: Tebbutt , 1983)

Table 2.4: Typical Agricultural water usage

Livestock	Consumption	Units
Dairy farming	150	l/cow/day
Pig farming	15	l/pig/day
Poultry farming	0.3	l/bird/day

(Source: Tebhutt, 1983)

2.3.3 Water Consumption

In modern settings, service pipes supply water to dwellings, commercial properties, industrial establishments and public buildings. Table 2.5 shows the normal water consumption in modern setting (UK).

Table 2.5 Normal water consumption in U.K.

Class of consumption	Quantity *lpcd	
	Normal range	Average
Domestic	60 - 280	230
Commercial and industrial	45 - 450	300
Public	20 - 90	45
Water unaccounted for	45 - 180	120
Total	180 - 1035	700

*lpcd = Litre per capita per day
Source (Gordon and John, 1983)

The quantities delivered in communities tend towards values shown in table 2.5 but with wide variations, because of differences in;

(1) climate;

(2) standard of living;

(3) extent of sewerage;

(4) type of mercantile;

(5) cost of water;

(6) availability of private water supply;

(7) quantity of properties of water for domestic, industrial and other usages;

(8) distribution system pressures;

(9) completeness of meterage; and

(10) system management.

Water rates are generally classified according to annual consumption per services, The domestic rate permits about 16 persons to draw water at a rate of 200 lpcd through a single service.

A breakdown of domestic water consumption according to Gordon and John (1983) is as follows:

41% to flushing toilets;

37% to washing and bathing

6% to kitchen use;

5% to drinking water;

4% to washing clothes;

3% to general household cleaning;

2% to watering the garden;

15% to washing the family car.

(Gordon, et. al; 1983)

2.3.4 Normal Variations

The smaller the community, the more variable is the demand, the shorter the period of flow, the wider is the departure from the mean. Variations are conveniently expressed as ratios to the mean. There are large differences between communities; common values are summarized in Table 2.6.

Table 2.6 Normal Variation Ratios

Ratio	Normal range	Average
Maximum day: average day	(from 1.2 to 2.0) : 1	1. 5. 1
Maximum hour: average hour	(from 2.0 to 3.0) : 1	2 . 5. 1

(Source: Gordon and John,1983)

Community water consumption takes on seasonal pattern, heavy in the "dry" season when home gardening plots are watered with occasioned high leaks, resulting in increased flows (Waterhouse, 1982).

Mean drawn off from the system by consumers varies in rate throughout a day. Tigbe, in 1967 remarked that " the daily pattern of water consumption in rural areas differs from that of urban area in the absence of any pronounced peak at mid-day. The rural peaks occur at morning and evening times". (Waterhouse, 1982).

2.4 Small Community Water Supplies in Developing Countries

In the urban centres of developing countries, community water supply systems of the t[illegible] developed in the industrialized countries can be suitable, with appropriate [illegible]ptions. In most small towns and rural communities in developing countries, the prevailing water conditions are very different from urban installations. Usually the number of people to be served by such a water supply scheme is small and the low population density makes piped distribution of the water costly. The rural population often is very low and, particularly in subsistence farming communities, little money can be raised. Funds are hardly available to pay for the operation and maintenance of the water supply scheme.

One important factor is the requirement to use a technology that is appropriate for the local conditions. This technology will differ from the conventional one which was mainly developed for the larger water supply systems of cities and towns of developed countries.

2.5 Rural Water Supply in Nigeria

In Nigeria, as much as 59.9% of the households in the rural areas depend on stream and 30.4% on private wells. In addition 2% draw their water from boreholes. The streams and private wells particularly stand the danger of being contaminated especially during the raining season and this exposes a very large proportion of the rural population to diseases which quite often reduce their effective time available for work and in turn affect their productivity. The situation is quite desperate in the riverine areas where the proportion of household that are dependant on stream even exceed 90%. For instance, in Anambra and Cross River State the percentage of households that depend on streams is Ogun 88%, Benue 80.3%, Plateau 76.7%, Niger 74.6%, Imo 72.8%, Oyo 72.9% and Kwara 71.4% ("Federal Office of Social Statistics in Nigeria,1987).

2. 6 Rural Water Consumption and Sources of Water Supply

This is made up of the quantity of water required by the populace for drinking, cooking, washing and for livestock which is usually small. The quantity of water required for domestic use in rural areas depends mainly on habits, social status and climate considerations.

Table 2.7 indicates the average domestic consumption in some selected regions/countries.

Table 2.7 Domestic consumption in some selected regions/countries.

Country	Average consumption under normal condition (lcd)
India	125
European countries	300
Zimbabwe	20
Nigeria	20 - 25

(Source: Hofkes, 1988)

2.6.1 Rain Water

Rain water is collected from roofs through roof-gutters and stored in cisterns for small individual supplies. For large community water supply, catches are prepared and the water is stored in reservoirs during the raining season for use in the period of drought. The practice of rain water harvesting is still limited to domestic collection and use in the wet season only.

In several parts of the world, rainwater catchments and storage reservation have been constructed since ancient times and have been preserved to this day. Rainwater is harvested as it runs off roof, or over natural ground, roads, yards, or specially prepared catchment areas. Historical sources mention the use of rainwater for domestic water supply some 4000 years go in the Mediterranean region. Roman villages and cities were planned to take advantage of rainwater for drinking water supply. In many countries in Europe and Asia, rainwater harvesting was used widely for provision of drinking water, particularly in rural areas.

On some tropical islands, rainwater continues to be the only source of domestic water supply. In arid and semi – arid areas where people mostly live in scattered or nomadic settlements, rainwater harvesting can be a necessary means of providing water for domestic purposes. This is especially the case where ground water resources are unavailable or costly to develop. In developing countries, rainwater is sometimes used to supplement the piped water supply. (Hofkes, 1988).

2.6.2 Surface Water

The surface water in rural communities exist in different forms as dictated by their various sources. It can come from natural ponds and lakes of sufficient size by continuous draft. Water is obtained from stream with low dry weather flows but sufficient annual discharge by continuous draft through storage or necessary flow in excess of daily use in one or more reservoirs impounded by dams constructed across the stream valleys. Surface water is generally contaminated and polluted during the wet season. It is seasonal inflow and usually located far from the rural communities. The cost of treatment, conveyance as well as the aforementioned limiting factors militate against the use of surface water as source for the rural community. (Hofkes, 1988).

2.6.3 Ground Water

Ground water comes from various outlets including

i) Wells;

ii) Infiltration galleries, basins or cribs

iii) Spring with flows augmented from some other sources:

(a) spread on the surface of the gathering ground

(b) carried into changing basins or ditches or

(c) led into diffusion galleries or wells.

Water fit for drinking exist in the ground in some form at some depth nearly every where on earth. Even the Sahara desert is underlain by water. Water comes into the soil as the infiltrated part of the rainwater that falls on the earth surface. The proportion of water that sinks into the ground varies with the character of the soil. If the soil is dry and porous, large amount will seep in. If sudden downpour fall on a slopping surface of less permeable soil, most of the rainwater will run off and be lost to the nearby strem.

The ground water itself, occurs in pores and voids in the ground materials. Ground water is stored inside the aquifer which may be hundreds of meters thick and lie just under the surface or hundreds of meters down. Water is conveyed to the earth surface by digging through the aquifer either by means of hand tools or bore hole equipment. (Hofkes, 1988).

2.6.4 Spring Water Development

Springs are found mainly in mountains or hilly terrain. A spring may be defined as a place where a natural outflow of groundwater occurs.

Spring water is usually fed from a sand or gravel water bearing ground formation (aquifer), or a water flow through fissured rock. Where solid or clay layers block the underground flow of water, it is forced upward and can come to the surface. The water may emerge either in the open as a spring, or invisibly as an outflow into a river, stream, lake or the sea. Where the water emerges in the form of a spring, the water can easily be tapped. The oldest community water supplies were, in fact, often based on spring. (Hofkes, 1988).

In catching the spring water, pollution must be prevented. In some cases, it may be possible to catch the water directly at source without allowing it to run on the surface .In most cases, due to the nature of the spring source and the terrain, the spring water can be caught without damage to the environment only after it has moved some distance away from the source. As a result of this contact with the surface in the small reach, the spring water which had been naturally filtered by the layers of the rock and soil gets contaminated. Other sources of contamination include exposure to surface run-off, biological interaction with the spring water source, and the geological conditions at the spring source.

There is an observed positive correction between the distance from spring source and the degree of spring water pollution. The longer the spring water stays on the surface the greater the tendency to interact with surface contaminants such as decayed leaves, bacteria, etc. In order to forestall pollution, the spring catchments should be as close to the spring source as possible. However, this should not be too close so as not to tamper in anyway with the natural hydrological conditions at the source which may disrupt the spring's natural flow rate. A minimum distance of about 5 metres from the spring source is recommended for the catchment tank. The actual distance, however, depends on the geological conditions of site.

The spring water usually flows along valleys, which also receives direct rainfall and surface run-off. A temporary but heavy pollution of the flowing water, as well as erosion of the channel, occurs at this time. Not only does such erosion damage the channel, it is also capable of altering the natural flow equilibrium.

The proposed solution according to Hofkes 1998 to this problem is to construct a protective structure around the spring catchment. (Hofkes, 1998).

2.7 Water Quality Consideration

Rain water, highland stream water and some ground water are generally good in quality, requiring little or no treatment. Water from village ponds, lowland stream and some underground sources may contain a variety of impurities which must be removed to make the water acceptable. The water into ponds and streams, which have passed through inhabited places is often contaminated by human and animal waste and may contain disease- causing organisms.

Surface water as compared with others usually has turbidity which may be in excess of the acceptable limits. Treatment plants are required for surface water from rivers, ponds and lake, and they can reduce the turbidity, which ranges from few µTvs in dry session. to few hundreds of µTvs in rainy season. The turbidity is mostly inorganic and its removal, which are of the main functions of many treatment plants, is achieved through chemical precipitation processes and sand filter operations. Algae might contribute to the presence of turbidity especially during the dry session, since they flourish in waters of low turbidity and high mineral contents when exposed to light. In water treatment plants, algae are recognized for the odour and taste problems, and caused clogging of sand filters. Also, algae often contribute large quantity of organic materials to the water, which changes the pH, alkalinity, colour and turbidity. (Twort, et, al. 1985).

CHAPTER 3

METHODOLOGY

3.1 Description of the Study Area

3.1.1 Location

Aponmu is a rural community in Akure South Local Government Area of Ondo State (figures 3.1 - 3.3). It is a farm settlement located along Akure - Ondo road, about 12kms south of Akure town. It is located between Latitude 7^0 20'Nand 7^0 24'N and Longitude 5^0 12'E and 5^0 14'E.

3.1.2 Climate

The climate is characterized by two distinct seasons- the dry season of about 5 months, from November to March and rainy season of about 7 months from April to October it has a mean total annual rainfall of approximately 2386mm, and mean daily minimum temperature of about 24.5°C. The relative humidity in the community varies from 60% in January to about 70% in July. (Appendix D).

3.1.3 Vegetation

Aponmu area has very thick vegetation with big tall and tap rooted trees particularly where deforestation has not taken place. The perennial river valleys and ngs are easily identifiable with their luxuriant evergreen thick vegetations that remain green throughout the wet and dry seasons.

3.1.4 Geological Setting of the Study Site (Aponmu)

From previous studies(Odeyemi and Okunfarasin, 1997) the study site is underlain by the magmatite Genesis complex rocks of pre Cambrian age. The rocks are composed of two parts: a mefic melanocratic and gneissic paleosomatic portion, made up essentially of blotted, hornblende and opaque are; and a leucocratic, felsic, neosomatic portion which is largely quartzofeldpathic. The melanocratic is characterized by a biotite-hormblende assemblage with biotite impacting a typical lepidoblastic schistosity on the rock.

3.1.5 Existing Water Supply

The main water supply in Aponmu community is from Aponmu Stream. The stream which is located 500m away from the community is seasonal in flow. It is highly polluted by man and animal. Another source of water for the community is the Omifunfun Spring. It is observed to be highly productive being a perennial spring. However, it is not protected from contamination by man and animal. Survey showed that it has a greater potential of serving the entire community if properly developed and managed.

3.2 Field Work

A reconnaissance field survey of the existing source of water supply for the village and the physical facilities for harnessing them was carried out by administering suitable questionnaires to the villagers. Water consumption pattern and other pertinent information were obtained and analyzed.

Evaluation of the present and the projected population of the village were estimated from the 1991 census figure. The population was, used to evaluate the future water demand.

Spot levels were taken for the village to determine the general topography and the slopiest of the route from the spring – source of water to be developed, to the village and the location of the storage tank.

3.3 Water Quality Sampling and Laboratory Analysis

Water samples were collected at various sources during dry and rainy sessions. The tests for water quality which were centred on chemical and microbiological analysis were determined at FUTA laboratories. The water sampling and analysis were conducted according to a recognised procedure e.g APHA and AWWA (1980).

3.4 System Design and Cost Estimation

Based on the data obtained, a water supply system consisting of source, transmission, and storage was designed. Cost estimates of the designed facilities were obtained to evaluate the economic feasibility of the system.

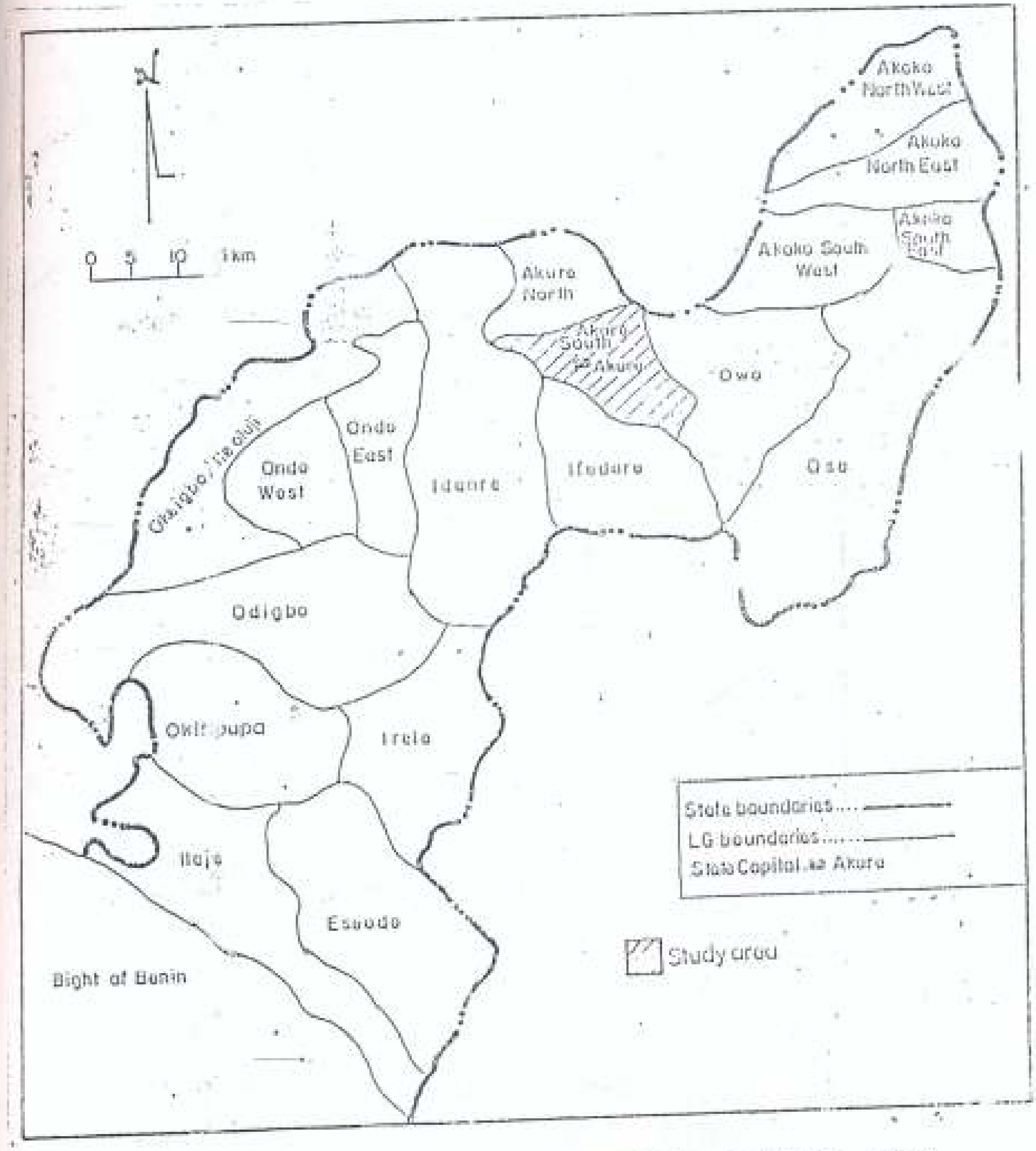
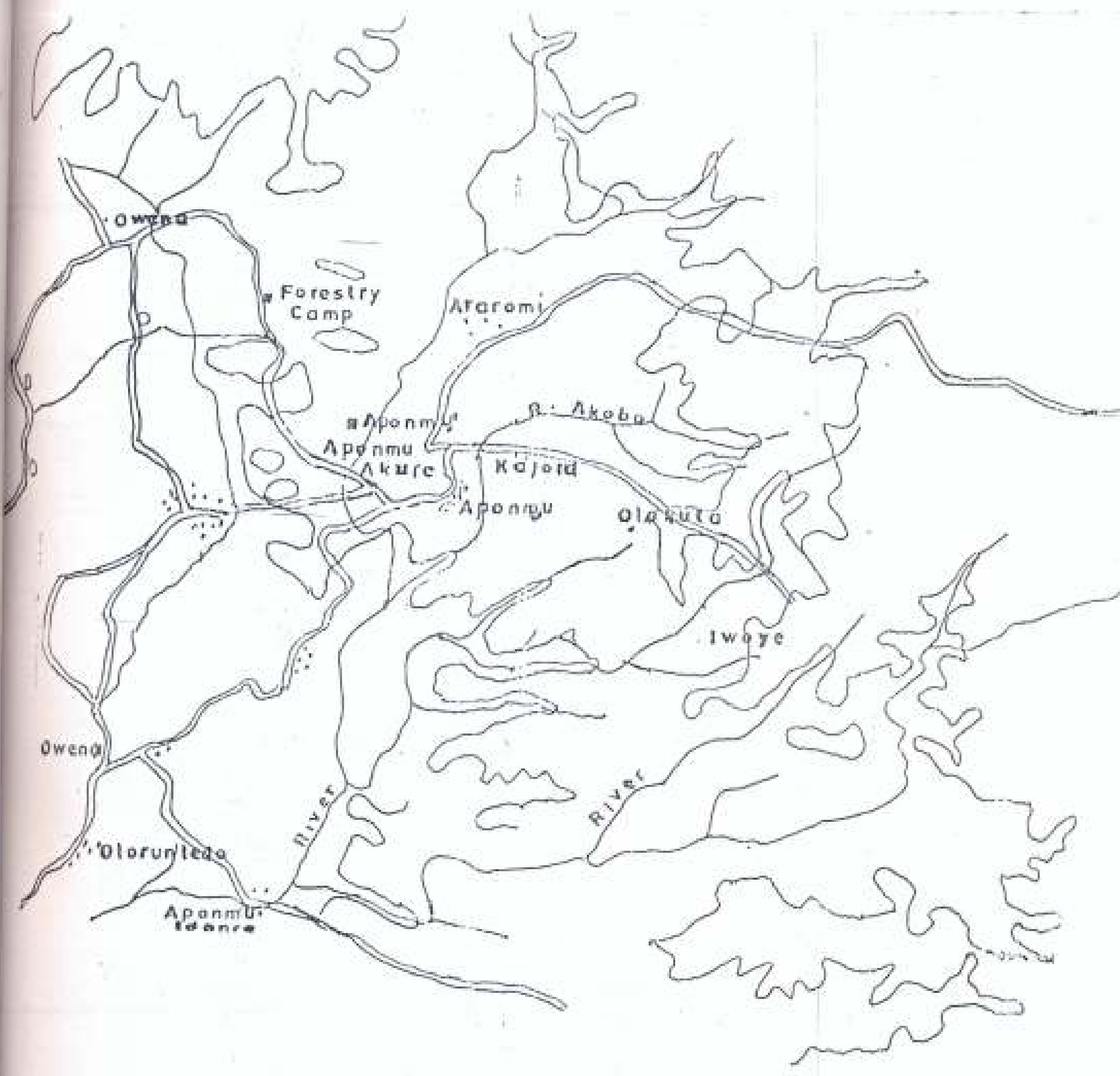
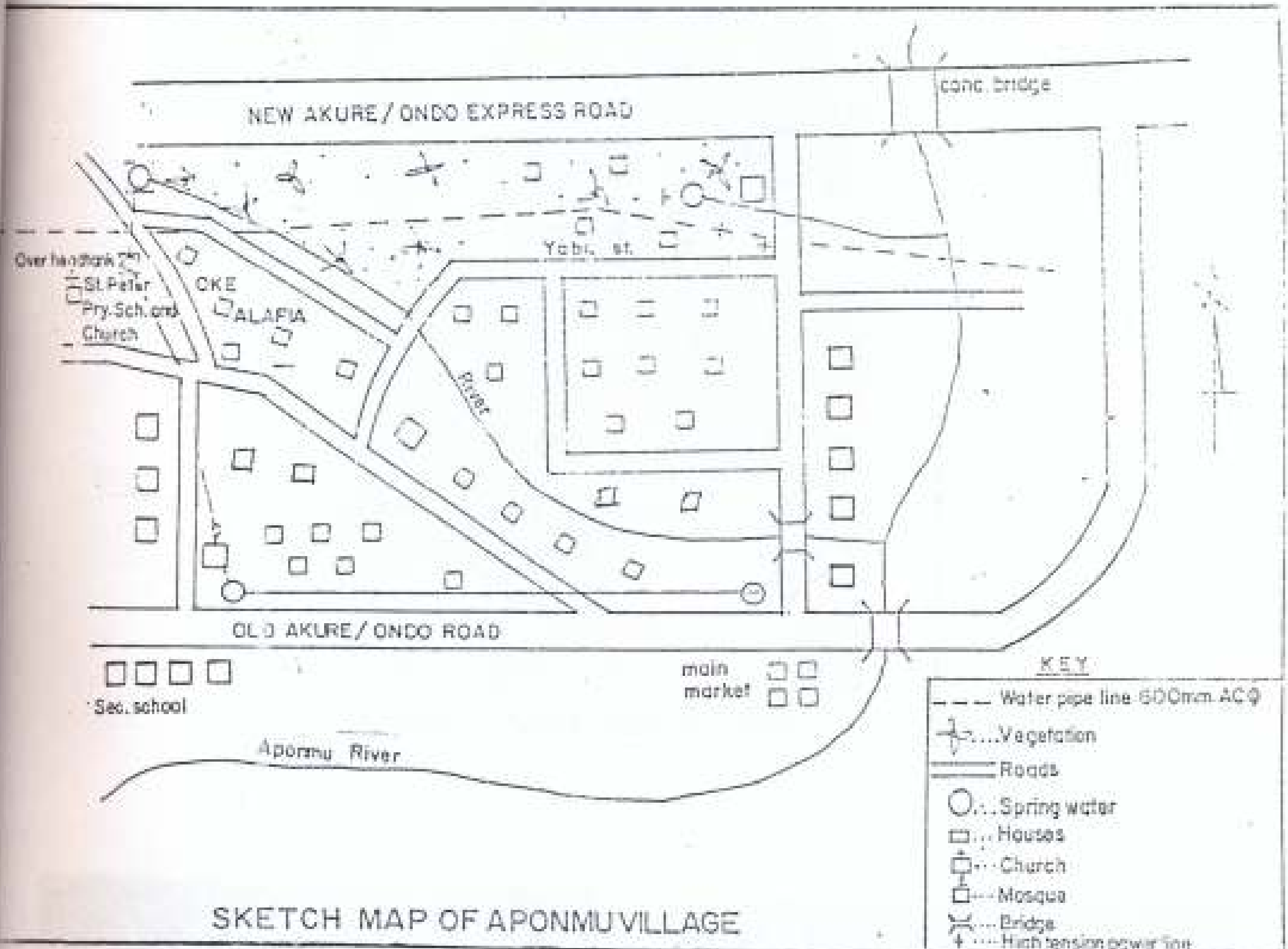


FIG 3·1 MAP OF ONDO STATE SHOWIMG VILAGE AND LOCAL GOVERVERNMENT AREA UNDER STUDY



E FIG. 3.2 MAP OF AKURE LOCAL GOVERNMENT SHOWING THE VILLAGE UNDER STUDY



SKETCH MAP OF APONMU VILLAGE

Plate 1: Typical Hand Dug Well

Plate 2: Roof Structure/Storage

Plate 3: Omifunfun Spring Source

Fig. 3.4 : The Village Setting at Aponmu.

CHAPTER 4

ASSESSMENT OF VARIOUS SOURCES OF WATER AND DESIGN PROCEDURE

4.1 Rainfall Assessment and Harvesting

The 15-year monthly data of rainfall gives a mean annual value of 2,386mm Appendix D. Rainfall is highly seasonal with well-marked wet and dry seasons.

The comparative seasonal use of water as shown in Appendix C shows that water supply situation is not critical during raining season. Results from the questionnaires (Appendix C) indicate the amount of water used per household per day during raining season as 150 litres for more than 55% of the population. Due to abundance of water in the rainy season, the household uses more water than in the dry season.

The average area of a roof in the village is $102.5m^2$, for mean annual rainfall of 2,386mm, expected volume from each roof is 2.45×10^5L per year.(Appendix C) The catchments from the roofs are not well developed, and there are no storage facilitic : for the rain water, hence most of it is lost as surface runoff.

4.2 Assessing Water from Hand Dug Wells

Fr m the questionnaire carried out in the village, less than 30% of the houses have hand dug wells. In this village, the depth of the hand dug wells ranges from 3m to 6.5m. The wells have more yields during rain season and much less in the dry season. Most of them are dry in the critical part of the season. Measurement shows that in the dry season water, column in shallow well ranges from 0 to 0.9m. At an average depth of 0.45m the volume of water available in a 1m diameter well is

$0.353m^3$. This is to be shared daily by 16 houses each with an average of 8 people. In the rainy season, the shallow well water column is approximately 1.5m yielding $18.85m^3$ of water for the same number of people. For deep wells with a column of 6.5m, the yield is $81.68m^3$.

From the above, the daily amount of water available for the village ranges form 2 litres per capita in the dry season to less than 40 litres per capita in the rainy season. These values underscore the fact that well water is grossly inadequate for the people in Aponmu village.

4.3 Spring and Protective Structure

Omifunfun spring has been the main source of potable water supply in the village, although this spring has not been properly harnessed. The spring is perennial in nature. The yield from this spring is $330m^3$ /day (see Appendix F). This yield is sufficient to serve the projected population of the village if properly harnessed.

Based on this finding, the spring water therefore recommended for development as the main source of water to the village. Although the rate of discharge of most springs fluctuates according to the infiltration replenishment, the yield from the springs compare favourably with those of bore holes which are more expensive to develop.

The plan view of the protected spring is shown in Figure 4.1 This structure is made of concrete block fence at the base, with a height of 60cm above the ground surface. Care must be taken to ensure that in the process of digging, the foundation for the fence is sufficiently large to prevent the intersection of the foundation with the subsurface fractures through which the spring water flows. On top of this block fence

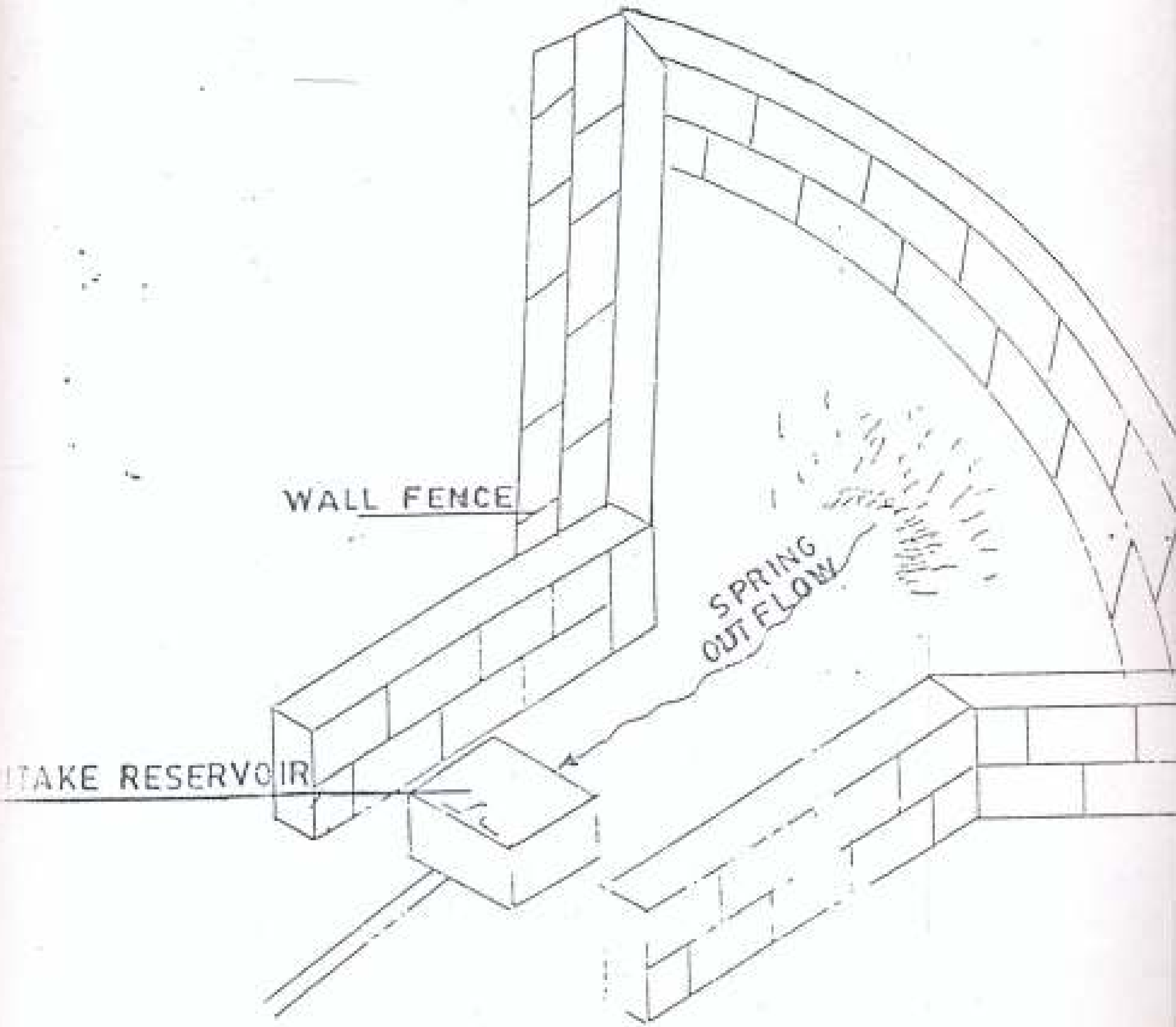


FIG 4.1 PROTECTION TO THE SPRING SOURCE

should be another fence layer made of wire gauze, with a height of 150cm. The entire structure should be roofed with zinc metal sheet or bamboo to prevent dead leaves and direct precipitation from falling into the channel.

The function of the wire gauze is to:

(i) allow illumination and adequate ventilation for the spring catchment, and

(ii) prevent man and other animals from direct access to the spring source.

4.4 Daily Water Requirement Estimates

The estimate of daily water requirement is based on actual data collected from Aponmu. One household consists of an average of 8 people, and uses 150 litres of water per day during rainy season when enough water is available. Per capital daily requirement is thus 18.75litres or approximately 20 litres. The amount is used for domestic purposes, washing cars, motor cycles and cleansing. This is far too small compared with the recommended 150 litres per capita per day (lcpd) by WHO standard

Water for livestock is estimated based on the fact that most of the livestock in the village are left loose i.e., open rearing. Hence their water need is based on table 4.4. The total water required for livestock is 310 litres per day ($0.3m^3/d$).

Table 4.4 Water for livestocks (litres per day including drinking and minor washing)

Species	Requirement (lda) Litre / day / animal (Source Water house 1982)	Number of animals (from Questionnaire)	Water demand (lcd)
Poultry	0.6	100	60
Piggery	10	10	100
Rabbittry	1.0	50	50
Goats and sheep	5	20	100

Total water required = 310 litres per day (l/d)

In the agricultural setting, water is required for the various farm crops such as yams, cocoa yam, cassava and vegetables. From the questionnaire, estimate of the requirement is 250 litres per day. Since in any water supply scheme, losses of water cannot be totally eliminated, but can be reduced, hence the total allowed losses is assumed to be 5 litres per capita per day.

In the rural areas, without any factories or industries, occurrence of major fires is very rare. It may be unrealistic in this case to include fire service a major water user. however for emergency, a small amount of 1,250l/d is allowed for fire services.

4.5 Water Demand Projection

The annual population growth rate for the rural areas of Ondo State is given as 5% (Olayide 1986). The population in 10 years will have increased by a factor of $(1.05)^{10} = 1.63$, in order words, by about 63%. So for a design lifetime of 10 years, the population will be equal to 1488 x 1.63 = 2,425; Say 2,500 people.

Hence for a population of 2,500, the net domestic water demand is

= 20 x 2500 + 5 x 2500 + 310 + 250 + 1,250

= 64,310 litres / day

= 64.310m^3/day, or approximately 65m^3 /day

Therefore, the total water demand, Q for Aponmu Village is 65m^3/day

The discharge from the spring is 330.912m^3/day which is adequate for the village. Hence the Omifunfun spring is suitable as main source of water supply to Aponmu village.

There has been a plan by the Ondo State Government to establish two beverage processing factories near Aponmu village. In view of this, it is economical to source much of the available water from the spring since only 20% of the estimated amount is actually needed for domestic purposes.

From the constant supply 80% of the spring can be abstracted for treatment that is 265m^3/day out which 200m^3/day is earmarked for the industrial use. The other 20% is allowed for watershed runoff for ecological purposes.

4.6 Design of Intake Reservoir

The required amount of water is to be treated within an 8-hr working day. The 265m^3 volume must be abstracted at a rate of 33.13m^3/hr or 9.2 L/s, from a spring supply of 330m^3.day or 13.75m^3/hr flowing continuously. Hence an intake reservoir is required.

A simple fluid balance as shown in fig. 4.6 indicates that difference of 19.375m^3/hr must be augmented from the intake reservoir in the 8hr pumping period.

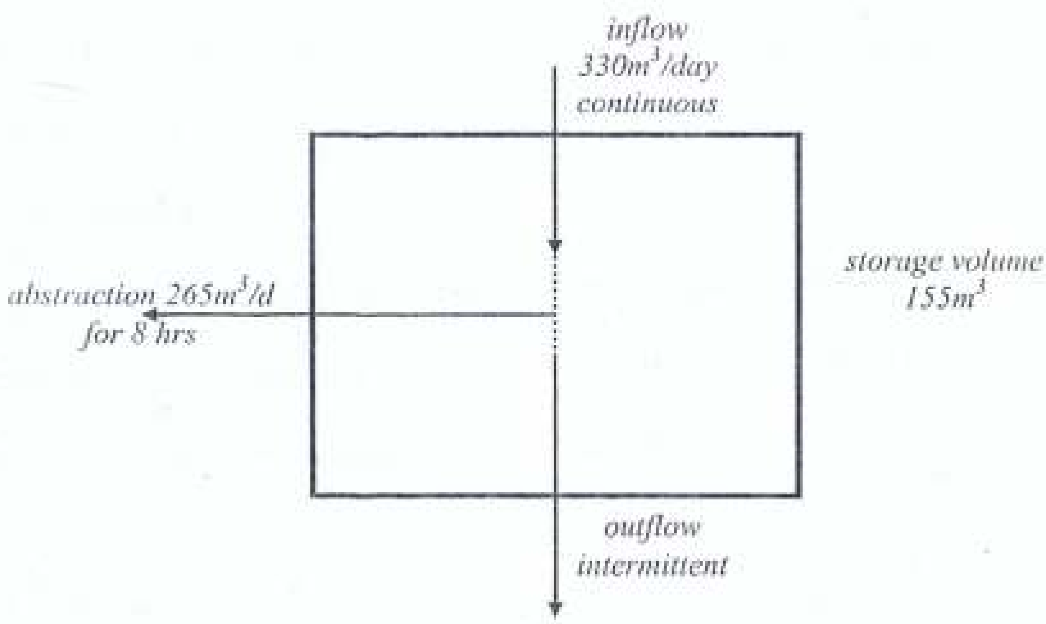


Fig. 4.6: Flow balance for intake reservoir

A tank of 155m^3 is required together with the abstraction appurtenances. An optimal dimension of: 8.5m (length) x 2.5m (depth) x 7.5m (width) is suggested.

4.7 Pumping: Low – Lift Pump

Allowing for an internal diameter of 120mm for the suction pipe, the velocity of water at the intake is ≈0.81m/s. The Hazei – Williams formula is used to calculated the head losses on the suction and also on delivery sides (see appendix H). The head loss in the suction sides and bends is 0.043m while the loss and the delivery is 0.52m.

Considering also other losses (gate valve, tee's and elbows to raise the water to a maximum height of 10m, a total head (gross lift) of 12.25m must be supplied by the lift pumps. Two low lift pumps of which one will serve as standby are to be provided.

4.8 Design of Treatment Plant

A simple treatment plant, affordable by the community is recommended for the spring water. The process consists of coagulation, filtration and disinfection prior to distribution.

4.8.1 Coagulation

A separate chamber within part of the intake reservoir is to be used for coagulation, using aluminium sulphate $(Al_2SO_4)3.14H20$ or Alum containing 20% Al_2O_3. The required dosage required is 0.265kg/day.

4.8.2 Filtration

Two filter beds of (2m x 3m x 3m) were designed to filter the quantity (33.13m3/h) of water required for the community using Rand sand filter. The filter bed is to be backwashed for 10min once in a month. Detailed designed of the filter bed are in Appendix H.

4.8.3 Disinfection

From the water quality analysis, the water requires simple disinfection to guide against bacterial contamination and any future sudden pollution. Calcium hypochloride (H.T.H) containing 70% of chlorine and 4% lime is to be sued as disinfc ant. The dosage required is 0.53kg/day.

4.9 torage and Service Reservoir

storage capacity for two days use was designed for, to take care of breakdown in the upstream system, and any other emergency. A storage volume of $530m^3$ requires a reinforced concrete tank of 14mn (length), 14m (width) and 3m (depth). A manhole (0.8m x 0.6m) is to be provided on top of the storage reservoir for general maintenance and where chemicals can be dosed manually (Appendix H)

A storage capacity for 2 days use is designed to take care of breakdown in the system and other emergency. A storage volume of 530m3 requires a tank of (12.5m x 12.5m x 3.5m). (Appendix H).

4.10 High – Lift Pump

Hazen – Williams formula was used to calculate the head losses in the suction and delivery side of the pump to be 0.035m and 6.774m respectively to raise the water to a maximum height of 50m. A total head (gross lift) of 66.82m must be supplied by the lift pump. Hence, two lift pump (12kw each) of which one is a standby are to be provided (Appendix H).

4.11 The Distribution system

The distribution pipes were designed based on the topography survey carried out to determine the size of various pipes as shown in Appendix H.

4.12 Summary of Design Parameters

The Design Parameter, discussed above, are summarized in table 4.13.

Table 4.13: Design Parameters

Parameter	Value
Population	2500 people
Design period	10 years
Total water requirement	265m3/day
Design flow rate	9.2 x 10-3/s
Intake reservoir	8.5m x 7.5m x 2.5m
Low lift pump	4.5kw (two numbers, one as standby)
Rapid sand filter	two filter beds (1m x 1m)
Backwashing, quantity of water needed for backwashing disinfections	1.36m3/minute
Calcium hypochloride (H.T.H)	0.53kg/day
Coagulant: Aluminium sulphate alum containing 20% Al_2O_3	0.27kg/day
Storage reservoir	14m x 14m x 3m
High – lift pump	12kw (two numbers, one as standby)
Service Reservoir	12.5m x 12.5 x 3.5m

CHAPTER 5

ECONOMIC ANALYSIS

5.1 Current Cost of Materials

The market cost survey, was carried out in the month of November, 2003, to determine the current prices of materials for the water scheme.

The range of life of components in a water supply scheme for purposes of depreciations is given in Table 5.1, which can be applied to the local conditions in Nigeria, in the absence of any current data.

Table 5.1: Range of life for water supply scheme components

	Range	Allowable	Depreciation
	(year)	(year)	% (year)
Permanent building	40 – 60	50	2
Water reservoirs	20 – 40	30	$3^1/_2$
Pump and associated Machinery	15 – 25	20	5
Water mains up to 300m diameter	25 – 35	30	$3^1/_2$

(Source: Waterhouse, 1982)

Table 5.2 provides The Cost of Materials used in the evaluation of the proposed water supply scheme.

Table 5.2: Current costs of the materials for the proposed water scheme

(a) Prices for intake to service reservoir

Type	Diameter (mm)	Total length (m)	Unit length (m)	Cost of unit length (m)	Number of unit pipe required	Total cost (₦)
Intake to service-Reservoir	102	195	6.1	2,500	32	80,000
	60	6.0	6.1	650	1	650
	100	310	6.1	2,500	51	127,500

(b) Main Trunk Pipes

BA	80	150	6.1	1,800	25	45,000
AB	75	150	6.1	1,800	25	45,000
BC	65	150	6.1	1,500	25	37,500
CD	40	150	6.1	1,200	25	30,000
AA_1	56	300	6.1	1200	50	60,000
AA_2	45	300	6.1	1200	50	60,000
BB_1	40	300	6.1	1200	50	60,000
BB_2	32	300	6.1	1000	50	50,000
CC_1	60	300	6.1	1500	50	75,000
DD_1	32	300	6.1	1000	50	50,000
DD_2	25	300	6.1	800	50	40,000
					Total	**760,650**

(c) Galvanized (Pipe Fitting)

TYPE	DIAMETER (mm)	NUMBER REQUIRED	UNIT COST (₦)	TOTAL COST (₦)
Elbows	120	8	150	2000
90^0	60	4	100	400
	100	4	150	600
REDUCERS	$^{60}/_{120} = 0.5$	2	50	100
AA1/AB	$^{56}/_{80} = 0.7$	1	50	50
BB_1/AB	$^{40}/_{75} = 0.5$	1	50	50
CC_1/BC	$^{60}/_{65} = 0.9$	1	50	50
DD_1/CD	$^{32}/_{40} = 0.8$	1	50	50
TOTAL				3,300

(d) ʼontrol Valves

TYPE	DIAMETER (mm)	NUMBER REQUIRED	UNIT COST (₦)	TOTAL COST (₦)
GATEVALUE (BRASS)	120 100	7 4	250 250	1750 1000
			TOTAL	**2750**

(e) Pump

TYPE	No of pumps required	Power required kw	Electrical unit cost 3- phase (kwh)	Working hours (hrs)	Unit cost of pump (₦)	Total cost of pump (₦)	Total Energy cost N/year	Total cost (₦)
Low lift	2	4.5	50	98	50,000	100,000	75,000	225,000
High lift	2	11	50	8	75,000	150,000	250,000	475,000
Back wash	1	4.5	50	1	50,000	50,000	1750	101,750
				Total	175,000	300,000	326,750	801,750

(f) Chemicals

Type	Wt/kg	Amount needed/ day kg/day	Cost N/ bag	No of bags Required per year	Total cost N (year)
H.T.H	50kg	1.2	850	440	374,000
Alum	50kg	0.6	500	219	109,500
				Total	**483,500**

5.2 Initial Investment and Operation

Table 5.3 is a summary of the initial investment required to get the rural water supply into commission.

Initial Investment Items	N
Structure construction & Installation	1,500,000
Treatment plants (2 filter beds)	100,000
Pumps	300,000
Electri : cost	362,750
Pipe fittings	3,300
Gate values	2,700
Pipes	760,059
Total	**2,991,570**

At a current interest of 20%, this amount can be armotized to ₦3,589,884 for operation, the salaries for the personnel for the project is summarized in Table 5.4 while table 5.5 provides the estimate of annual expenditure.

Table 5.4: Salaries

Type	Duration of working (hrs)	Daily pay (₦)	Amount needed per year (₦)
1 (skilled worker)	8	450	162,000
1 semi- killed	8	350	126,000
1 watch night	12	200	72,000
		Total	**360.000**

Table 5.5: Annual expenditure (Working Capital per annum)

Items	₦
Chemicals	483,000
Maintenance (allow 2% of initial investment)	59,831.40
Salary	360,000
Energy (Electricity)	372,000
Total	**1,274,831.40**

The total annual cost of the scheme is ₦4266401.40 which has to be borne by the community. For a population of 2500, per capital annual lost is ₦1,800. This appears to be reasonable and affordable by the government for provision of save drinking water and indirectly, adequate sanitation for the rural populace.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Aponmu village, the study area has access to four main source of water supply – rainwater, stream, hand dug well and spring. The prominent water sources are the first three, and are seasonal, hence the need to harness properly the available spring in the village. Determination of water requirements and consumption patterns were based on reconnaissance field survey and questionnaire served in the village.

The study area has an initial population of 1488 which was projected to be 2500 in the next 10 years for planning and design purposes

The study showed that most of the rainfall during the rainy season ended up as runoff directly to the Aponmu river. Good rain harvesting facilities are not in existence in the village. The study also revealed that most of the hand dug wells were shallow with depth less than 6.7m. They were predominantly seasonal with scanty water during the dry season when the water table is low.

The total water requirement of the village was $65m^3$/day and could be from the estimated discharge of $331m^3$/day of the spring which was perennial. The spring was thus identified as the best option of water supply to Aponmu village. The quality of the spring water was such that it required a simple treatment plant for portability to meet the WHO standard.

Based on the current market prices of materials, the capital investment needed to start the project is approximately 3.6 million while the actual operation and maintained cost is estimated to be approximately 1.29 million.

Economic analysis shows that the project is viable and beneficial to the community. It is not necessary to rely on the long distance water supply from the state water corporation, which has hitterto proved unreliable.

The protective measures recommended around the spring source would prevent pollution from human and animal activities.

6.2 Recommendations

Based on the findings of this study, the following policy recommendation are suggested:

a) A well protective structure should be constructed around the spring catchments to prevent animal and human intruders and other sources of pollutants into the spring.

b) Bi – monthly water quality analysis should be carried out, in order to detect any water pollution, both at the source and the consumer's outlets.

c) Adequate maintenance would be required for the village water supply scheme to be sustainable.

d) Selection of high quality materials, such as UDVC pressure pipes is important to prevent rusting, pipe burst and water leakage.

e) The State Water Corporation should be encouraged to assist the community in the development of the spring water, construct the reservoirs, treatment plants and service pipelines and arrange for the community to participate in paying water rates to maintain the scheme.

f) For future conjunctive use of all the water resources in the village, the method of harnessing rain water should be improved to last into the early part of the dry season.

The roof gutters should be designed to facilitate collection of rain water into a central storage reservoir for future use. Well owners should be encouraged to line their hand dug wells with concrete rings as against the present arrangement whereby most of the wells just have block walls built around them at the ground level.

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Table 14 Minor losses in pipelines.

(a) Enlargements
(values of k_L in $k_L = K_L \frac{(v_1 - V_2)^2}{2_1}$

∅	$\frac{D_2}{D_1} = 3$	$\frac{D_2}{D_1} = 1.5$
10	0.17	0.17
20	0.40	0.40
45	0.86	1.06
60	1.02	1.21
90	1.06	1.14
120	1.04	1.07
180	1.00	1.00

- The angle ∅ is the angle in degrees between the side of the tapering section

(b) Abrupt contraction
(values of k_L in $h_L = kL^{v}{}_{2g}$)

$\frac{D_2}{D_1}$	k_L
0	05
0.4	0.4
0.6	0.3
0.8	0.2
1.0	0.1

pipe entrance from reserve

Bellmouth $hl = 0.04\frac{V2}{2g}$

Square edge $hl = 0.5\frac{V2}{2g}$

(d) Benus

(values of K_L in $h_L = K_L\ ^{V2}/_{2g}$, the head loss in excess of that in a straight pipe of equal length)

Radius of bend	Deletion angle of bend		
Pipe diameter	90^0	45^0	22.5^0
1	0.50	0.37	0.25
2	0.30	0.22	0.15
4	0.25	0.19	0.12
6	0.15	0.11	0.08
8	0.15	0.11	0.08

(e) values and fittings

(value of K_L in $h_L = \frac{K_L V^2}{2g}$

Globe valve (wide open)	10
Swing chucki valve (wide open)	2.5
Gate valve (wide open)	0.2
Return band	2.2
Standard tee	1.8
Standard 90^0 elbow	0.9

From flow of fluid, Tech paper 410.

Crane Co 1965

SOURCE: Escritt, 1972 pg 282

Table 15 Pressure through service pipe fittings.

Fitting	Value of k in $kv^2/2g$
Elbows	10
Short radius bends	0.75
Long radius bends	0.7
Fully open gate valve	0.15
Fully open screwdown valve fig. 13.6	8.2
Tee flow to branch	1.3
Sudden contraction 2.1	0.3
Sudden contraction 4.1	0.4
Sudden Enlargement 2.1	0.4
Sudden enlargement 4.1	0.7
Joints in 13mm diameter pipe	1.2
Joints in 25mm diameter pipe	0.8

Note: The figures for joint losses are for service piping as laid without special attention to jointing.

Source: Twort et al 1985 Pg 525.

APPENDIX B

APPRAISAL OF WATER DEMAND IN APONMU COMMUNITY QUESTIONNAIRES

1 Name of Town and State.

2 Sex of respondent:- Male Female

Age: < 20 ☐ 20 – 50 ☐ > 50 ☐

3 Position of respondent in the family, town/quarters

Head ☐ Tenant ☐ Chief ☐

4 Type of house:- (one, two, three, four) flats

5 Number of families living in the house:- one ☐ Two ☐

Three ☐ Others ☐

6 Number of people living in the house:- < 10 ☐ 11-20 ☐

> 20 ☐

7 Adults: Male ☐ Female ☐

8 Source of water

From where do you get your water for domestic use during.

	Raining Season?	Dry Season?
Water cooperation	☐	☐
Wells	☐	☐
Boreholes	☐	☐
Streams/Rivers/Spring	☐	☐
Others	☐	☐

Comb nation

None

9 If water corporation

How often do you get water?

24 Hours ☐ 18 Hours ☐ Other ☐ None ☐

10 Do you community/ Town has a private mini dam/intake serving it alone?

Yes ☐ No ☐

11 If yes, who runs it: Community ☐ Water corporation ☐

Private Body ☐ Others ☐

12 What period of the year do you usually get water:-

Usually Morning ☐ Usually Afternoon ☐ Usually Night ☐

Others ☐

13 How can you describe the water supply situation in your area during:-

Dry Season			Raining Season		
Good	Critical	Very Critical	Good	Critical	Very Critical
☐	☐	☐	☐	☐	☐

14 Do you obtain water from any other source:- Yes ☐ No ☐

If yes, specify during:-

	Raining Season	Dry Season
Borehole	☐	☐
Well	☐	☐
Stream	☐	☐
Water Vendor	☐	☐

Rain Water Harvesting ☐ ☐

15 How much water do you household uses per day

	Raining Season	Dry Season
50 litres	☐	☐
100 litres	☐	☐
150 litres	☐	☐
200 litres	☐	☐
Others	☐	☐

16. Do you have any River/Stream/Spring that can be developed for as source of water for your village Yes/No.

17. If yes, what is the name and the nature.

Name: ....

Nature: Perennial/Annual

18. Will your community allow this river/Stream/Spring to be developed?

Yes ☐ No ☐

19. Is there any Shrine or taboo that can work against using this river/Stream/Spring? Yes ☐ No ☐

20. Do you have public/private borehole in your community?

Yes ☐ No ☐ ☐ With hand pump/motorized pump

21. If yes, what are their conditions?

Functioning ☐ Not functioning ☐

22. Do you pay when you fetch water from such borehole? Yes/No

Public ☐ Private ☐

23. If yes, how much do you pay? ______________________

24. Do you have a well in your house? Yes ☐ No ☐

25. If yes, is the well serving you throughout the year? Yes ☐ No ☐

26. How deep is the well?............ Any concrete rings? Yes ☐ No ☐

27. If No, when does it usually dry/have no water?

From October, November........................ March/April................

28. Do you have a water closet in your house? Yes ☐ No ☐

29. If Yes, how many units?

30. Do you get water often to run them? Yes ☐ No ☐

31. If water is made available regularly, will you be willing to pay your water rate?

32. How many times did you take your bath daily? One ☐ Two ☐

Three and above ☐

33. If a spring / river in your village is developed to supply water for your community, will you like it? Yes ☐ No ☐

34. Do you have any industry in your community? Yes ☐ No ☐

35. How many primary schools are in your community? One ☐ Two ☐

Three ☐ Others ☐

36. How many secondary schools are in your community? One ☐ Two ☐

Three ☐ Others ☐

37. If your community is given the opportunity to run this scheme to ensure regular water supply, will you be willing? Yes ☐ No ☐

38. If yes will you like to form water users Association? Yes ☐ No ☐

Will you be willing to contribute towards the finance of the of the water scheme? Yes ☐ No ☐

Finally, what do you think should be done to improve water supply in your community?

Private Facility that can sell water ☐

Build separate water – works for your community ☐

a. By Government ______________

b. The Community ______________

c. Private Organization ______________

Drill more boreholes ☐

Dig more wells ☐

Others ☐

APPENDIX C

STATISTICAL ANALYSIS OF THE QUESTIONNAIRE

FREQUENCIES

Statistics

		v2a-Sex	v2b-Age	v3-position in the family	v4-Type of house (flats)
N	Valid	50	50	50	50
	Missing	0	0	0	0
Mean		1.34	2.22	1.82	1.04
Std. Error of mean		6.77E-02	5.92E-02	7.39E-02	2.80E-02
Mode		1	2	2	1
Std. Deviation		48	42	52	20
Minimum		1	2	1	1
maximum		2	3	3	2
Sum		67	111	91	52

Statistics

		v5-Number of families in the house	v6-Number of People living in the House	v7a-Number of adults male	v7b-Number of adult female
N	Valid	50	50	50	50
	Missing	0	0	0	0
Mean		1.20	1.14	4.68	3.32
Std. Error of Mean		6.39E-02	4.96E-02	.39	.29
Mode		1	1	4	1
Std. Deviation		.45	.35	2.79	2.08
Minimum		1	1	0	0
Maximum		3	2	14	8
Sum		60	57	234	166

Statistics

		V8a-Sources of water during raining season	V8b-Source of water during dry season	V10-Do your Community has a private mini dam	V13a-How can you describe water supply in your area during dry season.
N	Valid	50	50	50	50
	Missing	0	0	0	0
Mean		4.98	3.78	2.00	1.90
Std. Error of Mean		2.00E-02	15	00	4.29E-02
Mode		5	4	2	2
Std. Deviation		14	1.04	00	30
Minimum		4	0	2	1
Maximum		5	5	2	2
Sum		249	189	100	95

Statistics

		v13b-How can you describe water supply in your area during raining season	v14a-Do you obtain water from any other sources	v14bi-If yes, where do you obtain water during the raining season	v14bii-If yes where do you obtain water during the dry season.
N	Valid	50	50	50	50
	Missing	0	0	0	0
Mean		3.00	1.06	6.68	2.86
Std. Error of Mean		00	3.39E-02	23	29
Mode		3	1	6	3
Std. Deviation		00	24	1.61	2.06
Minimum		3	1	0	0
Maximum		3	2	9	8
Sum		150	53	334	143

Statistics

		v15a-How much water do your household uses per day during raining season	v15b-How much water do your household uses per day during dry season	v15b-Do you have any river of water that can be developed to source of water for your village	v16-If yes, what is the nature of the river.
N	Valid	50	50	50	50
	Missing	0	0	0	0
Mean		2.66	1.28	1.00	100
Std Deviation		8.38E-02	6.41E-02	00	.00
Minimum		3	1	1	1
Maximum		59	45	00	.00
Sum		2	1	1	1
		4	2	1	1
		133	64	50	50

		v18-Will your community allow this river to be developed	v19-Is there any Shrine or Taboo that can work against using this water	v20-Do you have Public/private boreholes in your community	v21-If yes, what are their conditions
N	Valid	50	50	50	50
	Missing	0	0	0	0
Mean		1.00	2.00	194	12
Std. Error of Mean		00	00	3.39E-02	6.7902
Mode		1	2	2	0
Std. Deviation		00	00	24	48
Minimum		1	2	1	0
Maximum		1	2	2	2
Sum		50	100	97	6

Statistics

		v22a- Do you pay when you fetch water from such borehole	v22b- If yes, where do you fetch the water	v24- Do you have a well in your house	v25- If yes, is the well serving you throughout the year
N	Valid	50	50	50	50
	Missing	0	0	0	0
Mean		12	6.00E-02	1.48	1.00
Std. Error of Mean		6.79E-02	3.39E-02	7.69E-02	.14
Mode		0	0	2	0a
Std. Deviation		48	24	54	1.01
Minimum		0	0	0	0
Maximum		2	1	2	2
Sum		6	3	74	50

Statistics

		v26a- How deep is the well	V2z6b- Any concrete rings	v27- If no when does it usually dry	V28- Do you have a water closet in your house
N	Valid	50	50	50	50
	Missing	0	0	0	0
Mean		8.68	74	.12	2.00
Std. Error of Mean		1.30	.12	6.15E-02	.00
Mode		0	0	0	2
Std. Deviation		9.21	.85	44	00
Minimum		0	0	0	2
Maximum		25	2	2	2
Sum		434	37	6	100

Statistics

		v31-If water is made available regularly, will you be willing to pay your water rate.	v32- How many times do you take your birth daily	v33- If a spring in your Village is developed to supply water, will you like it.	v34-Do you have any industry in your community?
N	Valid	50	50	50	50
	Missing	0	0	0	0
Mean		1.02	1.00	1.00	2.00
Std. Error		2.00E-02	.00	00	00
Mode		1	1	1	2
Std. Deviation		14	00	00	00
Minimum		1	1	1	2
Maximum		2	1	1	2
Sum		51	50	50	100

Statistics

		v35- How many Primary Schools are in your Community	v36- How many Secondary Schools are in your Community	v37-If you Community is given the opportunity to run this scheme to ensure regular water supply, will you be willing	v38-If yes, will you like form water Association
N	Valid	50	50	50	50
	Missing	0	0	0	0
Mean		1.00	1.00	1.02	1.08
Std. Error of Mean		00	00	2.00E-02	3.88E-02
Mode		1	1	1	1
Std. Deviation		00	00	14	27
Minimum		1	1	1	1
Maximum		1	1	2	2
Sum		50	50	51	54

Statistic

		v39- Will you be willing to contribute towards the finance of the water scheme	v40a- what do you think that can improve water supply in your community	v40b- Build separate water- works for your Community by
N	Valid	50	50	50
	Missing	0	0	0
Mean		1.04	3.76	1.22
Std. Error of Mean		2.80E-02	25	12
Mode		1	5	1
Std. Deviation		20	1.78	82
Minimum		1	0	1
Maximum		2	6	5
Sum		52	188	61

Frequency Table

v2a-Sex

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	33	66.0	66.0	66.0
	Female	17	34.0	34.0	100.0
	Total	50	100.0	100.0	

v2b-Age

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid 20–25	39	78.0	78.0	78.0
50 and above	11	22.0	22.0	100.0
Total	50	100.0	100.0	

v3- Position in the Family

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Head	12	24.0	24.0	24.0
Tenant	35	70.0	70.0	94.0
Chief	3	6.0	6.0	100.0
Total	50	100.0	100.0	

v4- Type of House (flats)

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid One	48	96.0	96.0	96.0
Two	2	4.0	4.0	100.0
Total	50	100.0	100.0	

v5- Number of Families in the house

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	One	41	82.0	82.0	82.0
	Two	8	16.0	16.0	92.0
	Thre	1	2.0	2.0	100.0
	Total	50	100.0	100.0	

v6- Number of People living in the house

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Less than 10	43	86.0	86.0	86.0
11- 20	7	14.0	14.0	100.0
Total	50	100.0	100.0	

v7a- Number of adults male

		Frequency	Percent	Percent Valid	Cumulative Percent
Valid	0	2	4.0	4.0	4.0
	1	2	4.0	4.0	8.0
	2	7	14.0	14.0	22.0
	3	5	10.0	10.0	32.0
	4	12	24.0	24.0	56.0
	5	4	8.0	8.0	64.0
	6	9	18.0	18.0	82.0
	7	5	10.0	10.0	92.0
	10	2	4.0	4.0	96.0
	12	1	2.0	2.0	98.0
	14	1	2.0	2.0	100.0
	Total	50	100.0	100.0	

v7b- Number of adults female

	Frequency	percent	Valid percent	Cumulative percent
Valid 0	3	6.0	6.0	6.0
1	10	20.0	20.0	26.0
2	7	14.0	14.0	40.0
3	6	12.0	12.0	52.0
4	8	16.0	16.0	68.0
5	9	18.0	18.0	86.0
6	3	6.0	6.0	92.0
7	3	6.0	6.0	98.0
8	1	2.0	2.0	100.0
Total	50	100.0	100.0	

v8a- Source of water during raining season

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Stream/ River / Spring	1	2.0	2.0	2.0
	Combination	49	98.0	98.0	100.0
	Total	50	100.0	100.0	

v8b- Source of water during dry season

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid 0	3	6.0	6.0	6.0
Wells	1	2.0	2.0	8.0
Streams/River/spring	43	86.0	86.0	94.0
Combination	3	6.0	6.0	100.0
Total	50	100.0	100.0	

v10- Do your Community has a private mini dam

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid No	50	100.0	100.0	100.0

v13a- How can you describe water supply in your area during dry season

	Frequency	Percent	Valid Percent	Cumulative percent
Valid Very	5	10.0	10.0	10.0
critical	45	90.0	90.0	100.0
	50	100.0	100.0	

v13b- can you describe water supply in your area during raining season

	Frequency	percent	Valid percent	Cumulative percent
Valid Good	50	100.0	100.0	100.0

v14a- Do you obtain water from any other sources

	Frequency	percent	Valid percent	Cumulative percent
Valid yes	47	94.0	94.0	94.0
No	3	6.0	6.0	100.0
Total	50	100.0	100.0	

v14bi-If yes, where did you obtain water during raining season

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid o	1	2.0	2.0	2.0
Well, Stream and Raining harvest	34	68.0	68.0	70.0
Well and Stream	2	4.0	4.0	74.0
Stream and Raining harvest	1	2.0	2.0	76.0
Well and raining harvest	12	24.0	24.0	100.0
Total	50	100.0	100.0	

v14bii- If yes, where did you obtain water during dry season

Valid O	11	22.0	22.0	22.0
Well	4	8.0	8.0	30.0
Stream	25	50.0	50.0	80.0
Rain water harvest	6	12.0	12.0	92.0
Well and Stream	2	4.0	4.0	96.0
Stream And Raining harvest	2	4.0	4.0	100.0
Total	50	100.0	100.0	

V15a-How much water do your household uses per day during raining season

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	100 litres	20	40.0	40.0	40.0
	150 litres	27	54.0	54.0	94.0
	200 litres	3	6.0	6.0	100.0
	Total	50	100.0	100.0	

v15b- How much water do your household uses per day during dry season

	Frequency	percent	Valid Percent	Cumulative Percent
Valid 50 litres	36	72.0	72.0	72.0
100 litres	14	28.0	28.0	100.0
Total	50	100.0	100.0	

v16- Do you have any river that can be developed to source of water for your village

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Yes	50	100.0	100.0	100.0

v16-If yes, what is the nature of the river

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Perennial	50	100.0	100.0	100.0

v18- will your community allow this river to be developed

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Yes	50	100.0	100.0	100.0

v19- Is there any shrine or tobacco that can work against using this river

	Frequency	Percent	Valid percent	Cumulative percent
Valid NO	50	100.0	100.0	100.0

v20-Do you have public/private boreholes in your community

	Frequency	percent	Valid percent	Cumulative percent
Valid yes	3	6.0	6.0	6.0
No	47	94.0	94.0	100.0
Total	50	100.0	100.0	

v21- If yes, what are their conditions

	Frequency	Percent	Valid Percent	Cumulative percent
Valid o	47	94.0	94.0	94.0
Not functioning	3	6.0	6.0	100.0
Total	50	100.0	100.0	

v22a- Do you pay when you fetch water from such boreholes

	Frequency	Percent	Valid percent	Cumulative percent
Valid o	47	94.0	94.0	94.0
No	3	6.0	6.0	100.0
Total	50	100.0	100.0	

v22b- If yes, where do you fetch the water

	Frequency	Percent	Valid percent	Cumulative percent
Valid o	47	94.0	94.0	94.0
Public	3	6.0	6.0	100.0
Total	50	100.0	100.0	

v24- Do you have a well in your house

	Frequency	Percent	Valid percent	Cumulative percent
Valid o	1	2.0	2.0	2.0
Yes	24	48.0	48.0	48.0
No	25	50.0	50.0	100.0
Total	50	100.0	100.0	

v25- If yes, is the well serving you throughout the year

	Frequency	Percent	Valid percent	Cumulative percent
Valid o	25	50.0	50.0	50.0
No	25	50.0	50.0	100.0
Total	50	100.0	100.0	

v26a- How deep is the well

	Frequency	Percent	Valid percent	Cumulative percent
Valid 0	25	50.0	50.0	50.0
12	7	14.0	14.0	64.0
15	1	2.0	2.0	66.0
16	1	2.0	2.0	68.0
18	8	16.0	16.0	84.0
20	2	4.0	4.0	88.0
22	5	10.0	10.0	98.0
25	1	2.0	2.0	100.0
Total	50	100.0	100.0	

v26b- Any concrete rings

	Frequency	Percent	Valid percent	Cumulative percent
Valid 0	26	52.0	52.0	52.0
Yes	11	22.0	22.0	74.0
No	13	26.0	26.0	100.0
Total	50	100.0	100.0	

v27- If no, when does it usually dry

	Frequency	Percent	Valid percent	Cumulative percent
Valid 0	46	92.0	92.0	92.0
October/ November	2	4.0	4.0	96.0
March/ April	2	4.0	4.0	100.0
Total	50	100.0	100.0	

v28- Do you have a water closet in your house

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid No	50	100.0	100.0	100.0

v31-If water is made available regularly, will you be willing to pay your water rate

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Yes	49	98.0	98.0	98.0
No	1	2.0	2.0	100.0
Total	50	100.0	100.0	

v32- How many times did you take your birth daily

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid One	50	100.0	100.0	100.0

v33- If a spring in your village is developed to supply water, will you like it

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Yes	50	100.0	100.0	100.0

v34- Do you have any industry in your Community

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid No	50	100.0	100.0	100.0

v35- How many Primary Schools are in your Community

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid One	50	100.0	100.0	100.0

v36- How many Secondary Schools are in your Community

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid One	50	100.0	100.0	100.0

v37- If your Community is given the opportunity to run this scheme to ensure regular water supply, will you be willing

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Yes	49	98.0	98.0	98.0
No	1	2.0	2.0	100.0
Total	50	100.0	100.0	

v38- If yes, will you like from water users Association

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid yes	46	92.0	92.0	92.0
No	4	8.0	8.0	100.0
Total	50	100.0	100.0	

v39- Will you be willing to contribute toward the finance of the water scheme

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Yes	48	96.0	96.0	96.0
No	2	4.0	4.0	100.0
Total	50	100.0	100.0	

v40- What do you think that can improve water supply in your Community

Valid 0	7	14.0	14.0	14.0
Dig more wells	14	28.0	28.0	42.0
Drill more Boreholes and Dig more wells	28	56.0	56.0	98.0
private facility, Drill more boreholes $ Dig more wells	1	2.0	2.0	100.0
Total	50	100.0	100.0	

v40b- Build separate water – works for you Community

	Frequency	Percent	Valid Percent	Cumulative percent
Valid Government	46	92.0	92.0	92.0
Community	1	2.0	2.0	94.0
4	2	4.0	4.0	98.0
5	1	2.0	2.0	100.0
Total	50	100.0	100.0	

APENDIX D: RAINFALL DATA TYPICAL OF AKURE SOUTH LOCAL GOVERNMENT

YEAR	JAN	FEB	MAR	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL
1985	84.09	17.00	104.04	180.05	342.01	345.01	341.02	-	543.09	122.02	31.01	0.0	2112.04
1986	0.0	41.0	134.4	102.554	326.5	303.6	429.9	250.07	268.5	313.3	97.1	0.0	2275.5
1987	0.0	1.0	508.0	54.3	254.3	293.8	274.8	123.3	157.9	573.5	32.1	38.8	2311.8
1988	5.1	29.8	291.5	297.1	338.1	285.6	372.8	218.5	204.8	109.5	3.5	0.0	2186.1
1989	51.0	8.8	259.9	149.5	354.3	279.2	-	433.5	250.7	[illegible]	64.4	3.6	1980.1
1990	105.3	15.5	147.2	148.0	19.3	211.3	426.8	244.8	546.0	399.2	47.6	0.5	2482.7
1991	0.5	26.9	97.6	62.4	201.5	305.4	223.0	475.0	449.0	214.8	19.9	TR	2076.0
1992	10.9	12.2	172.2	187.6	2206	428.6	327.1	278.9	446.1	392.7	344.0	52.4	2873.3
1993	0.0	0.0	86.4	225.9	304.3	469.4	321.3	431.6	316.6	360.8	26.0	39.1	2581.5
1994	9.8	10.0	7.7	213.2	185.8	256.9	650.1	641.0	371.1	243.3	119.7	23.9	2731.9
1995	0.0	42.5	107.1	182.6	245.2	498.3	400.2	521.1	193.9	349.8	24.0	0.4	2565.1
1996	0.9	2.8	157.5	216.8	248.1	373.0	489.9	289.4	333.7	314.9	79.5	17.6	2424.1
1997	0.0	58.7	90.2	177.8	291.0	290.8	464.3	315.5	218.8	176.6	73.7	22.3	2179.7
1998	37.1	34.3	45.9	99.6	298.8	185.9	-	438.2	640.2	284.3	11.7	0.0	2176.0
1999	59.6	12.5	72.2	115.9	36.5	339.2	484.4	381.6	460.9	292.4	267.0	15.8	2862.6
AT TOTAL	365.1	313.0	2281.6	2413.7	416.4	4866.4	5205.4	5051.1	5402.1	4172.5	1341.3	214.4	35789.0
AVER-AGE TOTAL	24.34	20.87	152.11	160.91	277.49	324.43	347.03	336.14	360.14	278.17	89.42	109.5	2385.93

TOTAL MONYHLY RAINFALL

AVERAGE TOTAL MONTHLY RAINFALL

SOURCE: ONDO STATE WATER CORPORATION, AKURE.

APPENDIX E
Topography survey of the spring source to service reservoir

B.S	I.S	F.S	DIST (M)	RISE	FALL	R.L	
3.120						100.00	T.B.M
	0.560		20	2.56		102.56	
0.099		1.044	28		0.484	102.08	
2.660		3.034	65		2.935	99.14	
0.850		0.985	100	1.675		100.82	
	1.950		110		1.100	99.72	
2.522		0.740	120	1.210		10093	
	1.045		175	1.477		102.40	
		0.500	195	0.545		102.95	

Reduced level from the spring source to the proposed service reservoir

APPENDIX F

Discharge (Q) From The Spring

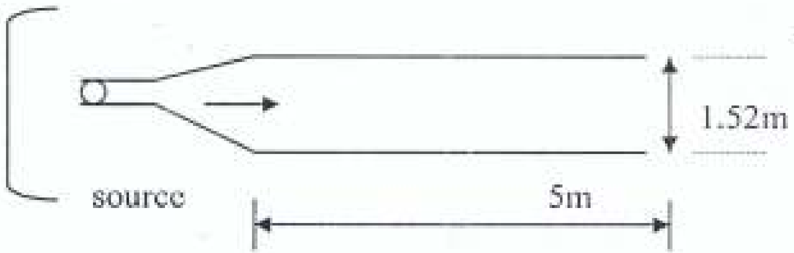


Fig. 4 Sketch of the flow measurement (Floating method)

Table Measurement of flow velocity

Trials	Time taken (sec)	Distance (m)
1	120 sec	5m
2	125	5m
3	115	5m
4	120	5m

$$\text{Average time taken} = \frac{120 + 125 + 115 + 120}{4}$$

$$= \frac{480}{4}$$

$$= 120 \text{ sec}$$

$$\text{Velocity} = \frac{\text{Distance (m)}}{\text{Time (s)}}$$

$$V = \frac{5}{120}$$

$$= 0.042\text{m/s}$$

Discharge (Q) = Velocity x Area

Velocity = 0.042m/s

Average depth of channel = 0.06m

Area of channel = 0.06 x 1.52 = $0.0912m^2$

∴ Discharge (Q) = $3.83 \times 10^{-3} m^3/s$ (3.83 litre/s)

= $13.79m^3/hr$

= $330.912m^3/day$

Appendix G.

Table 8: Water Quality results Obtained.

Characteristics (Parameters)	Rainy Season			Dry Season		W. H. O. Standard & Permissible
	Rain Water	Hand Dug Well	Spring Water	Hand Dug Well	Spring Water	
Colour (platinum – cobalt scale)	14.20	15.20	14.52	14.85	14.10	15 TCU
Total Dissolved Solid (TDS)	230	420	350	410	300	1000mg/L
Turbidity	1.58	5.2	5.0	3	2.5	5NTU
Taste	NIL	NIL	NIL	NIL	NIL	Not objectionable
Iron	0.04	0.08	0.04	0.08	0.03	1.0mg/L
Manganese	NIL	NIL	NIL	NIL	NIL	0.1mg/L
Copper	NIL	NIL	NIL	NIL	NIL	1.0mg/L
Zinc	NIL	NIL	NIL	NIL	NIL	5.0mg/L
Calcium	12	14.6	12.8	14.7	13.8	75mg/L
Ammonia	5.3	6.5	6.3	6.4	6.1	6.5mg/L
Nitrate	NIL	NIL	NIL	NIL	NIL	1.0mg/L
Microbiology Coliform organisms at 35^0c						
Total Coliform/100ml	NIL	0.2	0.1	NIL	NIL	1
Feacal Coliform/100ml	NIL	NIL	NIL	NIL	NIL	Absent
Salmonella	NIL	NIL	NIL	NIL	NIL	Absent

Design of Pumps, Filter beds, Reservoirs and Service Pipelines

Suction side of the pump

From HAZEN – WILLIAMS FORMULA

$$hfs = \left(\frac{QL0.54}{(0.283C)D^{2.58}}\right)^{1/_{0.54}}$$

where Q = Discharge, m^3/s

L = pipeline length

C = pipe wall roughness, from 80 for old iron pipe to 140 for new smooth pipe (Allow 100)

D = internal pipe diameter, m.

h_{fs} = head losses on the suction side (m)

$$h_{fs} = \left(\frac{9.2 \times 10^{-3}\,(1\text{-}5)^{0.54}}{(0.283 \times 100)\,(0.12)^{2.58}}\right)^{1/_{0.54}}$$

$$= 0.013m$$

From table 14

Standard 90° elbow, value of KL = 0.9

$$h_L = K_L \frac{v^2}{2g} = 0.9 \frac{(0.81)^2}{2x9.81} = 0.03m$$

.: Total head losses on the suction side

hfs = 0.018 + 0.03 = 0.043m.

Delivery side of the pump

$$hfs = \left(\frac{QL0.54}{(0.283C)D^{2.58}}\right)^{1/_{0.54}}$$

Where h_{fs} = head losses on the delivery side (m)

$$= \left(\frac{9.2 \times 10\text{-}3 \times (60)^{0.54}}{(0.283 \times 100)(0.12)^{2.58}} \right)^{1/0.54}$$

$$= \quad 0.52m$$

From table 14

- Gate valve (wide open), Value of K_L = 0.2

$$h_L = K_L \frac{V^2}{2g} \qquad 0.2 \frac{(0.81)^2}{2 \times 9.81}$$

$$= \quad 6.69 \times 10^{-3}m$$

.: For 2 gate values h_L = 0.013m

- Standard Tee, value of K_L = 1.8

$$hL = kL \frac{V^2}{2g} = 1.8 \times \frac{(0.81)^2}{2 \times 9.81}$$

$$= \quad 0.06m.$$

.: For 2 standard Tee's h_L = 1.12m

- standard elbow (90°), value of K_L = 0.9

$$h_L = k_L \frac{V^2}{2g} = 0.9 \times \frac{(0.81)^2}{2 \times 9.81} = 0.03m$$

For 5 elbow; Total h_L = 1.15m

- For other losses, allow h_L = 0.2m

Total h_{fd} (head losses on the delivery side)

$$= \quad 0.52 + 0.013 + 0.12 + 0.15 + 0.2$$

$$h_{fd} = \quad 1.003$$

Total head H (gross lift) = h + h_f

$$= h_s + h_{fs} + h_d + h_{fd}$$

Where, h_s = suction head, (m)

h_{fs} = head losses on the suction side, (m)

h_d = height to which water has been raised above the pump, (m)

h_{fd} = head loses on the delivery side, (m)

$H = 1.2m + 0.043m + 10m + 1.003$

$H = 12.25m$

Work done/ second by a pump may be expressed as follows

$P'' = Q\,^{e}gH$ (Watts)

Where Q == Discharge (m^3/s)

e = Density of water (kg/m^3)

g = acceleration due to gravity m/s^2

H = Total head loss (m)

$P'' = 9.2 \times 10^{-3} \times 9.81 \times 12.25 = 1105.59$ Watts

.: Power required taking into consideration the efficiency of power transmission from the electric motor to the pump.

Power will be $P''m = \dfrac{P''}{^{e}p\ ^{e}pt}$

where ^{e}p = efficiency of the pump (centrifugal pump $^{e}p = 0.4$ to 0.85)

^{e}pt efficiency of power transmission

= 1 (for motor an the pump coupled directly)

(Al-LAYLA et al; 1978)

Allow, $^{e}p = 0.65$

$P''m = \dfrac{1105.59}{0.65 \times 1}$

$= 1.7kw$

<u>Allow 2.0kw</u>

The electrical power required

$$Pm = \frac{P''m}{e_m} \text{ where } m = \text{efficiency of the motor}$$

Electric motor, m = 0.85 to 0.91

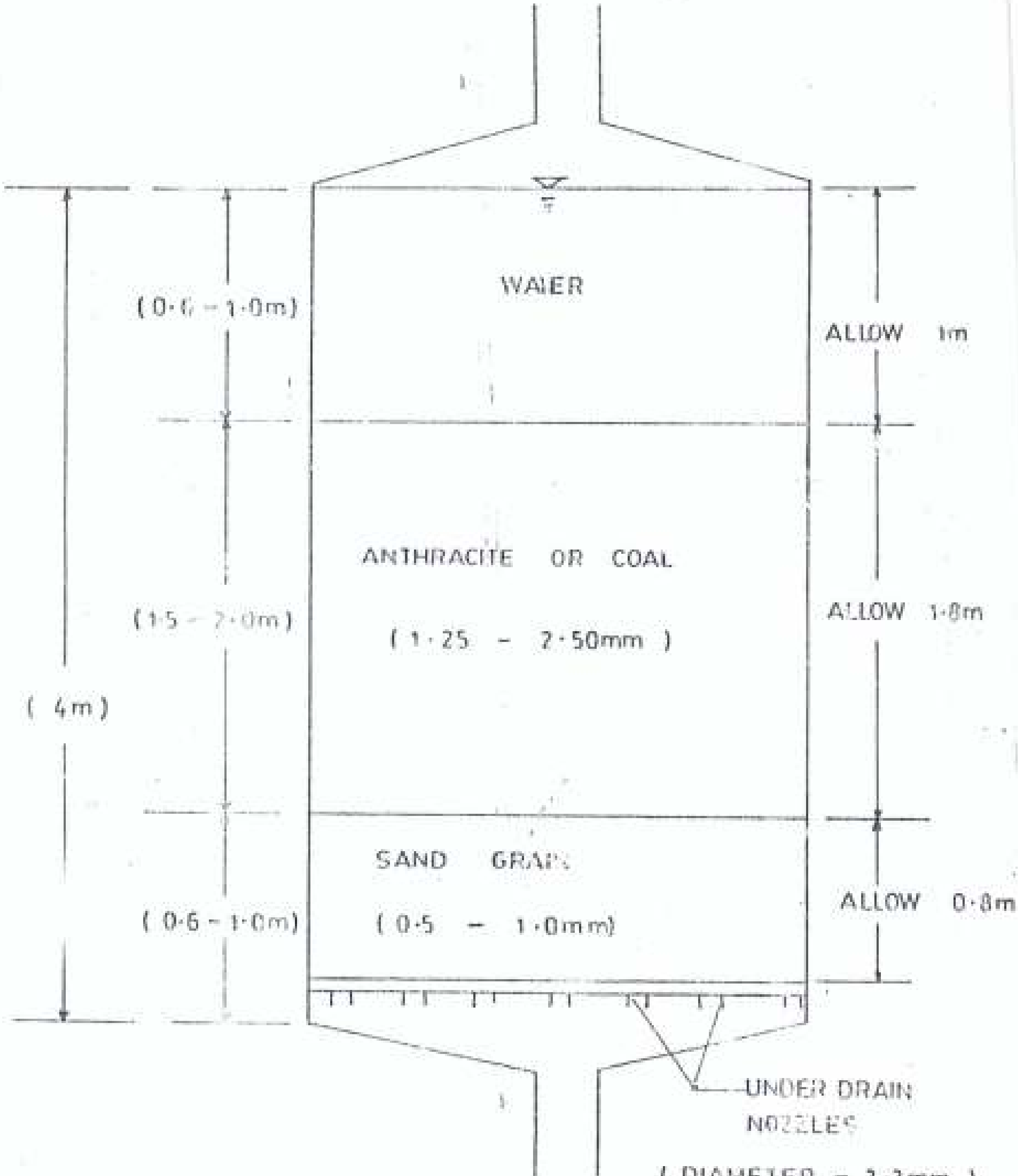
(AL-LAYLA et al, 1978)

(Allow 0.88)

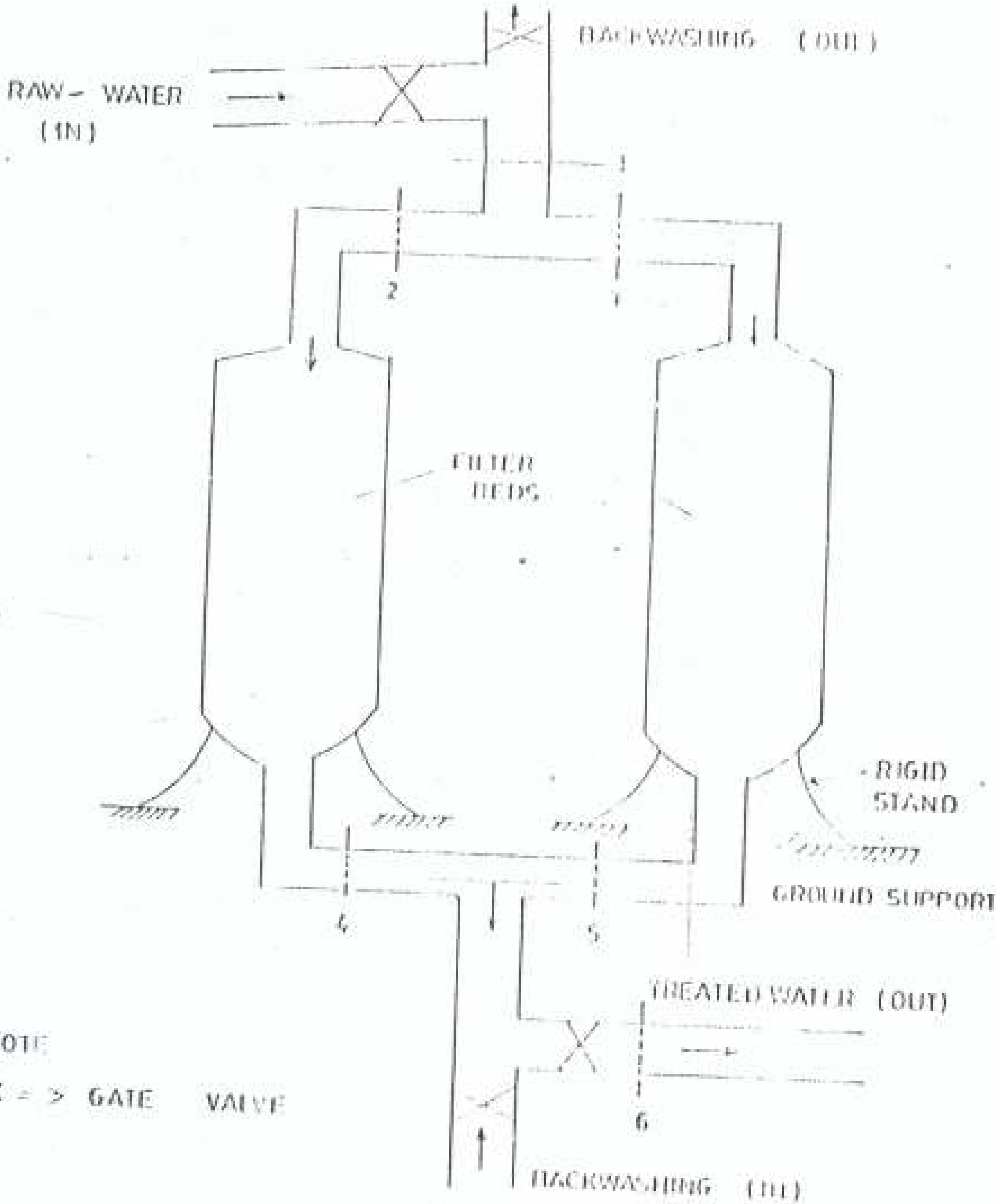
$$Pm = \frac{3.7}{0.88} = 4.2kw$$

Allow 2.5kw

Hence, two low-left pump, should be provided (Allow one for stand – by)



FOR ANTHRACITE OR COAL – SAND Filtration rate ranges between 6 to 12m / hr.



NOTE

X => GATE VALVE

$D_1 = D_6 = 0{\cdot}1$[illegible]

$D_{2,3} = D_{4,5} = 0{\cdot}060m$

TEE - JOINT REDUCER $\frac{D_2}{D_1} = \frac{1}{2}$

Rapid sand filter Design

Q = 33.13^3/hour

Filter bed flow rate, through dual media bed (Anthracite or coal sand) ranges between 6 – 12m/hr (Twort et al, 1985)

(Allow 9.0m/hr)

(a) Area of the bed + $\frac{33.13m^3/hr}{9m/hr}$ = $3.68m^2$

(b) Use two filter beds, each = $\frac{3.68}{2}$ = $1.84m^2$ = $2.0m^2$

For a rectangular bed (Allow 1m x 1m)

<u>Backwashing</u>

For dual media bed (Anthracite or coal sand) rate of backwashing = 0.29 - 0.38m/min (Twort el al; 1985)

Use 0.34m/min.

- Two filter beds are washed at the same time.

wash area = $2.0m^2 \times 2 = 4.0m^2$

Quantity of water needed for backwashing

= $4.0m^2 \times 0.34m/min = 1.36m^3/min$.

Backwashing for 10 minutes, volume of water needed

= $1.36m^3/min \times 10 = 13.6m^3$

Dimension of Tank = (2m x 3m x 3m)

Allow head loss during backwashing = 5m

Work done / second by pump = p" = QegH

$22.67 \times 10^{-3} \times 10^3 \times 9.81 \times 5m$ = 1.1kw

Power required = $P^1m - \frac{P^{11}}{Epept}$; ep = 0.65
cpt = 1

$P^1m = \frac{1.1kw}{0.65 \times 1} = 1.69kw$

Allow 2.0kw

The electrical power required

$Pm = \frac{P^1m}{{}^em}$; ${}^em$ = 0.85 to 91

(Allow 0.88)

$Pm = \frac{2kw}{0.88} = 2.3kw$

(Allow 2.5kw)

* Backwashing to be carried out <u>ONCE</u> in a month.

Disinfectant

From the water quality analysis carried out, the water requires simple disinfections, to guide against current water supply and any future sudden pollution.

Disinfection: Calcium Hypochlorite (H.T.H) containing 70% of Cl_2 (chlorine) and 4% lime.

Dosage required = 2.0mg/l

Contact time = $\frac{\text{volume of stored water}}{\text{Through put-rate}}$

$= \frac{265m^3}{33.13m^3/hr} = 8 \text{ hours}$

Treatment discharge = $33.13m^3$/hour

Mass of H.T.H required = 2.0mg/l x 33.13m^3/hour

= 0.066kg/hr

Daily mass of H.T.H required

= 2.0mg/l x 265m^3 /day

= 0.53kg (where 1 day = 8 working hours)

Coagulant

Aluminum sulphate ($Al_2 (so4)_3 . 14H_2O$) or Alum, contaiing 20% Al_2o_3

- Since the water is of low dissolved solids and turbidity, and to guide against any sudden pollution, Alum Dosage required = 1mg/l.

Treatment discharge = 33.13m^3/hr.

Daily mass of Alum required = 1.0mg/L x 265m^3 /day

= 0.265kg/day.

(Allow 0.27klg / day)

Storage Reservoir

Total water demand, Q for the village = 265m^3/day

Allowed for 2 days storage capacity

q = 2 x 265m^3/day = 530m^3/day

For ONE storage reservoir, Allow 3m deep, and 0.1m of storage.

(a) Allow detention period = 1 day

(b) Effective volume = Detention period x Q

$$= \frac{1 \text{ day x } 530m^3/\text{day}}{1 \text{ reservoir}} = 530m^3$$

(c) Surface area $= \frac{530}{2.9} = 182.8m^2$

$= 18m$

Allow $196m^2$ (14m x 14m)

(d) Surface rating $= \frac{q}{\text{surface area}}$

$= \frac{530}{196} = 2.7m/day$

Dimension: (3m x 14m x 14m)

Provision

Provide manhole (0.8m x 0.6m) on top of the strange reservoir where chemicals will be dosed inside the water (manually), and for general maintenance. (Manhole should be provided with an adequate cover)

Pumping: High-Lift Pump

Discharge to be pumped = $9.2 \times 10^{-3} m^3/s$

Pipe internal diameter, D = 0.1m

Velocity = 1.17m/s

Suction side of the pump

From HAZEN-WILLIAMS formula

$$h_{fs} = \left(\frac{QL^{0.54}}{(0.283c)D^{2.85}}\right)^{1/0.54}$$

$$= \left(\frac{9.2 \times 10^{-3} \times 1^{0.54}}{(0.283 \times 100)(0.1)^{2.58}}\right)^{1/0.54}$$

$= 0.02 / m$

From table 14

- Gate value (wide open), value of $K_L = 0.2$

$$h_L = k_L \frac{V^2}{2g} = 0.2 \times \frac{1.17)^2}{2 \times 9.81}$$

$$= 0.014m$$

Total head loss from the suction side = 0.021 + 0.014 = 0.035

Delivery side of the pump

$$h_L = \left(\frac{Q_L^{0.54}}{(0.283c)D^{2.58}} \right)^{1/0.54}$$

$$= \left(\frac{9.2 \times 10^{-3} \times (300)^{0.59}}{(0.283 \times 100)(0.1)^{2.58}} \right)^{1/0.54}$$

$$= 6.285$$

from table 14

Gate valve (wide open), value of kL = 0.2

$$hL = kL \frac{V^2}{2g} = 0.2 \times \frac{(1.17)^2}{2 \times 9.81} = 0.014$$

- standard 90° elbow, value of $k_L = 0.9$

$$hL = kL \frac{V^2}{2g} = 0.9 \times \frac{(1.17)^2}{2 \times 9.81}$$

$$= 0.063m$$

Allow for 3 elbnos, $h_L = 0.188m$

- for standard tee, value of $K_L = 1.8$

$$h_L = k_L \frac{V^2}{2g} = 1.8 \times \frac{(1.17)\ 2}{2 \times 9.81}$$

$$= 0.126m$$

From table 15

- For short radius bends, $K_L = 0.75$

$$h_L = \frac{K_L V^2}{2g} = 0.75 \times \frac{(1.17)2}{2 \times 9.81}$$

$$= 0.268m$$

- For long radius bends, $\frac{K_L V^2}{2g}$, $k_L = 0.7$

$$h_L = 0.7 \frac{(1.17)^2}{2 \times 9.81}$$

$$= 0.049$$

- Other losses, allow 0.06m

Total h_{fd} (losses on the delivery side)

$$= 6.285 + 0.014 + 0.188 + 0.126 + 0.052 + 0.049$$

$$= 6.774m$$

Total head H (gross lift) $= h + hf = h_{fs} + h_d + h_{fd}$

$$H = 0.035 + 60 + 6.78$$

$$= 66.82m$$

Work done/second by pump, $P'' = Q_e gh$

$$= 9.2 \times 10^{-3} \times 9.81 \times 66.82$$

$$P'' = 6030.64 \text{ Watts}$$

Power = required = $P''m = \frac{P''}{{}^eP\ {}^ept}$

$${}^eP = 0.65$$

$${}^ept = 1$$

$$\therefore \quad P'm = \frac{6030.64}{0.65 \times 1} = 9.3kw$$

(Allow 10kw)

The electrical power required

$$Pm = \frac{P'm}{{}^{e}m} \qquad {}^{e}m = 0.85 \text{ to } 0.91$$

Allow 0.83

$$Pm = \frac{10kw}{0.88} = 11.4kw \qquad \text{(use 12kw)}$$

Hence, two high-lift pumps should be provided (one to serve as stand-by.

Service Reservoir

Generally, 45 to 75 statei height is that which best suits the domestic distribution system (Twort et al; 1985)

The service reservoir is to be sited on natural elevation

Allow height = 5m.

(a) The service reservoir is to provide two days storage

(b) Allow q = 2 x Q = 2 x 265m^3/day = 530m^3/day

(c) effective volume for one reservoir $= \frac{1 \text{ day} \times 530m^3/\text{day}}{1 \text{ reservoir}} = 530m^3$

(d) Allow 3.5m deep

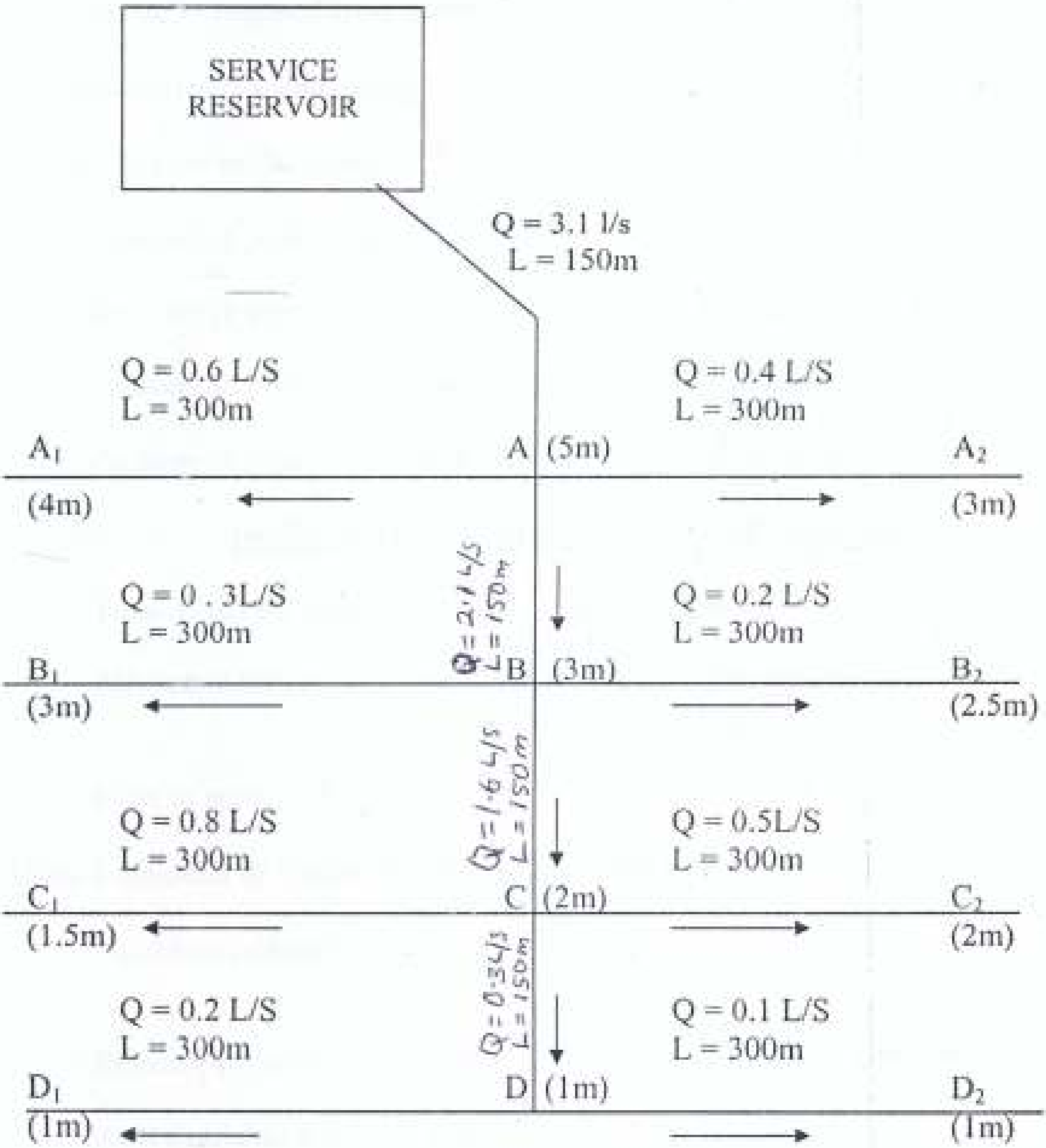
Surface area $= \frac{530}{3.5} = 151.43m^2$

Allow 156m^2 (12.50 x 12.50) m

(e) Surface rating $= \frac{530}{156} = 3.40$m/day

Dimension (3.5 x 12.5m x 12.5m).

Distribution Network



Dead – end system

The Sketch above shows the Distribution System

DISTRIBUTION SYSTEM

Design of a Dead End System

Water is supplied from a service reservoir at an elevation of 50m.

The elevation of various points in the pipeline are given brackets (Allow, minimum pressure in pipe in the village = 20m of water – (Twort, et al; 1985)

Pressure in pipe + elevation at A = 20 + 5 = 25m

Pressure in pipe + elevation at B = 20 + 3 = 23m.

Pressure in pipe + elevation at C = 20 + 2 = 22m.

Pressure in pipe + elevation at D = 20 + 1 = 21m

Design of Main Trunks: RA, AB BC, And CD

Total available head = 50 - (20 + 5) = 25m

Allowable loss of head per 100m = $100 \times \frac{25}{150}$ = 16.7m

Flow in pipe = 3.1 l/s

Allow a diameter of 80mm, the head loss is 0.9m in 100m (fig. 12)

Total loss of head = $\frac{0.9 \times 150}{100}$ = 1.35m

∴ Piezometric head at A = 50 - 1.5 = 48.65m, which is greater than 25m.

At B available head = 48.65 - (20 + 3) = 25.65m.

Allowable loss of head per 100m = $\frac{100 \times 25.65}{150}$ = 17.1m

Flow in pipe AB = 2.11/s

Allow a pipe diameter of 75mm, the head loss is 0.6m in 100m (Fig.12)

Total loss of head in AB = $\frac{0.6 \times 150}{100}$ = 0.9m

.: Piezometric head at B $= 48.65 - 0.9 = 47.75m$

At C the available head $= 47.75 - (20 + 2) = 25.75m$

Flow in pipe = 1.6 l/s

Allow a pipe diameter of 65mm, the head loss is 0.8m in 100m (fig. 12).

Total loss of head in BC $= \frac{0.8 \times 150}{100} = 1.2m$

.: Piezometric head at C $= 47.75 - 1.2 = 46.55m - 1.2 = 46.55m$

At D the available head $= 46.55 - (20 + 1) = 25.55m$

Flow in pipe = 0.3l/s
Allow a diameter pipe of 40mm, the head loss is 0.4m in 100m (fig.12)

Total loss of head $= \frac{0.4 \times 150}{100} = 0.6m$
.: Piezometric head at D $= 46.55 - 0.6 = 45.95m$

Design of Main Service Pipes

Design of Pipes, AA1 And AA2

At a, the available head $= 48.65 - (20 + 4) = 24.65m$

Loss of head per 100m $= 24.65 \times \frac{100}{300} = 8.2m$ (allowable)
Flow in AA_1 = 0.6l/s

Allow pipe diameter of 56mm, the loss of head is 0.25m in 100m (fig,12)
Total loss of head $= \frac{0.25}{100} \times 300 = 0.73m$
At A_2, the available head $= 48.65 - (20 + 3) = 25.65m$

Allowable loss of head per 100m $= \frac{25.65 \times 100}{300}$ 8.55m
Flow in pipe AA_s = 0.4 l/s

Allow pipe diameter of 45mm, the loss of head is 0.4m in 100m

(fig 12)

Total loss of head $= 0.4 \times \frac{300}{100} = 1.2m$

Design of Pipes BB_1 and BB_2

At B_1 the available head = 47.75m - (20 + 3) = 24.75m

Allowable loss of head per 100m = $24.75 \times \frac{100}{300} = 8.25$

Flow in pipe BB_1 = 0.3 l/s

Allow pipe diameter 40mm, the loss of head is 0.4m in 100m

(fig 4.2)

Total loss of head $= 0.4 \times \frac{300}{100} = 1.2$m

At B_2, the available head = 47.75 – (20 + 2.5) = 25.25m

Allowable loss of head per 100m $= \frac{25.25 \times 100}{300} = 8.42$m

Flow in the pipe BB_2 = 0.2 l/s

Allow pipe diameter 32mm, the loss of head is 0.6m in 100m

(fig 4.2)

Total loss of head $= \frac{0.6 \times 300}{100} = 1.8$m

Design of Pipes CC_1 and CC_2

At C_1 the available head = 46.55 - (20 + 1.5) = 25.05m

Allowable loss of head per 100m $= \frac{25.05 \times 100}{300} = 8.35$m

Flow in pipe CC_1 = 0.8 l/s

Allow pipe diameter 60mm, the loss of head is 0.3m in 100m

(fig. 4.2)

Total head loss $= \frac{0.3 \times 300}{100} = 0.9$m

At C_2, the available head = 46.55 - (20 + 2) 24.55m

allowable loss of head available per 100m = $\frac{24.55 \times 100}{300}$

= 8.2m

Flow in the pipe CC_2 = 0.5 l/s

Allow 50mm pipe, the head is 0.35m in 100m (fig 4.2)

Total loss of head = $0.35 \times \frac{300}{100}$ = 1.05m

Design of Pipes DD_1 and DD_2

At D_1 the available head = 45.95 - (20 + 1) = 24.95m

Allowable loss of head per 100m = $\frac{24.95 \times 100}{300}$ = 8.32m

Flow in pipe DD_1 = 0.2 l/s

Allow a 32m pipe, the loss of head is 0.6m in 100m (fig 12)

Total loss of head = $\frac{0.6 \times 300}{100}$ = 1.8m

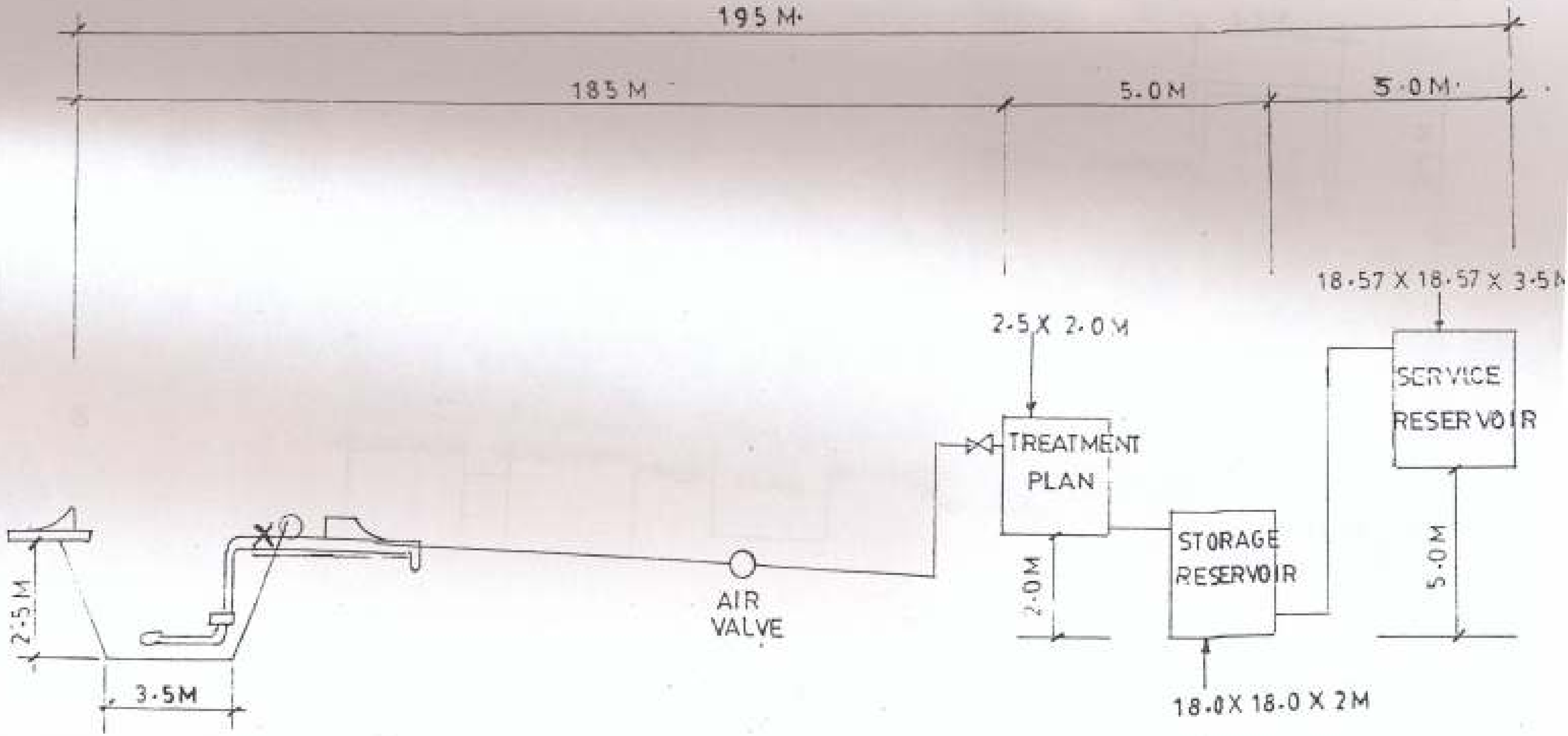
At D_2, the available head = 45.95 - (20 + 1) = 24.95m

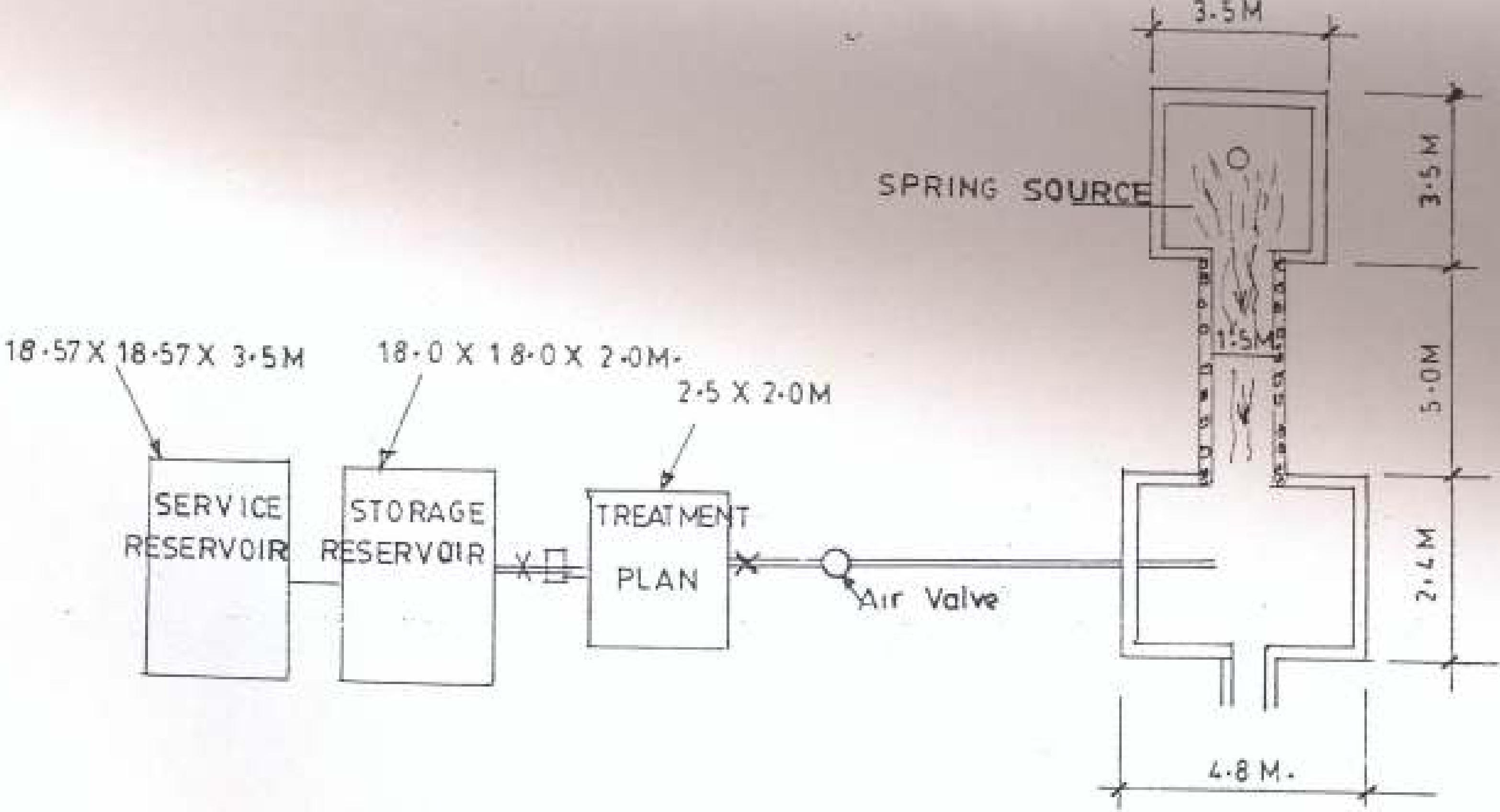
Allowable loss of head per 100m = $\frac{24.95 \times 100}{300}$ = 8.32m

Flow in DD_2 = 0.1l/s

Allow 25mm pipe, the loss of head is 0.55m in 100m (fig 12)

Total loss of head = $\frac{0.55 \times 300}{100}$ = 1.65m


195 M
185 M
5.0 M
5.0 M
18.57 X 18.57 X 3.5 M
2.5 X 2.0 M
SERVICE
RESERVOIR
TREATMENT
PLAN
STORAGE
RESERVOIR
AIR
VALVE
2.5 M
3.5 M
2.0 M
5.0 M
18.0 X 18.0 X 2 M



LAYOUT OF THE WATER SUPPLY SCHEME SHOWING CASCHEMENT OF THE SPRING TO SERVICE RESERVOIR

CASCHEMENT TANK
4·8 X 2·4 X 1·2M
(13,824 LITRES)