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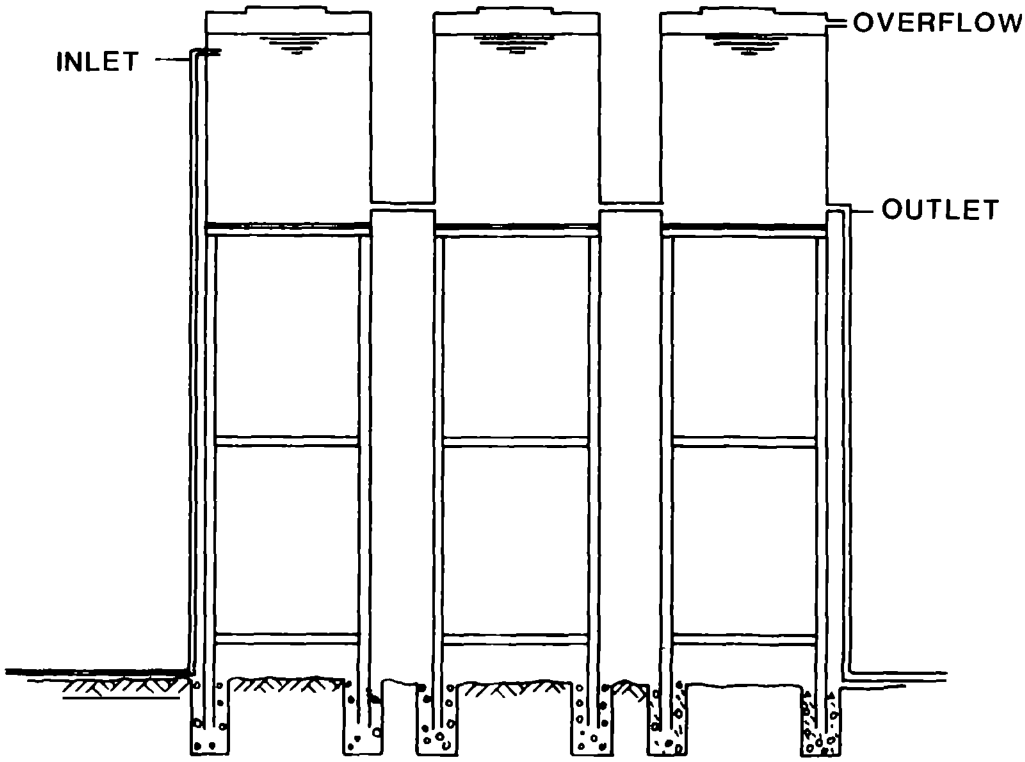
Planning a Demonstration Unit for the Water Recources Institute in Tanzania



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PLANNING A DEMONSTRATION UNIT FOR THE WATER RESOURCES INSTITUTE IN TANZANIA

TABLE OF CONTENTS

ABSTRACT

A demonstration unit for a technical training institution is a facility which helps to impart practical knowledge to trainees. A need of having such a unit at the Water Resources Institute in Tanzania has been realised after observing the guidelines of the national policy on technical training. The national policy stresses on a thorough practical training to trainees. The Institute has been preparing a curriculum which is in line with the national needs and guidelines.

A feasiblity study has been done on the river basin which is within the Institute premises by collecting and analysing the data.

A proper demonstration unit is the one which can show clearly how the water supply system works. The unit is purely meant for demonstration purposes and not for supplying water to consumers. This specific purpose has led to consider factors which are different from those of the actual water supply scheme in terms of technical and financial feasibility.

The selected feasible system includes a river bank intake, borehole, pumping main, raised metal tanks, distribution system which encompasses a testing/experimenting section.

The unit has been designed and an implementation cost estimate carried out using bill of quantities, leading to a cost of 300,000 Tsh.

1. INTRODUCTION

Water, being a basic necessity for a man, has been causing great problems in many communities. Consequently, the water sector was one of the technical areas which needed fast improvement. Water may be available in big quantities but of very poor quality thus requiring sophisticated treatment methods. In another place, there might be no water source nearby thus requiring a costly way of transmitting the water to the consumer. In both developing and developed countries, man has been striving to solve these water problems by inventing new technologies.

Tanzania, as a developing country has been experiencing such a problem. In order to solve the problem the nation has been asking for external assistance. As a response, many foreign countries have been extending assistance thus bringing in different technologies. Local experts were needed to plan, design, construct, operate and maintain the many water supply systems in the country.

The training needs for technicians became obvious and so the country had to formulate the policy for training the technicians. In that effort, the Water Resources Institute was established to train the much needed water technicians.

To suit the local water needs of the Tanzanian communities, the curriculum put much emphasis on conducting training which is performance-based. In other words, the trainee is taught about the areas which he will encounter in his working place. The Water Resources Institute lacks proper training facilities which are necessary for imparting practical skills. Consequently, a need for improving facilities at the Institute was very apparent. Due to this need which has been realized from the curriculum, the Institute decided to have a small demonstration unit to help students understand easily the water systems. Hence, it was decided to do a thesis work on planning a demonstration unit.

This work deals with the Tanzanian policy on training of technicians, the general trend of training technicians in developing countries, the specific training offered by the Water Resources Institute and finally the planning of the demonstration unit.

2. TRAINING OF WATER TECHNICIANS IN DEVELOPING COUNTRIES

2.1 General

Water technicians represent the middle cadre of the water resources engineering personnel, providing a vital link between the professional engineers and the craftsmen. They assist the professional water engineers and perform practical work on the field and at the same time supervie craftsmen.

Providing safe and palatable drinking water close to the people is one of the major goals in developing countries. Unfortunately, in these countries there is a lack of skilled water technicians making it a major constraint in managing water resources projects. For a proper management, a balanced ratio between professionals, technicians and craftsmen is very essential.

The lack of skilled technicians is mainly due to limited training opportunities, high costs involved in establishing technical training centres and the educational system of the country concerned.

Training of skilled manpower is a crucial factor in economic and social development. In developing countries there is a scarcity of financial resources consequently, giving priority to economic projects which are considered directly and immediately productive.

The water resources development sector which is considered as not directly productive, continues to suffer from the lack of skilled manpower due to less financial support. The sector is left to develop its own programmes mainly with external assistance.

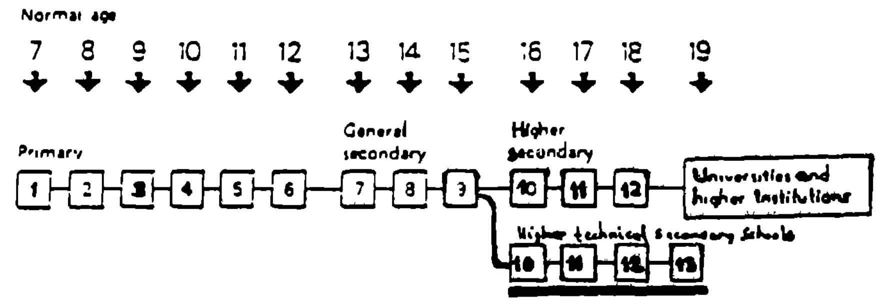
Due to this fact, many international organisations are providing training assistance to many developing countries to ensure the smooth running of water development projects.

2.2 Prerequisite for Technical Training

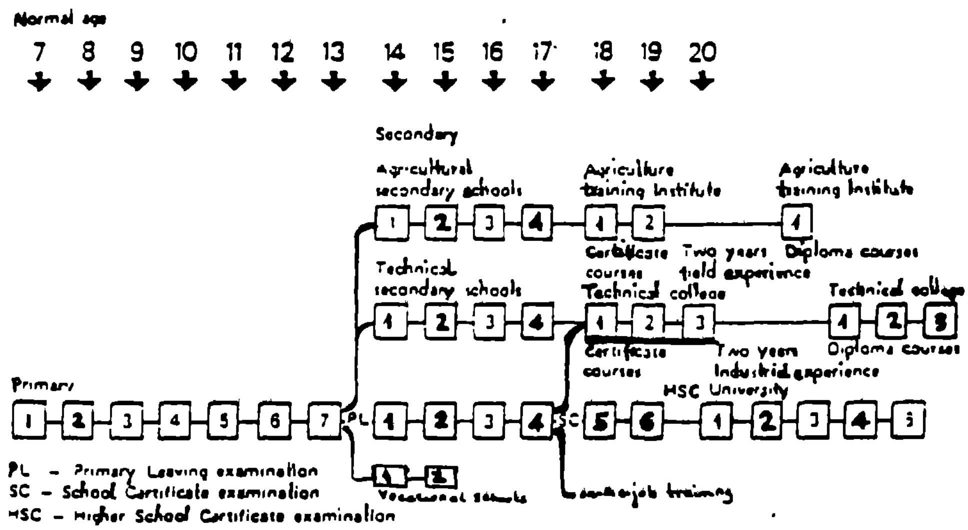
For an effective training outcome, there should be a certain minimum requirement for the aspiring training candidate. If a trainee has to benefit from the training, he has to have a proper background with necessary qualifications (Swere, 1980).

2.2.1 Education System

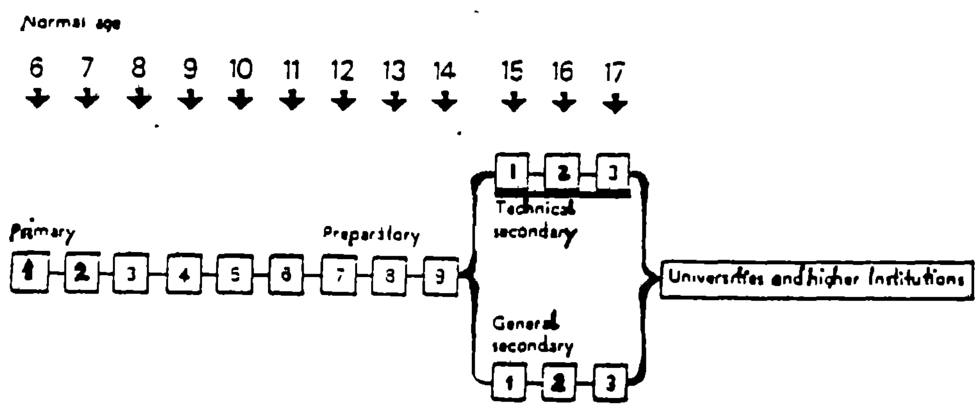
Different countries have different education systems mostly depending on the influence of foreign countries which were initially assisting in the education programmes. However, these systems have undergone various changes in some countries to suit their own development plans (Franklin et al 1982). Figure 1 shows three examples of National education systems from an engineering point of view, incorporating some recent changes. The craftsmen are trained in vocational schools after finishing primary education. Lower level technicians undergo on-the-job training after lower secondary education. The technicians (sub-professionals) are trained in technical institutes or higher technical secondary schools. The focus in this discussion is on the sub-professional which is underlined in the figure. From these examples it can be seen how the education system can influence the performance of the selected technician trainees.



(a) Sudan



(b) Tanzania



(c) Egypt

Figure 1. National Education Systems (a) Sudan, (b) Tanzania, (c) Egypt (UNESCO, 1976).

2.2.2 Choice of an Engineering Career

It is worth knowing the factors which influence a student to choose an engineering career. Depending on the influencing factor, the student may be a success or a failure in his studies and career in general. A survey conducted by Durchholz (1979) in the United States revealed 5 different factors:

1. Competence in mathematics and science in secondary schools. Those students who do well in mathematics and science look for a profession which is mathematics and science-oriented finally being led to choose engineering.

2. Suggestions from people (parents, teachers, etc). Parents who are engaged in engineering work influence their children even at home to develop an interest in engineering. Teachers who are fond of engineering from the experience of seeing top students going into the field, tend to push best students to join the profession.

3. Combining mathematics and science in future career. Some students are very fond of both mathematics and science to the extent that they are not ready to give up one of them by specialization. They finally find out that such combination is best achieved in engineering.

4. Engineering as a field of opportunity. Others think about life prospects, having big incomes. In this respect they feel that in engineering one can easily earn his own money by his engineering skills.

5. Love of problem solving. There are students who are curious about the physical world around them. They would like to see concrete results from their own initiative in problem solving involving physical sciences between people and things rather than between people and people.

When selecting students for a water technician course, it is wortwhile to note the decisive factors of the aspiring candidate. Each of the above factors plays its important role in the engineering career. The first and fifth factors in which competency in mathematics and science are combined with the high interest in problem solving mostly produce competent technicians.

2.2.3 Academic Requirements

Necessary competencies in a particular field of education is required for participating smoothly in the learning process. The three national education systems shown in Figure 1 have one thing in common which is that the main prerequisite for technician training is the lower secondary school education.

2.2.3.1 Mathematics

Mathematics plays an important role for a smooth engineering learning process. Every aspiring candidate for an engineering course should receive instruction in mathematics in secondary education (UNESCO and OAU, 1968). Many secondary school teachers suggest to students who have a high competence in mathematics to join the engineering field (Durchholz, 1979). A student who is weak in this basic subject should not be allowed to undergo an engineering training, otherwise a thorough and considerable upgrading would be necessary (Meskus and Vuoriranta, 1986).

2.2.3.2 Sciences

Science is a basic necessity for anyone who wants to exploit the scientific and technological potential of the world. The purpose of teaching sciences in the secondary schools is to understand the environment in which we live. Students should be scientifically minded and aware of the place of science in society. Scientific approach should be taught as a prerequisite to those who will go for engineering training. The main science subjects affecting engineering training are physics ans chemistry. The secondary school curriculum in these subjects affects the engineering training to a great degree (UNESCO and OAU, 1968). If a proper curriculum is followed at this level, then it is true that a student with good passes in physics and chemistry is a proper candidate for an engineering training.

2.2.3.3 Language

The language of instruction in training palys an important role for a smooth communication between instructors and students. Some deficiencies in language have been noted in a number of trainees in some technical institutions (Mabuba, 1986). To make sure that there are no language problems within students a number of technical colleges are teaching English as a separate subject (Meskus and Vuoriranta, 1986 and Mabuba, 1986). This means that secondary school education should include a thorough English training programme. Consequently, competence in English should strictly be a prerequisite for an engineering training. English has only been taken as an example of one of the languages of instruction.

2.2.3.4 Technical Subjects

In many national education systems students from the general secondary schools join technical colleges for engineering training. Little emphasis has been put on the role of technical secondary schools. One outstanding fact is that a technician is the one who helps a craftsman to transfer the technological information from the engineer to the user. To have this capability, various technical practices should be introduced earlier in his school life (UNESCO and OAU, 1968). This is well achieved by one passing through a technical secondary school. In technical schools, civil engineering practices are introduced including building construction, technical drawing, surveying and workshop technology. A student who has gone through such early engineering training is very suitable for a technician course. If a change is made in the National education system and such technical matter incorporated, best candidates will be obtained, instead of recruiting candidates from the general secondary schools.

The latter are most suitable for the higher secondary education and finally to the professional level.

2.3 Developing the Curriculum

2.3.1 Identifying Training Needs

Preparation of a curriculum is one of the stages in establishing a training programme. One of the World Bank's strategy in investing in education is to provide the education which is related to the work and environment. The purpose of this strategy is to improve quantitatively and qualitatively the knowledge and skills necessary for economic, social and other development (Psacharopoulos and Woodhall, 1985). Quantitatively in the sense that a trainee is equipped with all the knowledge and skills which he might need at his working place and qualitatively signifying the knowledge which is refined to suit the needs of his actual work. Every organization defines its own target performance for a successful completion of a task. If there is any gap between the level of competence of the worker and the defined target, then a training need exists (Stanley, 1984a). Identifying training needs preceeds any curriculum development work. Stanley (1984b) produced a model for the training process as indicated in Figure 2.

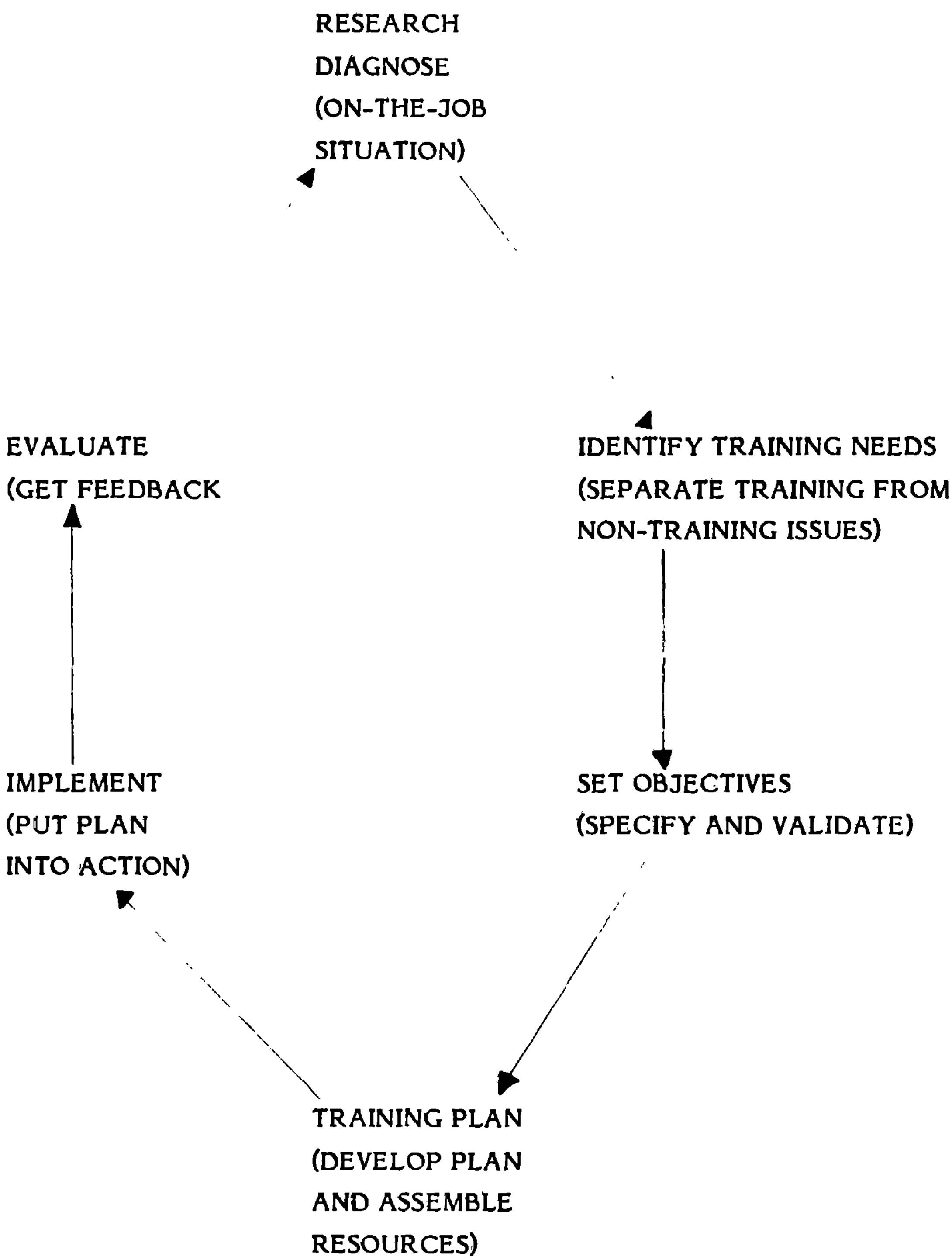


Figure 2. The training process (Stanley, 1984b).

To ensure that such competence is achieved, analysis of new technological development which affects the efficiency of the worker should be done (Colombo Plan Staff College, 1982).

A systematic investigation of a job is done by carrying out a task analysis. A task analysis reveals the nature of a job, procedure, equipment, knowledge and skills necessary for a satisfactory performance of a job. The Water Resources Institute in Dar es Salaam, Tanzania has carried out such a task analysis as reported by Francis (1984). The task analysis is carried out by first questioning the worker on what he does, how he does it, what he uses to do it, and what he needs to know to be able to perform it. Secondly, the worker's supervisor is questioned in order to verify the answers given by the worker. Furthermore, the supervisor is asked to give the deficiencies which he sees in the worker's ability and what he specifically expects him to do. Finally, the analyst takes time to observe the worker in actual practice for further verification of the answers he got previously. This approach will result in formulating a relevant curriculum for the technician training programme (Swere, 1980).

2.3.2 Science and Mathematics

Further consolidation of the knowledge in basic sciences and mathematics is essential even during the technician training course (Mwale, 1980). Contents of these subjects are decided on the basis of the task analysis performed, to verify their relevance (Edwards and Robertson, 1980). For a water technician, the following brief contents prove to be of much help:

Mathematics:

Algebra - Algebraic expression, solution of systems of equation, quadratic equations, fractions, ratios and proportions.

Trigonometry - Angles, trigonometric functions and graphs.

Logarithms - Exponential and logarithmic functions, logarithm of trigonometric function.

Geometry - Plane and solid geometry.

Analytic geometry - Rectangular coordinates, graphical solutions of equations, polar coordinates, graphs of logarithmic functions.

Calculus - Differentiation and integration.

Chemistry:

Water chemistry.

Geology:

Physical and structural geology.

Statistics:

Probability, frequency distribution, sampling theory, hypothesis testing.

Physics:

Light - General theory
Heat - General theory, heat transformation, thermodynamics.
Electricity - D.C and A.C theory.

There is a necessity of providing a bridge between mathematics, basic sciences and engineering practice through a thorough study in mechanics (Hansen et al, 1986). The most useful areas in mechanics are statics, properties of materials and basic theories in dynamics.

2.3.3 Technical Training

Technical training is the core area of the technician training programme. In this training, a student acquires technical knowledge and skills directly required to perform his duties. The task analysis which has been explained earlier, helps to determine precisely what a successful candidate must be able to do at the end of the proposed training programme.

To produce a competent water technician, the training programme must strike a balance between theoretical technical understanding and practical skills. Figure 3 illustrates the relative proportion of theoretical knowledge and practical skills required during training of the three major engineering personnel. Technician training is represented by about one to one ratio between theoretical and practical knowledge. This representation is only a general trend. The ratio depends on the skill level of the workers with whom the technician is working. It can therefore vary from place to place.

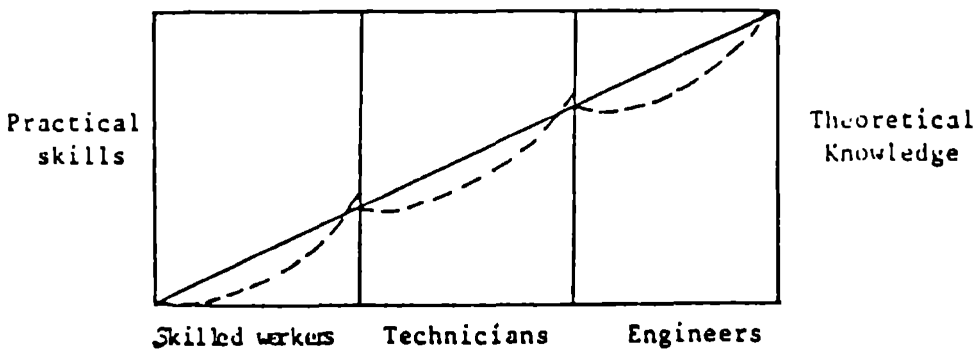


Figure 3. Relative proportion of theoretical and practical knowledge during training (Francis, 1984).

The water sector constitutes a variety of duties which cannot be undertaken by one technicain. It involves searching for water from a suitable source and conveying it to the user. Throughout this process, different people of different skills are involved. In planning for a technician training these facts cannot be overlooked. It is therefore necessary to divide the water sector in four groups namely, Hydrology, Hydrogeology, Water Supply and Water Analysis. The contents of the training programme are divided according to these four categories of water technicians.

1. Hydrology:

- Introduction to hydrology and meteorology
- Surveying and investigating water sheds
- Establishing hydrological and meteorological stations
- Hydrometry: Collecting and recording hydrological and meteological data
- Analysing and processing of hydrological data
- Inspecting, repairing and maintaining hydrological and meteorological instruments
- Water resources development

(Colombo Plan Staff College, 1982: WMO, 1983; UNESCO, 1983: 1984 and Mabuba, 1986).

2. Hydrogeology:

- Hydrogeological surveys
- Groundwater monitoring, evaluation and management
- Process of extracting groundwater
- Inspecting, repairing and maintaining drilling equipment
- Processing and documenting groundwater data
(UNESCO, 1984 and Mabuba, 1986).

3. Water Supply:

- Sources of water supply
- Water requirements
- Water and health
- Water installation systems
- Surveying measurement and computations
- Water supply designs
- Water treatment methods
- Cost estimates of water supply systems
- Maintenance of water supply systems
(Kamwanja, 1980; Hamad, 1984 and Mabuba, 1986).

4. Water analysis:

- Water and health
- Water quality surveillance
- Introduction to water analysis
- Laboratory techniques
- Physical analysis
- Bacteriological analysis
- Chemical analysis
- Laboratory organization procedures
(Hamad, 1984 and Mabuba, 1986).

The categories of water technicians may vary from country to country, depending on prevailing needs and conditions. Some countries may include sanitation, irrigation, hydropower etc in training water technicians. This work deals with training in supplying drinking water.

2.3.4 Practical Training

Practical skills can be obtained by conducting field training. Field training can be done in different ways depending on the financial resources available. It can take the form of field visits in which students perform the job practically under the supervision of the instructors (UNESCO, 1983 and 1984). Another form is to dispatch students to various water projects where they perform the actual job under practical on-the-job experience (Kamwanja, 1980 and Mabuba, 1986). Whichever way is used, it should be supplemented by a project work prepared at the training centre which will require the students to apply the theoretical knowledge taught in class (Mabuba, 1986). The project work can include data collection, data compilation and analysis; work planning and implementation, etc.

2.3.5 Management and Human Relations

Due to limited manpower in developing countries, water technicians have to perform non-technical duties (Oyebande, 1983). Such tasks can be managing and supervising skilled, semi-skilled and non-skilled workers. They should therefore have an art of administering staff and equipment in general. Many technicians are involved in rural water projects which in most cases require an element of community participation. This means that a technician will in one way or the other come into contact with technical and non-technical people. Definitely, such a technical person will need to know the social system around him so as to perform his duties successfully without frustrations. People who are most succesful in their career are not those who were thought to be most intelligent during school life but rather the ones who get along with others and have social skills in addition to the technical competencies (Peterson, 1982).

This special training to technical personnel can have the following contents:

- Personnel management
- Government procedures and regulation
- Planning and implementing work activities
- Project reporting
- Understanding people and effective communications
- The dynamics of attitude and your magnetic personality
- Rural community structure and organization
- Education for users

(Mwale, 1980; Kamwanja, 1980 and Peterson, 1982).

2.3.6 The Systematic Approach to Curriculum Development

The traditional way of developing the curriculum is to present the contents of the course in the form of subjects. There is no any clear guideline on what are the real objectives set for a particular skill and what sequence and methodologies should be applied. This has in many cases led to a poor training outcome. To avoid such ineffective manner of training, the curriculum should be developed by laying down objectives, sequence of instruction and resources of instruction.

Objectives:

The contents of the curriculum as outlined in the preceding sections is a result of the task analysis procedure. These contents have to be broken into smaller units in the form of performance objectives according to the skills required. If a particular task requires many skills, many performance objectives will have to be stated. The performance objective shows what the trainee must be able to do after undergoing a particular training.

These objectives have to be listed in terms of observable behaviour shown to a certain standard under defined conditions. An example of the performance objective is: Given correct tools and size of pipe, three valves, flange sockets and spigots, two bends and meter, install by-pass connection on main for leak detection meter without allowing leaks at connections (Carefoot and Gibson, 1984).

This performance objective states three things. Firstly, it states the observable behaviour required which is the installation of by - pass connection on main for leak detection meter. Secondly, it states the conditions in which the observable behaviour should be shown. These are the tools and connection parts to be used. Thirdly, it states the standard to which the trainee should perform, that is, the connection should not allow leaks.

Sequence of instruction:

For every performance objective there should be a statement which shows the knowledge required before one can start a particular training programme. This will help the instructors to carefully arrange the teaching items in order. He will be able to know which items should be taught first, which one should follow next and finally, building the entire skill in a logical manner.

Resources of instruction:

After setting the objectives and arranging the sequence of instruction, decisions should be made on three main components, that is, time, teaching methodologies and materials required for every instructional item. The time frame should include teaching and practice time, number of sessions and total number of days required for a successful completion of the task. The teaching methodologies leading to easy and effective learning will be discussed in the next section. Teaching materials such as handouts, manuals and media have to be well arranged.

2.4 Training Resources

As mentioned earlier, when a task analysis is carried out the worker is asked about what he uses to perform any given task. The purpose of such questioning is to list down the facilities which are essential for training the technicians. A final list of the required training facilities is arrived at after compiling the contents of the curriculum. A cost estimate of such facilities should be done in order to see if it is affordable (Carefoot and Gibson, 1984). In most cases these costs become so high that the local governments fail to meet them. To alleviate this problem, developing countries seek external assistance as indicated by UNESCO and OAU (1968), Musie (1980), Sere (1980) and FINNIDA (1983). The World Meteorological Organization and UNESCO recommend that for effective training, water technicians should be trained in their home countries (WMO, 1983). This means that individual governments have to find the solution to the prevailing financial constraint.

2.4.1 Instruction

The method of instructing the students will depend on the available training aids and facilities at the training centre. However, full utilization of the facilities relies on the competence of the instructors. The best instructors in technician training are those who have already acquired field-work experience (Mabuba, 1986). Table 1 lists done training methods which are considered effective in technician training, based on the content of the curriculum explained in the previous chapter.

Table 1. Training methods (Carefoot and Gibson, 1984).

Method	What it is	What it does	Points to watch
Guided reading	Trainee is given standard literature to read and comment upon in a structured situtation.	For management level and self motivated trainees. An effective means of knowledge transfer.	Danger of self deception. Requires strong motivation.
Lecture	Talk with little or no participation.	Information transfer to large audience with controlled content and timing.	Lack of participation likely to prevent some people's understanding or assimilation. Avoid giving too much information.
Discussion	Knowledge, ideas and opinions freely exchanged.	Useful when application of information is flexible or attitudes require changing.	Session may be blurre or incoherent. Attitude may be entrenched. Skilled leader required.
Demonstration	Trainee is told, shown and then does job, with correction and supervision.	Skills may be manual, clerical or social. Confidence helped.	Avoid excessive delay of practice The whole may be important as well as parts. The breakdown of skills can be a refined programme.

Method	What it is	What it does	Points to watch
Role playing	Trainees enact the roles they will play in work e.g. "In tray" exercises where by trainees receive letters, files, etc. to action.	Practice of face- to face skills, with feedback. Realistic pressure possible. Good for decision-making skills. Opportunity to learn things not directly related to exercise.	Embarrassment and tendency to joke must be avoided. Skilled leader required. Items must be realistic.
Coaching	An essentially personal on-the-job management training technique designed to inspire and develop individual.	Imparts knowledge, develops skills and forms attitudes during informal but planned encounters between managers and subordinates. This technique increasingly offers sound learning situations within a management development programme.	Successful coaching depends on a clear definition work and training objectives. Mutual confidence must be developed. Coaching can be a long process and be well planned to make time available for question checking, assimilation, giving feedback, rewarding reinforcing progress.
Case study	Real event with support facts presented to trainees for analysis.	Possible exchange of ideas and different solutions without penalty.	Unreal atmosphere and lack of background may encourage impractical decisions.

Method	What it is	What it does	Points to watch
Assignment	Task or investigation undertaken to close guidelines after a session of information absorption.	Practice encourages learning transfer to job situations. Useful as a test for the trainee.	Realistic exercises should be chosen to avoid frustration. Loss of confidence must be avoided.
Group exercise	Trainees examine problem and propose solutions as a group.	More effective group working and insight into the way groups think and arrive at decision.	A trainee's personal performance in the group can be analysed and fed back to him. Such actions require skilled handling and should be treated with care. Group of four and fewer ensure full commitment.

A clear look on the column headed "what it does" in Table 1 gives a brief account of principles of learning such as motivation, active involvement, individual approach, sequencing and structuring, feedback and transfer. A particular method is applicable to a particular lesson depending on human factors, namely, instructors, students and environment and the objectives of the training such as knowledge, skills and attitude.

Instructors should create a learning environment which will stimulate the desired reactions from students. It is what students do that determines what they learn and not what the instructor does (Gagne, 1965 cited by Grayson, 1979). Considering instructors as one of the human factors playing a role in a learning process, it is worth noting that individual preferences, styles and abilities exist. However, the main focus is centred on learning and not teaching thus calling for flexibility within the instructor's preferences (Irey, 1981). For example, two professors in Korea found it rewarding by making full use of equations, sketches - particularly isometric views - and body communication which earlier were not given much attention (Niebel and Liu, 1981).

2.4.2 Facilities

2.4.2.1 Teaching Aids

Setting up a technical training centre is not an easy task. Even teaching aids will require a big sum of money if an effective learning is to be achieved. Essential and effective teaching aids are stationery, blackboard, slide projector, screen and camera (Hamad, 1984). Overhead projectors, though widely used, tend to give too much information which cannot be absorbed effectively by students.

2.4.2.2. Library

When presenting the training methods in Table 1, guided reading was included as one of the methods. This can be well achieved by having a library equipped with a range of relevant reading materials. A photocopying machine will prove to be of much use especially when the reading assignments are numerous and requiring more extra time. Instructors should make sure that students are really utilizing the books, otherwise, the library will be acting as a place of guarding books and not as an information retrieval centre (Vogler, 1978).

2.4.2.3 Water Analysis Laboratory

Training water laboratory technicians without a water analysis laboratory is a vein undertaking. A well designed laboratory is essential for a technician. It should include apparatus and equipment required to carry out physical, bacteriological and chemical analysis of water as stipulated in the contents of curriculum. Since the capital cost of installing such a laboratory is high, it is profitable to use it for analysing samples from other interested organizations in order to get some revenue.

2.4.2.4 Workshop

Training in a workshop is one of the ways of imparting practical skills to students. Most of the instructional methodologies presented in Table 1 such as demonstration, project assignment and group exercises can be well performed in workshop. This means that a proper workshop should have equipment, instruments and materials covering the entire contents of the curriculum.

This will include surveying equipment and instruments, testing machines for building materials, hydrology, meteorology and hydrogeology instruments and equipment and water supply installation equipment.

2.4.2.5 Actual Life on Campus

At the training centre, definitely there is a water supply system and also a waste water disposal system. These service systems can be utilised for giving demonstrations to students. Students can also acquire some skills by repairing or maintaining the two systems wherever there is a need to do so, instead of using other workers.

2.4.2.6 Demonstration Unit

Two forms of practical training have been mentioned earlier, that is field visits and field training at actual place of work. When it is possible to set up a demonstration unit, it will help to consolidate practical training. A demonstration unit is feasible when the training centre is able to acquire an area where there is a possibility of getting different water sources. When such an area is within reach a plan can be made to take advantage of that natural resource.

A demonstration unit can include the following sub units:

- River gauging: water level, river flow
- Diversion structure: dam
- Hydraulic structures: notches, weirs, open channels
- Surface water intake
- Shallow or deep well with a small drilling equipment unit
- Water supply distribution system
- Irrigation water distribution system
- Meteorological station
- Water treatment unit.

A suitable water source for this purpose is a non-perennial river. The surface water intake has to supply water into the whole unit. When the river flow is very low and the impounded water by the dam is practically dry especially in dry seasons, a well can be used as a substitute in order to make sure that the unit has enough water throughout the year. The irrigation distribution system if planned well, can be beneficial by using it to irrigate plots. For planning and designing purposes sufficient data has to be collected. This includes hydrological, hydrogeological and topographical data. The erosion of the river bed and banks should be taken into account by analysing the natural soil conditions.

Other facilities, such as classrooms, hostels, administration offices, recreational facilities, and dining rooms should be well-provided to make it a complete training centre.

2.5 Evaluation of Training

The joint inspection unit of the United Nations defined evaluation as a learning and action-oriented management tool and process for determining, as systematically and objectively as possible, the relevance, effectiveness and impact of activities in the light of their objectives in order to improve both current activities and/or future planning, programming and decision-making (Sohm, 1978 cited by Stanley, 1984a). With a light on this definition, evaluation of technical training has been divided into two groups. One group is the evaluation during training which includes evaluating students and instructors and the other group is evaluation after training which is centred on the graduates at their working places. The former is termed as formative evaluation while the latter is termed summative evaluation (Greenfield, 1978).

2.5.1 Evaluation of Students

Evaluation when the training is in progress is meant to provide a feedback to instructors so that they can make mid-course corrections or modifications if required. The results of the evaluation can be reported back to students for proper improvement on what they are doing. This implies that evaluation should be a continuous process (Thomas and Friedman, 1978). Measuring student learning is not an easy process. Grading of students has long been used as a measure of learning although many setbacks have been noted. Table 2 gives three areas of objectives which should be observed in designing test questions for grading students if this method is used as a testing measure at all.

Table 2. Designing test questions (Thomas and Friedman, 1978).

Group of objectives	Evaluation instrument	Subject matter
Affective domain	Questionnaires, interviews and essay questions.	Attitudes, values and appreciation.
Psychomotor	Observation of performance.	Manipulation, drawing, physical performance.
Cognitive domain	Problem solving, experimental design, drawing inferences from data.	Intellectual ability.

2.5.2 Evaluation of Instructors

The learning process of a student is greatly affected by his instructor. A smooth process will need instructors who have technical competence and able to deliver the knowledge to students effectively. A low grade which a student gets from test questions does not necessarily mean that his knovledge is poor, but can be attributed to the performance and behaviour of the instructor (Thomas and Friedman, 1978).

This makes it necessary to evaluate the instructors although many engineerlng professionals do not like this idea (Centra, 1980). Result from such an evaluation will help to change, modify or incorporate new instructional methodologies.

Threre is no single method which is infallible in evaluating teaching. Centra (1980) carried out a series of studies for six years and came out with three promising methods of evaluating teaching. The three methods should be applied simultaneously.

- Self reports:
  In this method the instructor prepares a self report of his professional activites and teaching. The report should clearly include the objectives and contents of the curriculum, instructional methodologies used, the system of evaluating students, achievement of students and research activities.

- Student rating:
  Although this method is influenced by many factors it has proved to be useful if taken collectively with other methods. Students are provided with a questionnaire in which they rate the value of the course, the effectiveness of the instructional methodologies and the degree of smoothness in the learning process of the students.

- Colleague evaluation:
  The self report prepared by the instructor is given to his colleagues who go through it thoroughly in order to judge its contents. This method plays a principal role in the teaching evaluation process.

When all the three methods are used simulataneously, they can provide a means of proper advice on instructional improvement. They can also serve as a basis for preparing a staff development plan for raising the technical competence of the instructors. These methods can easily serve as a way of identifying training needs for instructors.

2.5.3 Evaluation After Training

Strictly speaking, evaluation after training is done in order to determine to what extent has the curriculum met the training goals and objectives. This kind of evaluation should form a part in the programmes of a training centre because training does not end at a point when a student steps out of the classroom but rather after the new skills have been put into practice successfully.

Due to the shortage of manpower in developing countries, graduates are in most cases placed in positions which are not relevant to their specific professions (Swere, 1980). Evaluation after training will be meaningful if a graduate is placed in a relevant position.

One should look at the goals and objectives of the curriculum in a broader way if an improvement in the training contents has to be done successfully. Table 3 gives an example in which the goal of the training is to teach a plumber to conduct a leak detection survey. The specific objective in this training is the plumber's ability to perform a leak detection survey and a general broader objective is to reduce the water shortage in the distribution system. These two objectives should be considered when evaluating this training.

Table 3. Example of useful data in training evaluation (WHO, 1981 cited by Carefoot and Gibson, 1984).

To evaluate the achievement of:	The following data is necessary:
Plumber's ability to perform a leak detection survey.	Performance appraisal at completion of training for all plumbers who participated in the course.
	Reports from supervisors who have observed performance of plumbers as they do leakage surveys on-the-job.
Reduction of water wastage in the distribution system.	Statistics showing estimated number of gallons of wastage in a specific district **before** training of plumbers.
	Statistics showing estimated number of gallons of wastage in the same specific district **after** training of plumbers.
	Percent reduction in water losses in the district.

The results of this evaluation are used to carry out necessary modification in the training system at the training centre. It can also help to arrange refresher courses for the former students in order to give them new developments in technology.

3. EDUCATIONAL POLICY OF TANZANIA ON TECHNICIAN TRAINING

3.1 History of Technical Education in Tanzania

Far back before independence, the Country's technical training was conducted at two centres, namely Ifunda and Moshi. The output from the two schools was mainly artisans and craftsmen to meet the manpower needs for the public works department.

Later in in 1965 the two schools were phased out into technical secondary school following an advise from the international labour organisation (ILO) expert. Following this report, vocational training programmes were transferred to the Ministry of Labour and Social Welfare. The Ministry of Education continued to develop secondary education and not craft training. Lacking proper coordination, craft training was phased out from the curriculum of middle schools. This created a vacuum of skills training in the education system under the Ministry of Education. This purely academic approach within the formal education programme was a draw back in the whole system of technical manpower development in the country.

For the past twenty-five years of independence Tanzania has undergone many changes regarding technical manpower training and demands. Technological changes have taken place asking for specialised training programmes. The Ministry responsible for water development in the country found itself having the same problem of an increased demand of technical personnel. This Ministry, like many others, realised that it needed its own specific training programme in order to solve the increasing technical manpower problem.

In its development programmes, the nation has been puting more emphasis on technological development thus demanding a lot from the country's resources. Many foreign countries started to assist in the development programme and so different technologies were brought in. This resulted in an increased demand of skilled technical personnel. Due to this demand, deliberate efforts were taken by various organisations, industries and government ministries in establishing technical institutions in order to meet their sectional technical manpower needs.

At that time there was no coordination unit in the government to make sure that all training programmes were properly carried out. The setting of various institutions was done in an uncoordinated manner. This resulted in under-utilisation of some training facilities and space in those institutions. A lot of resources were spent in establishing institutions without producing the expected positive results. Still there was a big demand for skilled technical personnel. To cite an example, an additional demand of technicians in various industries for the years 1981 to 1986, was 10,449; however, the present institutions were only able to train 3655 technicians during the same period. This represented only 35 % of the actual demand (DTTC, 1983). In 1983 there were 293 state and parastatal training institutions established or in the process of being established in Tanzania.

This situation posed a serious need for proper coordination in the technical training programmes. In 1979 the National Technical Training Advisory and Coordinating Council (NATTACC) was established having its secretariat in the Ministry of Manpower Development and Administration.

At about the same time a Directorate of Technical Training Coordination (DTTC) was formed in the Ministry of National Education. The two bodies decided to pool their resources in coordinating the technical field and so, in 1981, the NATTACC Secretariat was transfered to the Ministry of National Education, in which the DTTC assumed executive power.

The Directorate conducted a survey and research and put forward recommendations which were taken as the country's policy proposals on technical education and training.

The Directorate found out that the trends in technical manpower training indicated that greater emphasis has to be directed towards the training of middle level technical manpower. The training of technicians should therefore be realigned in accordance with the national needs.

3.2 Objective of Technical Education in Tanzania

3.2.1 Broad Objective

The Arusha declaration in 1967 stated clearly the need to have self-reliance in manpower needs. The Musoma resolution in 1974 emphasized the need to have manpower sufficiency by 1980. The aim was to train indigineous local manpower to man various institutions in order to eliminate dependence on foreign expertise.

3.2.2 Specific Objectives

- To provide basic education to every Tanzanian child between the ages 7 - 13.
- To provide further education justifiable by the manpower requirement for the rapid economic development of the country.
- To enable the country to attain self sufficiency in all technical manpower skill levels.
- Self-sufficiency in all technical manpower skill levels was not met by 1980 as it was intended due to various factors.
- Lack of coordination between education, manpower and economic planners.
- Expansion of education in general and technical education in particular has depended largely on foreign aid subsidies, grants and loans thus overshadowing the utilisation of internal financial resources.
- Absence of a clear policy on technical education and training.
- Uncoordinated establishment of technical institutions by various Government ministries and parastatal organisation.
- Lack of registration on training of technicians.

These setbacks indicate a need to have changes in the structure of technical education in Tanzania so that technical training at all levels is properly integrated with production.

3.3 Proposed Technician Training Act

A need to have a technician training act arises from the fact that:

- There is a general shortage of technicians in the different technical disciplines.
- There is a need for constantly improving the quality of training of technicians.
- The role of a technician is an important one, linking the engineer and the craftman.

3.3.1 Central Administration of Training of Technicians

3.3.1.1 The Ministry of National Education

This Ministry has to carry out particular duties as per this act;

- Formulate National policy and guidance to be followed in the training of technicians.
- Carry out official inquiries into the various aspects of training technicians in the country for the purposes of harmonising the programmes wherever possible.
- Carry out modification and changes in the programme for the training of technicians for both public and private institutions.
- Introduce requlations for the good and further promotion of technical education in respect of technicians having regard at all times to the national interest.

3.3.1.2 The National Technical Training Advisory and Coordinating Council (NATTACC)

Functions:

- To carry out research and make recommendations to the government on any matter connected with the training of technicians.
- To advice the government on means of insuring adequate supply of properly trained technicians for the industry, but leaving the industries free to train their own technicians.
- To issue circular and formulation of requlations to maintain or raise the quality of technician training, modifying the curriculum, examinations and awards as may deem necessary.
- To establish training committees for the purpose of training of technicians.

3.3.2 Establishment and Registration of Training Colleges and Institutes and Other Training Facilities

Any government ministry, department or public cooperation may establish institutes for the training of technicians with proper curriculum and training schemes for technicians. The establishment of such an institute must be duly enacted by parliament. The director of technical training is responsible for keeping a register of all technicians training institutes or colleges so formed. Similary employers in the private sector may establish training facilities for their own technicians only which should be recognized by the Ministry of National education after the approval of NATTACC in regard to curriculum and training schemes. After such approval, the Minister has to establish a board of governors for the college or institute.

3.3.3 Curriculum for Training Technicians

3.3.3.1 Aim

The curriculum is aimed at providing guidelines for the entire course of study that shall enable a technician to fit in the Tanzania industry. It should give the technician an understanding of engineering principles and act as an engineer's assistant as well as work independently in practical plans at the same time being capable of supervising and acting as a foreman.

3.3.3.2 Theory and Practice

It is necessary to allocate equal time to both theoretical training and practical training with more emphasis on the practical side.

Theoretical knowledge and skill are imparted through lectures and help the technician trainee to understand different scientific concepts. Lectures should include general subjects such as mathematics, physics, political education and communication and relevant technical subjects.

The practical work should be undertaken in laboratories, workshops, factory floors and field projects. During their training period, student technicians should repair and maintain college appliances. The college should establish contracts with individual customers, private industries or even public industries with a view of securing orders from them to fit in the training programme. They should be afforded the chance to participate in actual industrial projects outside the college in order to get different kinds of experience on site and in workers organisation. At the end of such practical work students should write general and technical reports of their activities.

3.3.4 Training Schemes

The National Technical Training Advisory and Coordinating Council (NATTACC) is responsible for making training scheme proposals which should be submitted to the Ministry of National Education for approval. The proposals should clearly specify the following conditions for efficient training of a technician in any field:

- Qualification and educational standards required for technical trainees.
- Practical training quidelines which should be provided by the Institute and employers.
- Theoretical training specifying definite subject matter to be covered.
- Proficiency tests or examinations which the trainee is required to undergo.
- Allocation of time for the week and eventually for an academic year in regard to theory and practical work.

Proper monitoring and inspection by the director of technical training coordination has to be carried out on the training facilities as registered.

3.3.5 Courses and Awards

NATTACC has the task of making recommendation of courses of study which are acceptable for technicians training. It should also recommend which institutions should award ordinary technicians certificate or Full Technicians Certificate as per the Institute's proposals. The recommendations should thereafter be approved by the Ministry of National Education.

The standard and quality of the awards for technicians should serve the purposes of employment and renumeration. As time goes by, more and more areas for technical training become necessary as changes take place in the economy of the country. This will require a continuous revision of the range of courses offered in the technicians training system. NATTACC should make sure that there is such a continuous revision from time to time.

Two modes of study in training technician can be used. Students may study on a full-time basis which takes 2 - 3 years, or on a part-time basis, whose duration varies depending on course specialisation and its contents.

4. TRAINING OF WATER TECHNICIANS AT THE RWEGARULILA WATER RESOURCES INSTITUTE IN TANZANIA

4.1 Establishment of the Institute

The government of independent Tanzania has from the beginning been keen on the need of providing safe and palatable water to every family in the country. This problem had a very high magnitude thus posing a big challenge.

To resolve this problem it called for modilisation of extensive human and material resources. Training of water technicians has long been done through programmes in a limited scope thus not able to meet satisfactorily the personnel requirement nationwide in terms of quantity and quality (RWRI, 1983).

A new Ministry of Water Development and power was formed in 1970. At the same time the government of Tanzania launched a twenty-year programme of providing safe and adequate water supply to all the people. The new Ministry was given a task of implementing this resolution. It started by addressing itself to the urgent problem of ensuring a steady supply of technical manpower to support its extensive rural water supply programmes. At that time there was an acute shortage of trained personnel of all cadres. i.e engineers, technicians, craftsmen, etc for the planning, implementation, operation and maintenance of water projects (RWRI, 1984).

It became apparent, therefore, that there was a need for establishing a well equipped institution for the exclusive training of water technicians. The persistent need of water technicians lead to the establishment of the Water Resources Institute in 1974 intending to make it a fully developed institution.

4.2 Goals and Objectives of the Institute

The primary responsibility of the Institute when it was established in 1974 was to train water technicians to take positions in the various branches of water engineering in the country. The objectives by then were set as:

a) to train middle level water technicians
b) to train skilled workers in those trades relevant to the water sector

c) to carry out applied research and offer consultancy services to the technical departments of the Ministry of Water, Energy and Minerals
d) to organise seminars and workshops in water resources
e) to collect, document and dissemimate information on water resources activities in the country.

The development activities within the water sector have gone through many changes. New developments and concepts have taken place. Due to this reason the role and responsibility of the Institute had to be reshaped and expanded accordingly.

The overall responsibility is now stated as to provide broad -based technical training programmes and professional support sevices for the water sector (Mabuba, 1986). In detail, the objectives can be listed down as follows:

a) Providing training programmes for technicians for skills development and career advancement.
b) Facilitating and supervising the training and certification of skilled workers for the water sector.
c) Providing competent regional trainers and supervising and directing training of regional, district and village operators.
d) Conducting appropriate technical research and studies.
e) Evaluating the impact of human resources development activities on improving the quality of service generally in the water sector.
f) Facilitating the effective integration of related health education, water and sanitation programmes through inter - institutional collaboration.
g) Developing performance-oriented training materials for use of water technicians, skilled and unskilled levels.
h) Developing appropriate operation and maintenance manuals for various technology options for the water sector.

4.3 Training Programmes at the Institute

4.3.1 Full Technicians Course

The Institute offers two full technician courses, one in water resources engineering and the other in water laboratory technology. Both courses last for three years, offered on full-time basis. Admission into the courses is given to those students who have successfully comleted the ordinary level secondary school education with passes in mathematics, physics or engineering science, and chemistry. During their third year of study, students taking the course in water resources engineering can opt for one of the three sections namely water supply, hydrogoelogy and hydrology. The first two years are devoted to studying the basics in civil engineering in general. Students in the water laboratory technology course follow the same curriculum during the whole course of study.

4.3.2 Short Courses

The Institute offers various water-related courses in its in-service department. The in-service department trains craftsmen in the following areas:

Motor vehicle mechanics, autoelectricity, building construction, carpentry, draughting, electrical installation, fitter and turner, hydrology, hydrogeology, meteorology, masonry, pump mechanics, plumbing, sign writing, soil mechanics, surveying, shallow wells prospecting, shallow well construction, water treatment, irrigation, hydraulics and safe driving. These courses are directed by the Institute but offered in all regional water engineer's offices by a regional recruitment panel. Candidates who are secondary school leavers become assistant technicians after passing an examination set by the Institute.

4.3.3 Evening Courses

The government asks for full utilisation of training facilities available at various training centres. In response to this policy the Institute started an evening classes course programme which is in high demand in the country. The curriculum which is followed is approved by the Ministry of National Education and the National Examination Council. On completion of these courses graduates join various industries in the country.

The courses currently on offer are:

1. General course in engineering (G.C.E.). This is a three-year programme for post-primary school trainees.
2. Construction technicians course. This is a one-year programme for ordinary secondary school leavers.

3. Civil engineering draughtmanship course. This is also a one-year programme for ordinary secondary school leavers.

4.4 The Proposed Curriculum at the Institute

4.4.1 Aims and Objectives of the Curriculum

The new curriculum aims at the training of technicians for service in Tanzania's water sector in the areas of:

1. Hydrology,
2. Planning and design
3. Construction and installation
4. Hydrogeology and drilling
5. Water laboratory technology.

The objectives of the curriculum are:

1. To develop and consolidate useful elements of general education reviewed in secondary school, so as to enable full active participation of the trainee in the training offered at the Institute and in preparation for a water technicians career.
2. To give the trainee basic understanding of the role and functions of a work supervisor, plus knowledge and skills for successfully carrying out these functions.
3. To provide a modular job oriented and performance based course programme which is easily adjustable to technical requirements or developments, and for the needs of special trainees.
4. To provide compatibility with similar technical institutions, within the framework of the country's manpower development programmes.
5. To enhance a trainees personal understanding and skill in specialised areas as a basis for further technical training.

4.4.2 Development of the New Curriculum

The Institute carried out on-the-job task analysis of water technicians working in the lake regions and in Dar es Salaam. This study established that there was a need to use performance oriented training using proper training facilities at the Institute. This approach is based on the skills that the trainee should have at the end of the training. The answers received from the task analysis lead to the establishment of task statements. Closely related job tasks were grouped together to form a duty statement. Out of the duty statement, a module of required knowledge and skill was formulated to make up the required technical competencies for a trainee (Kusare, 1987). A list of all modules is shown in Appendix 1. The task analysis also helped to prepare the curriculum guides, each outlining the resources, skills and conditions required for providing instruction in each job task. An example of a curriculum guide is shown in Appendix 2.

4.4.3 Organisation of the Curriculum

The modular, performance - based curriculum is to be offered through a number of learning activities:

1. Technical competence (TC) modules
2. General education (GE) modules
3. Basic supervisory management (BSM) modules
4. Field training
5. Project work
6. Elective (EL) modules

A brief description of these activities is given below.

4.4.3.1 Technical competence (TC) Modules

The curriculum stresses the acquisition and development of technical knowledge and skills directly required by the water technician. The task analysis gives such knowledge and skills which form the core content of the technicians course. The modules are given in five categories of technicians namely hydrology, planning and design, construction and installation, hydrogeology and drilling and water laboratory technology.

4.4.3.2 General Education (GE) Modules

Efficient learning of the technical competence modules will require competence in the general area of education. For a long time it has been observed that many incoming trainees at the Institute lack certain necessary competencies in general education. This means that the secondary education does not impart that knowledge sufficiently. For this reason the new curriculum has included modules for developing and consolidating competencies in such areas as language, technical reporting, public speaking, mathematical computation, problem solving, social, political awareness and general technical ability. In order to benefit and participate sufficiently in the learning process, instruction in the general education modules will be given in the beginning of the technicians course.

4.4.3.3 Basic Supervisory Management (BSM) Modules

The task analysis carried out revealed that the water technicians quite often act as supersisors over skilled, semi-skilled and non-skilled workers. The BSM modules are included to enable the technician to meet such supervisory and management task.

4.4.3.4 Field Training

The National Examination Council directs technical institutes to include periods of filed training in their curriculum. The Water Resources Institute has set a period of field training or industrial attachment for its trainees in order to meet the following objectives:

1. To offer trainees opportunity of applying knowledge and skills learned at the Institute, to see practical situations in the water sectors, and offer familiarity with equipment and facilities used there.
2. To give trainees more opportunities for participating in manual work and have a sense of appreciation.
3. To enable trainees realize the importance of cooperation and good human relationships to obtain desired work objectives.
4. To give trainees the chance to know the organisational and managerial problems apparent in engineering actitivies, and appreciate the importance of cost, efficiency etc. in engineering decision-making.

4.4.3.5 Project Work

The project work is one of the training methods and so can be taken as a learning activity. It makes the trainees creative and more interested in exercising decision making. It also helps the trainer to get information on trainee's knowledge and personality. This programme is strengthened to ensure that proper skill taught, for example, data collection, compilation, analysis, work planning and implementations, technical writing etc. are fully utilized.

4.4.3.6 Elective (EL) Modules

One of the objectives of the new curriculum is to enhance a trainee's personal understanding and skill in specialised areas as a basis for further technical training. This objective is met by including modules of specialised skills and knowledge in the new curriculum. There is a certain minimum and maximum number prescribed which has to be studied by each trainee.

4.5 Facilities at the Institute

The Institute has few facilities at its main campus despite the government's intention of establishing a well equipped training institution. Msimbira (1980) reports from one African regional meeting on water supply and sanitation that it was recommended to make full use of the available training facilities. Tanzania has been responding to this call in respect of the facilities at the Water Resources Institute. There is a classroom building but not sufficient.

Teaching aids in the classrooms are available, which include overhead projectors, slide projectors, film projector, audio cassette recorder, projection screens and chalk boards. More classrooms are still required.

An old building has been turned into a plumbing, carpentry and building construction workshop. The innovated workshop is so small that it is not practical to install proper equipment for all those trades. A new workshop is currently under construction which will be capable of housing various trades. A need of having a well equipped workshop is very apparent at the Institute and it is hoped that persistent efforts put on this issue will bear fruits.

Library services are offered to the Institute community. Similarly the services are still not proper. They are rendered using an old building which was not designed to act as a library. Proper library services in another major need at the Institute.

A meteorological station is being established at the Institute. The station is to be used for instruction and demonstration to trainees, and also act as one of the stations in the country's meteorological network.

Another old building has been turned into a water quality laboratory which is currently being utilized. Trainees are able to do experiments in water analysis using the equipment and instruments in the laboratory.

Trainees taking the water resources engineering course do not have a chance to perform the many practical experiments due to the absence of a laboratory. Practical instruction and demonstration to trainees are very necessary for imparting knowledge efficiently. A laboratory in which trainees can perform hydraulic experiments, materials testing and soil mechanics basic tests is essential. Trainees in water supply require a place where they can be demonstrated on the water supply systems. Trainees in hydrology have to be demonstrated on the hydrological measurement. Those in hydrogeology have to be demonstrated on groundwater exploration and well drilling.

5. FEASIBLITY STUDY OF THE SITE FOR ESTABLISHING A DEMONSTRATION UNIT AT THE INSTITUTE

5.1 Data Collection

5.1.1 Meteorological Data

There is a meteorological station near the Institute located at Maji Ubungo. The station records various meteorological data. For the purpose of this work, rainfall data has been gathered as shown in Appendix 3. The available rainfall data covers a period of 26 years, ranging from 1959 to 1980 and from 1983 to 1986. Records for 1981 and 1982 are missing. The wettest months are March, April and May. The driest months are June, July, August, September and October (CIDA and CBA Engineering LTD, 1979).

5.1.2 Hydrological Data

There has been a low-lying weir with a spillway, together with provision for hydrometric measurements by way of a cable-way upstream of the weir. Because of faulty construction (rectangular structure with shallow foundation and perhaps of weak concrete mix), the whole structure was washed away during the unpredicted 1975 floods.

The hydrometric measurement devices broke down as early as 1972. Since then there has been no hydrometric records for Sinza river. The records which were taken by then were not kept properly after the breakdown of the station. This means that presently there is no hydrological records for Sinza river.

After these findings it was intended to take a 2-month flow measurement of the Sinza river so as to get a rough idea of the flow during the months when the rainfall is average. Investigation was done on the upstream side of the river. From this investigation, it was found out that there is some water which overflows into the river from the city's water tanks located about 3 km upstream. This additional and periodical flow has made it difficult to carry out the flow measurement so as to know the actual flow in the river. Normally during the driest months of June, July, August, September and October, the river becomes practically dry. During these observations, there has been some flow in the river which varied during the day and also from day to day. This trend has caused great difficulties in carrying out flow measurements.

5.1.3 Soil Data

Soil investigations along the Sinza river basin have been carried out in order to determine the type and properties of the soil. Soil analysis over the project area is a very important task because it affects the planning of the whole system. The resulting curves and data after carrying out some tests on soils from the river basin, river bed and river banks were similar. Samples were taken using augers at depths of 0,5 m, 1 m and 1,5 m. The particle size distribution analysis revealed that the given size of the soil ranges from 0,08 to 1,5 mm. This indicates clearly that the type of soil along the project area is sand.

The permeability of the soil was determined by the constant head method bacause the soil is cohesionless. The coefficient of permeability, K, was found out to be 0,1 mm/s.

The shear strength of the soil was determined by the direct shear test (disturbed sample). The pore pressures which are built up during the shearing were allowed to dissipate fully during the test (i.e. drained test). The angle of friction ϕ', was found out to be 36^{o} and the cohesion, C', was zero. The magnitude of the angle of friction and the nature of the shear stress Vs horizontal deformation curve indicates that the soil is cohesionless loose sand.

5.1.4 Topographical Data

The topographical maps in the Ministry of Lands, survey division are drawn at a scale of 1 : 50 000 as is the case with all the maps in the national grid system. This scale is very small for the purpose of this work when you need to investigate such a small area. It was thus necessary to look for other useful maps. The project area was surveyed as far back as in 1957 and the resulting topographical map was approved in 1962. This is the only available map in respect of the topography of the area. There has been some occasional surveying projects done by the final year students at the Institute but they could not produce reliable results. This work had therefore to rely on the 1962 map, drawn at a scale of 1 : 1 250. The map shows that the elevation of the area ranges from 53 m to 61 m above sea level. Observing the present situation of the area, there is a change in the river course which seems to be a continuing process because of the nature of the soil as explained earlier.

The general contour system of the basin remains the same. The topographical map is shown in Appendix 4.

5.1.5 Hydrogeological Data

Currently there is a borehole in the project area which is functioning properly. The borehole is used as a supplementary water supply system to the normal city water supply to the Institute. There has been a persistent water shortage at the Institute for quite a long time. This resulted into an urgent need of having a different water supply system. Hydrogeological investigations were carried out and a borehole was constructed in 1984. These investigations have helped quite a lot in getting the hydrogeological data of the area. The data obtained are as follows:

Borehole	No DSM/5/84		
Strata:	Depth	0 - 3,3 m	sand, fine to medium
		3,3 m - 4,6 m	medium sand
		4,6 m - 6,1 m	clayey sand
		6,1 m - 10,7 m	medium sand
		10,7 m - 15,2 m	gravel sand
Yield:		8 l/s	
Depth:		79 m	
Static water level at		27,4 m	
Diameter:		15 cm	

The soil data obtained from soil tests and borehole reveals that the soil in the area is sand even to great depths.

With this type of soil, construction of a dam will face a lot of difficulties. The foundation of the dam will have a settlement and piping problem. The dam will not be able to impound water due to percolation losses. The construction material will have to be transported from distant places thus increasing the cost. Due to erosion of the river banks, the river course keeps on changing, also making it difficult to safeguard the dam. A dam is therefore not possible in this case. Consequently, a normal river intake cannot be constructed since it needs a sufficient water depth in the river which has to be created by a submerged weir or dam.

5.2 Feasible Systems

5.2.1 Intake

5.2.1.1 Bank River Intake

With the soil in the river bed and bank being sand, an alternative solution is a bank river intake. A sump is constructed in the river bank deep enough below the level of the river bed. Drains are laid under the river bed and run into the sump. Since the river bed above the drains is made up of sand, the river water will infiltrate down through the sand into the drains and then flow by gravity into the sump.

Water is then pumped from the sump to the storage tank.

5.2.1.2 Borehole

Within the project area there is a borehole which is currently used to supply water to the Institute when the normal supply from the city authority is cut off. The yield of the well is good enough to supply water to the demonstration unit. This can be considered to be a reliable source of water as compared to the river intake. The borehole can supply water into the demonstration unit throughout the year because the fluctuation in the water level is not significant. For the purpose of demonstration it has been found wise to utilise both intakes.

5.2.2 Transmission of Water

There are two different water intakes for the demonstration unit as discussed previously. Each intake will require its transmission line to the storage tank.

5.2.2.1 Pumping

The storage tanks are located 120 m away from the river intake. The static head between the river intake and the storage tank is 10 m, the latter being higher. For a small total head a centrifugal pump is recommended for pumping water from the river intake to the storage tank.

The borehole pump has been in use for sometime, pumping water to the tanks which are located on top of a 3-storey building. The pump can therefore meet an elevation difference of 7 m between the borehole and the storage tank.

5.2.2.2 Pipe Material

For the purpose of demonstration, the pipes are not supposed to be buried into the ground. This means that it will be exposed to direct sunlight and other weather conditions. In this case the pipe material chosen should be the one which is not easily affected by weather conditions and also not easily destroyed by people and animals. Polyvinylchloride (P.V.C.) pipe is easily affected by direct sunlight by loosing strength. Polyethylene (P.E.) pipe does not deteriorate when exposed to direct sunlight and is very corrosion resistant, but can easily be destroyed by people and animals. Steel pipe is very strong, but when exposed to different weather conditions is liable to corrode. Bamboo pipe has been used in different places in Tanzania but presently nothing can be concluded regarding its strength and durability because it is still under testing observations. For the purpose of demonstration all the four pipe materials are included in the distribution system. This will help to see the difference in their level of service after some years in terms of strength, durability and/or deterioration.

5.2.3 Storage of Water

Pumping water directly from the source to the consumer has several disadvantages. With power failure or shortage of fuel to operate the pump, the supply comes to a standstill. Pressures in the distribution lines are not constant because they are affected by the variation in water consumption. Careful operation of the pump and proper maintenance of the system is very essential.

The provision of a storage tank into which water is pumped from the source is a better system. In this case the minimum pressure in the pipeline even at the highest point in the area can be guaranteed. The storage tank helps to balance the supply and demand of water. Without a storage tank, the transmission line has to be made large enough to cope with the peak demand. This means that at normal demand the line will be very under-utilised. The storage tank meets the peak demand and other emergencies, maintaining fairly and adequately a uniform pressure throughout the distribution system. It also helps to avoid the total interruption of the water supply when repairing the line between the intake and tank. It is therefore found helpful to have a storage tank in this demonstration unit.

The maximum elevation difference in the project area is 8 m. For the purpose of demonstration, a ground water tank will not be able to create enough pressure. An elevated tank is the best alternative. Since the tank is not going to be used for the actual supply of drinking water but rather for demonstration purposes, its volume has to be small. In this case a metal tank (Aluminium) erected on top of a steel support or stand is preferred.

5.2.4 Utility of Water

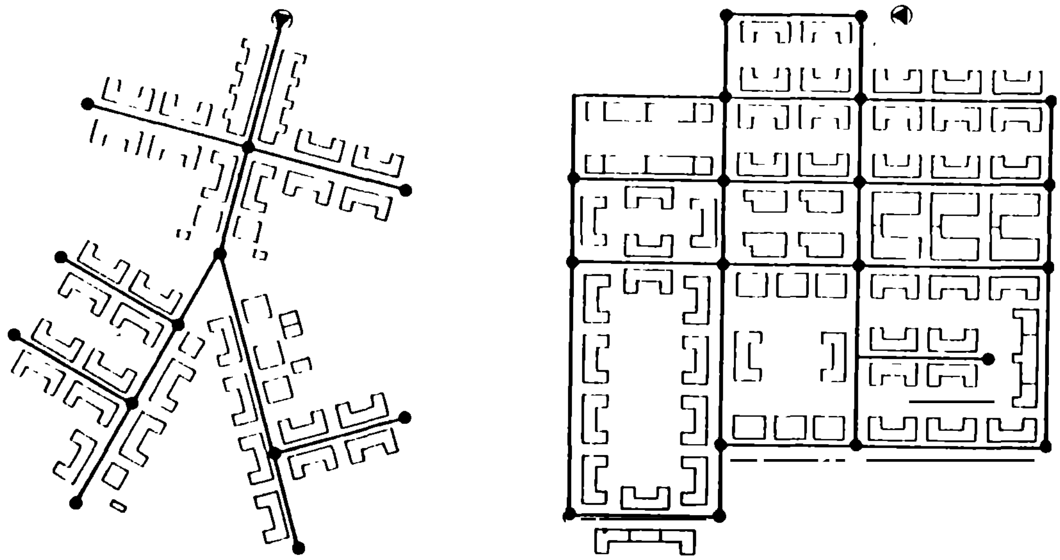
5.2.4.1 Drinking Water

It is desired to demonstrate the working principle of the two main types of distribution systems, namely dead end or branched system and the looped or grid-iron system. The branched system (Figure 4a) is mostly used for small-capacity community water supplies where public stand pipes are installed with only few house connections.

Their design is simple and straightforward because the direction of water flow and the rate of flow can be easily determined. The size of the main line decreases as its distance from the source increases due to the decreasing demand of water which the mainline has to carry. When there is any major repairwork, a large part of the system will be put out of service.

The looped system (Figure 4b) is most suitable for large distribution networks where house connections are a common phenomena. Each secondary pipe can be fed from two sides because the pipes are interconnected. This makes it difficult to carry out the hydraulic designs of the distribution network. Since there are too many junctions and connections, many fittings are needed thus entailing high construction and maintenance costs. In this system, the size of the pipes and the pressure are more uniform than in the branched system. Consumers get water from two parts and therefore repairs on one side will not cut off the supply to consumers.

Both systems are suitable in certain circumstances and so it has been found important to demonstrate both of them.



(a) Branched system (b) Looped system

Figure 4. Types of distribution systems (Hofkes, 1986).

5.2.4.2 Experiment

The demonstration unit is to be constructed in open air, thus being exposed to every kind of disturbance. This has imposed a number of limitations on feasible experimenting and testing facilities. An in-house unit could have featured various hydraulic experimental facilities, but this has been ruled out due to high cost demands. With an open-air unit, it is only possible to provide facilities which are not easily destroyed by external factors.

Measuring pressure difference between two points along the pipeline can be easily demonstrated by providing piezometric tubes. Short pieces of polyethylene pipes can be installed at some sections along the pipeline and piezometric tubes erected.

One part of the pipeline is set apart for demonstrating the leakage problems. Some joints are made flexible in which they can be tightened or loosened easily. During demonstration on leak detection, some joints are loosened so as to allow leaks. Methods of rectification are finally demonstrated.

The measurement of flow in a channel can also be demonstrated. A small trench is dug in the ground and an open concrete channel is constructed and across it, a weir is erected. Water from the pipeline is fed into the channel of moderate length, width and height and the flow is measured with the help of a submerged weir which will be designed in this work. Flow measurement can also be done by constructing a V-notch and flume in two other separate parallel channels.

6. DESIGN OF THE DEMONSTRATION UNIT

6.1 Intake Structure

The choice of the type of intake structure depends on the capacity of the water supply system, type and size of source and the topography of the source. The type and size of the source have led to choose the bank river intake using infiltration drains. These drains are constructed in order to increase the quantity of water flowing into the sump. Water is collected into the sump from the bottom and through the drains by the fact that the bottom of the sump is well below the river bed. Perforated plastic collecting pipes are placed in the gravel lined trenches and connected to the sump. The gravel in the trench filters out sediments and prevents clogging of the pipes (Figure 5). The size of holes on the pipe is 1 mm diameter.

6.2 Pumping

It has been observed that the static head between the intake and the storage tank is 10 m. A radial-flow centrifugal pump (Figure 6) has been chosen. A centrifugal pump has got an impeller which is a wheel having vanes radiating from the centre to the periphery. When rotated at a sufficiently high speed, the impeller imparts kinetic energy to the water and produces an outward flow due to the centrifugal forces. In a radial flow centrifugal pump the intake of the pump is axial and the outlet is tangential, the flow being converted into radial flow as it passes round the volute or spiral chamber surrounding the impeller blades. The increase in the cross-section of the volute produces the change from kinetic energy to pressure energy. This pressure forces the water into the delivery pipe. Immediately after the pump a non-return valve is installed followed by a flow meter and a pressure meter.

The water leaving the eye of the impeller creates a suction which will be replaced by water drawn from the sump and forced into the casing under static head.

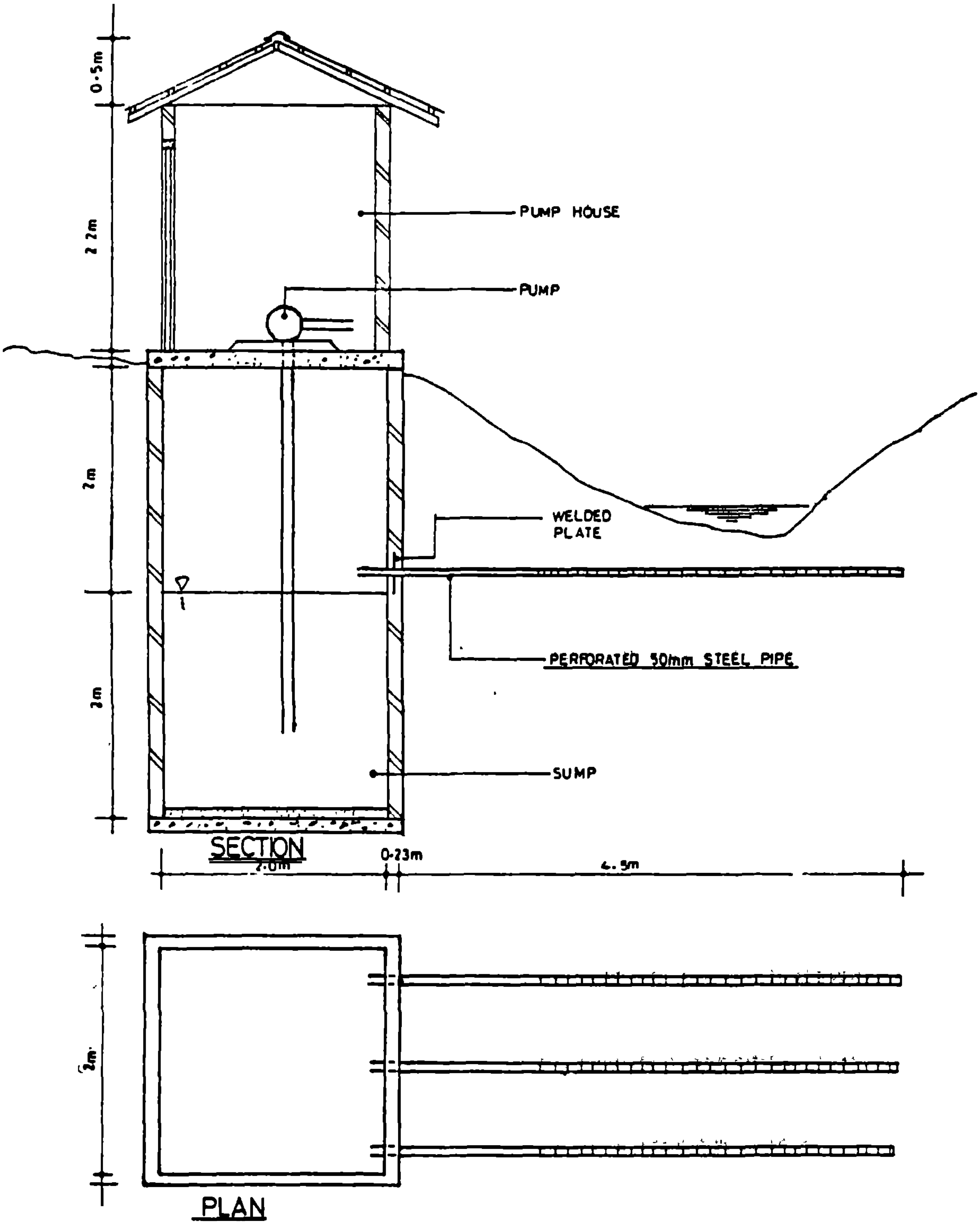


Figure 5. Bank river intake (Hofkes, 1986).

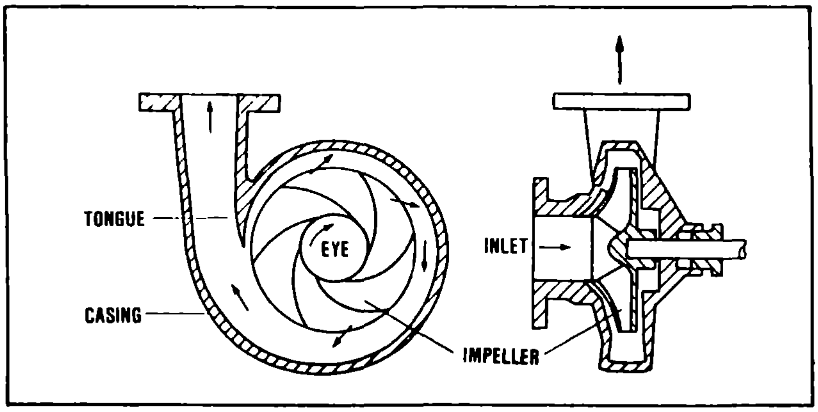


Figure 6. Centrifugal pump (Hofkes, 1986).

Selection of the pump:

The governing data is	pump discharge:	2l/s
	Pipe length:	120 m
	Pipe material:	Galvanized steel (surface roughness K = 0,15 mm)
	Pipe diameter:	50 mm

From Sarvanne and Borg (1979) pump nomograms, the friction loss using this data is 4 m, whereas the losses due to fittings are 0,3 m.

The static head is 10 m

The total head is the static head plus the head losses

$$
\begin{aligned}
Hf &= Hs + Hl \\
&= 10 + 4 + 0{,}3 \\
&= 14 \cdot 3 \text{ m} \\
&= 15 \text{ m}
\end{aligned}
$$

It is a good practice to have two pumps at the intake but since there is another pump at the borehole acting as an alternative, only one pump is installed.

For safety purposes a small house has to be constructed to shelter the suction pump which is erected on top of the sump. The walls are made up of cement blocks and the roofing material is corrugated iron sheets.

6.3 Storage Tank

A storage tank should be able to distribute water by gravity to all service points in such a way that the pressure head at the service point is at least 5 m (Hofkes, 1986). This means that the storage tank should be located at a high point where it can meet such a condition. For this matter, an elevated storage tank has to be erected. A 3,5 m-high steel stand is used to elevate the storage tank. The stand has two purposes, i.e. to carry the weight of the storage tank and to raise it to a desired elevation. It has four vertical steel posts on top of which there is a horizontal steel plate where the tank rests. The four vertical posts are erected into a firm concrete foundation (Figure 7).

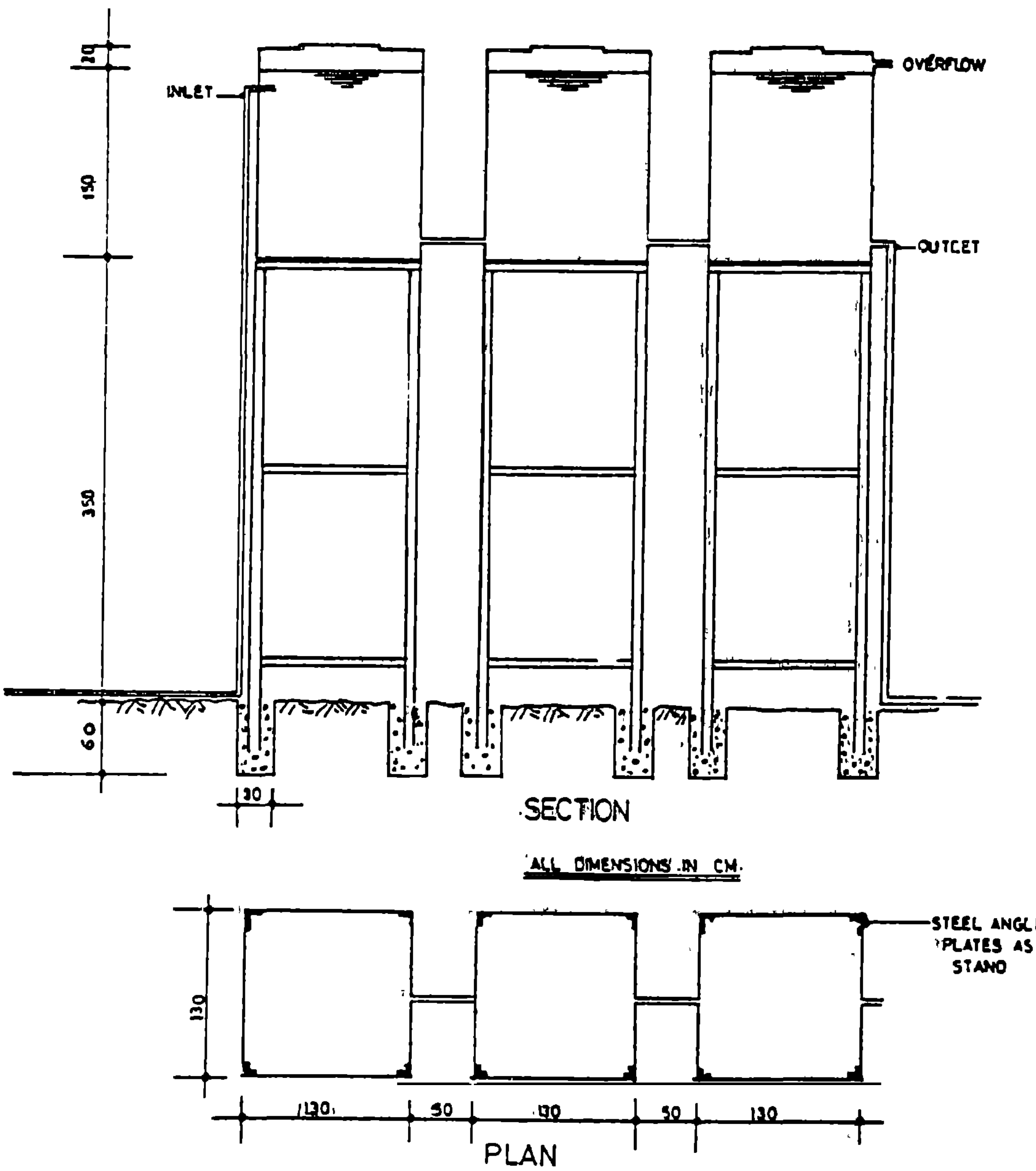


Figure 7. Storage tanks.

The size of the storage tank is determined by the pump discharge, pumping period and the water demand in the distribution system. Water in the distribution system is to be used during demonstration times only. This means that the water demand is quite low. The pump discharge is 2l/s. A one-hour pumping period will result into a storage volume of 2 x 3600 = 7,200 liters, when there is no consumption. The discharge from the river intake will be supplemented by the borehole pump especially during the demonstration. To avoid sucking air, the river intake pump should not be used during dry periods. The supply should then rely on the borehole pump.

The consumption discharge at one given time is estimated as follows:

4 stand pipes each 0,35 l/s =	1,4l/s
Channel for flow measurement =	0,5l/s
Leakages =	1,0l/s
Total consumption	2 l/s

If this discharge flows out for one hour, the volume of water consumed will be 2 x 3600 = 7,200 litres = 7,2 m^3.

Providing a storage capacity of 7,5 m^3 will meet the demand sufficiently at the same time remaining with a reserve. Since it is not likely to obtain a steel tank of this capacity, 3 tanks are provided having a storage capacity of 2,5 m^3 each. The dimensions are 1,7 m height, 1,3 m length, and 1,3 m width. To illustrate the concept of static head and friction loss, a longitudinal section has been drawn through the transmission line (Figure 8).

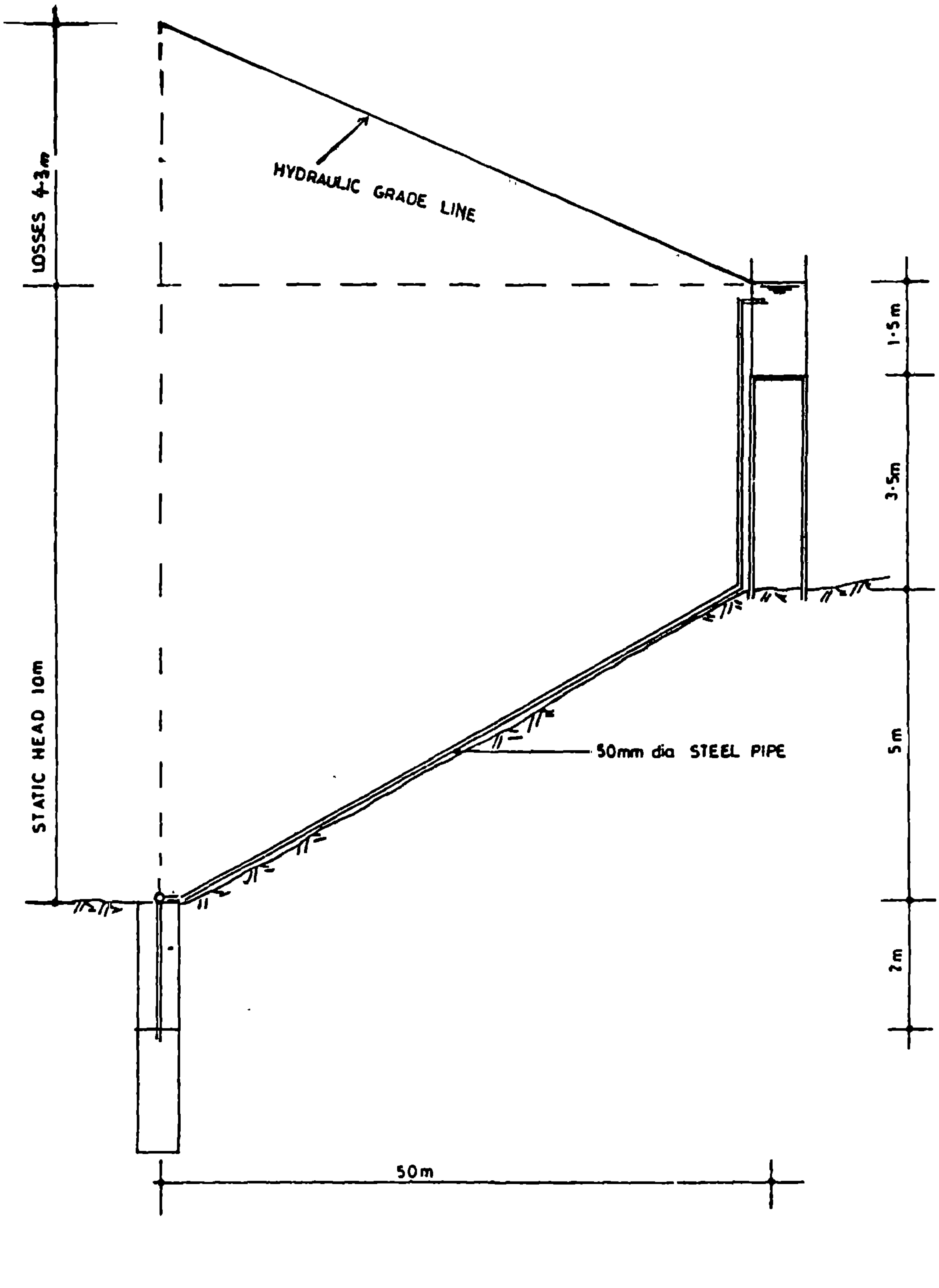


Figure 8. Longitudinal section of transmission line.

6.4 Distribution System

The utility of water in the demonstration unit has been narrowed to only a few systems, namely, water supply systems and experimental system after carrying out a thorough feasibility study.

6.4.1 Water Supply

Under the water supply system, two types of distribution networks namely branched and looped systems are to be demonstrated. There is only one pipe outlet from the storage tank which serves as a distribution main. The distribution main supplies water separately to both the branched and looped systems. Gate valves are connected at junctions for the purpose of controlling water flow during demonstration (Figure 9). Closing and opening of the various gate valves within the distribution network will affect the water flow. In the case of the looped system, the valves will even change the direction of water flow, thus demonstrating a clear difference between the two types of networks. The leakage problems have to be demonstrated by observing the various pipe joints and connections within the network.

6.4.2 Experiment

From the same distribution main, another service line branches off, supplying water to a section which measures the pressure difference and further to the flow-measuring channel (Figure 9). A section which measures the pressure difference and the flow-measuring channel are connected in series, that is, along one service line.

For easy erection of piezometric tubes, short lengths of polyethylene pipes are connected to the steel pipe. As the water flows through the pipe line, it will rise into the piezometric tubes to a level which corresponds to the pressure at that point in terms of metres of head of water. The difference between the water levels in the two piezometric tubes situated at two different points along the pipe line, will give the pressure difference between the two points.

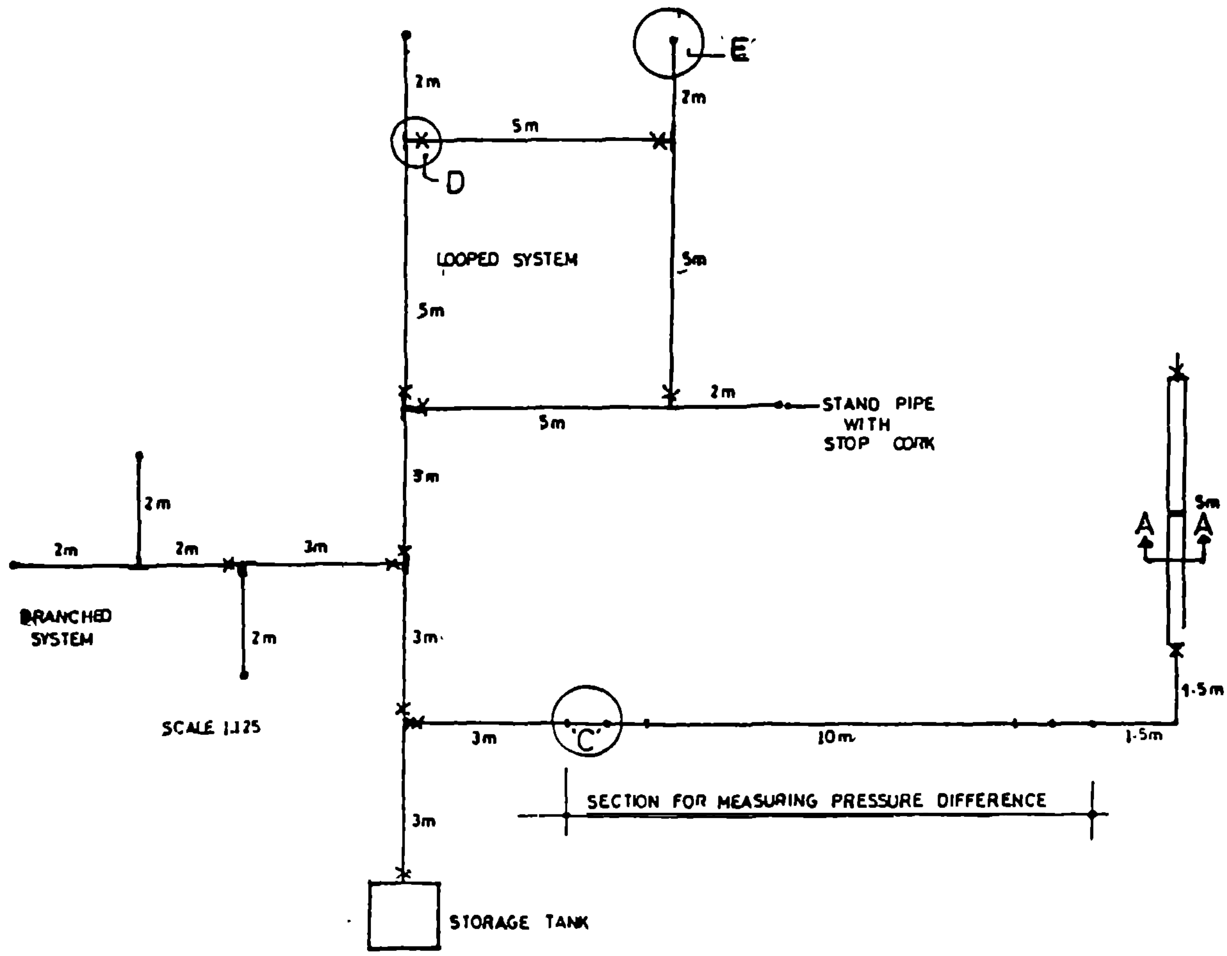
The flow-measuring channel is made up of concrete with a smooth cement creed finish. It has dimensions of 30 x 30 x 500 cm. A broad - crested weir is constructed at the centre and across the full width of the channel with a height of 20 cm. The discharge over the weir is calculated from the Plen equation:

$$Q = \frac{2}{3} \mu b \sqrt{2g} h^{\frac{3}{2}}$$

Where:

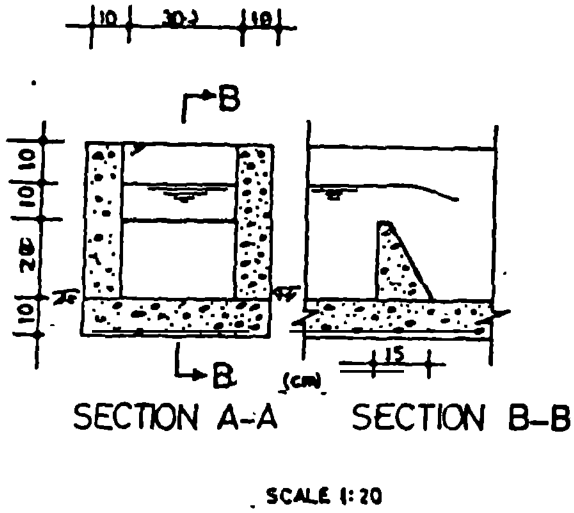
- Q = Discharge (flow) over the weir in m^3/s
- μ = Discharge coefficient depending on the shape of weir
- b = Width of weir in m
- g = Gravitational constant in m/s^2
- h = Head of water above the weir in m

The value of μ for the broad crested weir is 0,74. By measuring the head of water above the weir, the discharge can easily be determined.

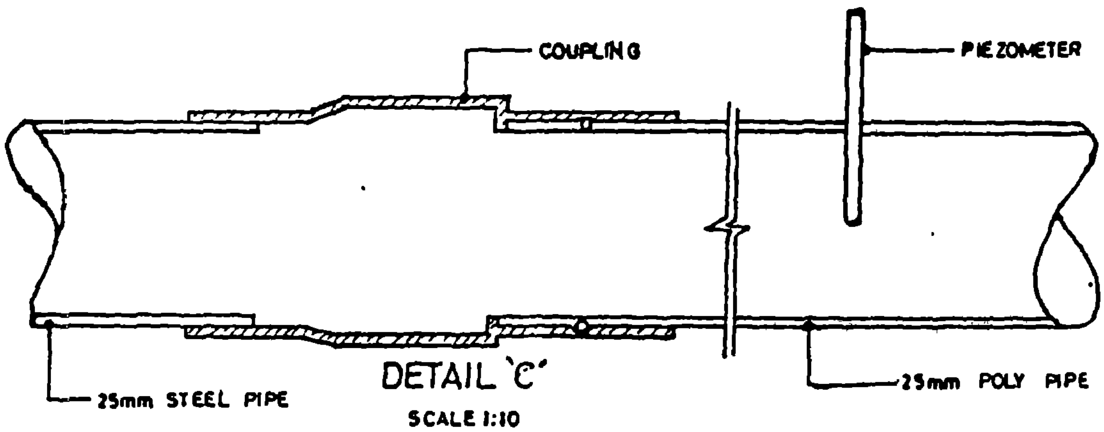


(a) Layout Plan

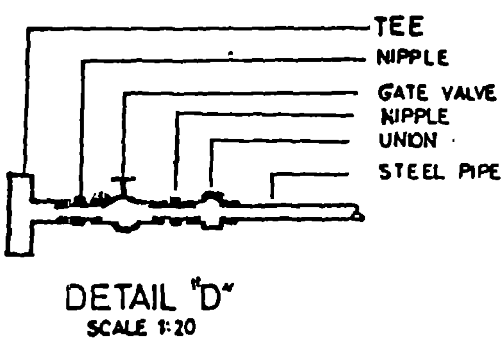
Figure 9. Distribution system.

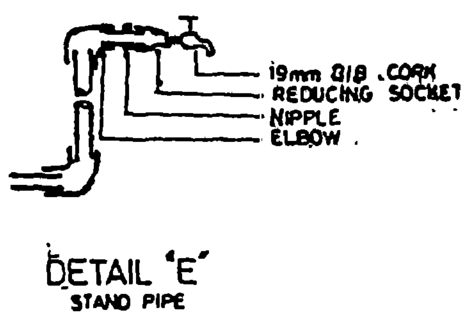


(b) Flow measuring channel



(c) Detail C





(d) Detail D

(e) Detail F

Figure 9. (cont.) Distribution System.

7. COST OF IMPLEMENTATION

7.1 Basic Considerations

The process of cost estimation involves assigning of cost to the right objects. There are various methods of cost estimation which can be used for different needs:

- User estimate:	Ascribing the cost according to the user, e.g hospital - cost per patient, school -cost per student,
- Product unit estimate:	Ascribing the cost according to the product unit, e.g cost per unit area cost per unit volume cost per unit length.
- Cost of the functional parts:	Ascribing the cost according to the functional parts e.g house - cost of all rooms.
- Element cost estimation:	The cost is based on the use of production factors and on their unit prices. Different executions are laid down and the bill of quantities is prepared.

The demonstration unit which has been planned has got many small elements as you start from the intake up to the standpipes. The cost of this unit can be best estimated by using the method of element cost estimation.

The breakdown of costs of a project can be as follows:

- Investigation costs:	This includes surveys, data collection and analysis, planning and designing.
- Construction costs:	This includes labour, material and transport.
- Operational costs:	This includes manpower and fuel.
- Maintenance costs:	This includes manpower and spareparts.

The investigation costs for the demonstration unit are not taken into account since they have been covered by this praticular work.

In order to establish the implementation costs of the project, consideration has been given to the construction costs.

The construction costs very much depend on the size and material of the pipe line, the material of other elements of the system and the construction method. Usually for a normal water supply project there should be different alternatives which are evaluated and compared in order to select the best one. This particular project is different from a normal water supply scheme in terms of the purpose. The purpose of the project is to demonstrate to students on how the water supply system works and not to supply water to consumers. This aim has led to different considerations in selecting the size and material of the pipes and other elements and the construction method. The basis for selection was to look for a system which is suitable for demonstration purposes in terms of material, construction method and appropriate scale.

7.2. Estimated Implementation Costs

The bill of quantities has been prepared in Table 4 and priced according to the 1988 market prices. Table 5 summarises the total costs.

Table 4. Bill of quantities.

Item	Quantity	Unit	Unit price (TAS)	Date of price	Total cost (TAS)
Intake					
Excavation for sump					
2 m x 2 m x 4 m deep					
Top 1,5 m	6	m^3	28	1988	168
next 1,5 m	6	m^3	30	1988	180
bottom 1 m	4	m^3	35	1988	140
Excavation and filling					
for perforated pipes					
0,3 m x 1 m x 4,5 m	3 x 1,35	m^3	50	1988	203
Portland Cement	5	bag	350	1988	1750
19 mm coarse aggregate	2	m^3	1,000	1988	3000

Item	Quantity	Unit	Unit price (TAS)	Date of price	Total cost (TAS)
Sand	4	m^3	500	1988	2,000
150x230x760 mm cement concerete blocks	700	No	35	1988	24,500
Corrugated Iron sheets					
3 m long gauge 26	3	No	1,000	1988	3,000
50 x 100 mm timber					
rafters	6	m	100	1988	600
50 x 50 mm purlins	12	m	75	1988	900
battened door	1	No	5,000	1988	5,000
KCH-4 pump and fitting	1	No	80,000	1988	80,000
Perforated pipe					
50 mm dia	13,5	m	120	1988	1620
Labour charge	20	day	200	1988	4,000
Transmission main					
50 mm steel pipe:					
- from river intake	125	m	110	1988	13,750
- from borehole	50	m	110	1988	5,500
50 mm plain sockets	20	No	100	1988	2,000
50 mm elbow	2	No	150	1988	300
50 mm Tee	1	No	200	1988	200
Laying of 50 mm					
steel pipe	100	m	20	1988	2,000
Storage of water					
Excavation					
300 x 300 x 600 mm	12	No	30	1988	360
Portland Cement	5	Bag	350	1988	1750
19 mm Coarse aggregate	2	m^3	1,000	1988	2,000
Sand	2	m^3	500	1988	1,000
Angle plates for stand					
50 x 50 x 10 mm	80	m	200	1988	16,000
1,3 x 1,3 x 10 mm					
steel flat plate	3 x 1,69	m^2	200	1988	1014
2,5 m^3 metal					
storage tanks	3	No	10,000	1988	30,000
Erecting the tanks	3	day	200	1988	600

Item	Quantity	Unit	Unit price (TAS)	Date of price	Total cost (TAS)
Distribution system					
Portland Cement	7	bags	350	1988	2450
19 mm aggreagates	4	m^3	1,000	1988	4,000
Sand	4	m^3	500	1988	1500
25 mm steel pipe	72	m	80	1988	5440
25 mm Gate valve	13	No	600	1988	7,800
25 mm Tee equal	8	No	160	1988	1280
25 mm Union	13	No	20	1988	2600
25 mm Elbow	15	No	120	1988	1800
25 x 19 mm reducing socket	6	No	150	1988	900
19 mm bib cork	6	No	400	1988	2400
25 mm polyethylene coupling	4	No	300	1988	1200
25 mm Nipple	32	No	100	1988	3,200
25 mm polyethylene pipe	10	m	60	1988	600
Laying of pipe	7	days	200	1988	1400
Construction of Measuring channel	7	days	200	1988	1400

Table 5. Summary of Costs

Item	Cost (TAS)
Excavation	1060
Cement	5950
Coarse Aggragates	9,000
Sand	4,500
Cement Blocks	24,500
Iron sheets	3,000
Timber	1,500
Door	5,000
Pump	80,000
Pipes	26,910
Storage tank	47,0140
Pipe fittings	23,680
Labour	9,400
Total	241,514

Add 20 % Contingencies = 48303 TAS

Total Cost 289,817 TAS Say 300,000 TAS (3350 USD)

8. SUMMARY

The process of training technicians is a very demanding task especially for developing countries. Historically, Tanzania has been carrying out technical education with many financial and technical constraints. In order to solve the problems, the nation realised the importance of having a clear educational policy on technical training. In this policy great emphasis was put on training of technicians who represent the middle cadre of the engineering personnel. Clear quidelines on the basic contents of the curriculum were laid down by professionals. By having such a national policy it has been easy to conduct and monitor the technical education throughout the country.

A programme for training of water technicians asks for huge financial resources which in many cases cannot be met by individual developing countries. For conducting successful training developing countries will have to, at least for the time being, seek external financial support.

The preparation of the curriculum for a training institution is a very important task for a successful training process. A task analysis should be done in order to identify training needs which determine the contents of the curriculum. A well-documented curriculum for training water technicians should include basic sciences and mathematics, management and human relations, technical and practical training.

Practical training should carry an equal weight to the theoretical training. It should be well planned and proper facilities hould be available. Practical training should be carried out in the field where the trainee can participate fully on the actual work. It should also be done in workshops and laboratories which are located within the Institute premises. A small demonstration unit can serve the same purpose wherever possible.

The demonstration unit can easily show the whole system of water supply at a very small scale. It can constitute elements such as intakes, transmission main, storage facilities, distribution systems and some experiments. During training, instructors can demonstrate to students the various elements of water supply.

Planning of such a demonstration unit should start by observing the objectives of training and contents of the curriculum. Such observation will lead to choosing the relevant type of demonstration unit. In this work the national policy and the general and specific training processes of water technicians have been observed. The feasibility study on the project area has been done and the feasible system has been planned. Two intakes has been utilised, namely, the borehole and the river bank intake. Steel pipes have been used for transmission and distribution of water because it can withstand different weather conditions since it is to be laid above the ground. Water is to be stored in raised metal tanks for easy construction and increasing pressure head. The dead-end and looped systems of distribution have both been included in the unit in order to demonstrate their difference. Provisions have been given on flow measurement by a submerged broad-crested weir and measurement of pressure difference by piezometers.

The estimation of the cost for the demonstration unit has been done by using the bill of quantities. This estimation has led to a total cost of 300,000 Tsh. There are items which will have to be purchased by using foreign currency. This work will be helpful in acting as a basis for requesting for financial assistance to construct the demonstration unit.

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APPENDICES

APPENDIX 1

LIST OF TRAINING MODULES

NUMBER	TITLE
TC/01	Introduction to Hydrology and Meteorology
TC/02	Planning Station Network
TC/03	Surveying and Investigating Watersheds
TC/04	Establishing Hydrological and Meteorological stations
TC/05	Inspecting, Repairing and Maintaining Stations and Instruments
TC/06	Collecting and Recording Hydrological and Meteorological Data
TC/07	Processing and Computing Data
TC/08	Analysing Data
TC/09	Water Resources Management
	HYDROGEOLOGY
TC/10	Conducting Hydrogeological Surveys
TC/11	Hydrogeological Sampling
TC/12	Groundwater Monitoring
TC/13	Processing and Documenting Groundwater Data
	DRILLING
TC/14	Introduction to Drilling Equipment
TC/15	Setting up Drilling Rig
TC/16W	Well Drilling Process
TC/17	Routine Repair and Maintenance of Drilling Equipment
TC/18	Documenting Drilling Information
	PLANNING AND DESIGN
TC/19	Planning Investigations
TC/20	Water Supply Designs
TC/21	Geometrical Drawing
TC/22	Quantity Surveying and Cost-estimating
TC/23	Surveying Measurements
TC/24	Surveying Computations and Drawings
	CONSTRUCTION
TC/25	Planning and Estimating for Construction

TC/26	Preparing Site for Construction and Installation
TC/27	Laying Out and Excavating
TC/28	Preparing and Laying Concrete Reinforcements
TC/29	Constructing and Dismantling Formwork
TC/30	Concreting and Curing
TC/31	Constructing Masonry Structures
TC/32	Pipe Laying
TC/33	Constructing Water Storage Facilities
TC/34	Maintenance of Water Systems and Facilities
	WATER QUALITY
TC/35	Water Quality Surveillance
TC/36	Water and Health
TC/38	Laboratory Techniques
TC/39	Analytical Chemistry
TC/40	Introduction to Water Analysis
TC/41	Bacteriological Analysis of Water
TC/42	Physiochemical Analysis of Water
TC/43	Application of Water Treatment Chemicals
TC/44	Laboratory Organization Procedures
	GENERAL EDUCATION
GE/01	Basic Mathematical Computations
GE/02	Applied Mathematics
GE/03	English
GE/04	Communication Skills
GE/05	Workshop Practise
GE/06	Siasa
GE/07	Kiswahili
	BASIC SUPERVISORY MANAGEMENT
BSM/01	Planning and Implementing Work Activities
BMS/02	Personnel Management
BMS/03	Office and Administration Procedures
BSM/04	Work Inspection and Evaluation
BSM/05	Water Sector Studies

APPENDIX 2

CURRICULUM GUIDE

JOB TITLE:	DRILLING TECHNICIAN
DUTY 9:	ROUTINE REPAIR AND MAINTAINANCE OF DRILLING EQUIPMENT
TASK 4:	CLEAN AND REPAIR DRILLING HAMMER AND SUBS
INSTRUCTIONAL TOPIC:	How to clean and repair drilling hammer and subs
OBJECTIVE:	Given the required tools disassemble, clean and repair damaged parts of drilling hammer and sub, assemble ready for undertaking drilling operation.
PRE-REQUISITE:	Mastery of TC 17
INSTRUCTIONAL RESOURCES:	Hammer, subs, oil, diesel, files, dustemery cloth, wire brush, tool box.
Related Knowledge:	Mechanism of drilling hammer, cleaning procedures, assembling and dismantling technics.
Reference and Resources Material:	Operation and maintainance manual, mechanical chart.

PERFORMANCE GUIDES:

Steps:	**Key Points:**
1. Clean top sub	1,0 Check top and bottom threads, and shoulders for galling and nicks
	1.1 Use file and emery cloth to restore threads good condition
	1.2 Check seat valve if smooth and free from scratches and polish with cloth
	1.3 Use air blast to remove sand and steel filling
2. Clean the check valve	2.0 Wash the valve and spring in the solvent
	2.1 Ensure the sealing surface is smooth
	2.2 Ensure it is free from wash cuts, embeded pipes scale and not badly worn. (replace if damaged)

3. Clean the piston	3.0 Wash inside and outside with solvent 3.1 Check the bore and polish with emery cloth to remove galling and nicks 3.2 Use the emery cloth wrapped on a half round file to smooth the bore. 3.3 Use air blast to remove all emery dust grit and steel fillings.
4. Cleaning piston case	4.0 Clean and examine bore 4.1 Ensure the bore is smooth, free and fit with the piston 4.2 Polish with emery cloth to remove buris and nicks 4.3 Check the thread ends 4.4 Check the piston retainer ring located in grooves inside the piston case. If damaged replace it. 4.5 Use clean solvent and blast with air.
5. Cleaning drivers sub	5.0 Wash clean before checking 5.1 Remove any irregularities on threads and shoulders with three cornered file. 5.2 Remove any irregularities from splines that might prevent bit from sending.
6. Clean the bit	6.0 Wash with solvents 6.1 Check the upper end for peening that might cause it bend in piston case. 6.2 Check springs that might prevent bit from sliding freely in drivers sub. 6.3 Check foot valve for cratches or other damage. 6.4 Remove irregularities with file.

PERFORMANCE EVALUATION:

Observe the trainee for:

1. Disassembling and reassembling procedures.
2. Methods of cleaning.
3. Operating principles of drilling hammer and sub.
4. Using the proper tools and procedure.

APPENDIX 3

RAINFALL DATA (mm)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1959	28	64	138	145	74	29	62	83	7	21	19	79
60	77	1	211	417	732	60	20	6	20	58	0	77
61	13	153	56	130	203	60	191	7	28	263	441	222
62	78	54	29	247	56	16	25	64	42	48	22	106
63	80	51	158	282	65	83	26	15	15	28	386	97
64	39	80	338	196	81	20	8	29	6	75	2	119
65	32	10	38	259	123	9	12	35	15	66	96	67
66	69	115	182	227	174	114	12	42	18	39	12	54
67	4	47	9	383	232	38	14	39	91	36	254	178
68	2	67	168	311	90	77	3	14	21	31	250	90
69	100	92	135	169	201	18	21	35	29	32	106	7
1970	80	40	54	262	133	6	10	11	59	31	9	155
71	64	36	163	156	154	45	15	15	2	40	36	181
72	58	80	139	332	214	3	39	7	72	86	125	132
73	135	49	100	297	69	73	7	40	11	25	34	22
74	134	14	25	258	67	7	26	3	7	49	28	28
75	24	31	23	312	345	25	9	4	99	24	27	60
76	27	32	260	138	190	82	92	6	15	22	47	31
77	105	41	60	549	112	6	12	28	98	58	79	188
78	108	45	130	398	130	60	27	18	16	55	200	238
79	198	129	52	243	292	67	20	17	34	34	2	71
1980	83	74	151	80	91	1	6	72	3	65	165	66
83	40	18	137	227	246	36	14	5	13	114	18	105
84	64	0	49	386	89	94	32	-	4	42	182	105
85	100	163	124	124	145	0	35	14	24	41	44	128
86	31	1	220	338	281	8	2	22	12	-	-	-

APPENDIX 4

TOPOGRAPHICAL MAP AND LAYOUT PLAN