Islamic Republic of Pakistan
Government of Azad Jammu & Kashmir

Local Government & Rural Development Department

Rural Water Supply & Sanitation Project

DESIGN MANUAL

(ENM1)

VOLUME - 1

MARCH 1995

BINNIE, HUNTING, TECHRED JOINT VENTURE
TECHNICAL ADVISORY UNIT

DESIGN MANUAL (ENM 1)

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CHAPTER 1

INTRODUCTION

1 PURPOSE

1.1 This design manual has been prepared to provide LGRDD staff with a practical reference for the design of water supply schemes of the IDA funded Rural Water Supply and Sanitation Project in AJK. The manual is particularly intended for the use of the incremental IDA staff of LGRDD, and in particular the district AEs in order to facilitate them in their advice and support to the communities in the design and their future construction activities for the construction of village water schemes.

1.2 In order to properly implement the works, in good time and to produce a sutainable scheme, it is necessary to produce good design. Design is not limited to the layout of the system and individual components thereof, but includes related issues such as planning when and how the works will be executed, and estimation of the quantities and the expected costs of the works. Most critically on this project which focuses on community participation, is that the people who will receive the improved facilities must be involved in the design and planning processes and must agree with the project proposed.

1.3 All concerned staff, and in particular the technical staff, should read and become truly familiar with the contents of this manual. This manual is to be read in conjunction with the complementary, the Standard Component Manual (ENM2) which contains a bound A3 set of the Design Drawings, Construction Manual (ENM3) and the Operation and Maintenance Manual (ENM4).

2 SCOPE

2.1 The contents of the manual has been developed over two years, during 1993/94. At various times throughout this period most of the contents of the manual have been presented to and discussed with, the engineering staff of LGRDD. Following these discussions some passages have received minor amendments. New sections include the texts of chapter 5 Construction Programmes and Progress Reporting and chapter 14 Scheme Completion Documents.

2.2 Chapter 7 on Design Process and Procedure is the core chapter which gives detailed guidance on design preparation. This the key chapter on design which has been substantially enhanced for ready understanding.

2.3 Chapters 2 to 6 inclusive essentially covers the pre-conditions and the preliminary work required for the design. Chapter 2 outlines the project implementation steps which are followed in the execution of the village schemes. Chapter 3 covers all aspects of how to prepare maps and sketches. Chapter 4 covers feasibility studies required in a village to cover the pre-engineering aspects. Such studies are required to explore with the villagers what options exist for possible development and consider the scope of individual schemes. Chapter 5 details how to undertake necessary yet appropriate survey. Chapter 6 states the approved project design criteria.

2.4 Chapters 8 to 12 inclusive give comprehensive guidance on the design of all civil works components for the water supply schemes from source development through storage and pipelines to delivery point. Guidance for the optimised design procedures for storage tanks and pipelines are contained in chapters 9 and 11 respectively. Chapter 9 includes the detailed material quantities for all types of water storage tanks as well as the costings for the various individual constituents. Chapter 12 includes instruction on how to quantify and schedule the materials required for pipelines.

2.5 The manual then outlines in chapter 13 how to develop cost estimates for a scheme. Cost estimation is essential to enable communities to agree and then to realise the necessary resources from their own means. Cost estimation will also permit LGRDD to assure that proposed schemes are economically feasible.

2.6 Chapter 14 sets out the reporting requirements of LGRDD and indicates how construction programmes are made, used and monitored.

2.7 Chapter 15 describes and includes the standard pro forma of the Memorandum of Understanding which is the fundamental document representing formal agreement between government and the people rgarding their respective responsibilities.

2.8 Finally Chapter 16 outlines the compilation of the Design Report for a scheme. The Design Report collates all the design information into one document which will then subsequently be used as the single essential reference for the villagers to construct the scheme.

Chapter 2

PROJECT IMPLEMENTATION STEPS

CHAPTER 2

PROJECT IMPLEMENTATION STEPS

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CHAPTER 2

PROJECT IMPLEMENTATION STEPS

INTRODUCTION

The following document sets out the main steps and activities in the development of improved water and sanitation in a village, from selection to scheme operation. The activities have been grouped into seven phases which broadly follow the steps outlined in the planning document PC-1 and develops further the steps presented in the TAU Inception Report. Also identified are the number of village visits envisaged as necessary to be made by the LGRDD staff during scheme development. Although activities, steps and visits are presented in roughly chronological order, it is expected that there will be considerable overlap between activities within each phase and even between phases of the development cycle. It is very likely that, particularly during the initial period, more visits may be required to address each step than is projected here.

1 PHASE 1: VILLAGE IDENTIFICATION

Step 1.1: Water Needs Assessment Survey (Visit A: UCS, EW)

1.1 In order to facilitate the selection of the remaining villages which are to be included in the project, it was intended that each of the approximately 1600 villages in AJK will be surveyed, using a brief survey proforma for a Water Needs Assessment (WNA), in order to establish their relative need for improved water supply. Basic information about the status of current water supplies would be collected by this initial survey. Data would be recorded in a standard format to enable entry and processing using computerised database software. The survey is intended to be completed using short interview techniques during a visit to every village by Union Council Secretaries assisted by extension staff. Villagers will be clearly informed that this survey does not necessarily imply their inclusion in the IDA project. The WNA survey is included in Annexure 2 - 3.

1.2 It should be noted that as an alternative to the WNA, LGRDD had in late 1994 committed themselves to undertake complete village baseline surveys in all villages of AJK. At time of writing most returns have been submitted to LGRDD Directorate for scrutiny, database entry and data processing.

Step 1.2: Village Selection

1.3 Government has proposed that the next villages to be selected for the project should be one village per Union Council of the 22 marakaz. The processed data from the water needs assessment survey and/or the baseline survey database, will be used by LGRDD to group villages on the basis of need. Initial selection may be made at LGRDD Directorate level with an even geographical spread of schemes across the 22 marakaz of the project area, according to population criteria given in the PC I document. Final village selection and approval will be given by the District Water Working Committee (DWWC). Selected villages will then be prioritised according to when they are likely to be implemented within the project, and approximate start dates may be allocated.

1.4 The AJK Water Working Committee will make final confirmation of approval. The selected villages will then be notified of their selection.

2 PHASE 2: VILLAGE PROJECT PREPARATION PRIOR TO WSC

Step 2.1: Informing the Village (visit 1: EWs, OS, UCS, PA)

2.1 After village selection, extension staff will arrange a series of meetings and discussions at village level to outline the general scope and terms of the project, and to build up an information profile of the community for the use project staff. Information would be presented to the community in a "village information document" which will contain:

- the terms and conditions of the project;
- the principles of community ownership and management through a water and sanitation committee (WSC);
- the specific responsibilities of the community and government;
- special focus on hygiene and sanitation improvement; and
- emphasis on the critical role of women in this community managed project.

2.2 Meetings and discussions would seek to reach all members of the community including respected leaders, notables, religious leaders, women's forums and school age children.

2.3 The need for measurement and regular monthly monitoring of the yield of all the spring sources for village water supply to the community will be carefully explained. Villagers will identify local people who will be responsible for taking the measurements and will then start the observations. The method of taking and recording yield measurements will be demonstrated by the overseer.

Step 2.2: Profiling the Community
(visit 1: EWs, OS, UCS, PA)

2.4 Each selected village will be surveyed to establish and confirm the details relating to existing conditions within the village. This process will be started whilst undertaking Step 2.1 above to inform the community and continued during this step through meetings, semi-structured interviews and map making in the village.

a) Baseline Survey

2.5 Through the baseline survey information will be collected about village population, infrastructure, current water supplies and sanitation and selected information required for outline scheme design. Data will be recorded in the standard format to enable entry and processing using computerised database software. The survey will be conducted by project staff during the first visit to the village.

2.6 If a baseline survey has been already undertaken over one year previous to the date of visit 1 (see para 1.2 above), it is vital that the baseine survey is now revised and updated so that changes in the physical and social data are made in order to reflect the true current conditions in the village.

b) Village Mapping

2.7 During this step project staff with the participation of villagers will prepare an initial sketch map of the village which visually records and presents the essential topographic and demographic data relating to the village in a simple form. Information about all the potential water sources including yield must be noted during this process and an initial assessment of the area coverage of possible schemes can be made.

c) Social Data Collection

2.8 Extension staff during this step will conduct semi-structured interviews with different focus groups within the community to collect social information of relevance to the project. Such interviews with small groups of people will also provide opportunities for the community to clarify their understanding of the project.

Step 2.3: Federated Water and Sanitation Committee Formation (visit 2: EWs)

2.9 Often there will be more than one scheme within a single revenue village, and/or the community served by a scheme may not be homogenous. It may be appropriate for a WSC to represent a single scheme within a group of schemes. Where individual scheme WSC are formed, each will be represented on a federated WSC. Although at this stage the individual schemes may not yet be identified, the community can begin the process of selecting representatives who will form the nucleus of a village committee. The extension staff will conduct a large village meeting to assist the community to select the federated committee. This federated committee can then represent the interests of the whole village.

2.10 Where women are not part of the WSC, project staff will guide the community in the establisment of a parallel womens group which will act as a forum for the opinions, discussion and participation of women on the project. Women extension staff, working as a team, will seek to identify influential women in the village who can form the nucleus of a federated women's group. At a later stage women's standpost groups will be formed with representatives on the federated women's group. It is expected that the male dominated WSC will seek women's advice and participation through this federated women's group.

Step 2.4: Establishing Community Commitment (visits 1 & 2: EWs)

2.11 During the initial meetings and contact with a wide cross-section of the community, the extension staff will explore:

- the perceived level of need for improved water supply and sanitation in the village;
- the acceptance of the community of equitable distribution of water through standposts.
- the ability and willingness of the community to provide their share of scheme contribution, estimated using the projects experience of costs.

Step 2.5: Letter of Intent

(visit 3: EWs, EO, AE, UCS, PM)

2.12 Provided the village is prepared to accept the project in principle, a Letter of Intent should be signed in the presence of a large gathering of the village population, by district representatives of the LGRDD and by the newly formed WSC. This letter serves to formally acknowledge the commitment of both parties to proceed with the project. A proforma for the Letter of Intent is annexed to this document (as Annex 2 - 3).

3 PHASE 3: VILLAGE PROJECT PREPARATION WITH WSC

Step 3.1: Project Feasibility Study

(visit 4: EWs, OS, EO, AE)

3.1 The feasibility study will build on information already collected during the baseline survey and will have the aim of identifying a feasible design for the water project. Both extension and engineering staff will cooperate to collect and assess topographical, technical and social data throughout the village. Different design/planning options will be examined so that alternatives may be offered to the villagers for their selection. The aim will be to bring water supply to the maximum reasonable number of households who require improved water supplies.

3.2 The feasibility study will necessarily require meetings with the villagers and individuals to seek their approval for planning the water source(s) to be used, tank sites and main pipeline routes. The study will consider the need of the WSC to obtain formal notarised dedications to public use for the source(s) or land for tanks etc. A large sketch map of the scheme will be prepared to explain the proposed design alternatives. Disagreements about proposed aspects of the plans should be resolved through discussion and compromise.

3.3 The feasibility study will contain outline cost estimates for each scheme. Agreement must be obtained on the general location and scope of the individual schemes and their components as proposed. If alternatives exist, the community and project staff together will select the most appropriate options. The study of the agreed option(s) will be forwarded to the LGRDD Directorate for information.

Step 3.2: Organisation and Development of the WSC
(visit 4 EWs, EO, AE)

3.4 During the feasibility stage, work will continue on the formation and development of the village committees for individual or groups of schemes. Extension staff will need to explain the overall role of the WSC and the specific responsibilities of the office holders. The names of the office holders of the WSC should be notified to LGRDD staff, and announced widely within the village. The office holders will include a chairman, secretary, treasurer and works supervisor. Extension staff will also advise the WSC on how to convene meetings , record minutes/decisions of meetings and prepare lists of households. Development of the WSC will be a continuing activity through all subsequent stages of the project.

4 PHASE 4: SCHEME DESIGN

Step 4.1: Completion of Scheme Design
(visit 5 OS, AE)

4.1 Using information gathered during the feasibility study the detailed scheme design will be prepared by district engineering staff (including topographic survey). Villagers nominated by the WSC will assist in the field work. Overall cost estimates for each scheme will be calculated which will identify the respective contributions of both the village and government for scheme construction and operation.

Step 4.2: Agree Final Design and Implementation Programme
(visit 6: EWs, OS, EO, AE)

4.2 After the final design has been prepared, the design of each scheme and cost thereof will be presented to the WSC and other interested members of the village. The design should be explained in detail by the Assistant Engineer using a sketch map of the scheme. The extension staff will assist with organising and facilitating the meeting.

4.3 Once the design has been agreed, the WSC with advice from project staff should agree an action plan and programme for implementation of the village project. The action plan will include details for:

- fund raising within the community;
- how and when pipe is procured and stored;
- arrangements and timing for civil construction work including pipe installation;

- construction of standposts and associated drainage channels;
- arrangements for complex source development works as required;
- organization of labour; and
- scheduling payments to be made by LGRDD for government funded works.

Step 4.3: LGRDD Directorate approval

4.4 All documents regarding scheme design in a revenue village will be compiled in a design report and submitted to the LGRDD Directorate for formal approval. The design report will include design drawings, design calculations, schedules of quantities, cost estimates, formal dedications of land and water access and proposed construction programmes.

Step 4.4: Signing of Memorandum of Understanding (MOU)
(visit 7: EWs, EO, AE, PM)

4.5 Once both parties agree and approve the design, the MOU between LGRDD and the WSC will be signed. The MOU will detail the respective responsibilities and obligations of both community and LGRDD. The design report will be annexed to the MOU. A second appendix will contain schedules which will include:

- amounts and expected dates of lump sum payments to be made to the village by LGRDD for construction of LGRDD funded works; and

- schedule of materials to be supplied by government to the village such as pipes and fittings.

4.6 The MOU will also detail procedures for the handling of any disputes which cannot be resolved through discussion and compromise within the WSC. The signing of the MOU must be attested by a member of the local judiciary. It is should be made possible that the signing of the MOU can be witnessed by villagers.

5 PHASE 5: SCHEME IMPLEMENTATION

Step 5.1: Community Capacity Building - Training WSC (visit 8: EWs, EO, OS)

5.1 Project staff will assist the village with establishing the organisation and funding systems required to manage the scheme construction, and to operate and maintain the scheme after handover. Specific training and support will be given to the WSC in carrying out the following tasks:

- certifying the quantity and quality of materials provided to site;
- collecting and accounting for cash contributions from the village;
- arranging labour for the construction of village tanks and carriage and laying of the pipelines;
- selecting tapstand design and constructing tapstands;
- assuming responsibility for operation and maintenance; and
- appointing a suitable person to act as WSC Supervisor to oversee the construction

5.2 Civil works such as tank construction and pipelaying will be largely undertaken by private sector artisans or contractors hired by the WSC. Villagers may choose to contribute voluntary labour in order to reduce the financial cost of those works which are the responsibility of the community. LGRDD will provide training, support and assistance to the WSC works supervisor for the proper execution of the works. This will include training village personnel in the techniques of masonry construction and pipe laying. Thus LGRDD staff will train selected local villagers in the necessary skills for future operation and maintenance work.

5.3 The extension staff will support the community in the development of women's standpost groups. Such groups will present women's concerns and interests to the WSC and serve as contact groups for hygiene education and latrine promotion.

Step 5.2: Scheme Construction (various visits by core staff: AEC, PM, OSC, PA)

5.4 Scheme construction will proceed in line with the implementation programme agreed between the WSC and LGRDD, as and when materials and labour are provided. Community tank construction will be completed by the village according to standard designs.

5.5 Project staff will need to ensure the timely procurement of equipment such as pumps and motors, and timetable activities such as the installations of electrical supply.

Step 5.3: Scheme Testing
(various visits by core staff: AEC, OSC, PA, PM)

5.6 At the completion of construction of each of the various components of the scheme, the operation of each component should be tested for performance and quality by LGRDD staff. This shall be undertaken in the presence of villagers and the WSC.

6 PHASE 6: SANITATION AND HYGIENE EDUCATION

Step 6.1: Hygiene Education
(visit 9: EWs)

6.1 During the process of project development within the village, LGRDD extension staff will discuss with the villagers the health benefits of improved water supply, sanitation and encourage changes in hygiene behaviour. Educational sessions will usually be held separately with groups of men and women. Before water is available more general personal and environmental hygiene practices will be considered. When water becomes available at the standposts, the focus will move to diarhoea transmission and its prevention in the community. Extension staff will make use of participatory methodologies such as the Diarrhoea Picture Story to inspire improvements in current understanding and practice.

Step 6.2: Latrine Construction
(visit 10: EWs, MT)

6.2 A second major component of the hygiene education will be on environmental sanitation improvements that villagers can undertake focusing on the reasons for and methods for construction of latrines. Village masons will be trained by LGRDD Mason Trainers through the building of different types of demonstration latrines at a village school. These masons will then be available to support and advise village householders who want to construct their own latrines at their own expense.

7 PHASE 7: SCHEME COMMISSIONING HANDOVER AND OPERATION AND MAINTENANCE

Step 7.1: Scheme Commissioning
(visit 11: EWs, OS, EO, AE, PM, AEC, OSC, PA)

7.1 The scheme will be commissioned under the guidance of LGRDD staff. The nominated operators appointed by the WSC who are to be responsible for the day to day operation and maintenance of the scheme will be trained by the overseer in the particulars for the secure running of the scheme.

Step 7.2: Scheme Handover
(visit 12: EWs, OS, EO, AE, AEC, OSC, PA, UCS, PM, ADLG)

7.2 Following the successful commissioning of all schemes in a village, the village water supply project will be formally opened and handed over to the WSC at a large gathering of the village. The respective responsibilities of both the WSC and LGRDD after handover will be restated.

Step 7.3: Monitoring and Maintenance
(annual visits: OS, EO, PM)

7.3 LGRDD will remain responsible for periodic monitoring of the operation of the completed scheme by the WSC. Routine maintenance will be the responsibility of the community. LGRDD will provide the replacement of mechanical/electrical parts and will assist to repair damage in the event of catastrophic failure within the scheme when this is not due to the negligence of the villagers.

ANNEXURES

ANNEXURE 2.1: STAFF DETAILS

KEY TO STAFF
The key to the initials of the staff members is as follows:

IDA incremental staff			Core Staff		
EWs	=	Extension Workers	PM	=	Project Manager
EO	=	Extension Officer	AEC	=	Assistant Engineer Core
AE	=	Assistant Engineer	UCS	=	Union Council Secretary
OS	=	Overseer	OSC	=	Overseer Core
MT	=	Mason Trainer	PA	=	Project Assistant
			ADLG	=	Assistant Director

Note: "EWs" are normally expected to be three in number ie one male and two females

VISITS, PHASES, STEPS AND STAFF

The following is an abstract of the number of visits expected to undertake each step within each phase together with the individual staff members which may be expected for execution of all the steps in an average village.

PHASE 1: VILLAGE IDENTIFICATION

Visit A: UCS, EW
Step 1.1: Water Needs Assessment Survey
Step 1.2: Village Selection

PHASE 2: VILLAGE PROJECT PREPARATION PRIOR TO WSC

Visit 1: EWs, OS, UCS, PA.
Step 2.1: Informing the Village
Step 2.2: Profiling the Community
a) Baseline Survey
b) Village Mapping
c) Social data collection
(Step 2.4: Establishing Community Commitment)

Visit 2: EWs, UCS,
Step 2.3: Federated Water and Sanitation Committee Formation
Step 2.4: Establishing Community Commitment

(Note that Visits 1 and 2 will require several visits by EWs to cover the revenue village)

Visit 3: EWs, EO, AE, UCS, PM
Step 2.5: Letter of Intent

PHASE 3: VILLAGE PROJECT PREPARATION WITH WSC

Visit 4: EWs, OS, EO, AE
- Step 3.1: Project Feasibility Study
- Step 3.2: Development of the WSC

PHASE 4: SCHEME DESIGN

Visit 5: OS, AE
- Step 4.1: Completion of Scheme Design

Visit 6: EWs, OS, EO, AE
- Step 4.2: Agree Final Design and Implementation Programme
- Step 4.3: LGRDD Directorate approval

Visit 7: EWs, EO, AE, PM
- Step 4.4: Signing of Memorandum of Understanding (MOU)

PHASE 5 SCHEME IMPLEMENTATION

Visit 8: EWs, OS, EO
- Step 5.1: Community Capacity Building - Training WSC

Various visits by core staff: AEC, PM, OSC, PA
- Step 5.2: Scheme Construction
- Step 5.3: Scheme Testing

PHASE 6: SANITATION AND HYGIENE EDUCATION

Visit 9: EWs
- Step 6.1: Hygiene Education

Visit 10: EWs, MT
- Step 6.2: Latrine Construction

PHASE 7: SCHEME COMMISSIONING, HANDOVER AND OPERATION AND MAINTENANCE

Visit 11: EWs, OS, EO, AE, PM, AEC, OSC, PA
- Step 7.1: Scheme Commissioning

Visit 12: EWs, OS, EO, AE, UCS, PM, AEC, OSC, PA, ADLG
- Step 7.2: Scheme handover

Annual visits: OS, EO, PM
- Step 7.3: Monitoring and Maintenance

VEHICLE REQUIREMENTS

In order to support the community to undertake the implementation steps, it is necessary that LGRDD staff have the mobility to visit the villages. Lack of mobility is presently recognised to be a constraint. Public transport is not convenient as normally such transport leaves the village setllements in the early morning to travel to the market centres and only returns to the village in the late afternoon, whereas the staff need to travel out from the market centres in the morning. Public transport is furthermore slow and sometimes connections are required.

In the future government proposes that at least one village project will be implemented in every union council of the 22 marakaz in the projetc area. Project implementation will therefore be particularly dispersed and ease of staff mobility will be vital.

It is therefore proposed that the following vehicles are purchased or otherwise made available to LGRDD staff in each district (note Muzaffarabad consists of two subdistricts).

IDA Incremental Staff:

		Totals
Assistant Engineer	1 Suzuki Jeep (6 existing)	12 nos
Extension staff	1 Suzuki Microbus (Bolan)	6 nos
Overseers & EWs (male)	3 Motorbikes	18 nos

Note: the vehicles are to be pooled so that they can be used by any staff requiring transport.

Core Staff:

		Totals
Project Managers	1 Suzuki Jeep	22 nos
Assistant Engineers	1 Motorbike	6 nos
Overseers	1 Motorbike	22 nos

ANNEXURE 2.2

LGRDD AJK Rural Water and Sanitation Project (IDA)
VILLAGE NEEDS ASSESSMENT SURVEY

This brief survey is to assist LGRDD in assessing the status of water supply in the revenue villages of AJK. The form is to be completed by the Union Council Secretary for all the <u>revenue</u> villages within his Union Council, with assistance from villagers. LGRDD Project Assistant may assist if available.

The following guidance notes are to aid the UCS to complete the questions:

Q.0.1 Report the approximate number of houses within the boundary of the revenue village. Do not include Dhoke.

Q.0.2 & Q.3 This question is to establish the type and number of water supply sources in the village. Only complete the rows which correctly describe the main water sources used in the village. The following points refer to the columns to be completed:

Nos: Indicate the number of water sources of each type used.

Distance: Assess the number of houses using each source. Estimate the appoximate average "one-way" distance in feet or miles to the water source from the the houses using the source(s). Indicate the number of houses in the columns under the distances listed for each type of source. Do not include those houses getting water from existing scheme as indicated in Q.4 (c)

Note:
- a) It is acceptable to approximate the number of houses in each group.
- b) It is important that the total number of houses stated in Question 1, 2 and 3 are equal.
- c) It is not permitted to report that a house is going to two sources - choose the single main source only.

Q.4
- a) Indicate with "yes" or "no" if any part of the village has ever installed one or more LGRDD schemes to improve water supply if
- b) indicate if the scheme(s) is working.
- c) Report the appropriate number of houses getting water from existing scheme.

Add any appropriate comments regarding the present water supply of the village.

PROPOSED MARKING SYSTEM

The need of a village, with respect to a water supply, can be determined from the three questions correctly answered on the survey. An index number is calculated for each village based on the following 6 steps. The higher the index number, the greater is the need of the village for a water supply system.

Step 1 For each source type the number of houses using the particular source is multiplied by the distance for those houses (except for those up to 500 ft which are to be ignored). For houses area 2 miles distance the number should be factored by 1.5.

Step 2 The resultant is totalled for each source type.

Step 3 Factors are to be applied to those sources which generally give poor quality water, viz:
Factor for Open well = 1.5
Factor for Surface water = 2

Step 4 The resultants for all sources are then totalled together.

Step 5 The total for the wet season is multiplied by 0.66 and the dry season total is multiplied by 0.33. These figures are then added together.

Step 6 Finally this sum total is then divided by the total number of houses in the village to give the needs index number for that village.

LGRDD AJK Rural Water and Sanitation Project (IDA)
VILLAGE NEEDS SURVEY

District:		Revenue Village Name:	
Union Council:		LG&RDD Village No	
Markaz:			

Q.1. TOTAL NUMBER OF HOUSES IN VILLAGE:

Q.2. SOURCES USED IN WET SEASON

Source	Nos of Source	Number of houses at average distances to the sources				
		upto 500ft	1/2 mile	1 mile	2 miles	Over 2 miles
Spring						
Hand Pump						
Borehole						
Open well						
Surface water						

Q.3. SOURCES USED IN DRY SEASON

Source	Nos of Source	Number of houses at average distances to the sources				
		upto 500ft	1/2 mile	1 mile	2 miles	Over 2 miles
Spring						
Hand Pump						
Borehole						
Open well						
Surface water						

	YES	NO
Q.4. a) ARE THERE ANY EXISTING PIPED WATER SCHEMES		
b) ARE THE EXISTING SCHEMES WORKING		
c) NUMBER OF HOUSES GETTING WATER FROM EXISTING SCHEME		

APPROPRIATE COMMENTS

1.

2.

3.

4.

SIGNATURE/DATE UNION COUNCIL SECRETARY	CHECKED SIGNATURE/DATE PROJECT MANAGER

ANNEXURE 2.3

Islamic Republic of Pakistan
Government of
Azad Jammu & Kashmir

Local Government and Rural Development Department (LGRDD)

Rural Water Supply and Sanitation Project

LETTER OF INTENT

District Name: Date:
Village Name: Village No:

This Letter of Intent is made between the two parties of the AJK Local Government and Rural Development Department (LGRDD) (Party 1) and the federated Water and Sanitation Committee representing the community of village: ______________________ (Party 2).

This letter serves to formally acknowledge that the community of the above village is committed to execute a water supply and sanitation project in this village and fully understands the project aims and the obligations and responsibilities of the village community in this regard.

The WSC on behalf of the village also agrees to:

- support and cooperate with LGRDD extension and engineering staff to hold meetings, collect information and plan activities for the project;
- organise the regular recording of the yield of water sources which are proposed for use in the new water schemes;
- facilitate and participate in surveying and field measurement during scheme design; and
- discuss final design and provisions of Memorandum of Understanding (MoU) with community.

This letter serves to formally acknowledge that LGRDD is committed to support the community of the above village in the execution of a water supply and sanitation project in this village with the aim to establish, as far as is practicable, comprehensive coverage of the village with water supply to standposts.

LG&RDD also agrees:

- to consult the villagers at each stage of the project and incorporate their views wherever possible;
- to provide and facilitate extension and engineering staff to cooperate with the village in.

  (i) promoting community participation and consultation in the project;

  (ii) assisting with project planning activities; and

  (iii) undertaking scheme design and investigation.

Signed: (Party 1) date:

Name and Post

Signed: (Party 2) date:

Name and Post

Witnessed: date:

Name

Chapter 3

MAPPING AND SKETCHING

CHAPTER 3

MAPPING AND SKETCHING

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CHAPTER 3

MAPPING AND SKETCHING

1 INTRODUCTION

General

1.1 The preparation of a village sketch is a vital step in the preliminary stages for planning of water supply scheme(s) for a village. The information for map making is to be obtained and noted by project staff during frequent visits, observations and discussions with the people of the community. The village sketch map can then be produced and plotted in a systematic but simple way.

Why Mapping is necessary

1.2 For all construction activities, it is necessary to prepare a plan for the proposed work. Drawings, plans and maps, are the most effective and convenient method of illustrating and describing to all interested parties what is proposed to be built and where it is to be built.

1.3 A sketch map is the essential aid in identifying and illustrating information about the village for both planning and design purposes. Later during construction the map can be used as a visual aid to identify where the works are to be undertaken and also to record and monitor progress. The preparation of a sketch map is an essential preliminary stage of detailed planning.

What to include in a sketch map ?

1.4 A sketch map gives demographic information about village/settlement boundaries, where people live and shows the main topographical features of the land. This locates all the salient features and details of the village. Any existing water supply pipe layout is recorded with as much detail and information as possible. The information must be illustrated on the sketch map with sufficient detail, and yet should be simple and easy to read.

2 VILLAGE SKETCH

Importance and Community Involvement

2.1 The preparation of sketch maps is an opportunity which allows the village population to participate in providing necessary information on their community whilst contributing to the planing of a future water supply system. It serves as an initial contact activity with the villagers when their problems relating to water supply can be examined and the villagers themselves can explore and suggest possible solutions. It is a means of initiating discussion about possible scheme layout and design. It will subsequently be a tool for deciding on the location of standposts.

2.2 The sketch is prepared by project staff together with the villagers. Besides helping staff to become familiar with the project area, the consultation with the villagers serves to develop an essential bond between the people and the government staff. Preliminary sketches are to be made whilst discussing with the community in the village. A fair copy can be produced later in the office.

2.3 For detailed planning work later, such as the actual development of scheme pipeline layout drawing, then additional drawings on a larger scale will be needed to show particular and specific details.

What does a sketch map show ?

2.4 The final village sketch map necessarily shows the boundaries of a village with all the salient features and names thereof as appropriate:

- river, streams, and nullah course(s);
- paths/tracks /roads:
- location of settlements and major buildings;
- electricity supply lines;
- major slopes, spot heights;
- locations of all springs and wells;
- layout of existing or proposed water supply scheme(s);
- major trees; and
- direction of North along with a key as required.

When is it made ?

2.5 The sketch map may be made over a single extended visit to the village or over several consecutive visits. A preliminary village sketch map of the village will be prepared during the initial visits of the Extension Workers following village selection. This will be first follow-up activity after the village baseline survey.

Who makes it ?

2.6 The village sketch is prepared by the Extension Staff with the involvement and indispensable assistance of community members. Sketches will be drafted during meetings in settlements throughout the village with interested villagers. Different staff members may work in separate parts of the village and each will make several component diagrams. Later in the office, a single final draft may be prepared which combines all the rough sketch components made in the field. This should preferably be drawn upon a single sheet of A3 size paper, although for larger villages this may need to be on a larger sheet.

2.7 The sketch thus prepared is studied and checked by the Overseer and the Assistant Engineer. The district draughtsman will then prepare a fair copy which should ensure that all sketches in the district are produced to the same standard.

2.8 As explained above the preparation of a sketch map is based on rough sketches and notes made during the field work. There is also office work where it is necessary to draw nicely all the required details using the rough sketches and notes.

Use of G T Sheets

2.9 Although the village sketch map does not need to be an accurate scale drawing, the Survey of Pakistan G.T. Sheets (scale 1:50,000) can aid the initial orientation of staff to the village area . The G T Sheets show accurate basic data of land topography and although the scale is too small for the purposes of this project, they are still useful because of their clarity and detail. Demographic details or information about the population is however likely to be out of date.

2.10 As the scale is small, the relevant portion from the G.T. Sheets should be enlarged (preferably 1:25,000) on a photocopier. Before going to the field, the essential detail of the salient features such as nullahs, roads and hills, can be identified and traced on to an A4 or A3 page. A photocopy of this tracing can then be developed and updated by the Extension Staff in the field with the help of villagers.

2.11 In addition to plan (or planimetric) detail, it is necessary to include information about heights or elevations. This is particularly important for pipe work projects. G.T. Sheets have contour lines and spot heights. Contours on maps are useful to clearly illustrate the topography. Contour lines are the lines joining points of equal height. When contour lines are close together, the land surface is relatively steep; when they are wide apart, it is relatively flat.

3 STEPS TO FOLLOW DURING MAP MAKING

3.1 The skills of map making will develop over time and as project staff gain experience and confidence. The following principles should be used for guidance:

(i) Before the first visit to the village, project staff should make and study, an enlarged photocopy of the relevant GT sheet as described above.

(ii) Project staff should themselves make and record their visual observations of the village layout from suitable vantage points.

(iii) The making of the sketch map and the details should be done with small groups of villagers.

(iv) The purpose of the map should be carefully explained to the villages. The map is needed to collate information about the village, and it should be discussed as a tool to solicit their ideas on the proposed water scheme. This will promote and ultimately enable the preparation of best possible design for the village.

(v) It is particularly important that the map making exercise should involve and be undertaken with groups of village women. Women are invariably responsible for the collection and carrying of water and their knowledge is also valuable.

(vi) Preliminary maps can be drawn in the earth with a stick or on a hard wall surface using chalk. There should be sufficient space to make a large drawing.

(vii) The extension worker should begin by drawing a small square to indicate where the group is sitting. The extension worker them invites the others to start from that point with drawing the roads, paths, schools, mosques and house holds.

(viii) When preparing a rough sketch map on the ground, leaves, pebbles, fruits, matchboxes and other objects can be used to indicate houses or other particular points. It is not vital if distances and proportions are not exactly right, as long as everybody is satisfied that all the important features, of the village or settlement are included, as listed in para. 2.4 above.

(ix) Once a map has been roughed out the discussion may move to the positioning of existing water sources and to the possible location of the scheme or pipe alignment. Women's groups may discuss the preferred and potential locations of standposts using the map drawn for the group.

(x) Any map drawn on the ground or wall/board should be copied onto sheet of paper using pens, for later interpretation and discussion. The extension worker should have several large sheets of paper (poster size) and coloured markers to prepare the finished map. This copy will be needed for later discussion with the village.

Points to Remember

3.2 Although the exercise is interesting and fun to do, it should be taken very seriously. For example, if a map is prepared on the ground then children should not be allowed to walk on the map to damage it before it has been completely finished and copied by the extension worker.

3.3 Villagers are to be invited to draw themselves but it may be necessary for the extension workers to take the lead in the drawing of the map. However this would tend to spoil the exercise as it may limit the opportunity for the community for truly participating in decision making. After the introduction, explanation and demonstration by the extension worker, it is better if the community members should draw the map.

Symbols used

3.4 Fig. No. 1 attached, shows all the standard symbolic representations for the information and features normally required for sketch mapping. These standard symbols only are to be adopted and used by project staff. Any additional features not specifically mentioned herein may also be appropriately symbolized, as and when required, in addition to this legend.

Field practice

3.5 Before starting the field work, it should be well understood what is to be done and how to do it. The following factors are important:

- Speed in the field work;
- Making of clear and careful notes which are subsequently safely filed or stored for future reference if required;
- Correctness of the observations measurements; and
- Neatness and accuracy.

4 SCHEME LAYOUT SKETCHES AND DIAGRAMS

Sketches for Feasibility Study

4.1 The overseer will subsequently use the village sketch map during his feasibility study and topographic survey to develop the scheme layout plan. Proposals or options for the scheme layout(s) are to be drawn superimposed on copies of the village sketch map. In this form the suggested layouts may readily be discussed with community members and modified as necessary. The scheme layout sketches will include proposals for the pipeline route, locations and sizes of tanks and the tapstands. Diameters and lengths of pipes need not be noted on such sketches.

4.2 For larger villages a new sketch may need to be prepared for each scheme. This will likely be the case if there are several schemes proposed in a specific village and the overall village sketch map is too small. In such cases however, care has to be taken to include a key to the various schemes on the overall sketch map of the village as a whole. This may be achieved by shading or hatching in order to locate the scheme area together with scheme numbers indicated; thus all the individual scheme sketches can be correlated together and related to each other.

Detailed Design - Scheme Layout Diagrams

4.3 During detailed design a more refined yet schematic layout diagram will be developed which will complement the computer aided hydraulic design ("Branch"). The scheme layout diagram is a vital construction aid to enable the scheme to be built and is to be included in the Design Report for each scheme.

4.4 This diagram will be similar in form to the examples produced by local consultants for the first 70 villages of the project. The scheme layout diagram will indicate:

- key features such as roads, nullahs, mosques etc;
- source location with elevation and safe yield;
- pipe nodes and numbers with elevations;
- pipe lengths from node to node, types and diameters;
- storage tank location, elevation and capacity;
- break pressure tank location and elevation;
- tapstand location, tapstand number, elevation and number of houses served and name of nearest householder;
- location and elevation of air valves and washouts with indication of distance from the upstream nodal point;
- location, length and type of all pipe crossings; and
- direction of north.

FIGURES

VILLAGE MAP SYMBOLS

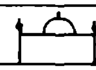
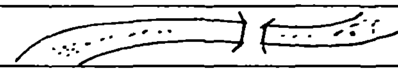
S No.	DESCRIPTION	SYMBOLS
1	Village boundary	—— · —— · —— · —
2	Settlement boundary	— — — — — — — —
3.	Settlement/Areas not coverd by scheme	
4	Slope (up) (down)	
5	Forest	
6.	Spot height	• 1055 ft
7	Mosque	
8.	Houses	□ 12 H
9	School PS = Primary school, MS = Middle school HS = High school, G = Girls, B = Boys	S
10.	Bazar	
11	Dispensary	D
12.	Vetinary dispensary	V
13.	Track	- - - - - - - - - - - - -
14	Nullah (with bridge)	
15	Spring (unprotected)	+
16	Spring (protected)	⊞
17	Tubewell / Borehole	⊙
18.	Open well	◎
19	Electricity supply line	——×——×——×——
20.	Pipeline (with direction of flow)	————►————
21.	Standpost	
22.	Ground storage tank	2000 g.
23.	Pump house	PH

Fig. 3·1

Chapter 4

FEASIBILITY STUDIES

CHAPTER 4

FEASIBILITY STUDIES

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Preface

The following poem may provide inspiration for project staff as they lead and serve the people of AJK:

Go to the people
Live among them
Learn from them
Love them
Start with what they know
Build on what they have
But of the best leaders
When their task is accomplished
Their work is done
The people all remark
"We have done it ourselves"

(Tao To Loa Truching)

CHAPTER 4

FEASIBILITY STUDIES

1 INTRODUCTION

1.1 The Project criteria is for water supply coverage for the entire village. Experience has shown that water supply to villages in AJK may be through one or several schemes. These schemes may be either gravity fed, pumped or a combination thereof; sources are generally springs or wells. Feasibility studies are undertaken by the project staff under the essential guidance and direction of the community in order to explore, develop and identify the scheme or schemes to be built.

1.2 During a feasibility study all the practical aspects for devising a village water supply scheme are to be examined upon which depends its eventual success. Such study involves the examination of a combination of aspects including financial/economic, social, institutional and technical. Throughout the world, many schemes have failed not because of the technical deficiencies but because of lacking in one or more of these important factors. These could be lack of community participation, incomplete data, ignoring economic considerations or absence of an effective institution in the form of a water and sanitation committee (WSC) to sustain the scheme.

1.3 The feasibility studies comprises work both in the office and in the field whilst collecting information, making observations and meeting with the villagers. The preliminary field work and information gathering is termed as "pre-feasibility study". This initial activity will be undertaken by project staff led by the Overseer and supported by the Assistant Engineer (AE). The subsequent follow-up work is known as "feasibility study" and is the formal assessment of the preliminary work which is to be made by the AE and the WSC. This will result in concrete proposals and decision by the community to identify workable, acceptable and appropriate option(s) for detailed design and development.

2 THE PROJECT CYCLE

2.1 The document "Project Implementation Steps" gives the order of proceeding with the various steps involved in a water supply scheme. For guidance these steps may be referred to and are briefly stated in Table 1.

PROJECT IMPLEMENTATION STEPS
Project Identification: - Water Needs Assessment Surveys; and - Village Selection.
Project Preparation: - Informing the village; - Baseline Survey; - Establishing Community Commitment; - Federated Water & Sanitation Committee Formation; - Letter of Intent; - *Project Feasibility Study*; and - Development of WSC.
Scheme Design: - Completion of Scheme Design; - Agree Final Design and Implementation Programme; - LG&RDD Directorate approval; and - Signing of MOU.
Scheme Implementation: - Community Capacity Building; - Scheme Construction; and - Scheme Testing.
Sanitation and Hygiene Education: - Hygiene Education; and - Latrine Construction.
Scheme Handover and Operation and Maintenance: - Scheme Commissioning; - Scheme Handover; and - Monitoring and Maintenance.

TABLE 4.1: PROJECT IMPLEMENTATION STEPS

3 COMMUNITY INVOLVEMENT

3.1 Community participation is the central philosophy of this project. The improvements that increased water supply will bring to the village can only be sustained if the village population themselves are intimately involved in the scheme implementation. The village population will identify schemes, plan their inputs, arrange construction and subsequently operate and maintain the schemes. The project staff are to facilitate all these activities.

Community Identifies the Schemes

3.2 In order to identify and subsequently design the village schemes, project staff need to study and survey the village. These studies and surveys tell the outsiders, or the project staff, what the insiders, or the village community, already know. During the feasibility studies, the community should be encouraged to search out their own ways of meeting their needs. These are indicated and discussed with the project staff. It is vital that there is total involvement of the community elders and leaders during the feasibility studies in order to ensure that local cultural factors are fully taken account of.

Role of Women

3.3 It should be kept in mind that community involvement should include a special focus on enhancing the role of women as an essential component of the overall strategy. Women are important being the predominant carriers and users of water in the community and their views must be sought and reflected. The female extension staff will also be involved in feasibility studies and consulting the village women for their essential inclusion in the development and planning of schemes.

Development of Confidence

3.4 The period of the feasibility studies is the first sustained contact between the villagers and the project staff. During this time the two parties will get to know each other. The community must be able to have confidence in the project personnel. Project staff themselves must be totally committed to the idea of community participation if the people are to trust their guidance. It is vital therefore that project staff must be able to communicate enthusiasm, determination, drive, commitment and inspiration to the village population. Project staff must also be ready and able to learn from the people, as well as share ideas with them.

Time Required for Village to Accept Options

3.5 Possible technical solutions should be carefully explored and explained in ways that the community can understand and subsequently make their own. It may take considerable time for a community to adopt a solution. There needs to be as much time as the community requires for any new idea to be seeded and become fully informed by all sections of the village. It must be remembered that a community project will move at the pace of the people. This may not fit in with LGRDD time schedule, budgets or work plans, but these must be adjusted to fit in with the seasons and the requirements of people who are farmers first and development workers second. LGRDD must therefore be flexible according to the needs of the village.

Visits to other Village Schemes

3.6 During the feasibility studies, the community should be actively encouraged to visit neighbouring villages where similar schemes have already been executed. Thus the community can see and learn from the experiences of other project villages.

4 PRE-FEASIBILITY STUDIES

4.1 After selection of a village, preliminary feasibility work can be undertaken by project staff. The Overseer and extension staff will be particularly active during this stage. The pre-feasibility study explores alternatives with the community. Alternatives are defined and discussed with the villagers to enable selection. The studies include the collection and analysis of available data regarding settlement, topography, population, source(s) location, yield measurement, including the minimum yield at any particular time of the year and other relevant information.

Scope of a Scheme

4.2 Before a single, or number of schemes, can be designed for a village the best and most feasible option must be identified. This will essentially indicate the scope of the scheme. The scope of the scheme means defining how many people can be served, from what source and where the potential consumers are located.

Desk Study Work

4.3 The pre-feasibility study will build on information collected during the village survey and mapping to begin identifying single or alternative workable design options for the water supply scheme(s). This exercise prepares the material which can then be discussed with the community during subsequent field visits. The project staff also become briefed and familiar with conditions in the village.

4.4 Topographical, demographic/social and physical data throughout the village shall first be compiled. The GT sheets for the area are also to be observed. Conceivable planning/design options will be examined so that possible alternatives may be offered to the concerned community for their selection. The object will be to provide water supply to the maximum possible number of households who need an improved service.

4.5 The village sketch map and baseline survey is scrutinised to establish the location of the potential water sources and also the location of the settlements.

Demand Profile

4.6 The potential demand is to be assessed. Firstly the location and number of houses is identified. Then by using a rule of thumb that each house has a approximate demand of 100 gpd the demand for each group of houses or settlements is estimated. This should be done settlement by settlement, and recorded on a copy of the village sketch map. Thus a demand profile of the village is developed.

Source Yields

4.7 The records of yield of all sources must be examined and the minimum and safe yields assessed. If no such records exist then project staff must as a matter of priority set up monitoring of the yields by the village people themselves.

Village Visit

4.8 Once project staff have completed their desk studies a visit to the village is required to meet with the villagers in order to seek their participation in the planning the water source(s) to be used, possible tank sites and main pipeline routes. Gaps in the information required will be filled during the visit(s). It is envisaged that this visit will be over several days and project staff will need to stay overnight in the village. This will require an initial earlier visit in order to arrange for the villagers to be ready to receive and suitably accommodate the project staff.

4.9 During the visit, the required data will be confirmed, such as:

- overall geography, topography and settlement patterns;
- main roads, paths and channels;
- location, yield and availability of water sources;
- existence of alternative sources (possibly in adjacent areas);
- the distance of the source from settlements;
- availability of rights to use the source;
- service details about existing schemes;
- social information such as whether the community is homogenous or otherwise, what historical conflicts exist, if any.

4.10 All the details are obtained from the villagers themselves who know the locality and related conditions of the available sources. The project staff with their specific training and experience also of other similar schemes will gather and record this information, adding their own observations as appropriate.

4.11 The Overseer and/or AE will now be in a position to form a preliminary idea about whether the village can be served by one scheme or more and whether possible schemes may be based on gravity flow, pumping or a mix of the two. The topography and/or the non-homogeneous nature of the community may itself lead to the planning of more than one schemes for a village.

4.12 It will be then necessary for topographic field survey work to be undertaken of the essential details for each scheme. This will be done by the Overseer, possibly augmented by the AE as necessary. Guidance for "field survey techniques" is covered in a separate section.

Village Discussions

4.13 The willingness of public to use the sources, pipe routes, tapstand locations and land for tanks etc. must also be considered at this time. As the project staff visit and investigate all the different areas of the community, impromptu discussions are to be made with the various villagers who are encountered.

4.14 Before leaving the village the possible design alternatives will be outlined on a sketch map for explaining to the villagers. This should be made on a copy of the village sketch map, but additional detail sketch layout plans may also need to be prepared. These sketches will be used in formal meetings with village representatives as a focus for consultation and discussion. Any additional observations or possible controversy about the proposed design options shall be resolved through dialogue and mutual compromise.

5 FEASIBILITY STUDY

5.1 When the pre-feasibility work is complete the project staff will return to their district office. If the AE has not been involved in the preliminary field work, he is now to be thoroughly briefed. The AE now undertakes the feasibility work proper.

5.2 During the feasibility study the AE carefully evaluates the proposals and alternatives. This may well require return visits to the village to clarify or follow up specific issues.

Main Considerations

5.3 The AE must formally appraise the options to ensure that they are truly feasible and viable. A scheme though technically feasible can fail due to not having the support of beneficiaries, lack of institution, or being economically unviable. It is very important that all these considerations are kept in view equally. For a scheme to be successful it should be:

- financially affordable;
- economically sustainable;
- institutionally manageable;
- socially acceptable; and
- technically efficient and appropriate.

5.4 The proposed schemes have to satisfy the needs of both the beneficiaries, as well as the requirements of LGRDD. Ignoring any one of the above considerations can result in the failure of the scheme. Many of schemes have failed only because one of the above important considerations have been either totally neglected or inadequately met.

a) Financial/Economic

5.5 A scheme has to be supported by finances from both the community and LGRDD. Funds are needed from the village for the management, construction and eventual operation and maintenance. If there is a lack of funds, the scheme though technically viable will not be completed.

5.6 The economic consideration of a scheme are important. It has to be seen that the benefits obtained from the scheme, justify the cost. It is necessary that the cost is within the affordability of the community and also there is a demonstrated commitment and willingness to pay for the estimated operation and maintenance cost. This is particularly critical for high head pumping schemes, which are not uncommon in AJK.

5.7 The feasibility study will therefore include outline cost estimates for each proposed scheme, including both capital and running costs. The outline estimate will include budget cost for all the standard components for tanks, pipe lengths, pumps etc. This will indicate the potential order of cost to both the community and LGRDD and it must be assessed if this is within acceptable limits of both parties.

b) Institutional

5.8 It has to be studied whether the villages have sufficient authority, skills and social cohesion to handle all aspects of the scheme effectively. The formation of a Water and Sanitation Committee (WSC) is a very important step in this direction. The WSC should be truly representative and consist of people of all cross sections of the community. It should also be duly represented by women if social conditions permit.

c) Social

5.9 The social set up of the particular village is to be closely studied. A well knit cohesive social set up will promote the ultimate success of the scheme. Any existing inter-community differences shall adversely affect the successful implementation and sustainability of a scheme. If the community is heterogenous or is based on persistent caste, creed, race or political differences, it is possible that the scheme may not have a bright future. The feasibility study must assess that all potential difficulties or differences have been resolved and that the community is united for the overall benefit of the people as a whole. Social factors are a critical aspect which cannot be over looked.

5.10 It must be appraised that the villagers know what the project will provide and what level of service will become available. For example under this project, house connections are not included or indeed permitted, at least for the first two years. It is important that the people do not have false expectations and this has been addressed during t he study period.

d) Technical

5.11 The AE will appraise that the options proposed are indeed technically feasible. All alternatives which have been identified, are to be properly appraised and checked to ensure that they are indeed feasible. It is particularly important to verify that the source yield has been properly evaluated and that there is sufficient water to meet demand and/or that the scheme is viable. Schemes involving water treatment must be avoided as such is not appropriate in rural communities.

5.12 The AE is the key person for sound technical advice to the village. The community may pursue what to them appears an ideal solution, but the engineer may perceive that this may not be feasible. For example village people generally do not have a sound appreciation of source yield and they may consequently overestimate how many people that a source can supply. What to the people is "enough" water may not be sufficient in the dry season to securely supply the number of people that they might propose.

5.13 Project staff must avoid any inclination to concentrate only on technical aspects; the other facets are equally important.

Decisions by the Village

5.14 The AE will focus on identifying the main decisions which need to be made by the community. These include:

- Final selection of the water sources based on flow measurement and water demand calculations;

- Possible scheme layout such as proposed pipe route, tank positions, tapstand locations etc.; and

- Budget cost estimates for each scheme identifying both village and LGRDD contribution.

Scheme Selection

5.15 Once the AE has completed his formal study, then again in a meeting in the village, the proposed schemes are to be agreed and selected by the community. Agreement must be obtained on the general location and scope of the individual scheme(s) and all the individual components as proposed. If alternatives exist, the community and the WSC will discuss and select the appropriate option.

5.16 The study and brief report indicating the agreed option(s) will be then forwarded to the LGRDD for information before project staff can begin the detailed design.

Chapter 5

SURVEYING TECHNIQUES

CHAPTER 5

SURVEYING TECHNIQUES

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SURVEYING TECHNIQUES

1 INTRODUCTION

General

1.1 Surveying is the art of making of such measurements, as will determine the relative positions of points on the ground in order then to be able to draw this on a plan. Levelling is the identification and illustration of elevations of different points on the earth surface relative to a level datum. Surveying and levelling are distinct operations, but the term surveying includes levelling.

1.2 Field surveying in this project is the simple determination of relative height of positions and distances in a village which can then be used in the detailed design of water supply schemes.

Accuracy and Precision

1.3 It must be recognised that for field surveying, accuracy is more important than precision. Accuracy is defined as "absolute nearness to the truth" where as precision is "degree of fineness in accuracy". In the generally hilly topography of AJK, it is normally not critical for gravity flow systems that elevations and distances need to be assessed with precision; the identification of positions to be within a tolerance 5 metres is normally sufficient. However accuracy with the field instruments is required so that positions are located as correctly as is possible.

Instruments and Survey Team

1.4 Surveying with a theodolite, even with the modern automatic instruments currently available, requires refined engineering skills and moreover considerable time to undertake the survey and subsequently even more time to interpolate the results. Such complex precision work will rarely be applicable or appropriate to this project and is not covered herein.

1.5 Field surveying can be readily undertaken by trained Overseer's with assistance from Extension Workers (E/W) and villagers, using measuring tapes/ropes, compasses, altimeters and abney levels. Field surveying is undertaken whilst making feasibility studies to identify conceivable schemes (see separate chapter for Feasibility Studies). It is anticipated that field survey methods should cover 99% of the survey needs for a village project. On occasions where the available pressure head is found to be critical it may be required to utilise a dumpy level to check the design of a particular part of a scheme.

Objective

1.6 The primary objective of a survey is the development of village layout from the already developed village sketch map (see separate chapter for Mapping and Sketching). The survey should be made of points and routes which will be associated with future storage tanks and pipelines. The results of survey when plotted and drawn to scale showing distances with elevations indicative of required points, will constitute a "Layout Plan".

Purpose

1.7 The purpose of the layout plan for the village / scheme is to focus upon schematic illustration of the conveyance and distribution of water from potential source(s) to the population. This layout plan enables technical staff to ascertain, propose and plot suitable pipeline routes, locations of source/distribution tanks, and tapstands by establishing relative distances and elevations. The layout plan will be the key document used by technical staff, the WSC, the WSC supervisor and plumbers to actually construct the scheme.

2 MEASUREMENTS

General

2.1 There are two kinds of measurements used in plane surveying i.e

- Linear
- Angular

2.2 Linear measurements are further subdivided into horizontal and vertical distances similarly angular measurements may be horizontal and vertical angles.

Unit of Measurements

2.3 The metric system is to be used for both surveying and subsequent design of water supply network on computer.

Methods of Measuring Distances

2.4 In surveying to plot the distance between two points it is always the horizontal distance regardless of relative elevations. For this project it is not the true horizontal distance but the actual distance which is required to produce a lay out plans. The actual distance is more appropriate and useable in order to identify the actual length of pipe for hydraulic design and quantities.

2.5 Various methods of determining distances are useful, depending upon the degree of precision required. The following are the methods of measuring distances on this project to the usual degree of accuracy required.

a) Pacing

2.6 A pace is a step taken by a person. Paces can be used to furnish a rapid means of approximately measuring distances. Before the start of pacing for distance measurement, Overseer or his assistant responsible for measuring distances should standardize his paces to establish his standard pace length.

2.7 Standardization is done by walking along a tape on a level, uneven and sloping ground and count the number of paces to determine how many meters on average their paces are over different terrains.

2.8 Repeat the exercise explained in 2.6 atleast for five times for each type of terrain and take average number of paces for the known distance and establish a factor for each pace as under:

$$\text{Factor} = \frac{\text{Known distance}}{\text{Average No. of Paces}}$$

2.9 Apply this factor to any number of paces to convert into distance measured. It is important to note that paces taken during the process of standardization should not be more than the normal, natural paces. Longer than normal may tire the surveyor on long job and resulted in erroneous distances.

b) Tape Measurement

2.10 The most common method of measuring distances is by direct measurement with a tape measure. Tapes are made of various materials such as cloth or linen, metallic, steel, invar, synthetic etc. Various materials for tape are used depending upon the precision required. As precision is not required for this project to that extent, hence any normal available tape can be used to measure the distances.

2.11 A simple "Nylon Rope" of standard known length can also be used to measure distance. Such rope should have knots at regular intervals of 10 m.

c) Other Instruments

2.12 Other instruments such as "Distance Measuring Wheel" or a "Pedometer" can also be used to measure the distances if available.

2.13 A distance Measuring Wheel is a single wheel provided with handle along with a meter which converts the angular movement of wheel in to linear distances read directly on the attached meter. The registered readings are more approximate on rough and sloping grounds.

2.14 A pedometer is device which surveyor either can wear on wrist or attached to his waist. Pedometer will sense the number of paces taken by the person carrying it and convert into the distance travelled. The conversion to distance is done automatically by pedometer using a factor of standard pace length entered in the pedometer at the start of the work.

3 WORK OF SURVEY TEAM

3.1 The work of a survey team is usually divided into three parts, which are briefly explained as under:

Preparation Work In Office

3.2 The following preparation work should be completed and thoroughly checked in the office before going in the field to carry out survey:

(i) Prefeasibility assessment for the village should be complete showing all the available source(s) of the village along with their yield.

(ii) There must be an assessment of potential water demand i.e. the number of houses, settlements / areas that can be served from this scheme. A rule of thumb can also be used that one house has a design water demand of approximately 100 gpd. Multiplying this figure of 100 gpd with the number of houses will give potential water demand for areas to be served.

(iii) Baseline survey should also be consulted to ascertain and cross check the number of settlements and population and thus the potential demand.

(iv) Village sketch produced by the extension workers should also be cross checked from the G.T Sheets.

(v) Together with all the information on the sketch map and considering the points explained above, source reliability and viability must be checked using yield measurement records. Scope of survey work should be drawn up and outlined on the village sketch map.

Field Work

3.3 Field work consists of measuring distances and angles, locating the details, recording of field notes, determining relative altitudes/elevations of points, and setting out major buildings, such as schools, mosques, certain houses etc.

Office Work

3.4 Office work consists of the computation of field data, plotting of data and the development of layout plans. From the layout plans, preparation can be made for the data required for the computer aided hydraulic design of the scheme.

3.5 All preliminary scheme layout sketches and the final layout plan will utilise a standard set of legends as indicated in Fig. 5.1. Once the scheme design including CAD hydraulics has been agreed in principle with the WSC and approved in principle by the LGRDD competent authority, the final layout plan will be properly drafted on A1 tracing paper. This drawing then can be readily produced and used in the field for construction purposes.

4 BAROMETRIC ALTIMETER LEVELLING

General

4.1 Atmospheric pressure on earth's varies inversely with the elevation. As altitude increases, barometric pressure decreases. Using this principle barometric altimeters are used for making observations of variation in pressure and translate the atmospheric pressures into elevations calibrated directly by the instrument. An aneroid barometric altimeter is commonly used because it is light and easy to transport. The face of altimeter should be given a gentle tap with a finger nail before taking any readings to ensure the pointer is free and showing proper variations

Principle

4.2 In aneroid barometer altimeter, there is a vacuum chamber or system below thin corrugated metal. At one end the diaphragm is fixed, the other being connected by train of levers to scales pointer which records the movement of the diaphragm under changing atmospheric pressures and correspondingly translates the observations into elevations .

Weather Effects

4.3 Normal weather pattern causes the air pressure at any altitude to fluctuate slightly throughout the day. Thus, even if an altimeter is at a point, the elevation reading may increase and/or decrease by several meters throughout the day. Such altitude variations must be recorded and accounted for when conducting barometric Altimeter survey.

Procedure

4.4 Three persons each with their own altimeter are required to carry out altimeter levelling properly. The following procedure should be observed to carry out altimeter levelling:

(i) Calibrate all three altimeters together at a point of known elevation at the same time. Calibration is carried out by setting the pointer at the same corresponding reading on the scale.

(ii) One assistant takes his altimeter to the highest point along the survey route while the other assistant takes his altimeter to the lowest point. These persons remain at their highest and lowest points during the entire time of the survey. These two fixed stations are called "Upper Base" and "Lower Base". Two assistants at Upper Base and Lower Base must record variations in elevation readings on altimeter at regular intervals such as every 15 minutes along with time irrespective of variations.

(iii) The third person (surveyor) take his altimeter along the survey route. Measure the ground distances with tape / rope and record the elevation reading along with time at required points such as tapstand location, water storage reservoir and complete the entire survey.

Computation

4.5 Computation of the survey data collected from the altimeter needs to be corrected according to the variations in the atmospheric pressures recorded at upper and lower base proportionately. Sample readings and corrections made for the Altimeters are given as under:

(i) Given an elevation of upper base 275 m and lower base elevation 56 m.

(ii) The difference in elevation between upper and lower base is 275 m - 56 m = 219 m.

(iii) At any instant, from the field data three altimeter readings indicate that the difference in elevation of an intermediate point from the upper base is 209 m and from lower base is 25 m.

(iv) Thus the indicated elevation difference between the upper and lower base is 209 m + 25 m = 234 m which is greater than 219 m.

(v) Hence elevation of intermediate point is corrected proportionately. Corrected elevation of intermediate point proportionate to:

Upper base $\frac{219 \times 209}{234} = 195$ m

Lower base $\frac{219 \times 25}{234} = 24$ m

(vi) The above corrected elevation of intermediate points can be checked by calculating the elevation difference between the upper and lower base with respect to the intermediate point, which is 195 m + 24 m = 219 m. This 219 m elevation difference is the same as at the start of survey.

(vii) Hence the elevation of the intermediate point under consideration in this example is 275 m - 195 m = 80 m or 56 m + 24 m = 80 m which are the same.

Procedure With Two Persons

4.6 Alternatively two persons, the surveyor or and one assistant, may undertake the survey with two altimeters only. Similar procedure to that above is undertaken but the assistant remains at the approximately middle elevation of the area under survey. This procedure with two persons is necessarily less accurate and not preferred.

5 ABNEY LEVEL FOR DIRECT LEVELLING

General

5.1 A level is an instrument commonly used for direct levelling has its essential features such as a "line of sight" and a "level tube". On this project an "Abney level" and or an "Automatic level" shall be used to carry out levelling. Adjustment, procedure and calculations required for the Abney level is explained under.

5.2 Abney level is the most common type of clinometer used for simple direct levelling. The standard method for conducting surveys for water system is using the Abney hand level. It is faster to use than an automatic level or a theodolite and also accurate to the extent required on this project except possibly for a few more critical "U" shape profiles.

Adjustment of Abney

5.3 An abney level is liable to creep out of adjustment from time to time therefore before each use in the field it should be checked for levelling accuracy. Adjustment of Abney is a quick and simple task. Following are methods briefly explained for its necessary adjustment.

a) Flat surface method

5.4 This is the first step to adjust the centre bubble of Abney level. To carry out this adjustment follow the steps as under:

(i) Smooth level surface is required, if not available place a smooth board on a firm support arranged so that it is possible to sight length wise on the board.

(ii) Fix the vernier index at 0°.

(iii) Place the Abney on the board and outline its position with a pencil.

(iv) Centre the bubble against the etched index mark of the bubble level with the help of screws at the bubble tube.

(v) Reverse the Abney end for end and place within pencil outline and check the bubble if it is in centre Abney is adjusted.

(vi) If the bubble is not in centre, move it half way adjusting with the screw again.

(vii) Again reverse the instrument end for end repeat the whole procedure until the bubble centres in both positions.

b) Two Post Method

5.5 After the bubble adjustment the following method is applied to adjust the line of sight. To adjust the abney level by this method follow the steps as under:

(i) Select two posts, trees or building corners that are about 7-10 meters apart and name as station A & B.

(ii) At station A make a mark at eye level.

(iii) Set the index of abney at 0°.

(iv) At station A surveyor hold the Abney level against a mark and sight over to station B.

(v) Assistant at station B moves a target such as pencil, pen or stick up a down until it lies exactly in the line of sight.

(vi) Make a Mark at station B at the point of intersection on the target.

(vii) Exchange the stations between the surveyor and the assistant.

(viii) Surveyor sights the mark A from station B back towards station A. Assistant similarly mark the point at station A in the line of sight.

(ix) If this new mark at station A coincides with the mark already made at station A, then the Abney is truly level and no adjustment is required.

(x) If the two marks on station A do not coincide, then the abney requires adjustment.

(xi) Make a third mark exactly half way between the two marks at Station A and sight on this half way mark at station A, and adjust the bubble with the help of the screws on the bubble tube until its alignment is correct with the cross hairs and target mark.

Survey with Abney

5.6 To carry out survey with the abney level, a minimum of two persons are required, but an additional one is always helpful for ancillary works, such as recording measurements etc.

a) Check Points

5.7 Following are important points to check before surveying with the abney.

(i) Survey should begin at some fixed reference point such as source or some prominent bench mark.

(ii) In case of survey for pipeline route, villagers should be invited to lead the survey team on some convenient foot paths. It is important to note that survey should be carried out along the actual proposed route of pipeline on which the actual trench will be dug and not the convenient route to walk only.

(iii) It is important that the target rod which the surveyor sights must be of the same height above the ground as the abney, which is the same as the surveyor's eye level. Hence the target stick should be cut exactly to the same length as the height of surveyor's eye.

(iv) A flag can be tied to the top of the target rod to ease the surveyor for sighting it.

(v) It is also useful for the surveyor to use a fork stick of his height of his eye level to rest the abney for steady readings.

b) Procedure

5.8 The following steps should be observed to carry out survey with an abney level along with the computations:

(i) Surveyor sights through the Abney at a target held by his assistant.

(ii) Adjust the bubble in the centre of the hair while sighting the target in the centre of hair with the help of vernier index screw. This adjustment brings the bubble exactly to the horizontal line i.e the line of sight.

(iii) Record the angle θ from vernier index of abney. Angle should be recorded as negative while sighting downhill and positive for uphill.

(iv) Measure the ground distance "D" between the surveyor and the target by tape or rope.

(v) Elevation "h" of the target point is then given by $h = D \sin \theta$.

5.9 Sample data is shown in the Table 5.1 given below to demonstrate the pattern of computation along with remarks.

Sample Data of Abney Level For Computation of R.L					
Sta-tion	"D"	θ	Vertical Distance	Reduced Level	Remarks
1				1000.0	Start Point
2	8	-12°	-1.6	998.4	Site for Collection Box
3	7	-17°	-2.0	996.4	Bed of Nullah
4	6	-10°	-1.0	995.4	Site for Reservoir

Table 5.1 : Sample Data For Abney Level

Closing Check On Survey

5.10 Closing check on survey in the hilly area can only be done by repeating the entire survey exercise back to the start point but not necessarily along the same route.

5.11 It is important atleast check some few levels, where elevation differences are critical such as a crossing over top of ridges or bottom of U-profiles, a few short sections of the route can be resurveyed. It is important to do closing check on a survey to ensure accuracy.

6 LEVEL FOR DIRECT LEVELLING

General

6.1 A level is the instrument used for more refined direct levelling as compared to the abney. Keeping the fact that survey is to be supervised or carried out by the AE or Overseer's, it is assumed that they must be aware of the use of such levels from their tertiary education. Therefore details for the construction of level along with its setting are not explained here. In case of any difficulty in setting up level, the user is referred to any good survey book or in Chapter 10, page 508 to 537 of the book "Surveying & Levelling" by "T.P Kanetkar".

6.2 In this section only the procedure for carry out survey and steps to compute field data by using level instrument is explained.

Procedure of Using Level

6.3 The following steps should observed to carry out levelling:

(i) Setup the instrument in a convenient position and distance (not more than 80 m away) from the start point.

(ii) Staff man is to hold the measuring staff properly vertical at the start point.

(iii) Where the cross wires cut the measuring staff, the reading on the measuring staff is noted and entered in the level book under the column headed "Back Sight"(B.S).

(iv) Staff man then moves his measuring staff to various points along the survey route while the surveyor at the level instrument record all readings in the level book under the column headed "Intermediate Sight" (I.S);

(v) Appropriate remarks should be entered in the last column headed "Remarks" such as bed of stream, electric pole etc;

(vi) When no more I.S readings can be obtained from the last instrument setup, the last reading observed from that setup should be recorded under the column headed "Foresight' (F.S) and staff man should not move the measuring staff from the observation point as this is the turn to move the instrument.

(vii) Move the instrument to another convenient position, number it such as "station 2". Setup the level instrument at station 2, read the measuring staff where it was last kept and record the reading under the column headed "Back Sight" (B.S).

(viii) Staff man then moves measuring staff again to various intermediate points along the survey route and observe the readings as already explained. This exercise is carried out till the finish of survey.

6.4 A typical schematic sketch illustrating closing of survey BM work for: a) close traverse; and b) dead end traverse in attached Fig 5.2. Sample data along with all calculations is shown in the following Table 5.2.

Example Of Level Booking By Line Of Collimation Method						
Station	**B.S**	**I.S**	**F.S**	**H.I**	**R.L**	**Remarks**
1	2.3			102.3	100.0	Assumed Height of Start Point
		3.7			98.6	Bed of Stream
		0.8			101.5	Road Junction
		2.6			99.7	Base of Electric Pole
2	3.8		0.9	105.2	101.4	Corner of Field
		3.8			101.4	Tapstand No "Y"
			2.7		102.5	Tank No "Z"
Check on the Calculations						
Sum of B.S = 6.1 and Sum of F.S = 3.6. Difference = 2.5						
Difference of Assumed and Last R.L = 102.5-100 = 2.5 , which is same for the difference of sums of B.S & F.S. Hence the calculations are correct.						

Table 5.2 : Example of Level Booking and Check

Method of Computing Levels

6.5 The following are two systems in use for the calculation of elevations / levels at required points from field data recorded by using levels:

- Line of Collimation
- Rise and Fall

6.6 Line of collimation is defined as the imaginary line passing through the optical centre of the object glass of instrument and the intersection of the cross hairs in the diaphragm.

6.7 On this project it is recommended to adopt "Line of Collimation method which is explained with the help of Table 5.2. Line of Collimation can also be called Line of Sight. In this method the height of instrument is calculated by reading the measuring staff, which is the height of line of collimation above ground level. That's why this method is called Line of Sight.

6.8 The procedure for the calculation of levels at required points is explained as under:

(i) Elevation of the starting point should be assumed as 100 m, 1000 m or any appropriate whole number according to the site topography and estimated range of level differences for the area to be surveyed. This is known as the reference datum. In Table B elevation of the start point is assumed as 100 m.

(ii) Last three columns in Table B are the "Height of Instrument" (H.I), "Reduced Level" (R.L) and "Remarks" respectively. Reduced level is defined as the elevation of point above or below than the reference datum i.e assumed level of the start point.

(iii) B.S, I.S and F.S observations are already in their relevant columns as explained above.

(iv) Assumed level of 100 m for the start point is entered in R.L column against the B.S reading as shown in Table B.

(v) Height of Instrument is calculated by adding R.L and B.S readings i.e **H.I = R.L + B.S.**

(vi) Reduced Level for the intermediate point is calculated by subtracting the "Intermediate Sight" from the "Height of Instrument" as
R.L = H.I - I.S.

(vii) By moving the instrument to another station such as 2, the height of instrument is disturbed and shall be calculated for the new station. Height of Instrument at new station is calculated by adding "Reduced Level" of the last point to the new Back Sight reading as clearly shown in Table 5.2.

(viii) Repeat the steps to calculate the reduced levels for the whole survey.

(ix) Arithmetic check on the calculations can be done by adding all B.S readings and all F.S readings separately and then by subtracting one total from the other, this should be equal to the difference between the first and last reduced level as shown in Table B.

7 GENERAL COMMENTS

7.1 Some general comments in survey execution are listed below as a summary. These general comments should be observed. By observing the following comments, errors in levelling and time spent in checking the errors will be reduced.

(i) Each and every day the survey booking should start on a new page noting the date, location, bookers name, weather conditions, etc.

(ii) All surveys should start from one fixed bench mark (BM). Either a BM of known reduced level or a BM with an arbitrary reduced level should normally be taken as 100 m or 1000 m depending upon the topography of the area and difference of elevations within the area to be surveyed.

(iii) Further temporary bench marks (TBM) should be located on an immovable objects such as electricity poles, concrete structures, gate posts, location of reservoirs, near pipeline branches, along transmission pipeline route at every 500 m in normal and/or 300 m in slope areas.

(iv) All BM and TBM should be clearly marked along with the level defined either by a nail in post or a metal plate in concrete. During the preparation of layout plans positions of these BM and TBM must be clearly shown.

(v) Before taking any survey TBM should be made or identified accurately and always be checked back to the main BM. Any errors must be rechecked until the levels agree exactly.

(vi) Levelling should start after the confirmation of TBM or BM on every day.

(vii) In case of survey required along "dead end" a closing check should be made by returning back to the starting TBM.

(viii) To reduce the errors while surveying using Back Sights (B.S) and Foresight (F.S), the distances of B.S and F.S should be approximately of same length. About 80 meters is the maximum sight distance likely to allow accurate work.

(ix) Any special details should be noted in the field/level book such as river or stream crossing, concrete structures, landslide areas, soil types, buildings and other permanent structures.

(x) Changes in direction or alignment of the pipeline route should be noted to approximate angle since this will require special fittings to be ordered. Note all junctions for the fittings, all bends for 90°, 45°, 22½°, 11¼° bends.

(xi) Possible locations of tapstands should be noted these will be confirmed by the Engineer and WSC later.

8 SURVEY EQUIPMENT

8.1 In the following list there is a standard set of survey equipment comprising the items necessary for field survey including survey instruments, point marking and stationery. This standard set is the general set of items which are to be carried by the survey team for any type of survey. In case a more refined survey is to be carried out with automatic level or theodolite, additional equipment is also identified. These additional sets are to be added to the standard general set of survey equipments as and when required.

Sets of Survey Equipment

a) Standard Set

(i) Survey Items

- Altimeter	3 Nos
- Abney Level	2 Nos
- Ranging Rods	4 Nos
- Measuring Tapes:	
- 100 m	1 No
- 10 m	1 No
- 3 m	1 No
- Simple Rope (nylon) 100 m	1 No
- Compass	1 No
- Spirit Level (2 ft)	1 No

(ii) Survey Point Marking Items

- Paint (Red)	1 Tin
- Paint Brush (1")	2 Nos
- Wooden Mallet	1 No
- Pegs (Made locally)	As required
- Machete (to make wooden pegs)	1 No

(iii) Stationery Items

- Level / Field Book	1 No
- Pencil	6 Nos
- Rubber	6 Nos
- Sharpener	2 Nos
- Scale (1 ft)	2 Nos

b) Additional Equipment for Automatic Level

- Level with Matching Tripod	1 No
- Measuring Staff	2 Nos

c) Additional Equipment And Stationery for Theodolite

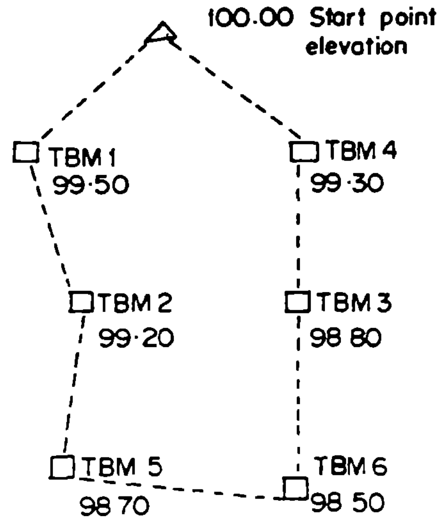
- Total Station Theodolite with Matching Tripod	1 No
- Target Prisms and Matching Tripod	1 No
- Measuring Staff	2 Nos
- Tacheometry Book	1 No

FIGURES

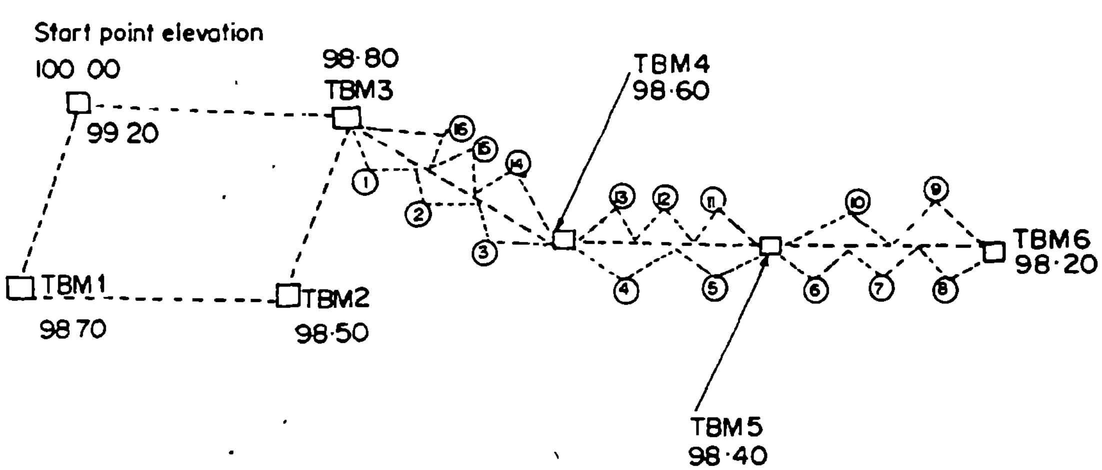
LEGEND FOR PIPELINE LAYOUT PLANS

S No.	DESCRIPTION	SYMBOLS
1.	Pipe in the direction of flow and number.	17
2.	Pipe node number	4
3	Suspended or supported pipe crossing	SX=18M
4	Public stand post (with number)	SP3
5.	Break pressure tank	B.PT
6	Control valve	
7	Washout	WO
8	Air valve	A.V
9.	Spring (unprotected)	
10.	Spring (protected)	
11.	Spring collection box	
12.	Hand dug well	
13.	Borhole / Tubewell	
14.	Storage reservoir with capacity	2000 g
15	Pump house	PH
16	Number of houses (eg 12 Nos)	12 H.
17	Mosque	
18.	School { Ps = Primary school, MS = Middle school, HS = High school, G = Girls, B = Boys	S
19.	Dispensary	D
20	Veterinary Dispensary	V
21.	Bazar	
22.	Nallah (with bridge)	
23.	Road.	
24.	Track	

Fig. 5·1



a) CLOSE TRAVERSE



b) DEAD END TRAVERSE

TYPICAL SCHEMATIC SKETCH FOR CLOSING OF SURVEY BENCH MARK WORK

Fig. 5·2

Chapter 6

DESIGN CRITERIA

CHAPTER 6

DESIGN CRITERIA

1. **Design life:** 10 years for structures and pipelines;
   10 years for mechanical/electrical plant.

2. **Population per household:** assume 8 persons unless actual figure is known

3. **Population growth rate:** assume 3%

4. **Consumption per capita:**

standpost	: 10 gpd
house/yard connections	: 10 gpd
school	: 1 g/pupil
clinic	: 1 g/patient
office/shop	: 2 gpd
mosque	: 15% population x 3gpd
cattle	: not included
unaccounted for water	: add 20% to total Demand

5. **Tapstands/Standposts:**

Tapstand flow:	ideal	: 2 gpm (0.15 l/s)
	absolute minimum	: 1 gpm (0.075 l/s)
Distance to tapstand		: up to 500 ft max.
Houses served:	normally	: 4 to 7 Nos. houses
	maximum	: 10 Nos. houses

6. **Peak factor** (maximum hourly consumption):
   2 x average daily demand for storage calculation
   3 x average daily demand for design of pumping mains

7. **Safe yield of source:** 0.7 x minimum yield of springs
   0.7 x specific yield of wells

8. **Pipeflow velocities:**

Maximum velocity	: 10 ft/sec (3m/s)
Minimum velocity	: 2.5 ft/sec (0.75 m/s)
Absolute Minimum velocity	: 1 ft/sec (0.3 m/s)

9. **Pressure limits at consumer points:**

Absolute minimum:	5m = 7.1 psi
Desired minimum/ideal:	10m = 14.2 psi
Desired maximum:	15m = 21.3 psi
Absolute maximum:	30m = 42.6 psi

Flows at certain standposts which are unavoidably and exceptionally above the absolute maximum residual pressure, must have high pressure bibcocks and be regulated by the tapstand seat valve.

10. **Maximum pumping duration:** total 8 hours per day

11. **Transmission Main Design for Gravity Flow Systems**

11.1. If minimum measured yield of source is less than 30% of the total daily design demand then the scheme is unviable, ie:
Min yield < 0.3 x Demand = unviable scheme

11.2. If twice the total daily design demand is greater than maximum measured yield of source, then design the transmission main (TM) on maximum yield, ie:
2 x Demand > Max. yield = design TM on max. yield

11.3. If twice the total daily design demand is less than the maximum measured yield of source, then design the transmission main on twice the daily demand, ie:
2 x Demand < Max. yield = design TM on 2 x Demand

12. **Storage Capacities**

12.1. Storage for Pumped systems:

A) Source Tank:

Assuming 8 hours pumping per day in two 4 hour shifts starting at the same time am/pm, a source tank for the pump is sized for no more than 40% of total demand.

If the source safe yield > 3 x the daily demand then storage should be only that sufficient for a pump sump

If the safe yield is > 2 x the daily demand the storage should be 30% of the daily demand

If the safe yield of the source is equal to, or < the daily demand then the storage should be 40% of daily demand

B) At secondary pump stages:

Any subsequent pump stage tank should be sized for 35% of demand of the distribution from that tank (not including the demand to be pumped from that tank).

12.2. Storage within Service Reservoirs on Distribution System

Assuming peak demand of 2 x average daily inflow occuring over a continuous 4 hour period then there are four cases for sizing the capacity of service storage tanks.

Case a: Safe yield or Inflow <1.25 x demand, then:
tank capacity = 33% demand from that tank.

Case b: Safe yield or Inflow >1.25 but <1.5 x demand, then:
tank capacity = 20% demand from that tank.

Case c: Safe yield or Inflow >1.5 and <2 x demand, then:
tank capacity = 10% demand from that tank.

Case d: Safe yield or Inflow >2 x demand, then:
storage tank is not required (ie open system)

13. Pipelaying

13.1. Galvanised Iron Pipe

Galvanised iron pipes may be laid on the surface except where crossing roads, paths, streamcourses or drainage channels where pipes shall be buried at least 2 feet or encased in concrete. Pipes laid on the surface shall be securely anchored at least every third pipe length and at any bend. Distribution mains in areas where snow settles or severe frost occurs (ie above elevations of 6,000 feet) shall be buried with 2 feet of cover over pipe crown.

13.2. Polyethylene Pipe

Polyethylene pipe shall not be laid on the surface but shall be buried at least 2 feet underground in soil surround and not in contact with hard or sharp surfaces

13.3. Pipe Crossings

Any pipe crossings of nullahs, roads etc., other than suspended crossings, must be securely supported at no more than 12 metre intervals at the mid point of alternate pipes.

Chapter 7

DESIGN PROCESS AND PROCEDURE

CHAPTER 7

DESIGN PROCESS AND PROCEDURE

CONTENTS

LIST OF ANNEXURES

CHAPTER 7

DESIGN PROCESS AND PROCEDURE

1 INTRODUCTION

1.1 This chapter provides guidance to LGRDD staff, and the design staff in particular, on the specific aspects to be addressed when designing schemes for village water supply. The design methodology to be adopted is similar to and developed from the approach used for the review of the initial schemes of the first 70 villages which were designed by national consultants (NESPAK). This chapter identifies the process and procedure to be followed as is described in Chapter 2 (Village Implementation Steps), Phase 4, step 4.1, of this manual.

1.2 The design procedure stages to be followed are described in section 3 of this chapter and the completion of the design review proforma which is required to be completed for all schemes, is explained in detail in section 4. The Assistant Engineers have received detailed training in this work. Designers must remember the essential philosophy of this project which is that the designs must be prepared with full consultation with and agreement by the communities concerned.

1.3 The terms of reference of the project requires improved water supply coverage for the whole of those revenue villages which have been selected for assistance by the project. Most villages have more than one scheme and each scheme is to be reviewed separately. Some schemes will take longer to review than others. It is vital that sufficient staff resources are dedicated to the design process and that the time required should not be underestimated.

1.4 Although this chapter gives comprehensive guidance for the technical staff in the design of rural water supply schemes, engineers need to develop their own technical skills and sound engineering judgement. Such judgement will be gained by experience and discussion with colleagues.

2 DESIGN APPROVAL

2.1 It is necessary for all scheme designs to be approved from the competent authority in LGRDD Directorate, before the Memorandum of Understanding (MOU) can be signed with the Water and Sanitation Committee (WSC). A check list of items to be submitted with scheme Design Review to the Directorate is included in this chapter as Annexure 7.3. There are two stages of design approval as outlined below.

Approval in Principle

2.2 "Approval in Principle" is required in order to ensure that the essential philosophy of the scheme design is sound. For this purpose certain basic information and design work is required as per the design review pro forma which can then be checked and appraised at the Directorate. Such principle approval is required to ensure good technical quality and prevent possible abortive work being produced by district staff. For example there is no point in a district draughtsman producing a proper scheme layout drawing if the layout will significantly revised following design check/appraisal.

2.3 It is also important that the community is involved in the preliminary design work and that the WSC "agree in principle" to the proposed design. Again there is no point in submitting a design for Approval in Principle if the community have not been properly consulted and who may later demand revisions or extensions to a design.

Final Approval

2.4 Once the Approval in Principle has been given then design work can proceed to complete and finalise the design and develop the Design Report for sanction with Final Approval by the LGRDD competent authority (see chapter 16). This final stage of the design process includes the proper drafting of the pipeline layout and other drawings to enable construction, quantity schedules, cost estimates, construction programmes. All elements of the design are to be fully discussed and agreed by the villagers who will signify this by signing the Memorandum of Understanding following Final Approval by LGRDD.

3 DESIGN PROCEDURE

3.1 The process of design review of the water supply schemes is necessarily a comprehensive exercise which is undertaken in 14 main design stages as set out in this section below.

Design Stage 1: Village Survey and Fieldwork

3.2 Before the detailed design work can proceed detailed survey and fieldwork must be carried out within tne village. Central to the ideology of this project is the participation of the community and as such it is vital that the people are involved in the planning and design of the schemes. This involvement is advanced and achieved during the period of

this fieldwork. The community representative (WSC Chairman) formally signifies the community's participation by signing the scheme review/summary form.

a) Baseline Survey

3.3 As a prerequisite to design, the village baseline survey (BLS) will already have been completed and/or updated under Step 2.2 a) of the Village Implementation Steps (see Chapter 2). The information contained in the BLS give the scheme designers necessary information regarding the scope of the scheme and data required for demand assessment.

b) Source Measurement

3.4 Regular source measurement in the village and by the villagers should already have been established under Step 2.1 of the Village Implementation Steps (see chapter 2). The records of the source measurements are now required for proper assessment of the supply available to the village scheme(s) and design of the transmission mains and the storage requirements.

c) Scheme Feasibility

3.5 The feasibility of the design will already have been assessed as per Step 3.1 of the Village Implementation Steps (see chapter 2). The feasibility study is the foundation upon which the design is developed. Again it is emphasised that it is required that the community through the WSC is involved and agree to the proposed design.

d) Detailed Survey

3.6 As a development from the village mapping and sketching (see chapter 3) and the feasibility study (see chapter 4), it will be necessary to now undertake more detailed survey for each scheme. This survey work is required to agree with community members the proposed pipeline routes and the locations of tanks and tapstands.

3.7 The survey work determines the population to be served by each scheme and at each and every tapstand, remembering that no household to be served should be more than 500 feet from a tapstand.

e) Physical Topographic Survey.

3.8 Physical topographic surveys must be made in order to ascertain the relative elevations of and distances between the various elements of the scheme. Using techniques explained in chapter 5, this will entail detailed surveys of:

(i) the source;
(ii) pipeline routes and their profiles to identify the locations for airvalves and washouts;
(iii) storage and break pressure tanks; and
(iv) tapstands.

f) Source Protection Works

3.9 The AE will need to visit with key community members, the source to be used. The AE will advise the community and determine the best method of source protection. He will develop and produce a clear and simple sketch of the works to be undertaken, in both plan and section. It is essential that the WSC supervisor in particular clearly understands what work is to be done and how.

Design Stage 2: Assistant Engineer Design Preparation

3.10 At this stage the AE prepares collates in the district office all the necessary design data including:

(i) annotated sketch map of the village;
(ii) calculations for demand assessment;
(iii) source yield monitoring records;
(iv) calculations for storage assessment;
(v) sketch design of the source protection;
(vi) completed village coverage monitoring form; and
(vii) schematic pipeline layout.

3.11 With this information prepared, the AE can now draft the Design Review/Summary pro forma and process the computer aided hydraulic design (CAD).

Design Stage 3: Computer Aided Hydraulic Design (CAD)

a) Pipeline Design

3.12 The AE processes the hydraulic design using BRANCH and LOOP computer programmes. Pipe flow velocities and pressures are evaluated. The identification of optimum locations and elevations of tapstands and tanks for good distribution of

pressures, is likely to necessitate a return visit to the village. Flow velocities and static pressures at tapstands are not generated by the computer but must be identified from the print text of the CAD designs.

b) Pump and Pumping Mains Design

3.13 For a pumping scheme, the AE must generate the standard computerised design for the optimised design of the pump and pumping mains. This process is explained in chapter 11. The estimated cost of pump operation anticipated is also made by this spreadsheet. It is important that the projected operational cost is advised to the community and that they are agreeable to this expected operational cost which will be born by them in the future.

Design Stage 4: Draft Design Preparation

3.14 The AE will now prepare the Design Review/Summary ready for submission to the competent authority in LGRDD for Approval in Principle. The pro forma used to summarise the vital aspects of the design are annexed to this chapter. There are two pro forma:

(i) "Design Review Form" attached as Annexure 7.1 was developed for villages Nos 1 to 70 which were originally designed by NESPAK; and
(ii) "Design Summary Form" attached as Annexure 7.2 produced for villages Nos 71 to 500 and which is similar to the above review form.

3.15 A check list of all the data and information which must be submitted with the above pro forma for Approval in Principle and Final Approval respectively, is contained in Annexure 7.3.

3.16 Section 4 of this chapter gives detailed guidance on how to complete the respective pro forma. Once the AE has satisfactorily completed the proforma, it must be agreed by the WSC and then checked by the Technical Resource Pool (TRP).

Design Stage 5: Agreement in Principle by WSC

3.17 Once the AE has completed the design work and the summary/review pro forma, the signature of a community representative is to be obtained on the form. The representative will normally be the chairman of the WSC, This signature is to demonstrate that the community has been

properly involved in the decision making and the development of the design, and that the community is agreed in principle to the design.

Design Stage 6: Check by Technical Resource Pool

3.18 It is essential for all designs that there is a thorough and competent check of all aspects and calculations. An engineer of the TRP must check the design. The original design engineer (district AE) must address any comments or queries which the TRP may raise. This may, or may not, entail a return visit to the village. The draft of the Design Review/Summary is revised as necessary. This check process by the TRP is most appropriately made during a visit to the District where it is most convenient for the District AE.

Design Stage 6A (Optional): TAU Appraisal

3.19 During the training period of the AEs, the TAU has appraised each of the initial designs which have been prepared/reviewed by LGRDD staff. The TAU has assessed and commented in detail on each and every design review and reported to LGRDD on the soundness of the design. However as the skills of the district AEs and the TRP LGRDD becomes established, TAU appraisal of every scheme is not be necessary. In the future therefore, the TAU will undertake only periodic appraisal of few designs to be randomly selected. The TAU will continue to advise on specific or complex design issues as may be required.

Design Stage 7: LGRDD Design Approval in Principle

3.20 Following the checks by the WSC, any appraisal by the TAU and any necessary revisions by the AE (which themselves must be checked by the TRP), the design review/summary is finalised and submitted to the competent authority in LGRDD for Approval in Principle to the design. When Approval in Principle has been given, then the following subsequent steps proceed in order to finalise the design and produce the Design Report (see chapter 16) for "Final Approval" and the signing of the MOU.

Design Stage 8: Fair Copy of Drawings

3.21 Following Approval in Principle the AE will supervise the district draughtsman in the preparation of pipe schematic layout and other scheme specific design drawings, such as the source protection works or village/scheme sketch maps. The pipe layout drawing will be properly traced and normally be A1 size. The draughtsman can as required produce a fair copy of the design sketch of the source protection works which must be easily understood by the WSC Supervisor.

Design Stage 9: List of Tapstand Nos with Address

3.22 The defined actual location of each and every tapstand must be agreed with the WSC. A list is to be produced numbering each tapstand and identifying the name of the householder who lives closest to the tapstand location.

Design Stage 10: Quantities Assessment

a) Pipe and Fitting Quantity Schedule

3.23 The AE and his staff will prepare the schedule which identifies all the pipes for all the works using the standard components for tanks, tapstands, pipeline branches, washouts, airvalves etc which is set out in chapter 12. The schedule for the required pipes and fittings is prepared abstracting information from the CAD hydraulic design and the schematic layout. The schedules will be used to procure the pipes and fittings.

b) Bill of Quantities for Tanks

3.24 Using the detailed schedules set out and explained in chapter 9, the AE will develop a bill quantifying all the materials required to build each and every tank on the scheme. The WSC and/or contractors will require this information to procure the materials in order to build the civil works.

Design Stage 11: Construction Programme and Report Pro Forma

3.25 The AE together with the WSC prepare and chart a detailed programme for the implementation of the scheme. This is described and illustrated in chapter 14.

3.26 The AE is to prepare the specific construction report pro forma for the routine and regular (bi-monthly) reporting of progress on the scheme construction. A standard pro forma report has been produced but this must now be modified to be made specific to the scheme. For example for this particular scheme, the total lengths of pipes of different diameters, the total number of tapstands, tanks of various sizes are to be identified. The form will be in typed format. Thus progress reporting becomes a relatively simple exercise. The pro forma is attached to chapter 14.

Design Stage 12: LGRDD Cost Estimate

3.27 The cost estimate for all the works is to be made at this point identifying the necessary financial contributions from both the village community and from LGRDD. The estimate includes cost of structures, pumps and electrical connections as well as the cost of pipes and fittings. This activity will be computer assisted. The rates for each of the elements of the works must be those agreed by the community as appropriate to the location of the village and the works. Guidance on the preparation of the Cost Estimate is included in chapter 13. The Cost Estimate must be discussed and agreed by the WSC so that the community is aware and in agreement to the expected cost which the people will have to bear. The figure of the projected cost per capita is of particular importance to government to assess if the cost of the scheme is acceptable.

Design Stage 13: Preparation of the Design Report

3.28 At this point a Design Report is prepared. This report collates and documents all the above work and represents the culmination of the work of the design team on the scheme. The design report will be used by the WSC and the LGRDD core staff in order to build the works. Instruction on the preparation of the Design Report is included in chapter 16.

Design Stage 14: Final Approval

3.29 The Design Report is submitted to LGRDD for Final Approval by the competent authority. Following sanction with Final Approval, the MOU can then be signed by both LGRDD and the WSC. Procurement and construction can now proceed.

4 DESIGN PROCEDURE

General Points

4.1 This section gives specific guidance on how to undertake design and to complete the design review and/or design summary forms which are contained in Annexures 7.1 and 7.2 respectively. The two forms are similar to each other. The district offices have functioning computers with all the various pro forma installed and the AEs have been trained in the use of Word Perfect and Lotus. The district staff should practice and develop their computing skills with the aim to submit all pro formas in typed format rather than handwritten.

4.2 A review/summary of all proposed designs must be undertaken and submitted to LGRDD Directorate for checking and approval, as is explained above. The remainder of this chapter gives specific guidance on the completion of the design review/summary forms according to the headings and/or question numbers on the form. All questions on the Design Review/Summary form are to be answered. All relevant calculations are to be submitted on separate attached pages. Where alternatives answers are indicated on the forms, eg yes/no, delete the option which does not apply. Any information or calculations which have been superseded should not be included.

Section 1: Sketch Maps

4.3 It must be noted that few villagers are engineers or builders and do not generally have. All village maps and scheme design sketches and layouts must be uncomplicated yet in sufficient detail to enable villagers to both understand and construct the works,

a) Village Sketch Map

4.4 A sketch map of the revenue village is necessary to demonstrate the required information regarding the location and topography of the village and all the schemes therein. The sketch map must clearly locate and identify the coverage areas of each of the schemes with the respective scheme numbers indicated. Shared boundaries with the surrounding neighbouring revenue villages must also be shown. A generalised layout of the main tanks and pipelines within each scheme

4.5 The sketch map of the revenue village may be produced by using the GT sheets which are at scale of 1:50,000. These may then be expanded by photocopier to twice the scale ie 1:25,000. Guidance on the production of maps and sketches is contained in chapter 3.

4.6 The village sketch map will indicate:

(i) roads and tracks;
(ii) river/stream/nullah courses;
(iii) Location of each settlement/mohra;
(iv) major slopes and spot-heights;
(v) location of source(s) used for schemes with scheme number(s);
(vi) generalised pipeline layout of each of the schemes;
(vii) direction of north; and
(viii) coverage area of the scheme with scheme number.

b) Pipe schematic layout

4.7 A marked up pipeline schematic layout drawing is also to be included which should clearly identify all the pipeline numbers, nodes, diameters and elevations with locations of reservoirs, break pressure tanks (BPT), and standposts.

Section 2: Population/Demand

a) Demand Calculations

4.8 Using the village baseline survey (BLS) and through discussion with the community, assess the number of houses to be served in the whole of the revenue village. Then calculate the average number of people per household in the village according to the BLS. If there is any doubt in the accuracy of the BLS data a figure of 8 persons per household is to be used. In case of doubt the AE must report the issue to the Assistant Director and investigate his reservations about the accuracy in order to either confirm or discount his doubts. It may reasonably be expected that the figure for population per household may vary between 6 and 10 persons but there may be villages whose actual populations may exceed, or be less than this figure.

4.9 The population of each scheme is assessed on the basis of the total number of houses to be served multiplied by the average number of people per house in the revenue village. The design population is based on the population according to the village baseline survey data multiplied by 1.34 which is the factor obtained at 3% compounded growth rate over the 10 year design life.

4.10 In the case of the NESPAK designed schemes, the recorded number of houses and population in the NESPAK design report must be compared with the total numbers surveyed for the BLS. These are likely to vary as all the revenue village may not have been included in the NESPAK study and experience has shown that the number of people per house is likely to be greater than the figure of 6.5 used by NESPAK.

4.11 The design demand figure should now be assessed using the parameters set out in the design criteria (see chapter 6). For the NESPAK schemes the original estimates for demand from mosques and school(s) etc. should be used, unless there is an error or miscalculation. The demand for cattle should not normally be included. As a safety margin, an additional 20% is to be added to the demand total as "unaccounted for water" ie water which will be lost through leaks, illegal connections etc.

b) Village Coverage Monitoring Form

4.12 This IDA funded project sets out to cover the entire populations of 500 revenue village with improved water and sanitation facilities. A Village Coverage Monitoring Form (VCMF) has been developed to indicate and record what population is covered by each scheme in a revenue village selected to be covered by this project. The VCMF is particularly important for two reasons. Firstly on the initial 70 villages, the coverage by NESPAK designs usually do not cover the entire village. Secondly implementation of the various schemes in a revenue village may not be simultaneous and it is necessary to monitor what degree of coverage is in hand or is outstanding. The VCMF and guidance on its completion is included in Annexure 7.4.

Section 3: Source Works

4.13 The sustainability of any scheme is dependant upon the security of supply from its source. The designer must have confidence in:

(i) what quantity of water is available from the source to meet the calculated demand; and
(ii) robust design of civil works to protect the source to safely abstract good quality and quantity of water over the design life of the scheme.

a) Spring Yield Measurement

4.14 The yield of springs is to be checked as has been demonstrated in the field in order to monitor the spring yields over the year and with particular intent to assess their dry season - and thus the minimum yield. This should be done with the greatest possible accuracy with use of plastic sheet, stopwatch (digital) and a container of known capacity. It is essential that the yields are checked and regularly monitored, at least monthly. The standard springflow monitoring form, which should be submitted with the design review/summary form for Approval in Principle and guidance thereupon is included in chapter 8 as annexure 8.2.

4.15 For the first 70 villages it must be noted that it is general experience that the yields will differ from those reported by NESPAK. It is also possible that NESPAK may not have considered or included all the spring sources or spring eyes. There may be additional sources nearby and/or downstream of the recorded source which may also be incorporated into the source assessment.

4.16 Project staff must carefully explain and demonstrate to WSC why yield measurement monitoring is so important. The WSC must arrange for a dependable village member to be responsible for this. Project staff will train this person in how to make the measurement and properly record it. Guidance on the method of measurement is included on the springflow monitoring pro forma (see Annexure 8.1 and for further detail Appendix E of Design Manual Groundwater Resources - WRM1). Project staff will periodically collate the results and send them to the Directorate for entry onto a hydrological springflow database.

b) Hand-dug Well Yield Measurement

4.17 The yield of a hand-dug well will be assessed with assistance from by the LGRDD hydrogeologist and the Test Pump and Maintenance Unit (TPMU) which has specialist equipment for this purpose. A constant discharge test should be done over a period of 8 hours or less. Water tables generally fluctuate markedly between dry and wet seasons and thus the measurement of the yield of hand-dug wells should be done during the dry seasons of November/December or mid-May/mid-July. For comprehensive guidance on well yield measurement see Appendix J of the Design Manual Groundwater Resources, WRM1.

c) Borehole Yield Measurement

4.18 The yield of a borehole will be evaluated by the LGRDD hydrogeologist. New tubewells will normally be pump tested by the drilling contractor but there are several methods to assess existing tubewells depending upon particular circumstances such as whether an existing pump is already in situ. The borehole pump test will determine the specific yield of the borehole and the pumping level for a given discharge. For comprehensive guidance see Design Manual Groundwater Resources WRM1, Appendix I.

d) Safe Yield and Critical Yield

4.19 The safe yield of a spring or hand-dug well is considered to be 0.7 times the minimum measured yield. Regular measurement of flow from spring sources provides the only method of determining their yield and its variation during the year. From this information assessment can be made for long term safe yield. Safe yield is taken to be the minimum flow from the source over a year which has had an average rainfall. As there are generally not sufficient spring flow measurements available to determine this minimum flow, a factor of 0.7 times of the lowest recorded flow is to be taken as safe yield. The safe yield is used to calculate the storage required for the scheme.

4.20 Ideally the demand of a scheme should be less than or equal to the figure for safe yield. However it may be that the safe yield of sources may be less than demand. Where this is the case and there are no additional sources available, the community must be advised that the source has a critical yield and the distribution system may require rationing at certain times of year and private connections will never be permitted.

4.21 For schemes with critical yield as defined above, it is recommended that a statement should be prepared confirming that the designs have been thoroughly discussed with the WSC. The statement should indicate that the concerned households understand fully that the minimum available yield is less than the demand and that it will be necessary for the community to ration their water supply during the dry periods. Such a statement should be signed by the WSC.

e) Viability

4.22 For schemes with critical yield, a constant is to be obtained by dividing the safe yield by the demand. The figure of 0.3 is taken as the threshold of viability. At values less than 0.3, the scheme may be considered to be unviable. If the minimum measured yield has ben recorded during the relatively dry months of November/December or between mid-May and mid-July then alternatively the minimum measured yield may be considered as safe yield and divided by the demand to determine viability.

f) Unviable Schemes

4.23 If a scheme is determined as unviable then development of the scheme should not proceed. In case of unavailability the WSC must be fully consulted and the water resources in the area of the community must be further examined to assess if there are any more sources available. Any additional sources will incur greater capital cost so the economic feasibility must be considered.

g) Comments

4.24 The section for comments on the form is meant for remarks concerning the source, eg whether critical or unviable and also for comment about alternative sources.

h) Civil Works

4.25 Civil works at the source must be designed and undertaken with particular care. The civil works at the source are vital to the success of the schemes to provide the consumers with quantity of the best possible quality of water. Source works at springs are to be designed to capture 100% of the available water wherever practicable.

4.26 Detailed consideration must be given as to how best to protect and develop the source(s). Standard spring protection drawings for typical springs have been prepared but every source has different characteristics and the source works design is particular for every source. Standard spring protection sketches alongwith common mistakes on protecting spring catchments are annexed to chapter 8. Field survey must be undertaken in order to determine and detail the siting and dimensions of the physical works to be built. A sketch design for the works required for the protection of a spring source should be produced in the field whilst inspecting the site with WSC

members. This sketch may then be further developed in the office and is to be given to the WSC for their reference during execution of the works. The sketch is to be included in the submission to LGRDD for Final Approval.

4.27 Standard design drawings have been prepared for the protection of groundwater sources including the rehabilitation of hand-dug wells.

Section 4: Extension Activities

4.28 Extension activities are of central importance to the philosophy of this community development project. The Assistant Engineer will closely lead and supervise the district extension staff to fully integrate the community of selected revenue villages in the planning, design and construction of the village schemes. Discussions about the scope and layout village schemes should be held at an early stage of the review process between the WSC and LGRDD. Whilst developing the details of the scheme designs, specific reference will be made to the previous designs or feasibility studies, the BLS and data therein and also sketch maps.

a) Coverage (Q4.1 to Q4.3)

4.29 The project aims to consider coverage of 100% of the houses of the revenue village selected for inclusion in the project. The main location(s) of any houses and/or settlements are to be shown on the sketch map of the revenue village. It may be that certain settlement(s) and/or a number of these houses, do not need any assistance from the project as they may have adequate alternative supplies close to the houses such as an existing scheme which does not need rehabilitation, nearby protected springs or wells; but if this is so it must be reported as such. It must be investigated from the householders in these areas as to whether water for these houses is in short supply and/or is the source far (ie >500 ft) from the individual houses? A proforma to evaluate the village coverage monitoring from is attached as Annexure 7.4.

4.30 For the designs of the initial 70 villages, often the NESPAK design serves only a part of the revenue village. There must be discussion with the WSC concerning the needs of the people who have been missed. If it is determined by the missed householders, the WSC and the AE that additional scheme(s) may be appropriate, then the AE should examine the feasibility to modify the design and/or to build additional scheme(s). It should be determined how this need may be met, by either:-

(i) extending the present NESPAK design using the same source (or a combination of sources); or

(ii) developing designs for additional scheme(s) each with its own source.

4.31 In the case of (i) above, this will call for additional design work. As a rule of thumb, the percentage increase in the demand will give some indications regarding both the feasibility of extending the existing hydraulic design (for which the community may have already built their tanks) and the extent of the new design work involved. If the additional water demand is greater than 30% of the original estimate then it is indicated that extension may not be feasible and the original NESPAK design will require complete redesign. However every case is site specific and must be considered individually.

4.32 In the case of (ii) above, additional design work will be necessary for the new scheme; however, subject to hydraulic design review, it is more likely that the implementation of the original NESPAK designed scheme may proceed with the original tank capacities but with possibility of minor changes of pipe diameter.

4.33 For new designs (for villages Nos 71 to 500), the extent of the coverage by each schemes must be carefully examined. The WSC must confirm that no houses have been missed from the limits of the design.

b) Composition of WSC (Q4.4)

4.34 It is vital that the WSC properly formed and truly represents all sections and settlements in the scheme. The officers of the WSC need to be ready and able to take an active role in <u>their</u> project. For each scheme project staff must record the names and positions of the WSC members on a list to be included in the design report.

c) Community Commitment and Design Consultation (Q4.5)

4.35 As a matter of priority the LGRDD must obtain confirmation that the community is ready to participate in the construction of their water supply scheme. The project staff are to advise and discuss with the WSC what will be required by the community for them to get their scheme built. Outline cost estimates for all the elements of the work are to be considered by the WSC. Discussion will include what skilled and unskilled labour inputs will be required for physical works such as trenching, pipeclaying,

tank construction and for the necessary collection of funds and construction materials. LGRDD must be assured that the community can call on sufficient resources to mobilise, manage and pay adequate numbers of skilled and unskilled labour.

4.36 Generally for the initial 70 schemes, the designs have not been presented and discussed with the WSC. This must be done so that the people know the extent of the scheme and the scope of the work.

d) MOU (Q4.6)

4.37 The MOU will be signed by both parties (LGRDD for government and the WSC for the community) when the scheme is agreed with the WSC and received final approval by the competent authority in LGRDD. However it is vital that the MOU is fully discussed and understood by the WSC at an early stage. The community must be fully aware of what commitments are being made by both the village and government.

e) Tapstands (Q 4.7 to 4.8)

4.38 The various types and options of tapstands are to be discussed with the WSC and the villagers at large. Discussion should include the relative costs of the tapstand options. The people of each tapstand are to be invited to select which option they prefer. People should also be invited to offer any possible amendments or improvements they may propose. The tapstands selected and the any refinements suggested must be recorded by the project staff.

f) Latrines (Q4.9)

4.39 For future development and improvement of sanitation within the scheme area it is useful and simple to record the number of latrines which presently exist.

Section 5: Yard Connections

a) Critical Yield = No Yardtaps (Q5.1)

4.40 Consideration is to be given to the future installation of yard connections to households. The demand criteria for consumption from yard connections has been promulgated by the World Bank for this project to be the same as that from tapstands. However it is likely that this may not prove to be realistic in practice. If as and when water to the

village as a whole falls short, the monitoring and control by the WSC, of the consumption of individual households from yardtaps is substantially more difficult. Also the addition of such service pipes to the mains will significantly increase the risk of unaccounted losses. It is essential therefore that the WSC must be advised, clearly understand and agree that yard connections may only be made for schemes where the safe yield of the source exceeds demand. It is must be advised to the WSC that if the scheme has critical yield ie the safe yield falls below demand, then yard connections will <u>not be appropriate</u> at any time in the life of the scheme.

b) Community Requirement for Yard Connections (Q5.2)

4.41 Assistance to the village by this IDA funded project is limited to the provision of water supply to tapstands, which should be within 500 feet of all houses covered. It is perceived however that a substantial proportion of householders would prefer connections to their property. Such connections however normally increase demand on the system. However if the source yield is sufficient, the hydraulic capacity of the piped distribution system is generally adequate for a number of extensions to serve yardtaps (installation of which must be paid by the individual householder). LGRDD need to collect and record information on the perceived need of people for yardtaps. The WSC and the community are to be asked to report what they consider will be the percentage of households within each scheme, which will require and be able to pay for the installation of yard connections within the design life of the scheme ie within the next 10 years.

c) No Connections Permitted in First Two Years (Q5.3)

4.42 As a project rule, there will be no yard connections in any scheme within the first two years of operation following the feel for the availability of water & is sufficient for house connection commissioning date of the scheme. This rule must be agreed by the WSC who then have to enforce it. This rule is to ensure that the WSC will have two years to establish and to get complete working routine all the procedures for the efficient operation and maintenance of the scheme including the regular collection and disbursement of the village funds. Furthermore during there two years source yield measurements will continue to be made and the community will gain an appreciation of the quantity of water available according to season.

Section 6: Storage Calculation

4.43 All storage calculations and estimates must be clearly and neatly written out and appended to the design review/summary in accordance to the design criteria (see chapter 6).

a) Existing Tanks

4.44 For the schemes of the initial 70 villages, it is likely that the communities will have been advised already of the number and capacities of tanks that they are obliged to build for the NESPAK design. As the NESPAK design capacities are normally greater than required to the approved design criteria, if these tanks have been built or are in construction according to NESPAK design, then the capacity need <u>not</u> be revised, However as the storage capacities may be reduced, in all other cases the storage requirements are to be reassessed as is set out below. If such review results in a tank capacity being less than 5000 gallons, then the responsibility to fund construction should remain with LGRDD on the basis that the community have already been advised of their commitment to the scheme.

b) Storage for Pumped System At Source

(i) For a total of 8 hours pumping per day in two 4 hour shifts starting at the same time am/pm, (normally one hour or more before peak consumption times) a source tank needs to be sized for not more than 40% of the daily demand or 10 hours supply.

(ii) If the safe yield is >3 times the daily demand then storage need be no more than sufficient for a pump sump (say 1000 gal or 1.5 m x 1.5 m x 1.75 m deep)

(iii) If the safe yield is >2 times the daily demand the storage should be 30% of the daily demand

(iv) If the safe yield of the source is equal to or less than the daily demand then the storage should be 40% of daily demand

c) Storage for Pumped System At Secondary Pump Stages

(i) If the second stage tank does not serve distribution, it should be considered to cancel the second stage pump and adopt a single high lift pump at the first stage.

(ii) The second stage tank should be sized for 35% of demand of the distribution from that tank and not include any demand to be pumped from that tank.

d) Service Reservoir for Pumped or Gravity scheme

4.45 Assuming a peak demand of 2 x average daily inflow occurs over a continuous 4 hour period then four cases may be made for calculating the capacity of service storage tanks.

(i) Case 1: Safe yield or Inflow is < 1.25 x demand

- If the safe yield and/or flow into the service tank is at a rate of 1.25 times or less the average daily demand, then a storage tank should be built with capacity 33% demand from that tank.

(ii) Case 2: Safe yield or Inflow is >1.25 but <1.5 x demand

- If the safe yield and/or flow into the service tank is at a rate between 1.25 times and 1.5 times the average daily demand, then a storage tank should be built with capacity of 20% demand from that tank.

(iii) Case 3: Safe yield or Inflow is > 1.5 and < 2 x demand

- If the safe yield and/or flow into the service tank is at a rate between 1.5 times and 2 times the average daily demand, then a storage tank should be built with capacity of 10% demand from that tank.

(iv) Case 4: Safe yield/Inflow is >2 x demand

- If the safe yield and/or flow into the service tank is at a rate of double the average daily demand (ie equivalent to peak demand), then a storage tank is not required, although smaller break pressure chambers may still have to be built depending on location.

4.46 However the potential saving of reducing the design capacities of the tanks or even cancelling tank construction must be compared with the consequential cost of increasing in the diameter of the supply main into the tank to carry the higher flow.

e) Storage Tank Location

4.47 Most schemes in AJK involve significant head differences within the pipeline systems. Storage tanks and break pressure tanks (BPT) are used to keep pressures within serviceable limits. The flow through storage tanks must be regulated or the tanks throughout the system would drain and overflow at the tank of lowest elevation. Control valves on tanks may be manually regulated, but this is a grossly inefficient operational practice which leads to intermittent supply to the consumers and their consequent dissatisfaction.

4.48 The automatic regulation of flows through each tank is properly achieved by the fitting of angular float valves. Such valves, which have to date been identified as available in Pakistan, are rated at a maximum working pressure of 10 bar (ie they can close against a maximum head of 100 m). Polyethylene (Pe) pipe is also commonly produced at a maximum pressure rating of 10 bar. Furthermore a typical working pressure for airvalves is 10 bar. Thus all tanks should be located such that no tank should have more than 10 bar (approx. 100 m) of static head exerted upon it.

4.49 The storage requirement on the distribution system of a scheme is allocated around the scheme to regulate the pressures. Once the total storage requirement for a scheme has been assessed, it is useful to divide this figure by the total number of standposts. Thus a figure for the average storage requirement per standpost is calculated. This figure will assist the engineer to determine the capacity of individual tanks located around the distribution system. It should be noted that a BPT itself has some 100 gallons of storage.

f) Future Additional Storage

4.50 Additional storage on the system which may be required to cater for future yardtap connections, is relatively cheap compared to the cost of additional pipeclaying, and can always be built or installed by the village at a later stage, under advise from project staff.

Section 7: Pipe Hydraulics

a) Computer Aided Hydraulic Design (BRANCH)

4.51 Once all the above steps have been satisfactorily addressed, it is necessary to check the hydraulic design of the system using the World Bank programme "BRANCH". Chapter 10 gives

more detailed guidance on the use of this Computer Aided Hydraulic Design package (CAD).

4.52 It is not normally tolerable to reduce the residual head required to be input by the computer programme, below the minimum limit of 5 m. To go lower than 5 m will place too much reliance on the accuracy of the original survey. Furthermore it must also be noted that the survey levels are for ground level and the tap itself is located approx. 1.2 m above ground level, which will further reduce the residual head.

4.53 In case the computer cannot produce satisfactory design to within the criteria, it should be considered to modify the elevations of the reservoir and/or tapstand locations. For example if the residual head at a tapstand is too low it must be assessed if the tapstand may be lowered.

4.54 On the other hand it may be that the computer programme indicates that at some few tapstand nodes, the residual pressure may be somewhat above the absolute maximum acceptable limit. In this case there are several options to be investigated:

(i) If the CAD (minimum) residual head is set at 10 m which is the ideal residual, it should be considered to run the programme at 5 m and note if the high residuals have sufficiently reduced;

(ii) It should considered if it is possible to raise the elevation of individual tapstands with high residual pressure by relocation;

(iii) It should be considered if it is possible to lower the elevation of the service tank by relocation;

(iv) It may be necessary to introduce break pressure tank(s) (BPT) or additional storage tanks, which also break pressure; and

(v) Physical means to reduce flow and pressure may be adopted such as through the use of orifice plates (see paras. 4.61 and 4.62 below) or seat valves at tapstands. However it is better preferred not to rely on such mechanical means to do this, as they need to be carefully set, not tampered with and orifice plates in particular have tendency to become blocked.

b) Sub-section 7.1: Flow velocities

4.55 The hydraulic design of the pipe must be checked. It is undesirable for flows to exceed 7 ft/sec and should not normally exceed 10 ft per second. In order to reduce excessive flows or pressure, orifice plates and break pressure tanks should be adopted rather than small diameter pipes which generate high friction factors

4.56 The velocity limits for design are:

(i)	Maximum	- 10 ft/sec (3 m/s)
(ii)	Minimum	- 2.5 ft/sec (0.75 m/s)
(iii)	Absolute Minimum	- 1 ft/sec (0.3 m/s)

4.57 Pipe velocities must never fall below 1 ft/sec (0.3 m/sec).

c) Sub-section 7.2 Pressure Limits at Standposts

4.58 The residual pressure should be within these limits:

(i)	Absolute minimum:	5 m = 7.1 psi
(ii)	Desired minimum/ideal:	10 m = 14.2 psi
(iii)	Desired maximum:	15 m = 21.3 psi
(iv)	Absolute maximum:	30 m = 42.6 psi

4.59 Flows at certain standposts which are unavoidably and exceptionally above the absolute maximum residual pressure, must be regulated by carefully setting the flow at the seat valve at each tapstand. Alternatively an orifice plate may be used but these are problematic to make, replace and can get blocked and/or erode quickly.

4.60 High residual pressures at standposts may be unavoidable but in all cases it must be investigated if it is possible to raise the elevation of the individual tapstands or if it is necessary to insert a BPT on the mains. This is preferred to other physical means to reduce flow and pressure such as seat valves or orifice plates. The seat valves at tapstands can be set to control the flow to deliver 2 gpm and induce a headloss through the valve. Alternatively an orifice plate can be inserted within a union to reduce the head (see below). However these physical means must be carefully set and not tampered with by consumers. Experience has shown that if orifice plates get blocked consumers are inclined to remove them permanently. It must also be remembered that such control valves or orifice plates do not affect the static pressure exerted on the standposts.

4.61 Having recognised the deficiencies of orifice plates, there are occasions nevertheless when their use may be considered appropriate. For example an orifice plate may be installed for a single tapstand which has high residual pressure, rather than to construct a BPT costing several thousand rupees. A example calculation for the determination of the size of the orifice is included in annexure 7.5. The calculation should be for the orifice plate will give 10 m residual pressure at the tapstand. A computerised format will be developed for this purpose until when such calculations are to be manually generated.

4.62 Not only must the residual pressures at the standposts under normal operation be considered, but also the static pressures at each standpost must be checked. When the distribution system is not in use, say at night, all the standpost taps are closed. During these times the static pressure on the system must be contained by these bibcocks/taps. Regular bibcocks are designed to work for pressures up to 60 psi (40 m head). If the static pressure exceeds this figure then regular bibcocks are particularly vulnerable to wear when they are first opened, and will therefore have a short working life. More robust taps are available which are rated to withstand much higher pressures up to 300 psi (210 m) or higher.

4.63 Many tapstands on hill schemes may be subjected to high static pressures and higher specification bibcocks must be used. Therefore the static pressure at all standpost elevations must be calculated and examined. This is simply done from the CAD hydraulics data. The correctly rated bibcocks (ie up to 60 and 300 psi or 40 m and 210 m, respectively) must be identified for the scheme pipe schedule. It must be clearly and separately recorded as to which standposts numbers are to have which specification of tap and this is to be explained to the WSC for any future replacement of bibcock with same specification.

d) Sub-section 7.3 Hydraulic Gradeline (HGL)

4.64 The NESPAK designs for the first 70 villages and the CAD hydraulic do not consider pipe profiles (long sections). Only the elevations at the beginning and end of the pipe are noted. In order to avoid potential airlocks which may prevent flow or to avoid low and negative pressures, a check must be made for each and every pipe length to locate high points in the ground profile (using hand held levels etc) and to check that the HGL does not ever fall below ground level and should remain 10 m above ground level. On critical pipelines the hydraulic gradeline and pipe/ground profile should be drawn in long section. This is

particularly important for gravity flow transmission mains.

4.65 Low pipe flow velocities indicate pipelines where the difference in elevation from the start to end of the pipeline is small and the HGL may be problematic. It is therefore stressed that the HGL is checked on all pipelines where flow velocities are less than 0.75 m/s.

e) Sub-section 7.4 Air Valves, Washouts and BPT

4.66 The location of airvalves and pipeline washouts must be identified and detailed/ noted on the schematic pipeline layout drawing. Absence of air valves and washouts may lead to pipe blockage and problems when attempting to maintain the pipelines. The locations are to identified on the ground with reference to surrounding features, during a physical visit with WSC members. On gravity transmission main and on all distribution pipelines an air valve must be placed at least every running 1500 ft. However airvalves may omitted if there is a tapstand above the pipeline, which will bleed air from the pipe,

4.67 If suitable tee pieces and isolating valves are fitted it is possible for the operator to periodically bleed air manually from high points on the pipeline. However this practice is not reliable or recommended and the installation of airvalves automates this process. There are generally two types of air valve available of large and small orifice for large and small capacities of air. On this project which utilises smaller diameters of pipe up to 4" dia, small orifice air valves are appropriate. For pipes up to 2" dia., a 0.5" dia small orifice "bleed" air valve suitable for pressures up to 10 bar, has been identified. For larger diameter pipes heavier duty 25 mm or 32 mm dia airvalves shall be used.

f) Sub-section 7.5 Transmission Mains

4.68 The safe yield is to be evaluated as in section 3 above. For gravity schemes consideration should be given to sizing the mains to transmit all available yield or twice the revised demand figure (whichever is less) to the first reservoir on the system. The method of calculation and an example sheet for the design of transmission main is found in annexure 10.2 to chapter 10.

4.69 There should normally be no tapstand connections to gravity transmission mains. This is unavoidable in certain circumstances in which case the tapstand must preferably be located at a high spot above the pipeline and so that it will act as an air valve. The tapstand flow delivery must be restricted to 1 gpm and regulated by the seat valve.

g) Sub-section 7.6 Design of Pumps and Pumping Mains

4.70 The pumping rate should be based on a total of 8 hours per day. Thus pumps(s) and pumped mains should be designed to supply total daily demand over 8 hours. Chapter 11 gives detailed guidance on the computer aided optimised design of pumps and pumping main. It is vital that the WSC is advised and agree to the projected pumping cost, which itself must be reported in Q8.3 below.

4.71 It must be noted that there can never be permitted any tapstand or service connection from a pumping main.

Section 8: Summary of Pipe Quantities and Costs

4.72 The pipe quantities are to be abstracted and collated from the various outputs of the CAD hydraulic designs and reported in summary in this section. An additional 5% is to be added for contingency and to cater for wastage. Chapter 12 of this manual contains the pro forma and instruction on how to prepare the detailed schedules for quantities of pipes and fittings.

a) Capital costs (Q8.1 & 8.2)

4.73 The estimated cost of the pipe for the scheme is also to be abstracted from the CAD hydraulic design outputs. This estimated cost of pipe from CAD hydraulic design outputs should be increased by 5 % for respective diameters to cater for wastage during laying. To this total, an additional 10% cost is to be added for the projected cost of fittings. The cost per capita of the pipe and fittings is to be calculated and given in Q8.2.

4.74 Detail component costs of the works, inclusive of both materials and labour, must be estimated in detail for each of the village schemes as a separate exercise. The Provisional Cost Estimate pro forma is to be used for this purpose where the costs to both the WSC and the LGRDD are indicated. Detailed guidance on the preparation of cost estimates is in Chapter 13.

b) Operation Cost (Q8.3)

4.75 For pumped schemes an estimate of the total monthly power cost for the scheme will be made within the computer aided cost optimised design for pump and pumping main as in chapter 11. This potential cost is to be discussed with the WSC and is to accepted and agreed by the people

ANNEXURES

ANNEXURE 7.1

DESIGN REVIEW FORM (NESPAK DESIGN)

Date:

District: Markaz: Village Name:

Scheme Name: Village.Scheme No:

1. **SKETCH MAPS:** Village sketch attached? Yes/No
   Pipe schematic attached? Yes/No

2. POPULATION/DEMAND:

	As NESPAK	As Revised
Number of houses in Village:		
Population of Village:		
Average persons/household:		
Houses served by this scheme:		
Population served by this scheme:		
Domestic Demand (at 10g/cap/day):		
Demand for sch, mosques etc:	--------	--------
Total Demand:	________	________
+ 20% Unaccounted for water:		________

3. **SOURCE WORKS:**

Source Name: No of yield measurements:

Maximum Measured Yield (gpd): Date:

Minimum Measured Yield (gpd): Date:

Safe Yield (gpd):

Average Yield (gpd):

Comments:

Sketch civil works design made? Yes/No

4. EXTENSION ACTIVITIES:

4.1	Coverage - Number of houses in village missed:	
4.2	Can any missed houses be served by this scheme?:	Yes/No
4.3	If "yes" above, is demand increased by >30%?:	Yes/No
4.4	Is a broad based and representative WSC formed?;	Yes/No
4.5	Is this scheme discussed and agreed with WSC:	Yes/No
4.6	MOU discussed with WSC?:	Yes/No
4.7	Are tapstand positions located and agreed?:	Yes/No
4.8	Have tapstand options been decided?:	Yes/No
4.8.1	How many tapstand option type 1 selected?:	
4.8.2	How many tapstand option type 2 selected?:	
4.8.3	How many tapstand option type 3 selected?:	
4.9	Number of latrines existing in scheme area?:	

5 YARD CONNECTIONS:

5.1	Does the scheme have critical yield?	Yes/No
5.2	Percentage of houses which desire and can pay for yard connections over next 10 years:	
5.3	Has it been explained to the WSC that there can be no yard connections in first two years:?	Yes/No

6. STORAGE CALCULATIONS (tank capacities):

No	Size (gal)	Status	% complete	Revised size?

7 PIPE HYDRAULICS

7.1 Flow Velocities:

7.1.1	Pipe numbers exceeding 10 ft/sec:	
7.1.2	Pipe numbers under 2.5 ft/sec:	
7.1.3	Do any pipes have < 1 ft/sec	Yes/No

7.2 Standpost (SP) Pressures

7.2.1 Total number of standposts:
7.2.2 SP Srl Nos with residual pressure outside limits:
7.2.3 Number of SP with high static pressure:

7.3 Hydraulic grade lines (HGL) checked: Yes/No

7.4 Air valves (AV), washouts (WO) and break-pressure chambers (BPT):

7.4.1 Located on site: Yes/No
7.4.2 Located on Drawing layout: Yes/No
7.4.3 Number of BPT required:
7.4.4 Number of air valves required:
7.4.5 Number of washouts required:

7.5 Transmission Mains:

7.5.1 Is design for 100% of the maximum yield: Yes/No
7.5.2 Is design for twice demand figure?: Yes/No

7.6 Pumping design and rising mains (if applicable):

7.6.1 Is optimised pumping design attached: Yes/No
7.6.2 Does WSC agree to the projected pumping cost: Yes/No

8 BILL OF QUANTITY:

Dia(Inches)	NESPAK (feet)	Branch length + 5% (metres)

8.1 Branch pipe cost + 5%:
8.2 Pipe Cost per capita:

Submitted By: **Date:**

Checked in TRP By: **Date:**

Design Review approved By: **Date:**

ANNEXURE 7.2

DESIGN SUMMARY FORM **Date:**

District: **Markaz:** **Village Name:**

Scheme Name: Village.Scheme No:

1 SKETCH MAPS: Village sketch attached? Yes/No
Pipe schematic attached? Yes/No

2 POPULATION/DEMAND:

Totals

2.1 Number of houses in Village:. . . . .

2.2 Population of Village:. . . . .

2.3 Average persons/household:. . . . .

2.4 Houses served by this scheme: . . . .

2.5 Design Population served by this scheme:. . .

2.6 Domestic Demand (at 10g/cap/day): . . . . . .

2.7 Demand for sch, mosques etc:. . . . .

Total Demand: ___________gpd

20% Unaccounted-for water: ___________ gpd

3 SOURCE WORKS:

Source Name: No of yield measurements:

Maximum Measured Yield (gpd): Date:

Minimum Measured Yield (gpd): Date:

Safe Yield (gpd):

Comments:

Sketch civil works design made? Yes/No

Date:

4 **EXTENSION ACTIVITIES:**

4.1 Coverage - Number of houses of village covered:. . .
4.2 Coverage - Percentage of houses in village covered:.
4.3 Are there any houses missed from the design?: Yes/No
4.4 Is a broad based and representative WSC formed?; Yes/No
4.5 Is this scheme discussed and agreed with WSC: Yes/No
4.6 MOU discussed with WSC?: Yes/No
4.7 Are tapstand positions located and agreed?: Yes/No
4.8 Have tapstand options been decided?: Yes/No
4.8.1 How many tapstand option type 1A selected?:. . . .
4.8.2 How many tapstand option type 1B selected?:. . . .
4.8.3 How many tapstand option type 2 selected?: . . . .
4.8.4 How many tapstand option type 3 selected?: . . . .
4.9 Number of latrines existing in scheme area?:. . . . . .

5 **YARD CONNECTIONS:**

5.1 Does the scheme have critical yield? Yes/No
5.2 Percentage of houses which desire and can pay for yard connections over next 10 years:. . . . .
5.3 Has it been explained to the WSC that there can be no yard connections in first two years:? Yes/No

6 **STORAGE CAPACITIES** (calculations to be attached):

No	Node No	Size (gal)	Existing/RCC/Brick/Stone/Prefab

7 **PIPE HYDRAULICS**

7.1 **Flow Velocities:**

7.1.1 Pipe numbers exceeding 10 ft/sec: . . . .
7.1.2 Pipe numbers under 2.5 ft/sec:. . . . .
7.1.3 Do any pipes have < 1 ft/sec Yes/No

Date:

7.2 Standpost (SP) Pressures

7.2.1 Total number of standposts (SP):. . . . .
7.2.2 SP Srl Nos with residual pressure outside limits:
7.2.3 SP Srl Nos with high static pressure: . . . . . .

7.3 Hydraulic grade lines (HGL) checked: Yes/No

7.4 Air valves, washouts and break-pressure tanks (BPT):

7.4.1 Located on site: Yes/No
7.4.2 Located on schematic layout: Yes/No
7.4.3 Number of BPT required: . . . .
7.4.4 Number of air valves required:. . . . .
7.4.5 Number of washouts required:. . . . .

7.5 Transmission Mains:

7.5.1 Is design for 100% of the maximum yield: Yes/No
7.5.2 Is design for twice demand figure?: Yes/No

7.6 Design of Pump and pumping mains (if applicable):

7.6.1 Is optimised pumping design attached: Yes/No
7.6.2 Does WSC agree to the projected pumping cost: Yes/No

8 SUMMARY OF PIPE QUANTITIES AND COSTS:
Nominal Dia.(mm) BRANCH length + 5% (metres)

8.1 "Branch" design pipe cost + 10%:. . . . . .Rs
8.2 Pipe Cost per capita of design population:. . . . . .Rs
8.3 Projected Pumping Cost per household (if applicable):Rs

Design Summary Agreed by WSC: **Date:**

Design Summary Submitted by: **Date:**

Design Summary Checked in TRP by: **Date:**

Design Summary Approved by: **Date:**

ANNEXURE 7.3

CHECK LIST OF ITEMS TO BE SUBMITTED WITH DESIGN REVIEW/SUMMARY

Before scheme Design Reviews are submitted to the competent authority in the Directorate TAU for either principle or final approval, the information is to be checked by LGRDD staff of the Technical Resource Pool to confirm that the designs are complete and proper. The TAU will may appraise some of the design reviews/summaries.

1 APPROVAL IN PRINCIPLE

Without "Approval in Principle" completion of the design and implementation of the scheme cannot proceed. The following items must be included with each scheme design review/summary:

Completed design review/summary pro forma
Village Coverage Monitoring Form
Sketch Map of revenue village indicating scheme locations
Scheme Pipeline layout sketch
Source yield measurement records
CAD hydraulic design input data and outputs
Storage assessment calculations

Following items are also to be submitted if appropriate:

Optimised design of pumps and pumping main (all pumped schemes)
Hydraulic gradeline profiles

2 FINAL APPROVAL

Before materials can be procured and construction can proceed, it is necessary that the scheme is given final approval by LGRDD. The Memorandum of Understanding can then be signed and the Design Report (see chapter 16) can be compiled. To enable LGRDD to give "Final Approval" to scheme design in addition to the items listed above, the following information must be submitted:

Final Pipeline layout drawing
List of Tapstand Nos with address (name of householder)
Source works Design Sketch (minimum A4 size)
Schedule of pipes and fittings
Construction Programme
Scheme Construction Report Pro forma
Cost Estimate
Composition of WSC

ANNEXTURE 7.4

LG&RDD RWSSP (IDA)

Village Coverage Monitoring Form

Note: This form is to be submitted with the design review of each scheme for <u>each</u> revenue village in each construction phase. Information on number of houses is to be obtained from the Baseline Survey for question No 1 and 2.

District Name: **Date:**
Village Name : **Village/Scheme No:**
Construction Phase No:

1) Total Number of Houses in Revenue Village : (A)

2) Number of Houses covered by the following schemes in the revenue village:

Scheme No 1:
Scheme No 2:
Scheme No 3:
Scheme No 4:
Scheme No 5:
Scheme No 6:
Scheme No 7:
Scheme No 8:
Scheme No 9:
Scheme No 10:
etc

Total Number of Houses Served: (B)

3) Percentage coverage:

$$\frac{(B)}{(A)} \times 100 = \quad \% \ (C)$$

4) Percentage remaining for future coverage:

$$100 - (C) = \quad \%$$

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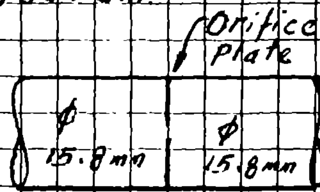
Job ______ Job No. ______ Calc. by RIAZ

Subject CALCULATION EXAMPLE FOR DESIGN OF ORIFICE PLATE Chkd JTA

Ref: Appendix D, page 205, "A Handbook of Gravity Flow Systems" by Thomas D. Jordan Jnr.

General equation for flow through a small orifice is:



$$Q = CA\sqrt{2gH}$$

where Q = Rate of flow

C = Co-efficient of orifice (0.6 for a sharp edged orifice)

A = Cross sect'l area of orifice

g = Gravitational acceleration

H = Head loss through orifice

CALCULATIONS

Given: Nominal pipe dia = 15 mm
Actual inside dia = 15.8 mm

For a single tapstand, $Q = 0.152$ LPS $= 0.152 \times 10^{-3}\ m^3/s$

Head at upstream end of orifice = 50 m of water
Reqd. head at downstream end of orifice = 10 m of water
$\therefore H = 50 - 10 = 40$ m

Applying the equation of flow, the area of cross-section of orifice is given by

$$A = \frac{Q}{C\sqrt{2gH}} = \frac{0.152 \times 10^{-3}}{0.6 \times \sqrt{2 \times 9.8 \times 40}} = 9.048 \times 10^{-6}\ m^2$$

If d is the dia of the orifice, we have

$$\frac{\pi}{4} d^2 = 9.048 \times 10^{-6}$$

Solving we get,

$$d = \sqrt{\frac{4 \times 9.048 \times 10^{-6}}{3.1416}} = 0.003394\ m = 3.4\ mm$$

To the nearest half mm, d = 3.5 mm

Chapter 8

WATER SOURCE DEVELOPMENT

CHAPTER 8

WATER SOURCE DEVELOPMENT

CONTENTS

CHAPTER 8

WATER SOURCE DEVELOPMENT

1 INTRODUCTION

1.1 The development and protection of the source of any scheme is of crucial importance to the success of the scheme to provide water in sufficient quantity and of good quality to the consumers. The source of water used for the village water supply schemes is either from springs or wells (hand dug large diameter, small diameter handpumps or tubewells).

1.2 The following chapter highlights a number of points to be considered when preparing to utilise springs or hand dug large diameter wells as sources for water supply schemes. Although the protection of the tubewell headworks is included herein, the actual installation or rehabilitation of tubewells are complex tasks which will be undertaken by a specialist contractor and which are not covered in this section; further details may however be found in the Groundwater Design Manual.

1.3 There are many possible causes for a water supply to fail. In broad terms they can be divided into two; firstly deterioration of the source itself and secondly changes in local hydrogeological conditions. The main symptom in all cases is a deterioration in yield and consequently it is very easy to mistake the cause. However all water abstraction systems need regular maintenance to prevent the yield from decreasing. This chapter therefore also considers the rehabilitation of springs and hand dug wells which may be necessary.

2 SPRING SOURCES

2.1 A standard design drawing for the protection and development of springs has been prepared (Drawing No 040 "Typical Spring Protection") and is included in the Standard Component Manual (ENM2). The guiding principle for the spring protection works is to ensure that no impedance to the flow is permitted. If a spring eye is impounded and the water is caused to back up, then the source may shift its location to where it is easier to flow. This may mean that the source protection works become bypassed by the water. A second, but equally important, principle is to ensure that there is no opportunity for pollution to enter the source water.

2.2 It has been observed that there are many examples in AJK of poorly executed spring protection works. There has been a marked tendency to build a spring box at the very spring eye, but this however can cause the spring to back up. It is always better to insert drains which leads the water to a collection box at a ground level below the eye(s) and properly cover and seal the drain. It cannot be overemphasised how important it is that this work is executed correctly. Figure 6.1 illustrates common mistakes which can be made when protecting springs. Project staff must become skilled in this aspect of scheme construction and ensure that these mistakes are avoided.

2.3 It must be noted that every spring has different and particular characteristics. Springs may be similar but no two springs are the same. It is therefore important that particular design details are carefully considered for every spring which is identified for protection and development. The design engineer must therefore provide a spring protection design sketch which will detail the work to be undertaken to develop each spring. Figures 6.2, 6.3, 6.4 and 6.5 show examples of spring source protection sketches.

2.4 It must be remembered that the spring protection works will be undertaken by the village community who are unlikely to be skilled in the work of spring protection. It is therefore important that the design sketches are clear, that the project staff and in particular the engineers explain carefully to the community and the WSC supervisor what work is to be done and ensure that the community members clearly understand this. During construction of the spring protection works, the LGRDD engineers and overseers must visit the site to support WSC supervisor and ensure the work is carried out satisfactorily.

2.5 The routine and regular measurement of spring flow is a critically important exercise required in order to monitor the flow over time. It is important that this exercise is begun as soon as the village is selected for assistance by the project and the spring source is identified. Spring flow monitoring should continue, even after the spring is protected and developed. Fluctuations in the flow can thus be observed. A note on springflow measurement is included as Annexure 6.1.

3 REHABILITATION OF EXISTING SPRING PROTECTION WORKS

3.1 At some spring sources the community may have previously undertaken some works to protect and capture the water. If there is an existing springbox or catchpit constructed, then project staff must examine the structure to check if there is source water leaking and/or not being captured and whether pollutants can enter the source. A sanitary survey proforma for spring protection works has been prepared and is annexed to this chapter. The works should be thoroughly inspected and the survey proforma completed so that the engineer can determine what remedial works, if any, would be required or whether the community should be advised to rebuild the works.

3.2 Spring catchments may slowly silt up as fine grained material is washed out of the aquifer formation into the protected catchment area. Some of the fines will settle in the spaces between the stones in the catchment area thereby reducing its permeability. This is likely to cause the groundwater level to rise in the immediate vicinity of the source and as a result the groundwater may be caused to discharge elsewhere. Cleaning out the catchment area may be the solution but where the source eyes have moved it may be better to rebuild the source protection altogether.

4 HAND DUG WELLS

4.1 Hand dug wells in the project area are often of large diameter up to 10 ft (3 m) or more, but are usually shallow, rarely exceeding 30 ft (10 m) in depth. The shallow aquifers and the soil seepage zone which recharge these wells are particularly susceptible to the seasonal dry season when the level of the water table tends to fall. The yield of the well will be thus be at a minimum during the dry season.

4.2 A hand dug well would not normally be considered worthy of rehabilitation if the well ever becomes dry. However if the villagers intend to continue to use the well seasonally, they should be advised to undertake certain works in order to improve the potability of the water and yield. A well should always have a good sanitary seal, a waterproof apron and be covered to prevent ingress of pollutants into the well.

4.3 If, at any time of the year, a well is assessed to have a safe yield (0.7 times the minimum measured yield) of less than 1000 gpd, this may only be sufficient for water supply for up to 10 households. A safe yield of 1000 gpd is approximately equivalent to 1440 gpd or 1 gpm over a day. Such wells should normally be covered and fitted with a handpump and it is considered to be a "point source". Such sources are outside the scope of this project for capital assistance but project staff remain obliged to give advice to the community for necessary remedial work as may be required.

4.4 If a well has a safe yield of more than 1000 gpd, ie a minimum yield of greater than 1440 gpd, then the village feasibility study will consider the estimated capital and running costs. The village WSC and project staff may then opt to design an appropriate lift pump to supply a distribution system. Any necessary remedial works to the well must also be considered.

5 REHABILITATION OF EXISTING WELLS

5.1 An existing hand dug large diameter well is likely to require some rehabilitation before they may be included in a village supply scheme. The type of work that can be carried out will depend on the construction of the well. A standard design drawing for a properly protected large diameter well has been prepared titled "Hand dug well Rehabilitation, Drawing No 029.

5.2 The yield of wells may slowly decline as a result of clogging of the well face. This can be due to fine grained particles moving into the well as for the spring catchments. Clogging can also be caused by the precipitation of minerals on the well face or by the growth of bacterial slimes. The effect of clogging is to reduce the permeability of the well face hence the pumping rate will be reduced for any given drawdown. The main symptoms of clogging are a decline in yield or an increase in drawdown, or more commonly a combination of the two. Although the pumping levels may have fallen the rest water levels should recover to values similar to those when the well was first constructed.

5.3 Cleaning out of debris within the wells would be carried out using the equipment provided with the Test Pump and Maintenance Unit (TPMU). For the most part this would involve lowering the electric submersible sludge pump to the bottom of the well and proceeding to pump out the water. The pump would also be capable of removing any silt and loose material that was less than 50 mm (2 inches) diameter. If it was considered that manual excavation could be safely

carried out then the pump would be kept running whilst men were lowered to the bottom of the well to carry out the cleaning operation. This work would have to be carried out by experienced well diggers. Thus the original excavated depth of the well would then be recovered.

5.4 The depth limitation of the above method is controlled by the total delivery head capability of the pump and that is about 15 metres. If the wells are deeper than this an alternative method of dewatering the well with a small electric submersible pump which would normally be used in tubewells may be used to allow manual excavation at the bottom of the well. This pump is not suitable however for pumping sludge and must be kept at least 1 ft from the bottom of the well.

5.5 The rehabilitation of the fabric of the large diameter wells would generally involve masonry or brickwork repairs. The internal lining of the well may require some renovation. For example in old wells the masonry may have deteriorated due to vegetation growth or erosion from water flow. Bricks may need to be replaced and/or the mortar repointed. This work should also be done by skilled well diggers.

5.6 The surrounding aprons are also likely to require construction or remedial work to ensure that there is no possibility of polluted water entering the well either through cracks in the apron or at the junction between the apron and the wall of the well. Construction of the necessary covers for these wells would also involve concreting and brickwork.

6 PROTECTION OF TUBEWELLS

It is important that the wellhead of a tubewell is properly and securely protected. Three options have been developed for the design of the protection of the wellhead at tubewells. These design Drawing Nos 024, 025, and 026 and are titled "Tubewell Wellhead Protection Option (1, 2, 3)" respectively.

ANNEXURES

ANNEXURE 8.1

NOTE ON SPRINGFLOW MEASUREMENT

1 INTRODUCTION

1.1 The majority of water sources in AJK are springs. However the amount of water which flows from these springs varies markedly throughout the year. Thus the amount of water which is available to give a secure, all year around, supply to the village population must be established so that proper design can be made. The regular measurement and monitoring of each flow from all the spring sources within a village boundary is therefore an essential and vital component of the design procedure. This note is to guide extension staff as to how to make simple springflow measurements.

2 WHO WILL MEASURE THE SPRINGFLOWS

2.1 The yield of springs is to be physically and regularly checked in the field in order to monitor the spring yields over at least a one year period. It is particularly important to assess the low yield of the dry season of springs and thus to identify the minimum yield. Springflow measurement should be done with the greatest possible accuracy with use of plastic sheet or pipe or chute, a watch with second hand (ideally a stopwatch) and a container of known capacity. The yields may differ from those reported by NESPAK and it is essential that the yields are checked and regularly monitored, at least monthly.

2.2 It is not possible or desirable for project staff to undertake this work every month themselves. The regular measurement of the spring flows should be the responsibility of the village themselves and such activity will promote the villagers interest and commitment to their village project. The extension staff must carefully explain and demonstrate to WSC and other interested villagers as to why flow measurement monitoring is so important. The WSC themselves must then arrange for one or more dependable village member(s) to be responsible for the regular measurement of the springflows. Project staff will give training to the appointed person(s) as to how to make the measurement and how to properly record it. Project staff will periodically collate the results and send them to the Directorate.

2.3 For the first 70 villages, it has been found that NESPAK may not have considered or included all the spring sources or spring eyes which may be present and/or be available to the village. There may be additional sources nearby and/or downstream of the identified source which may also be incorporated into the source assessment and be incorporated into the design as required.

3 HOW TO MAKE THE MEASUREMENT

3.1 The simplest method of measuring the flow is to time how long it takes to fill a container of known volume. This method can be used for flows ranging:

- up to 0.25 litres/sec. using a 1 litre sized jug,
- up to 3 litres/sec. using a 10 litre sized bucket, and
- up to 60 litres/sec. using a 45 gallon (205 Litre) drum.

3.2 The flow can be measured in litres per second (lps) or in gallons per minute (gpm) or other any other unit which can later be converted to lps or gpm. Most villagers will be familiar with the imperial system or gallons. It is likely that there will be available within a nearby house an accurate container that is used for measuring fluids such as milk; this may be in pints or quarts. There may also be readily available a tins in which oil was purchased. These tins are often for 5 kg of oil. Care must be taken to note that although 5 kg of water is equivalent to litres, 5 kg of oil will be more than 5 litres. It is vital that unless the volume is clearly indicated/marked on the container, the internal dimensions (length, breadth, and depth) of the container is measured and recorded.

3.3 It is essential that all of the flow is directed and goes into the container and that none splashes out. The measurement should be taken at least three times and the average should then be taken as the correct flow. If there is a large discrepancy between the three readings, say more than 10%, then more readings should be taken again in order to reduce the error.

3.4 It is easiest to use this method when all the flow has been diverted through a short length of pipe or channel. The channel may be made up from metal or plastic sheeting. The container is then placed below the end of the pipe or channel. It may be necessary to modify the spring or stream channel by building a small dam of stones and clay through which the pipe or channel passes. The important thing is to make sure there are no leaks and that all the water goes through the pipe or along the channel. A small hole/shallow depression may have to be dug into the stream bed beneath the end of the pipe to place the container in.

3.5 The measurements must then be recorded on the standard springflow monitoring proforma, sample attached.

ANNEXURE 8.2

LG&RDD RWSS (IDA) AJK – SPRINGFLOW MONITORING

District______________ Markaz________________ Month________________Year______________________

VILLAGE NO	NAME OF VILLAGE	NAME OF SCHEME	SR.NO	NAME OF SPRING	CONTAINER		MEASURED ON (DATE)	GPM	MEASURED BY	REMARKS
					VOLUME	TIME				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)

Checked and submitted by: Name______________ Desig._________ Signature.____________ Date:___________

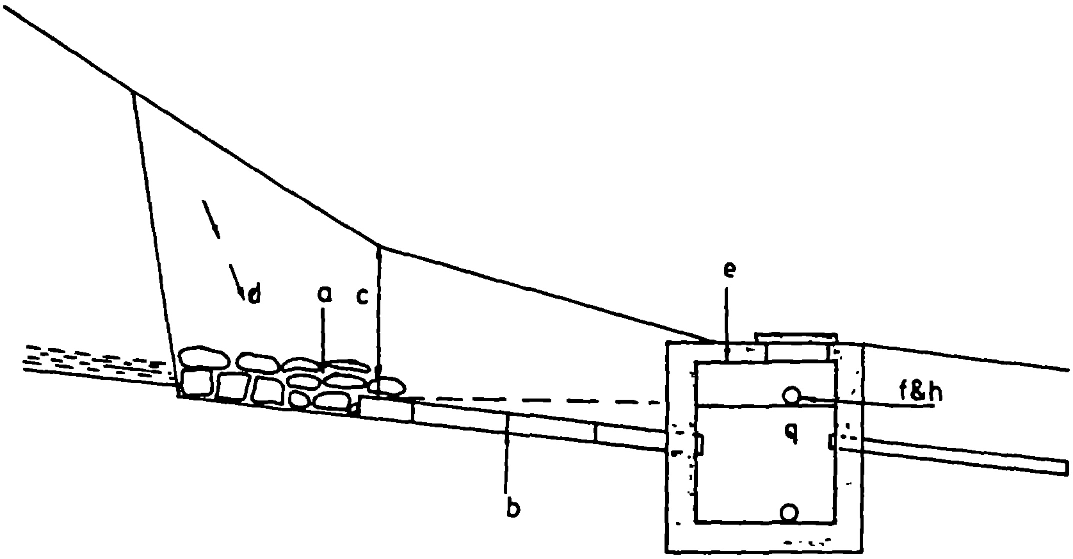
Notes for Col. Nos.

1. The AEs should write the village No or advise the PMs.
2. Give the name of the village same as it is in the revenue record.
3. One network is to be taken as one scheme.
4. Each spring will be given separate serial number. This same serial number should be repeated in all future monthly reports.
5. Most of the springs have names, where one has not then give name of the settlement in which spring situates.
6. Use a container which can be simply measured. Filled up volume should be measured with as much accuracy as possible. The AEs should advise the subordinate staff.
7. Give time in minutes and seconds. Take at least three measurements and make one average time of all three.
8. Give date, month and year as, Day/Mon/Yr. Date should be same in every month or in same week at least.
9. Change measurement into gallons per minute based on data of columns 6 and 7.
10. Write the name and status of the person who took measurement.

The completed form must be checked by the AE and copy sent to the Team Leader, TAU Binnie Hunting Techred, Box.77 Muzaffarabad, at the end of each month.

FIGURES

Common Mistakes on Protecting Spring Catchments



a)	permeable cover	surface water can pollute the spring water
b)	leakage from pipe joints	
c)	covering over the spring is inadequate	
d)	no surface water drainage	
e)	chamber cover should be above ground level	
f)	position of overflow too high	obstruction to spring flow
g)	position of outlet too high	
h)	no wire-mesh covering the overflow	animals or dirt can pollute the spring water

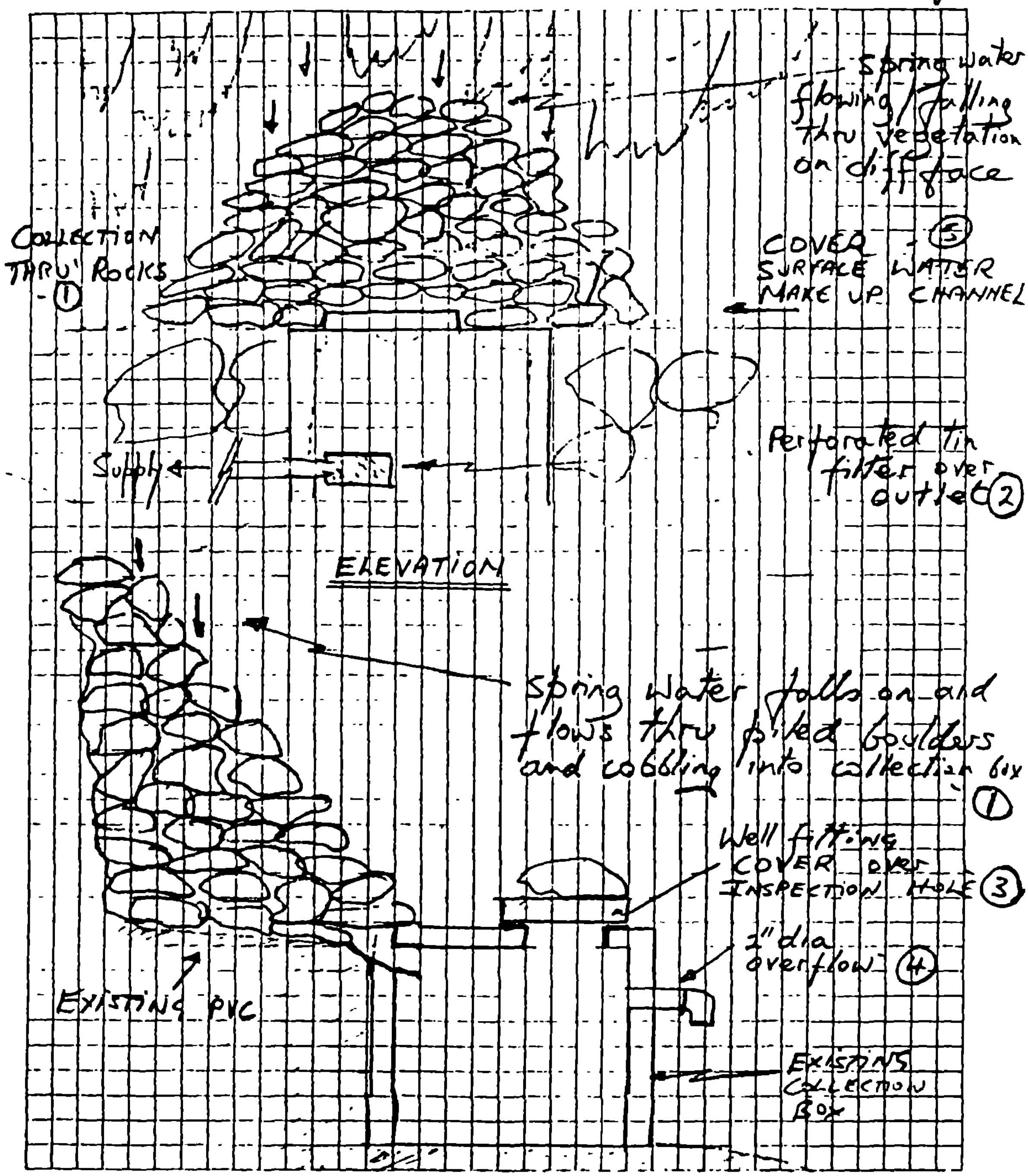
FIGURE 8·1 Common Mistakes on Protecting Spring Catchments

BINNIE, HUNTING, TECHRED JOINT VENTURE
Rural Water Supply & Sanitation Project

Date 3/6/94 Page ____ of ____

Job HAIL - PATTI WALA TAKKI Job No 5305-2 Calc by JTA

Subject SOURCE PROTECTION Chkd. MM



SECTION

Notes:
Remedial/Completion works: (1) PILED BOULDER/COBBLES
(2) OUTLET FILTER
(3) WELL FITTING COVER
(4) PLACE OVERFLOW
(5) COVER SURFACE WATER CHANNEL

FIGURE 8·2 Sketch of Spring Protection - Hale: Patti Wala Takki

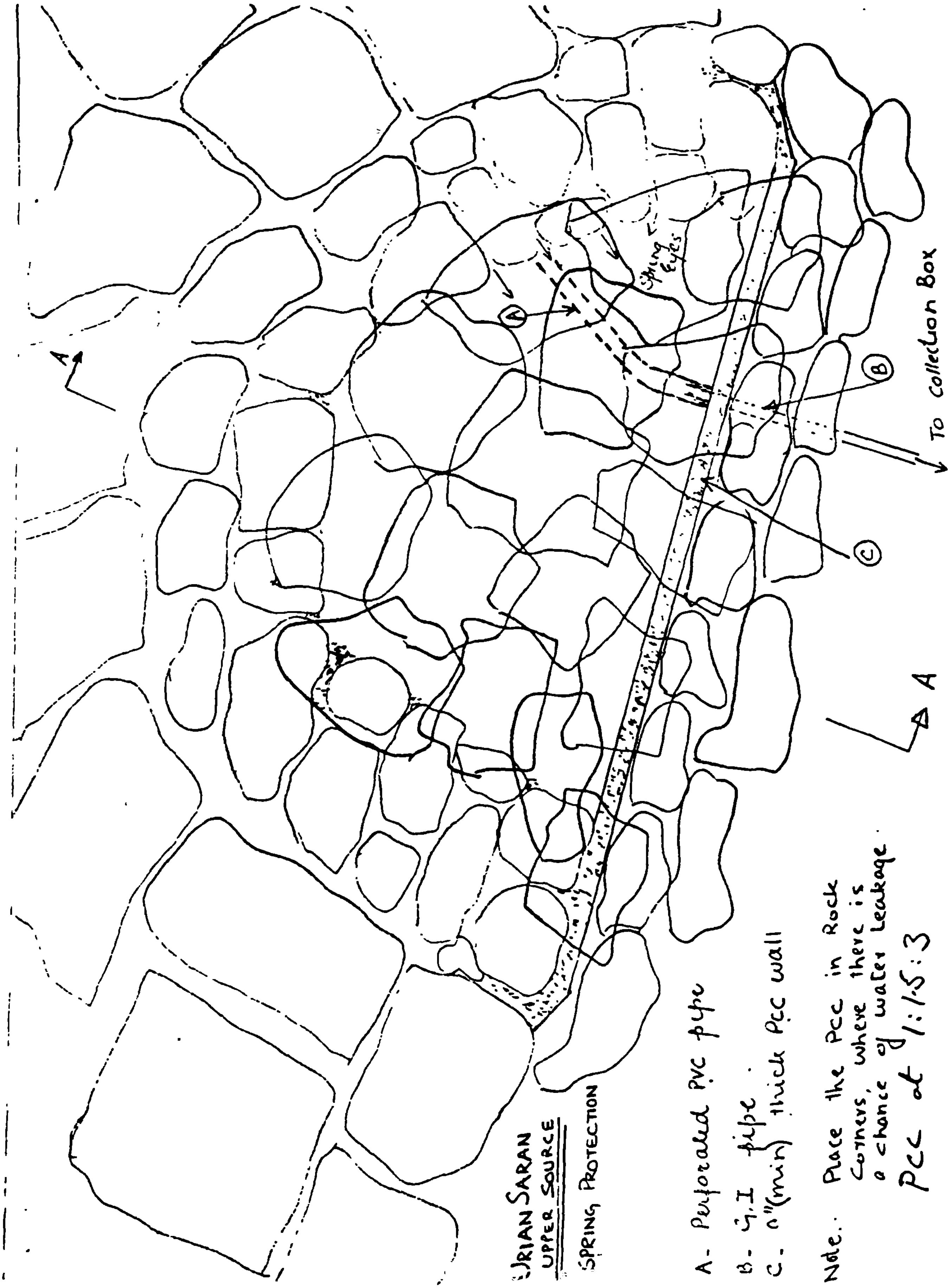


FIGURE 8·3 **Sketch of Spring Protection – Urnian Saran & Battlian Upper Spring (Plan)**

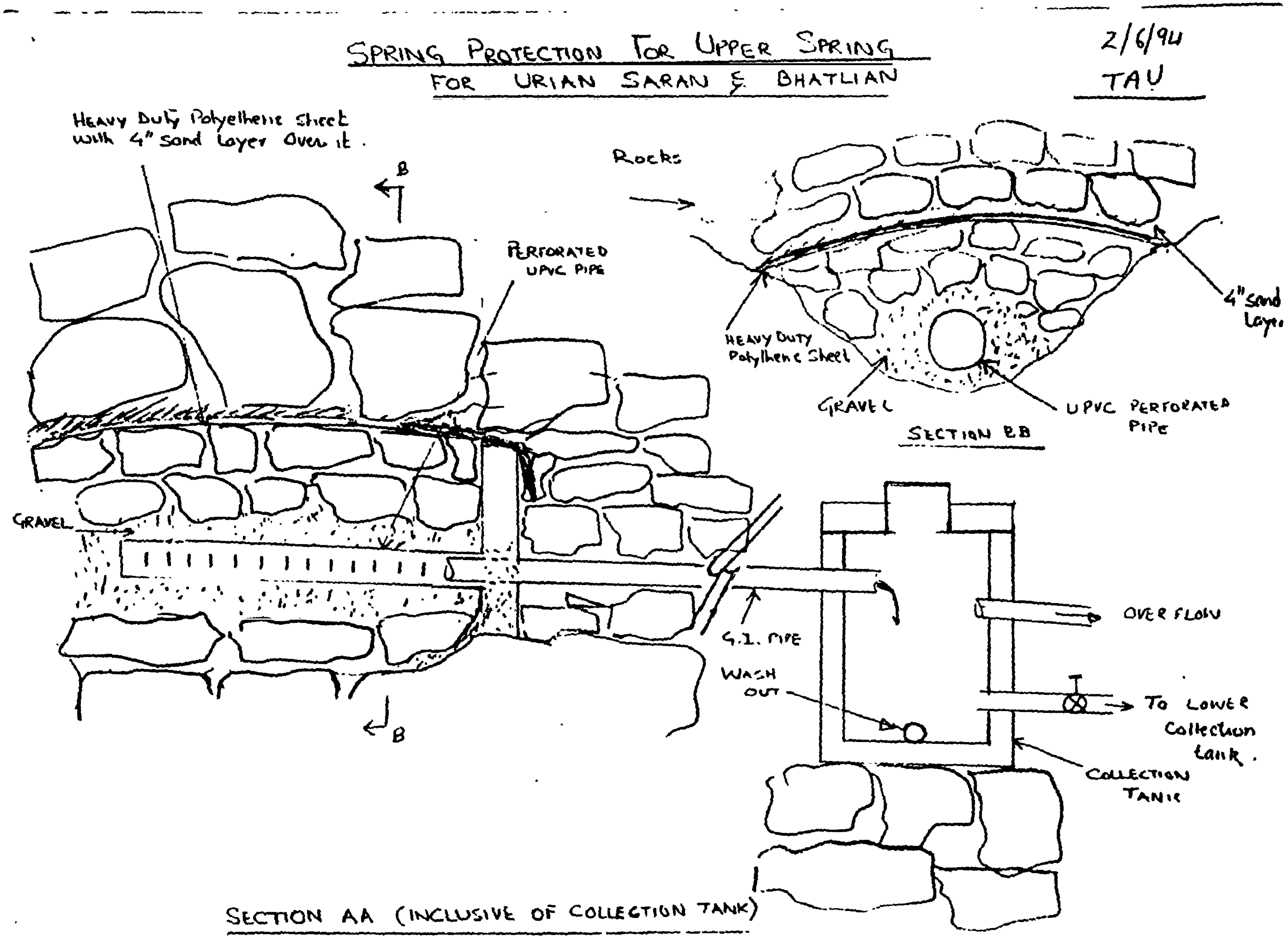


FIGURE 8.4 Sketch of Spring Protection - Urian Saran & Battlian Upper Spring (Section A - A)

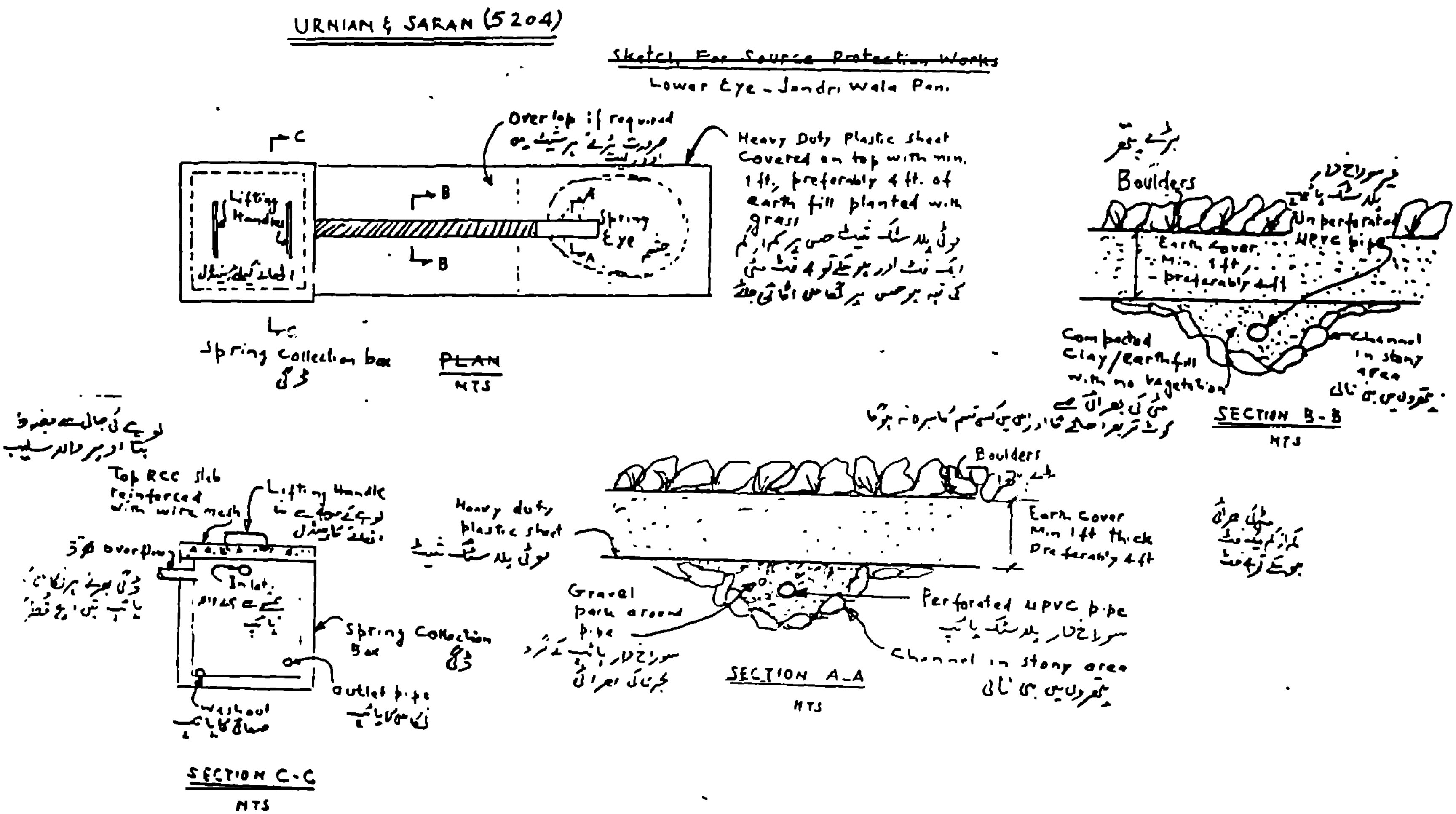


FIGURE 8.5 Sketch of Spring Protection - Urnian Saran & Battlian Lower Spring

Chapter 9

DESIGN NOTE FOR WATER STORAGE TANKS

CHAPTER 9

DESIGN NOTE FOR WATER STORAGE TANKS

CONTENTS

ANNEXURE 9.1

ESTIMATED DETAILED QUANTITIES FOR WATER STORAGE TANKS

CONTENTS

CHAPTER 9

DESIGN NOTE FOR WATER STORAGE TANKS

1 INTRODUCTION

1.1 This chapter refers to the TAU drawings pertaining to water storage tanks of 1000 -20000 gallons capacity as under:

(i) 1000 - 4500 gallons to be funded and built by the community; and

(ii) 5000 - 20000 gallons to be funded and built by the LG&RD department, Government of AJ&K.

1.2 Design for the water storage tanks 1000 - 20000 gallons is based on the following main options. These options are given to village WSC to select depending on their local conditions with advise from the Assistant Engineer:

(i) Stone Masonry Retaining Wall Structure;
(ii) Brick Masonry Retaining Wall Structure; and
(iii) RCC Cantilever and Brick Wall Structure.

1.3 Stone masonry water storage tanks have further two sub-options as follows:

(i) Simple stone Masonry (1000-4500 gallons)
(ii) Stone Masonry with PCC Core wall (5000-20000 gallons)

1.4 Selection for any of the above mentioned options for the required capacity of water tank depends on the following:

(i) Site conditions; and
(ii) Availability of materials at site with respect to cost.

1.5 This chapter sets out the general procedure to select the type and sizing of required water storage tank and the use of TAU drawings.

2 LIST OF DRAWINGS

2.1 A list of TAU drawings pertaining to water storage tanks with its titles is as under for ready reference to use:

TAU/010	Simple Stone Masonry & Brick Work Retaining Wall Structure for 1000 - 4500 gallons Water Storage Tanks;
TAU/011	Details for 1000 - 4500 gallons Water Storage Tanks;
TAU/012	Stone Masonry Retaining Wall Structure For 5000 - 20000 gallons Water Storage Tanks;
TAU/013	RCC Cantilever & Brick Wall Structure for 5000 - 20000 gallons Water Storage Tanks;
TAU/014	Structural Drawing for RCC Base Slab 5000 - 20000 gallons Stone Masonry & RCC Water Storage Tanks;
TAU/015	Structural Drawing for RCC Roof Slab 5000 - 20000 gallons Stone Masonry & RCC Water Storage TanKs;
TAU/016	Details for 5000 - 20000 gallons Stone Masonry & RCC Water Storage Tanks;
TAU/017	Pipe Schedule for 1000 - 20000 gallons Water Storage Tanks; and
TAU/018	Water Storage Tanks - Option for CGI roofing.

3 NOTE ON DESIGN AND COST OPTIMISATION

3.1 Water depth is the most sensitive factor for the retaining/cantilever wall structure which influences the cost of water storage tank. Detailed study for the cost optimisation of all types of water storage tanks was carried out by analyzing a range of water depths for 1000 - 20000 gallons capacities.

3.2 Detailed analyses shows a pattern which gives a minimum cost at a certain depth of water either side of which there is an increase in cost. The water depth at which the cost of each type of water tank is at a minimum is called the cost optimised depth and in turn this establishes the cost optimisation of the water storage tank design.

3.3 The following are the cost optimised water depths for each type and capacity, thereof:

For 1000 - 4500 gallons Water Storage Tank

(i)	Brick Work Retaining Wall Structure	3 Ft - 03 In
(ii)	Simple Stone Masonry Retaining Wall Structure	4 Ft - 09 In

For 5000 - 20000 gallons Water Storage Tank

(i)	Stone Masonry Retaining wall Structure	7 Ft - 06 In
(ii)	Rcc Cantilever Wall & Brick Work Structure	7 Ft - 06 In

4 SELECTION OF WATER TANK CAPACITY

4.1 Water storage capacities and tank locations required for the scheme are calculated in accordance with the design criteria set out for the purpose.

4.2 If the calculated capacity of water tank lies within the range of 1000-4500 gallons the tank may be of either Simple stone masonry or Brick masonry. The following schedule of tank capacities for construction should be observed.

(i) 1000 gallons
(ii) 1500 gallons
(iii) 2000 gallons
(iv) 2500 gallons
(v) 3000 gallons
(vi) 3500 gallons
(vii) 4000 gallons
(viii) 4500 gallons

4.3 By example the following schedule shows a pattern of selection for the water capacity calculated against that to be provided.

Calculated Capacity		Provided Capacity
- 2800 gallons	Select	3000 gallons
- 3200 gallons	Select	3500 gallons
- 4200 gallons	Select	4500 gallons
- 4550 gallons	Select	5000 gallons capacity to be built by LG&RDD

4.4 If the calculated capacity of water tank lies in the range of 5000 to 20000 gallons the tank may have either a Stone masonry retaining wall or RCC cantilever wall with brick work. The tank capacity provided should be selected as the next highest thousand gallon with the increment of 1000 gallons.

4.5 By example the following schedule shows a pattern of selection for the water capacity calculated against that to be provided.

Calculated Capacity		Provided Capacity
- 5100 gallons	Select	6000 gallons
- 6900 gallons	Select	7000 gallons
- 15200 gallons	Select	16000 gallons

5 AVAILABILITY OF LAND AND LAND REQUIREMENT

5.1 The availability and orientation of land at site will determine the actual length and breadth of water storage tank. Three different standard length to breadth ratios are available for each design of water storage tanks. The plan area of the site is to be surveyed and drawn out on sketched scale plan. (1" to 3')

5.2 Cost optimised designs for each type of structure have been produced with three different length to breadth ratios (L/B) i.e 1:1, 1.5:1 & 2:1. **A schedule for the selection of internal dimensions for three length to breadth ratios is shown on each General Arrangement drawing for the different types of water storage tank. (See drawings TAU/010, TAU/012, and TAU/013).**

6 PROCEDURES OF USING THE DRAWINGS

To select capacity, type & concerned set of drawings

6.1 Decide the capacity and type of water tank to be built at site as in Chapter 2 "Design Criteria" of this manual. Determine with WSC the cost and availability of material and site conditions and then select the most appropriate option.

6.2 Following the final selection of type for water tank and agreed by the WSC, the following drawings should be consulted with respect to each type of tank.

CAPACITY	TYPE OF WATER TANK	DRAWING NOS
1000-4500 Gallons	Brick & Simple Stone Masonry Structure.	010 ; 011
5000-20000 Gallons	Stone Masonry with PCC Core Wall	012 ; 014 015 ; 016
5000-20000 Gallons	RCC Cantilever & Brick Wall Structure	013 ; 014 015 ; 016

6.3 Identify the relevant set(s) of standard drawings to the village scheme requirements. Note that the above drawings 010, 012 & 013 are the general arrangement (G.A) drawings for each type.

6.4 Two sets of the selected relevant drawings for each tank to be constructed are to be obtained from the Executive Engineer. Both sets are to be marked up to make them specific to the location and hydraulic design. One set is to be issued to the WSC and one set retained by the overseer supervising construction.

Calculation of land area for the required capacity of water storage tank

6.5 For the given type of water tank note down the internal dimensions from the Schedule Of Internal Dimensions on the relevant drawing. There is an option for three length and breadth ratios depending on the orientation of piece of land at site. Select the best suited L/B ratio to the piece of land available.

6.6 Add the following to the internal dimension taken from the relevant GA drawing:

a) Two times the width of the foundation/retaining wall/ tank wall at the base.

b) Two times the thickness of internal plaster i.e 1.5 inches.

c) The sum of these will give net dimensions for the piece of land required for tank construction.

6.7 Cross reference to the sketched scale plan and confirm that the land is both available and suitable for these dimensions

7 BILL OF QUANTITIES

7.1 The Bill of Quantities (BOQ) for the water storage tanks are identified in two groups:

Construction Material

7.2 Quantities for the construction materials shown on the drawings for each type of three L/B ratios have been calculated. Refer to the annexed document on "Estimated Detailed Quantities For Water Storage Tank" which covers comprehensive schedule of quantities alongwith the summary of materials and cost for the approved drawings of water storage tanks. This document is self explanatory.

Pipe and Fitting Materials

7.3 All the fittings alongwith different lengths of pipe required for all types of tanks are standardised. A comprehensive pipe schedule is given on the pipe schedule drawing no TAU/017. It is intended that the pipe and fitting may be procured with the pipe order so that special lengths are pre cut and threaded. Specialist tasks such as the welding of pipe fixing flanges will however be required in local workshops.

7.4 Each item on the BOQ is allocated with a four digit item code number. The first two digits are the "prefix" codes of which first digit represents the item diameter and the second digit represents the pipe material. The last two digits indicates the item "suffix" codes for the actual item description.

7.5 The item which is allocated with four digits code is standard item used for all water storage tank construction sites. The items which are allocated with only two digit in circle denotes item "suffix" only. This items are site specific and complete four digit codes are assigned after the determination of item diameter and pipe material.

7.6 By example; if the diameter of inlet pipe to the water storage tank is 2", the first two digits will be "60" for all the items shown under the pipe schedule for inlet pipe.

7.7 The items which are indicated in the range of code numbers such as 40 to 48 indicated that any item from item suffix codes 40 to 48 can be used. These items are site specific and first two digits for the prefix code are to be assigned after the determination of item dia and pipe material.

8 IMPORTANT POINTS TO REMEMBER DURING CONSTRUCTION OF WATER TANKS

8.1 Always refer to concerned chapters in this construction manual.

8.2 Read carefully all the notes on each of the concerned drawings and keep strict to those notes.

8.3 Structural details must be read and implemented very carefully. Checks of steel fixing by the competent supervisor must be made before placing concrete. This competent supervisor should be present throughout any major concrete pours.

8.4 All pipes and steel rungs in the tank as shown in the drawings must be fixed during the course of construction in sequence and not after the completion of masonry / concrete work.

9 WORKS PROCUREMENT

9.1 For the construction of water storage tanks work procurement can proceed in the following ways:

(i) Direct labour recruited and managed by the WSC.
(ii) Identification, Selection and appointment of contractors by individual WSC.
(iii) Pre-qualification and tendering of contractors by LG&RDD for construction of water storage tanks in each district, division or statewide.

9.2 Presently, tanks are built under procedures i) and ii) above. Considerations of procedure iii) for the construction of large tanks using pre-qualified contactors from 5000 gallons funded by LG&RDD is under way within the Directorate.

10 CONSTRUCTION TIME

10.1 The time required for the construction is variable with the type and capacity of water storage tank. From the experience at various construction sites, construction time after availability of materials is 45, 60 and 75 days approximately for 5000, 10000, and 20000 gallons water storage tank respectively. This time may be slightly longer in case of stone masonry and lesser for the RCC/Brick wall tanks.

ANNEXURES

ANNEXURE 9.1

ESTIMATED DETAILED QUANTITIES FOR WATER STORAGE TANKS

1 INTRODUCTION

1.1 This document covers comprehensive schedule of quantities along with the summary of materials and costs for the approved drawings of Water Storage (W.S) tanks. W.S tanks were designed in the size range 1000 - 20000 gallons based on the following main options against size range shown in the Table A. This complete document is an annexure 9.1 "Users Note for Water Storage Tank Drawings" of this Construction Manual.

Type of Water Storage Tank	Size Range (Gallons)	Reference Drawings
Simple Stone Masonry	1000-4500	TAU/010, 011
Brick Masonry	1000-4500	TAU/010, 011
Stone Masonry (Core Wall)	5000-20000	TAU/012, 014, 015 and 016
RCC / Brick Masonry	5000-20000	TAU/012, 014, 015 and 016

Table A: Main Options Of W.S Tanks Against Size Range & Reference Drawings

1.2 Each type of water storage tanks mentioned above was designed for three different Length / Breadth (L/B) ratios i.e 1:1, 1.5:1 and 2:1. After the completion of design work, main work was to calculate the quantities of all items involved in each type and L/B ratio of W.S tank cost estimation. All the quantities calculated are for the approved drawings of W.S tanks. The drawings referred to calculate quantities involved are shown against each type of W.S tank in Table A above.

1.3 There are four sections in this annexure 9.1 for each type of W.S tank. Each section contains as follows;

- Summary of Cost Estimate (1 sheet)
- Summary of Materials (1 sheet)
- Detailed Estimate of Quantities and Cost for W.S tank L/B ratio 1:1, 1.5:1 and 2:1 (1 sheet each for first two types of W.S tank and 2 sheets each for last two types of W.S tank indicated in above Table

A).

1.4 As there are four sections for each type of W.S tanks, each section is separated by a title page showing its type and capacity range.

2 BRIEF EXPLANATION OF SHEETS IN SECTIONS

Detailed Estimate For W.S Tank

2.1 In the Detailed Estimate For W.S tank, sheet, the first column shows the capacity of W.S tank along with water depth, whereas the second column indicates size of water storage tank. The dimensions indicated in this sheet are internal.

2.2 In the remaining columns, except the last two columns, each individual item involved is separated by lines with a title along with unit of measurement marked at top. Each item is further divided into further 3 columns bearing titles of "**Qty**", "**Rate**" and "**Cost**".

2.3 **Quantities** calculated in all such columns are for approved drawings for W.S tanks. **Rates** applied are from Composite Schedule Of Rates (CSOR) 1979 at 0 % premium for respective items and **Cost** is result of rates applied to the quantities calculated. Similarly all the quantities and costs are calculated for each type of W.S tanks.

2.4 The second last column of the sheet i.e **Total Cost** is the summation of cost calculated for all items involved for W.S tank. The last column is the **Rate / Gln** (Rate/Gallon) for each capacity of W.S tank. Similarly the calculations are carried out for all three L/B ratios. L/B ratios are indicated at top right side of set in each sheet.

2.5 Sets of quantities calculated will enable the AEs in the Districts to produce quantity estimate for any particular W.S tank. It is also important to note that apart from steel which includes 10% wastage, the quantities calculated are exclusive of wastage.

Summary of Materials

2.6 One sheet for the summary of materials is produced from "Detailed Estimate Sheets" calculated for each L/B ratio as explained above. In the **Summary of Materials**, quantities are tabulated in units available in the market. This summary will help the WSC to easily procure the required materials for the respective capacity of W.S tank. It is also important to note that this Summary of Materials include 5% wastage for all items except for steel which is 10%.

Summary of Costs

2.7 Similarly a **Summary of Costs** is produced from three "Detailed Estimate Sheets" calculated for each L/B ratio as explained above. Cost calculated for each capacity of tank is at 0% premium of CSOR 1979. Rates in the Summary of Costs for each capacity of W.S tank are readily convertible for any premium by multiplying the cost with premium factor and all that is required for cost estimation. By example in order to calculate cost at 240% premium above CSOR 1979, multiply the total cost given in the Summary of Costs (against right capacity and type of tank) by a factor of 3.40 to obtain cost of W.S tank at required premium.

2.8 All the above explained sheets are repeated in each Sections for each type of W.S tank.

WATER STORAGE RESERVOIRS - SUMMARY OF COST ESTIMATES
BRICK MASONRY 1000 - 4500 GALLONS

CAPACITY (IN GALLONS)	LENGTH / BREADTH RATIO					
	1 : 1		1.5 : 1		2 : 1	
	TOTAL COST	RATE / GLNS	TOTAL COST	RATE / GLNS	TOTAL COST	RATE / GLNS
	AT 0% PREM		AT 0% PREM		AT 0% PREM	
FOR 1000	5444	5.44	5359	5.36	5465	5.46
FOR 1500	7043	4.70	6959	4.64	7160	4.77
FOR 2000	8505	4.25	8526	4.26	8788	4.39
FOR 2500	10083	4.03	10078	4.03	10221	4.09
FOR 3000	11430	3.81	11545	3.85	11732	3.91
FOR 3500	12852	3.67	12936	3.70	13123	3.75
FOR 4000	14349	3.59	14367	3.59	14433	3.61
FOR 4500	15520	3.45	15798	3.51	15859	3.52

WATER STORAGE RESERVOIRS – SCHEDULE OF MATERIALS
BRICK MASONRY 1000 – 4500 GALLONS (FOR ALL " L / B " RATIOS)

CAPACITY & DEPTH (Glns)	LENGTH / BREADTH RATIO 1 : 1 BRICK WORK (Cft)	BRICK WORK Brick (Nos)	CEMENT (Kgs)	CEMENT (Bags) (Nos)	SAND (Cft)	AGG. (Cft)	STEEL (Kgs)	LENGTH / BREADTH RATIO 1.5 : 1 BRICK WORK (Cft)	BRICK WORK Brick (Nos)	CEMENT (Kgs)	CEMENT (Bags) (Nos)	SAND (Cft)	AGG. (Cft)	STEEL (Kgs)	LENGTH / BREADTH RATIO 2 : 1 BRICK WORK (Cft)	BRICK WORK Brick (Nos)	CEMENT (Kgs)	CEMENT (Bags) (Nos)	SAND (Cft)	AGG. (Cft)	STEEL (Kgs)
FOR 1000 3 25	264	3824	1998	40	131	87	193	264	3824	1963	39	130	85	187	273	3956	2008	40	133	85	188
FOR 1500 3.25	318	4615	2537	51	164	118	268	318	4615	2513	50	163	116	262	332	4813	2592	52	169	118	266
FOR 2000 3 25	364	5274	3032	61	194	147	340	368	5340	3045	61	194	147	338	386	5604	3150	63	203	150	343
FOR 2500 3 25	409	5934	3561	71	225	180	421	414	6000	3567	71	225	178	417	427	6197	3630	73	231	179	417
FOR 3000 3 25	446	6461	4008	80	251	208	492	455	6593	4056	81	252	209	493	473	6857	4139	83	261	210	492
FOR 3500 3 25	482	6989	4478	90	278	238	568	491	7120	4516	90	279	238	567	509	7384	4599	92	288	239	566
FOR 4000 3 25	518	7516	4968	99	307	270	650	532	7714	4995	100	306	268	641	541	7846	5029	101	313	267	638
FOR 4500 3 25	546	7912	5351	107	328	296	715	573	8307	5474	109	330	297	714	577	8373	5499	110	340	298	715

NOTES .–

1. Refer to the drawing numbers TAU/010 and TAU/011
2. Schedule includes 5% wastage for all the items except for steel which is 10%.

BRICK MASONRY
1000 - 4500 GALLONS
ESTIMATED QUANTITIES AND COST

WATER STORAGE RESERVOIR - COST ESTIMATE
(AT 0% PREMIUM ON COMPOSITE SCHEDULE OF RATES 1979)
BRICK MASONRY: 1000 - 4500 GALLONS

LENGTH / BREADTH RATIO 1 : 1

WATER HEIGHT (FT)	INTERNAL DIM (FT) B x L	BRICK MASONRY RATE PER CFT			BASE SLAB CONCRETE PER CFT			BASE SLAB STEEL PER KG			TOTAL	ROOF SLAB CONCRETE PER CFT			ROOF SLAB STEEL PER KG			TOTAL	PCC CORE WALL CONCRETE PER CFT			LAND COST PER SQFT			EXCAVATION COST PER 1000 CFT			PLASTERING 1:5 COST PER 100 SQFT			PLASTERING 1:2 COST PER 100 SQFT			TOTAL	POINTING 1:3 COST PER 100 SQFT			PCC AT BASE 1:4:8 COST PER 100 CFT			TOTAL	RATE
		QTY	RATE	COST	QTY	RATE	COST	QTY	RATE	COST	COST	QTY	RATE	COST	QTY	RATE	COST	COST	QTY	RATE	COST	AREA	RATE	COST	QTY	RATE	COST	QTY	RATE	COST	QTY	RATE	COST	COST	QTY	RATE	COST	QTY	RATE	COST	COST	PER GALS
FOR 1000 3.25	7.25	264	8.69	2292	26	17.65	464	79	6.53	516	980	38	21.05	792	114	6.53	746	1537	0.00	15.04	0	248	0.00	0	158	0.18	29	138	0.79	109	138	0.92	127	236	138	0.75	103	27	9.90	266	5444	5.44
FOR 1500 3.25	8.75	318	8.69	2767	38	17.65	676	115	6.53	752	1428	50	21.05	1061	153	6.53	1000	2061	0.00	15.04	0	298	0.00	0	196	0.18	36	166	0.79	131	166	0.92	153	284	166	0.75	125	35	9.90	343	7043	4.70
FOR 2000 3.25	10.00	364	8.69	3162	50	17.65	883	150	6.53	983	1865	63	21.05	1316	190	6.53	1240	2556	0.00	15.04	0	342	0.00	0	230	0.18	42	190	0.79	150	190	0.92	175	325	190	0.75	143	42	9.90	413	8505	4.25
FOR 2500 3.25	11.25	409	8.69	3557	63	17.65	1117	190	6.53	1244	2361	76	21.05	1598	231	6.53	1505	3104	0.00	15.04	0	390	0.00	0	265	0.18	48	214	0.79	169	214	0.92	197	366	214	0.75	160	49	9.90	487	10083	4.03
FOR 3000 3.25	12.25	446	8.69	3875	75	17.65	1324	226	6.53	1475	2799	88	21.05	1844	266	6.53	1737	3581	0.00	15.04	0	431	0.00	0	294	0.18	54	233	0.79	184	233	0.92	214	398	233	0.75	175	36	9.90	351	11430	3.81
FOR 3500 3.25	13.25	482	8.69	4189	88	17.65	1549	264	6.53	1725	3274	100	21.05	2107	304	6.53	1985	4092	0.00	15.04	0	475	0.00	0	324	0.18	59	252	0.79	199	252	0.92	232	431	252	0.75	189	62	9.90	618	12832	3.67
FOR 4000 3.25	14.25	518	8.69	4505	102	17.65	1792	306	6.53	1995	3787	113	21.05	2388	344	6.53	2249	4637	0.00	15.04	0	518	0.00	0	355	0.18	65	271	0.79	214	271	0.92	249	463	271	0.75	203	69	9.90	688	14349	3.59
FOR 4500 3.25	15.00	546	8.69	4743	113	17.65	1986	339	6.53	2211	4197	124	21.05	2610	376	6.53	2458	5068	0.00	15.04	0	552	0.00	0	380	0.18	69	285	0.79	225	285	0.92	263	488	285	0.75	214	75	9.90	743	15620	3.45

LENGTH / BREADTH RATIO 1.5 : 1

WATER HEIGHT (FT)	INTERNAL DIM (FT) B x L	BRICK MASONRY RATE PER CFT			BASE SLAB CONCRETE PER CFT			BASE SLAB STEEL PER KG			TOTAL	ROOF SLAB CONCRETE PER CFT			ROOF SLAB STEEL PER KG			TOTAL	PCC CORE WALL CONCRETE PER CFT			LAND COST PER SQFT			EXCAVATION COST PER 1000 CFT			PLASTERING 1:5 COST PER 100 SQFT			PLASTERING 1:2 COST PER 100 SQFT			TOTAL	POINTING 1:3 COST PER 100 SQFT			PCC AT BASE 1:4:8 COST PER 100 CFT			TOTAL	RATE
		QTY	RATE	COST	QTY	RATE	COST	QTY	RATE	COST	COST	QTY	RATE	COST	QTY	RATE	COST	COST	QTY	RATE	COST	AREA	RATE	COST	QTY	RATE	COST	QTY	RATE	COST	QTY	RATE	COST	COST	QTY	RATE	COST	QTY	RATE	COST	COST	PER GALS
FOR 1000 3.25	5.75 8.75	264	8.69	2292	25	17.65	444	76	6.53	494	938	37	21.05	772	111	6.53	727	1499	0.00	15.04	0	246	0.00	0	157	0.18	29	138	0.79	109	138	0.92	127	236	138	0.75	103	27	9.90	262	5359	5.36
FOR 1500 3.25	7.25 10.25	318	8.69	2767	37	17.65	656	112	6.53	730	1386	49	21.05	1042	150	6.53	981	2022	0.00	15.04	0	295	0.00	0	195	0.18	36	166	0.79	131	166	0.92	153	284	166	0.75	125	34	9.90	339	6959	4.64
FOR 2000 3.25	8.25 12.00	368	8.69	3201	50	17.65	874	149	6.53	973	1846	62	21.05	1312	189	6.53	1234	2548	0.00	15.04	0	343	0.00	0	231	0.18	42	192	0.79	152	192	0.92	177	329	192	0.75	144	42	9.90	414	8526	4.26
FOR 2500 3.25	9.25 13.50	414	8.69	3596	62	17.65	1102	188	6.53	1227	2329	75	21.05	1589	229	6.53	1496	3085	0.00	15.04	0	391	0.00	0	264	0.18	49	216	0.79	171	216	0.92	199	370	216	0.75	162	49	9.90	488	10078	4.03
FOR 3000 3.25	10.00 15.00	455	8.69	3952	75	17.65	1324	226	6.53	1474	2798	88	21.05	1853	267	6.53	1746	3599	0.00	15.04	0	435	0.00	0	298	0.18	55	238	0.79	188	238	0.92	219	406	238	0.75	178	56	9.90	557	11545	3.85
FOR 3500 3.25	10.75 16.25	491	8.69	4268	87	17.65	1542	263	6.53	1717	3258	100	21.05	2109	304	6.53	1987	4096	0.00	15.04	0	476	0.00	0	328	0.18	60	257	0.79	203	257	0.92	236	439	257	0.75	192	63	9.90	622	12936	3.70
FOR 4000 3.25	10.75 18.50	532	8.69	4624	99	17.65	1755	299	6.53	1954	3709	112	21.05	2366	341	6.53	2228	4594	0.00	15.04	0	520	0.00	0	360	0.18	66	278	0.79	219	278	0.92	256	475	278	0.75	208	70	9.90	690	14567	3.59
FOR 4500 3.25	10.75 20.75	575	8.69	4980	112	17.65	1969	336	6.53	2191	4160	125	21.05	2632	378	6.53	2470	5092	0.00	15.04	0	563	0.00	0	392	0.18	72	299	0.79	236	299	0.92	276	512	299	0.75	224	77	9.90	758	15798	3.51

LENGTH / BREADTH RATIO 2 : 1

WATER HEIGHT (FT)	INTERNAL DIM (FT) B x L	BRICK MASONRY RATE PER CFT			BASE SLAB CONCRETE PER CFT			BASE SLAB STEEL PER KG			TOTAL	ROOF SLAB CONCRETE PER CFT			ROOF SLAB STEEL PER KG			TOTAL	PCC CORE WALL CONCRETE PER CFT			LAND COST PER SQFT			EXCAVATION COST PER 1000 CFT			PLASTERING 1:5 COST PER 100 SQFT			PLASTERING 1:2 COST PER 100 SQFT			TOTAL	POINTING 1:3 COST PER 100 SQFT			PCC AT BASE 1:4:8 COST PER 100 CFT			TOTAL	RATE
		QTY	RATE	COST	QTY	RATE	COST	QTY	RATE	COST	COST	QTY	RATE	COST	QTY	RATE	COST	COST	QTY	RATE	COST	AREA	RATE	COST	QTY	RATE	COST	QTY	RATE	COST	QTY	RATE	COST	COST	QTY	RATE	COST	QTY	RATE	COST	COST	PER GALS
FOR 1000 3.25	5.00 10.00	273	8.69	2371	25	17.65	441	75	6.53	491	933	37	21.05	779	112	6.53	734	1513	0.00	15.04	0	250	0.00	0	161	0.18	29	143	0.79	113	143	0.92	131	244	143	0.75	107	27	9.90	268	5485	5.48
FOR 1500 3.25	6.25 12.00	332	8.69	2885	38	17.65	662	116	6.53	757	1399	50	21.05	1062	153	6.53	1001	2063	0.00	15.04	0	302	0.00	0	202	0.18	37	173	0.79	137	173	0.92	160	297	173	0.75	130	35	9.90	350	7160	4.77
FOR 2000 3.25	7.00 14.25	386	8.69	3359	50	17.65	880	150	6.53	980	1860	64	21.05	1339	193	6.53	1261	2599	0.00	15.04	0	353	0.00	0	240	0.18	44	202	0.79	159	202	0.92	186	345	202	0.75	151	43	9.90	428	8758	4.38
FOR 2500 3.25	8.00 15.50	427	8.69	3715	62	17.65	1094	187	6.53	1218	2313	76	21.05	1594	230	6.53	1505	3099	0.00	15.04	0	396	0.00	0	272	0.18	50	223	0.79	176	223	0.92	206	382	223	0.75	167	50	9.90	498	10221	4.09
FOR 3000 3.25	8.50 17.50	473	8.69	4110	74	17.65	1313	224	6.53	1462	2774	88	21.05	1862	269	6.53	1754	3616	0.00	15.04	0	442	0.00	0	306	0.18	56	247	0.79	195	247	0.92	228	423	247	0.75	185	57	9.90	567	11732	3.91
FOR 3500 3.25	9.25 18.75	509	8.69	4426	87	17.65	1531	261	6.53	1704	3235	101	21.05	2118	305	6.53	1995	4113	0.00	15.04	0	484	0.00	0	336	0.18	62	266	0.79	210	266	0.92	245	455	266	0.75	200	64	9.90	633	13123	3.75
FOR 4000 3.25	10.00 19.75	541	8.69	4703	99	17.65	1743	297	6.53	1941	3684	112	21.05	2364	341	6.53	2226	4590	0.00	15.04	0	525	0.00	0	364	0.18	67	283	0.79	225	283	0.92	260	484	283	0.75	212	70	9.90	694	14433	3.61
FOR 4500 3.25	10.50 21.25	577	8.69	5019	112	17.65	1969	334	6.53	2193	4162	125	21.05	2628	379	6.53	2475	5103	0.00	15.04	0	565	0.00	0	394	0.18	71	302	0.79	238	302	0.92	278	516	302	0.75	226	77	9.90	761	15859	3.52

STONE MASONRY
1000 - 4500 GALLONS
ESTIMATED QUANTITIES AND COST

WATER STORAGE RESERVOIRS – SUMMARY OF COST ESTIMATES
STONE MASONRY 1000 – 4500 GALLONS

CAPACITY (IN GALLONS)	LENGTH / BREADTH RATIO					
	1 : 1		1.5 : 1		2 : 1	
	TOTAL COST	RATE / GLNS	TOTAL COST	RATE / GLNS	TOTAL COST	RATE / GLNS
	AT 0% PREM		AT 0% PREM		AT 0% PREM	
FOR 1000	5076	5.08	5018	5.02	5078	5.08
FOR 1500	6459	4.31	6400	4.27	6560	4.37
FOR 2000	7649	3.82	7704	3.85	7857	3.93
FOR 2500	8914	3.57	8946	3.58	9179	3.67
FOR 3000	10254	3.42	10104	3.37	10349	3.45
FOR 3500	11308	3.23	11319	3.23	11508	3.29
FOR 4000	12404	3.10	12380	3.09	12713	3.18
FOR 4500	13542	3.01	13525	3.01	13806	3.07

WATER STORAGE RESERVOIRS – SCHEDULE OF MATERIALS
STONE MASONRY 1000 – 4500 GALLONS (FOR ALL " L / B " RATIOS)

CAPACITY & DEPTH (Glns)	LENGTH / BREADTH RATIO 1 : 1						LENGTH / BREADTH RATIO 1.5 : 1						LENGTH / BREADTH RATIO 2 : 1					
	STONE WORK	CEMENT		SAND	AGG.	STEEL	STONE WORK	CEMENT		SAND	AGG.	STEEL	STONE WORK	CEMENT		SAND	AGG.	STEEL
	(Cft)	(Kgs)	(Bags) (Nos)	(Cft)	(Cft)	(Kgs)	(Cft)	(Kgs)	(Bags) (Nos)	(Cft)	(Cft)	(Kgs)	(Cft)	(Kgs)	(Bags) (Nos)	(Cft)	(Cft)	(Kgs)
FOR 1000 4.75	290	2307	46	160	63	135	290	2290	46	159	61	131	296	2325	47	162	62	130
FOR 1500 4.75	350	2883	58	197	85	187	350	2866	57	197	83	183	362	2947	59	203	85	185
FOR 2000 4.75	398	3368	67	229	105	235	404	3401	68	229	105	234	416	3480	70	237	106	236
FOR 2500 4.75	446	3874	77	261	127	289	452	3901	78	261	126	286	470	4021	80	272	128	288
FOR 3000 4.75	495	4402	88	294	151	348	495	4359	87	292	147	337	513	4483	90	301	149	340
FOR 3500 4.75	531	4813	96	320	170	396	537	4833	97	320	169	392	555	4941	99	330	169	391
FOR 4000 4.75	567	5235	105	346	191	447	573	5246	105	345	188	440	597	5412	108	360	191	445
FOR 4500 4.75	603	5670	113	373	212	501	609	5683	114	372	210	495	633	5834	117	386	212	496

NOTES :–

1 Refer to the drawing numbers TAU/010 and TAU/011

2 Schedule includes 5% wastage for all the items except for steel which is 10%.

WATER STORAGE RESERVOIR - COST ESTIMATE
(AT 0% PREMIUM ON COMPOSITE SCHEDULE OF RATES 1979)
STONE MASONRY 1000 - 4500 GALLONS

LENGTH / BREADTH RATIO 1 : 1

WATER HEIGHT (FT)	INTERNAL DIM (FT) B x L	STONE MASONRY RATE PER CFT QTY	RATE	COST	BASE SLAB CONCRETE PER CFT QTY	RATE	COST	BASE SLAB STEEL PER KG QTY	RATE	COST	TOTAL COST	ROOF SLAB CONCRETE PER CFT QTY	RATE	COST	ROOF SLAB STEEL PER KG QTY	RATE	COST	TOTAL COST	PCC CORE WALL CONCRETE PER CFT QTY	RATE	COST	LAND COST PER SQFT AREA	RATE	COST	EXCAVATION COST PER 1000 CFT QTY	RATE	COST	PLASTERING 1:3 COST PER 100 SQFT QTY	RATE	COST	PLASTERING 1:2 COST PER 100 SQFT QTY	RATE	COST	TOTAL COST	POINTING 1:3 COST PER 100 SQFT QTY	RATE	COST	PCC AT BASE 1:4:8 COST PER 100 CFT QTY	RATE	COST	TOTAL COST	RATE PER GLN
FOR 1000 4.75	6.00	290	9.48	2744	18	17.65	318	54	6.53	354	671	27	21.05	561	81	6.53	529	1090	0	15.04	0	210	0.00	0	128	0.18	23	138	0.79	109	138	0.92	127	236	138	0.75	104	21.00	9.90	208	5076	5.08
FOR 1500 4.75	7.25	350	9.48	3315	26	17.65	464	79	6.53	516	980	36	21.05	750	108	6.53	707	1457	0	15.04	0	248	0.00	0	158	0.18	29	167	0.79	132	167	0.92	154	285	167	0.75	126	26.89	9.90	266	6459	4.31
FOR 2000 4.75	8.25	398	9.48	3773	34	17.65	601	102	6.53	669	1269	44	21.05	921	133	6.53	868	1789	0	15.04	0	281	0.00	0	183	0.18	33	190	0.79	150	190	0.92	175	325	190	0.75	143	31.97	9.90	316	7649	3.82
FOR 2500 4.75	9.25	446	9.48	4230	43	17.65	755	129	6.53	841	1596	53	21.05	1110	160	6.53	1045	2156	0	15.04	0	315	0.00	0	209	0.18	38	213	0.79	168	213	0.92	196	364	213	0.75	160	37.39	9.90	370	8914	3.57
FOR 3000 4.75	10.25	495	9.48	4687	53	17.65	927	158	6.53	1032	1960	63	21.05	1316	190	6.53	1240	2556	0	15.04	0	352	0.00	0	236	0.18	43	236	0.79	186	236	0.92	217	403	236	0.75	178	43.14	9.90	427	10254	3.42
FOR 3500 4.75	11.00	531	9.48	5030	61	17.65	1068	182	6.53	1189	2257	70	21.05	1482	214	6.53	1396	2878	0	15.04	0	380	0.00	0	258	0.18	47	253	0.79	200	253	0.92	233	433	253	0.75	191	47.67	9.90	472	11308	3.23
FOR 4000 4.75	11.75	567	9.48	5373	69	17.65	1218	208	6.53	1357	2575	79	21.05	1658	239	6.53	1562	3220	0	15.04	0	410	0.00	0	279	0.18	51	270	0.79	213	270	0.92	249	462	270	0.75	203	52.39	9.90	519	12404	3.10
FOR 4500 4.75	12.50	603	9.48	5716	78	17.65	1379	235	6.53	1535	2914	88	21.05	1844	266	6.53	1737	3581	0	15.04	0	441	0.00	0	301	0.18	55	288	0.79	227	288	0.92	265	492	288	0.75	216	57.29	9.90	567	13542	3.01

LENGTH / BREADTH RATIO 1.5 : 1

WATER HEIGHT (FT)	INTERNAL DIM (FT)	STONE MASONRY RATE PER CFT QTY	RATE	COST	BASE SLAB CONCRETE PER CFT QTY	RATE	COST	BASE SLAB STEEL PER KG QTY	RATE	COST	TOTAL COST	ROOF SLAB CONCRETE PER CFT QTY	RATE	COST	ROOF SLAB STEEL PER KG QTY	RATE	COST	TOTAL COST	PCC CORE WALL CONCRETE PER CFT QTY	RATE	COST	LAND COST PER SQFT AREA	RATE	COST	EXCAVATION COST PER 1000 CFT QTY	RATE	COST	PLASTERING 1:3 COST PER 100 SQFT QTY	RATE	COST	PLASTERING 1:2 COST PER 100 SQFT QTY	RATE	COST	TOTAL COST	POINTING 1:3 COST PER 100 SQFT QTY	RATE	COST	PCC AT BASE 1:4:8 COST PER 100 CFT QTY	RATE	COST	TOTAL COST	RATE PER GLN
FOR 1000 4.75	4.75 7.25	290	9.48	2744	17	17.65	304	52	6.53	338	642	26	21.05	548	79	6.53	516	1063	0	15.04	0	209	0.00	0	127	0.18	23	138	0.79	109	138	0.92	127	236	138	0.75	104	20.74	9.90	205	5018	5.02
FOR 1500 4.75	6.00 8.50	350	9.48	3315	26	17.65	450	77	6.53	501	951	35	21.05	737	106	6.53	694	1431	0	15.04	0	247	0.00	0	157	0.18	29	167	0.79	132	167	0.92	154	285	167	0.75	126	26.63	9.90	264	6400	4.27
FOR 2000 4.75	6.75 10.00	404	9.48	3830	34	17.65	596	102	6.53	663	1259	44	21.05	921	133	6.53	867	1788	0	15.04	0	282	0.00	0	185	0.18	34	193	0.79	152	193	0.92	178	330	193	0.75	145	32.19	9.90	319	7704	3.85
FOR 2500 4.75	7.50 11.25	452	9.48	4287	42	17.65	745	127	6.53	829	1574	52	21.05	1104	159	6.53	1040	2144	0	15.04	0	316	0.00	0	211	0.18	39	216	0.79	170	216	0.92	199	369	216	0.75	162	37.50	9.90	371	8946	3.58
FOR 3000 4.75	8.25 12.25	495	9.48	4687	51	17.65	892	152	6.53	993	1885	61	21.05	1281	185	6.53	1207	2488	0	15.04	0	348	0.00	0	234	0.18	43	236	0.79	186	236	0.92	217	403	236	0.75	178	42.47	9.90	420	10104	3.37
FOR 3500 4.75	9.00 13.25	537	9.48	5087	60	17.65	1052	179	6.53	1172	2224	70	21.05	1471	212	6.53	1386	2857	0	15.04	0	381	0.00	0	259	0.18	47	256	0.79	202	256	0.92	236	438	256	0.75	193	47.69	9.90	472	11319	3.23
FOR 4000 4.75	9.50 14.25	573	9.48	5430	68	17.65	1195	204	6.53	1330	2525	78	21.05	1639	236	6.53	1544	3183	0	15.04	0	410	0.00	0	280	0.18	51	273	0.79	216	273	0.92	252	467	273	0.75	206	52.25	9.90	517	12380	3.09
FOR 4500 4.75	10.25 15.00	609	9.48	5773	77	17.65	1357	231	6.53	1511	2868	87	21.05	1827	263	6.53	1720	3547	0	15.04	0	441	0.00	0	302	0.18	55	290	0.79	229	290	0.92	268	497	290	0.75	219	57.19	9.90	566	13525	3.01

LENGTH / BREADTH RATIO 2 : 1

WATER HEIGHT (FT)	INTERNAL DIM (FT) B x L	STONE MASONRY RATE PER CFT QTY	RATE	COST	BASE SLAB CONCRETE PER CFT QTY	RATE	COST	BASE SLAB STEEL PER KG QTY	RATE	COST	TOTAL COST	ROOF SLAB CONCRETE PER CFT QTY	RATE	COST	ROOF SLAB STEEL PER KG QTY	RATE	COST	TOTAL COST	PCC CORE WALL CONCRETE PER CFT QTY	RATE	COST	LAND COST PER SQFT AREA	RATE	COST	EXCAVATION COST PER 1000 CFT QTY	RATE	COST	PLASTERING 1:3 COST PER 100 SQFT QTY	RATE	COST	PLASTERING 1:2 COST PER 100 SQFT QTY	RATE	COST	TOTAL COST	POINTING 1:3 COST PER 100 SQFT QTY	RATE	COST	PCC AT BASE 1:4:8 COST PER 100 CFT QTY	RATE	COST	TOTAL COST	RATE PER GLN
FOR 1000 4.75	4.25 8.00	296	9.48	2801	17	17.65	300	51	6.53	334	634	26	21.05	548	79	6.53	516	1064	0	15.04	0	210	0.00	0	129	0.18	24	141	0.79	111	141	0.92	130	241	141	0.75	106	20.98	9.90	208	5078	5.08
FOR 1500 4.75	5.25 9.75	362	9.48	3430	26	17.65	452	77	6.53	503	955	35	21.05	747	108	6.53	704	1451	0	15.04	0	251	0.00	0	161	0.18	30	173	0.79	136	173	0.92	159	295	173	0.75	130	27.28	9.90	270	6560	4.37
FOR 2000 4.75	6.00 11.25	416	9.48	3944	34	17.65	596	102	6.53	663	1259	44	21.05	930	134	6.53	876	1805	0	15.04	0	286	0.00	0	189	0.18	35	198	0.79	157	198	0.92	183	339	198	0.75	149	32.81	9.90	325	7857	3.93
FOR 2500 4.75	6.50 13.00	470	9.48	4459	42	17.65	746	127	6.53	830	1576	53	21.05	1118	161	6.53	1053	2171	0	15.04	0	323	0.00	0	217	0.18	40	224	0.79	177	224	0.92	207	384	224	0.75	169	38.46	9.90	381	9179	3.67
FOR 3000 4.75	7.25 14.00	513	9.48	4859	51	17.65	896	153	6.53	997	1893	62	21.05	1298	187	6.53	1223	2521	0	15.04	0	354	0.00	0	241	0.18	44	244	0.79	193	244	0.92	225	418	244	0.75	184	43.48	9.90	430	10349	3.45
FOR 3500 4.75	7.75 15.25	555	9.48	5259	59	17.65	1043	178	6.53	1161	2204	70	21.05	1475	213	6.53	1389	2864	0	15.04	0	386	0.00	0	265	0.18	48	265	0.79	209	265	0.92	244	453	265	0.75	199	48.45	9.90	480	11508	3.29
FOR 4000 4.75	8.25 16.50	597	9.48	5659	68	17.65	1201	205	6.53	1338	2539	79	21.05	1663	240	6.53	1566	3230	0	15.04	0	419	0.00	0	289	0.18	53	285	0.79	225	285	0.92	262	487	285	0.75	214	53.63	9.90	531	12713	3.18
FOR 4500 4.75	8.75 17.50	633	9.48	6002	77	17.65	1351	230	6.53	1505	2856	87	21.05	1839	263	6.53	1732	3570	0	15.04	0	449	0.00	0	311	0.18	57	302	0.79	238	302	0.92	278	517	302	0.75	227	58.33	9.90	578	13806	3.07

STONE MASONRY
5000 - 20000 GALLONS
ESTIMATED QUANTITIES AND COST

WATER STORAGE RESERVOIRS – SUMMARY OF COST ESTIMATES
STONE MASONRY 5000 – 20000 GALLONS

CAPACITY (IN GALLONS)	LENGTH / BREADTH RATIO					
	1 : 1		1.5 : 1		2 : 1	
	TOTAL COST	RATE / GLNS	TOTAL COST	RATE / GLNS	TOTAL COST	RATE / GLNS
	AT 0% PREM		AT 0% PREM		AT 0% PREM	
FOR 5000	23646	4.73	23780	4.76	24154	4.83
FOR 6000	26325	4.39	26420	4.40	27013	4.50
FOR 7000	28389	4.06	28815	4.12	29729	4.25
FOR 8000	31215	3.90	31273	3.91	32111	4.01
FOR 9000	33390	3.71	33454	3.72	34324	3.81
FOR 10000	35613	3.56	35970	3.60	36813	3.68
FOR 11000	37883	3.44	38188	3.47	39021	3.55
FOR 12000	39423	3.29	40161	3.35	41271	3.44
FOR 13000	41021	3.16	40403	3.11	41414	3.19
FOR 14000	43356	3.10	42296	3.02	43296	3.09
FOR 15000	44942	3.00	44217	2.95	45443	3.03
FOR 16000	46565	2.91	46166	2.89	47596	2.97
FOR 17000	48980	2.88	48142	2.83	49246	2.90
FOR 18000	50631	2.81	49693	2.76	50896	2.83
FOR 19000	52301	2.75	51700	2.72	52782	2.78
FOR 20000	53971	2.70	53383	2.67	54474	2.72

WATER STORAGE RESERVOIRS – SCHEDULE OF MATERIALS
STONE MASONRY 5000 – 20000 GALLONS (FOR ALL " L / B " RATIOS)

CAPACITY & DEPTH (Glns)	LENGTH / BREADTH RATIO 1 : 1						LENGTH / BREADTH RATIO 1.5 : 1						LENGTH / BREADTH RATIO 2 : 1					
	STONE WORK (Cft)	CEMENT (Kgs)	CEMENT (Bags) (Nos)	SAND (Cft)	AGG (Cft)	STEEL (Kgs)	STONE WORK (Cft)	CEMENT (Kgs)	CEMENT (Bags) (Nos)	SAND (Cft)	AGG. (Cft)	STEEL (Kgs)	STONE WORK (Cft)	CEMENT (Kgs)	CEMENT (Bags) (Nos)	SAND (Cft)	AGG (Cft)	STEEL (Kgs)
FOR 5000 7.50	1187	10912	218	691	366	772	1201	11006	220	692	367	770	1229	11218	224	712	371	772
FOR 6000 7.50	1300	12064	241	762	411	881	1314	12148	243	763	411	875	1356	12475	249	790	419	882
FOR 7000 7.50	1384	12942	259	816	447	967	1413	13170	263	820	452	974	1469	13637	273	862	465	993
FOR 8000 7.50	1497	14132	283	889	496	1088	1511	14208	284	889	495	1079	1568	14655	293	925	506	1092
FOR 9000 7.50	1582	15039	301	945	534	1183	1596	15117	302	945	533	1175	1653	15572	311	980	545	1190
FOR 10000 7.50	1667	15958	319	1001	573	1282	1695	16170	323	1003	577	1284	1752	16618	332	1044	588	1297
FOR 11000 7.50	1752	16889	338	1057	613	1385	1780	17088	342	1059	616	1383	1836	17534	351	1100	627	1395
FOR 12000 7.50	1808	17517	350	1095	641	1456	1850	17885	358	1102	652	1476	1921	18460	369	1156	667	1497
FOR 13000 7.50	1893	18654	373	1162	702	1387	1921	18674	373	1155	687	1306	1992	19251	385	1204	702	1311
FOR 14000 7.50	1978	19624	392	1220	746	1489	1992	19470	389	1209	722	1387	2062	20050	401	1252	738	1390
FOR 15000 7.50	2034	20278	406	1259	776	1560	2062	20275	405	1251	759	1470	2147	20973	419	1308	777	1477
FOR 16000 7.50	2091	20937	419	1299	806	1635	2133	21088	422	1295	796	1554	2232	21902	438	1365	817	1562
FOR 17000 7.50	2175	21935	439	1358	853	1741	2204	21909	438	1349	834	1641	2288	22576	452	1405	849	1638
FOR 18000 7.50	2232	22608	452	1399	885	1816	2260	22559	451	1388	863	1708	2345	23255	465	1445	882	1712
FOR 19000 7.50	2288	23285	466	1439	917	1893	2331	23394	468	1433	903	1796	2415	24055	481	1494	918	1791
FOR 20000 7.50	2345	23969	479	1479	950	1969	2387	24077	482	1473	935	1873	2472	24746	495	1535	951	1868

NOTES –

1 Refer to the drawing numbers TAU/012,TAU/014,TAU/015 and TAU/016

2 Schedule includes 5% wastage for all the items except for steel which is 10%

WATER STORAGE RESERVOIR - COST ESTIMATE
(AT 0% PREMIUM ON COMPOSITE SCHEDULE OF RATES 1979)
STONE MASONRY 5000 - 20000 GALLONS

LENGTH / BREADTH RATIO [illegible] : 1

[illegible]

LENGTH / BREADTH RATIO 1.5 : 1

[illegible]

WATER STORAGE RESERVOIR - COST ESTIMATE
(AT 0% PREMIUM ON COMPOSITE SCHEDULE OF RATES 1979)
STONE MASONRY 5000 - 20000 GALLONS

LENGTH / BREADTH RATIO 2 : 1

WATER HEIGHT (FT)	INTERNAL DIM (FT) L / B	STONE MASONRY RATE PER CFT QTY	RATE	COST	BASE SLAB CONCRETE PER CFT QTY	RATE	COST	BASE SLAB STEEL PER 100 QTY	RATE	COST	TOTAL COST	ROOF SLAB CONCRETE PER CFT QTY	RATE	COST	ROOF SLAB STEEL PER 100 QTY	RATE	COST	TOTAL COST	CORE WALL CONCRETE PER CFT QTY	RATE	COST
FOR 5000 7.50	7.50 14.25	1229	9.48	11647	77	17.45	1342	232	6.53	1517	2859	100	21.05	2110	481	6.53	3143	5253	162	15.04	2435
FOR 6000 7.50	8.00 16.00	1356	9.48	12852	90	17.45	1589	271	6.53	1769	3357	114	21.05	2394	546	6.53	3565	5960	180	15.04	2707
FOR 7000 7.50	8.75 17.25	1469	9.48	13925	103	17.45	1806	311	6.53	2033	3860	127	21.05	2683	612	6.53	3996	6679	193	15.04	2903
FOR 8000 7.50	9.25 18.50	1568	9.48	14860	115	17.45	2035	347	6.53	2266	4301	140	21.05	2957	670	6.53	4375	7311	208	15.04	3130
FOR 9000 7.50	10.00 19.25	1653	9.48	15665	128	17.45	2250	384	6.53	2506	4756	152	21.05	3190	728	6.53	4754	7944	219	15.04	3299
FOR 10000 7.50	10.50 20.50	1752	9.48	16600	141	17.45	2482	423	6.53	2764	5246	163	21.05	3467	791	6.53	5162	8629	233	15.04	3497
FOR 11000 7.50	11.00 21.50	1834	9.48	17406	153	17.45	2696	460	6.53	3002	5698	177	21.05	3719	848	6.53	5537	9256	244	15.04	3666
FOR 12000 7.50	11.50 22.50	1921	9.48	18206	165	17.45	2919	498	6.53	3250	6169	189	21.05	3980	908	6.53	5926	9906	255	15.04	3833
FOR 13000 7.50	12.00 23.25	1992	9.48	18876	177	17.45	3120	532	6.53	3474	6595	200	21.05	4212	684	6.53	4469	8681	264	15.04	3976
FOR 14000 7.50	12.50 24.00	2062	9.48	19543	189	17.45	3327	567	6.53	3703	7032	211	21.05	4451	724	6.53	4728	9179	274	15.04	4117
FOR 15000 7.50	12.75 25.25	2147	9.48	20348	201	17.45	3547	605	6.53	3950	7497	224	21.05	4709	769	6.53	5023	9732	285	15.04	4286
FOR 16000 7.50	13.00 26.50	2232	9.48	21155	214	17.45	3773	643	6.53	4201	7975	236	21.05	4973	812	6.53	5303	10276	295	15.04	4436
FOR 17000 7.50	13.50 27.00	2288	9.48	21687	225	17.45	3967	676	6.53	4417	8384	247	21.05	5192	832	6.53	5564	10756	304	15.04	4568
FOR 18000 7.50	14.00 27.50	2345	9.48	22223	236	17.45	4165	710	6.53	4638	8803	257	21.05	5416	889	6.53	5808	11224	311	15.04	4681
FOR 19000 7.50	14.25 28.50	2415	9.48	22892	248	17.45	4374	745.82	6.53	4870	9244	269	21.05	5636	929	6.53	6068	11704	321	15.04	4822
FOR 20000 7.50	14.75 29.00	2472	9.48	23427	260	17.45	4582	781.37	6.53	5102	9685	280	21.05	5890	948	6.53	6322	12212	328	15.04	4935

WATER HEIGHT (FT)	LAND COST PER SQFT AREA	RATE	COST	EXCAVATION COST PER 1000 CFT QTY	RATE	COST	PLASTERING COST PER 100 SQFT QTY	RATE	COST	PLASTERING COST PER 100 SQFT QTY	RATE	COST	TOTAL COST	POINTING COST PER 100 SQFT QTY	RATE	COST	CORE WALL STEEL PER 100 QTY	RATE	COST	TOTAL C/WALL	FOUNDATION COST PER 100 CFT QTY	RATE	COST	TOTAL COST	RATE PER GALL.
FOR 5000 7.50	339	0.00	0	305	0.18	56	370	0.79	292	370	0.92	341	633	370	0.75	278	59	6.53	385	2807	58	9.90	571	24151	4.83
FOR 6000 7.50	609	0.00	0	337	0.18	62	408	0.79	322	408	0.92	376	698	408	0.75	307	65	6.53	425	3130	65	9.90	647	25805	4.30
FOR 7000 7.50	658	0.00	0	364	0.18	67	442	0.79	349	442	0.92	407	756	442	0.75	332	70	6.53	458	3391	73	9.90	721	29772	4.25
FOR 8000 7.50	702	0.00	0	388	0.18	71	472	0.79	372	472	0.92	435	807	472	0.75	355	75	6.53	489	3619	79	9.90	786	32211	4.02
FOR 9000 7.50	742	0.00	0	409	0.18	75	497	0.79	393	497	0.92	458	851	497	0.75	374	79	6.53	516	3815	86	9.90	849	34321	3.81
FOR 10000 7.50	787	0.00	0	433	0.18	79	527	0.79	416	527	0.92	486	902	527	0.75	397	84	6.53	547	4063	93	9.90	918	34803	3.48
FOR 11000 7.50	828	0.00	0	454	0.18	83	553	0.79	436	553	0.92	509	945	553	0.75	416	88	6.53	575	4259	99	9.90	980	39022	3.55
FOR 12000 7.50	870	0.00	0	475	0.18	87	578	0.79	456	578	0.92	533	989	578	0.75	433	92	6.53	599	4435	105	9.90	1044	41371	3.44
FOR 13000 7.50	906	0.00	0	492	0.18	90	599	0.79	473	599	0.92	552	1025	599	0.75	451	95	6.53	621	4598	111	9.90	1100	41414	3.19
FOR 14000 7.50	944	0.00	0	510	0.18	93	621	0.79	490	621	0.92	572	1062	621	0.75	467	99	6.53	644	4761	117	9.90	1157	43284	3.09
FOR 15000 7.50	985	0.00	0	530	0.18	97	646	0.79	510	646	0.92	595	1105	646	0.75	485	103	6.53	670	4936	123	9.90	1221	45443	3.03
FOR 16000 7.50	1027	0.00	0	551	0.18	101	672	0.79	530	672	0.92	619	1149	672	0.75	506	107	6.53	696	5132	130	9.90	1283	47596	2.97
FOR 17000 7.50	1060	0.00	0	563	0.18	103	689	0.79	544	689	0.92	634	1178	689	0.75	518	109	6.53	714	5282	133	9.90	1357	49044	2.88
FOR 18000 7.50	1094	0.00	0	579	0.18	106	706	0.79	557	706	0.92	650	1207	706	0.75	531	112	6.53	732	5415	140	9.90	1388	50896	2.83
FOR 19000 7.50	1131	0.00	0	596	0.18	109	727	0.79	574	727	0.92	670	1243	727	0.75	547	115	6.53	754	5576	146	9.90	1446	52782	2.78
FOR 20000 7.50	1166	0.00	0	610	0.18	112	744	0.79	587	744	0.92	685	1273	744	0.75	560	118	6.53	771	5706	152	9.90	1500	54474	2.72

RCC/BRICK MASONRY
5000 - 20000 GALLONS
ESTIMATED QUANTITIES AND COST

WATER STORAGE RESERVOIRS – SUMMARY OF COST ESTIMATES
RCC / BRICK MASONRY 5000 – 20000 GALLONS

CAPACITY (IN GALLONS)	LENGTH / BREADTH RATIO					
	1 : 1		1.5 : 1		2 : 1	
	TOTAL COST	RATE / GLNS	TOTAL COST	RATE / GLNS	TOTAL COST	RATE / GLNS
	AT 0% PREM		AT 0% PREM		AT 0% PREM	
FOR 5000	24570	4.91	24723	4.94	25124	5.02
FOR 6000	27356	4.56	27472	4.58	28106	4.68
FOR 7000	29502	4.21	29963	4.28	30932	4.42
FOR 8000	32436	4.05	32517	4.06	33409	4.18
FOR 9000	34692	3.85	34781	3.86	35705	3.97
FOR 10000	36995	3.70	37394	3.74	38291	3.83
FOR 11000	39346	3.58	39695	3.61	39695	3.61
FOR 12000	40940	3.41	41737	3.48	42914	3.58
FOR 13000	42853	3.30	43095	3.31	44210	3.40
FOR 14000	45286	3.23	45094	3.22	46436	3.32
FOR 15000	46938	3.13	47121	3.14	48473	3.23
FOR 16000	48626	3.04	49177	3.07	50520	3.16
FOR 17000	51139	3.01	51260	3.02	52489	3.09
FOR 18000	52856	2.94	52896	2.94	54225	3.01
FOR 19000	54592	2.87	55010	2.90	56327	2.96
FOR 20000	56327	2.82	56778	2.84	57995	2.90

WATER STORAGE RESERVOIRS – SCHEDULE OF MATERIALS
RCC CANTILEVER / BRICK WALL 5000 -- 20000 GALLONS (FOR ALL " L / B " RATIOS)

CAPACITY & DEPTH (Glns)	LENGTH / BREADTH RATIO 1 . 1							LENGTH / BREADTH RATIO 1.5 . 1							LENGTH / BREADTH RATIO 2 . 1						
	BRICK WORK		CEMENT		SAND	AGG.	STEEL	BRICK WORK		CEMENT		SAND	AGG.	STEEL	BRICK WORK		CEMENT		SAND	AGG.	STEEL
	(Cft)	Bricks (Nos)	(Kgs)	(Bags) (Nos)	(Cft)	(Cft)	(Kgs)	(Cft)	Bricks (Nos)	(Kgs)	(Bags) (Nos)	(Cft)	(Cft)	(Kgs)	(Cft)	Bricks (Nos)	(Kgs)	(Bags) (Nos)	(Cft)	(Cft)	(Kgs)
FDR 5000 7 50	564	8171	7760	155	419	456	1629	570	8268	7817	156	421	458	1636	584	8463	7955	159	431	464	1660
FDR 6000 7 50	617	8949	8616	172	465	510	1821	624	9046	8664	173	466	511	1825	644	9338	8879	178	480	522	1863
FDR 7000 7 50	657	9533	9273	185	500	552	1969	671	9727	9427	189	504	560	1997	698	10116	9746	195	526	577	2058
FDR 8000 7 50	711	10311	10167	203	547	610	2173	718	10408	10206	204	547	611	2175	745	10797	10506	210	566	626	2229
FDR 9000 7 50	751	10894	10852	217	583	655	2331	758	10992	10893	218	584	656	2333	785	11381	11201	224	603	672	2390
FDR 10000 7 50	792	11478	11550	231	620	701	2492	805	11673	11687	234	624	708	2516	832	12062	11988	240	644	723	2570
FDR 11000 7 50	832	12062	12259	245	657	748	2658	845	12256	12384	248	660	753	2677	845	12256	12384	248	664	753	2677
FDR 12000 7 50	859	12451	12739	255	682	780	2771	879	12742	12996	260	690	795	2822	912	13229	13387	268	718	815	2895
FDR 13000 7 50	899	13034	13944	279	744	877	2728	912	13229	14083	282	748	883	2726	946	13715	14493	290	774	906	2785
FDR 14000 7 50	939	13618	14708	294	784	929	2891	946	13715	14713	294	783	926	2860	986	14299	15207	304	812	953	2930
FDR 15000 7 50	968	14007	15223	304	811	965	3002	979	14202	15350	307	814	970	2995	1020	14785	15848	317	845	997	3066
FDR 16000 7 50	993	14396	15744	315	838	1000	3118	1013	14688	15996	320	846	1014	3133	1053	15272	16496	330	879	1042	3201
FDR 17000 7 50	1033	14980	16536	331	879	1055	3285	1047	15174	16650	333	882	1060	3273	1087	15758	17117	342	911	1084	3332
FDR 18000 7 50	1060	15369	17071	341	907	1093	3402	1073	15563	17167	343	909	1095	3381	1114	16147	17662	353	940	1122	3448
FDR 19000 7 50	1087	15758	17611	352	935	1130	3519	1107	16050	17835	357	941	1142	3522	1147	16633	18295	366	973	1166	3597
FDR 20000 7 50	1114	16147	18156	363	963	1169	3636	1134	16439	18384	368	970	1180	3642	1174	17022	18853	377	1002	1205	3699

NOTES –
1 Refer to the drawing numbers TAU/013,TAU/014,TAU/015 and TAU/016
2 Schedule includes 5% wastage for all the items except for steel which is 10%

WATER STORAGE RESERVOIR - COST ESTIMATE
(AT 0% PREMIUM ON COMPOSITE SCHEDULE OF RATES 1979)
RCC / BRICK MASONRY 5000 - 20000 GALLONS

LENGTH / BREADTH RATIO 1 : 1

WATER STORAGE	INTERNAL DIM	EARTH WORK QTY	RATE	COST	LEAN CONCRETE QTY	RATE	COST	BASE SLAB STEEL QTY	RATE	COST	TOTAL COST	TOP SLAB CONCRETE QTY	RATE	COST	TOP SLAB STEEL QTY	RATE	COST	TOTAL COST
FOR 5000 7.50	10.50	364	8.69	4898	55	17.65	971	186	6.58	[illegible]	2054	92	21.05	1930	640	6.58	2814	[illegible]
FOR 6000 7.50	11.50	617	8.69	5364	66	17.65	[illegible]	199	6.58	1300	2487	[illegible]	21.05	[illegible]	[illegible]	6.58	3374	5473
FOR 7000 7.50	12.25	657	8.69	5714	75	17.65	1324	226	6.58	1475	2799	115	21.05	[illegible]	[illegible]	6.58	3592	6004
FOR 8000 7.50	13.25	721	8.69	6180	88	17.65	1549	264	6.58	1725	3274	129	21.05	2712	[illegible]	6.58	4038	6730
FOR 9000 7.50	14.00	751	8.69	6531	98	17.65	1730	295	6.58	1926	3656	140	21.05	2948	672	6.58	4390	7338
FOR 10000 7.50	14.75	782	8.69	6800	109	17.65	1920	327	6.58	2138	4058	152	21.05	3194	728	6.58	4756	7951
FOR 11000 7.50	15.50	832	8.69	7230	120	17.65	2120	362	6.58	2361	4481	164	21.05	3450	787	6.58	5138	8588
FOR 12000 7.50	16.00	859	8.69	7464	128	17.65	2259	385	6.58	2516	4775	172	21.05	3626	827	6.58	5400	9026
FOR 13000 7.50	16.75	899	8.69	7813	140	17.65	2470	422	6.58	2757	5233	183	21.05	3889	673	6.58	4396	8286
FOR 14000 7.50	17.50	939	8.69	8163	153	17.65	2703	461	6.58	3009	5712	198	21.05	4182	725	6.58	4732	8814
FOR 15000 7.50	18.00	966	8.69	8396	162	17.65	2859	488	6.58	3184	6043	208	21.05	4375	761	6.58	4967	9542
FOR 16000 7.50	18.50	998	8.69	8680	171	17.65	3020	515	6.58	3363	6383	217	21.05	4573	800	6.58	5225	9798
FOR 17000 7.50	19.25	1033	8.69	8980	185	17.65	3270	536	6.58	3640	6911	232	21.05	4878	852	6.58	5564	10442
FOR 18000 7.50	19.75	1060	8.69	9213	195	17.63	3442	587	6.58	3833	7275	242	21.05	5087	850	6.58	5823	10601
FOR 19000 7.50	20.25	1087	8.69	9446	205	17.65	3619	617	6.58	4029	7648	252	21.05	5301	929	6.58	6067	11368
FOR 20000 7.50	20.75	1114	8.69	9679	215	17.65	3800	649	6.58	4231	8031	262	21.05	5519	966	6.58	6306	11825

WATER STORAGE	CONCRETE QTY	RATE	COST	LABOUR QTY	RATE	COST	EXCAVATION QTY	RATE	COST	PLASTERING QTY	RATE	COST	PLASTERING QTY	RATE	COST	TOTAL COST
FOR 5000	[illegible]	15.04	3198	[illegible]	[illegible]	0	[illegible]	[illegible]	[illegible]	357	0.79	282	[illegible]	[illegible]	[illegible]	[illegible]
FOR 6000	250	15.04	3439	380	0.00	0	232	0.18	42	388	0.79	309	388	0.92	360	669
FOR 7000	243	15.04	3665	410	0.00	0	251	0.18	[illegible]	417	0.79	329	417	0.92	384	713
FOR 8000	263	15.04	3989	452	0.00	0	278	0.18	51	453	0.79	356	453	0.92	415	771
FOR 9000	280	15.04	4211	484	0.00	0	299	0.18	55	476	0.79	376	476	0.92	438	814
FOR 10000	295	15.04	4437	518	0.00	0	320	0.18	59	502	0.79	396	502	0.92	462	858
FOR 11000	310	15.04	4662	532	0.00	0	342	0.18	63	527	0.79	416	527	0.92	486	902
FOR 12000	320	15.04	4813	576	0.00	0	357	0.18	63	544	0.79	429	544	0.92	501	931
FOR 13000	333	15.04	5059	613	0.00	0	379	0.18	69	570	0.79	450	570	0.92	525	974
FOR 14000	350	15.04	5264	630	0.00	0	403	0.18	74	595	0.79	470	595	0.92	548	1018
FOR 15000	360	15.04	5414	676	0.00	0	419	0.18	77	612	0.79	483	612	0.92	564	1047
FOR 16000	370	15.04	5565	702	0.00	0	435	0.18	80	629	0.79	497	629	0.92	580	1076
FOR 17000	385	15.04	5790	743	0.00	0	459	0.18	84	655	0.79	517	655	0.92	603	1120
FOR 18000	385	15.04	5791	770	0.00	0	476	0.18	87	672	0.79	530	672	0.92	619	1149
FOR 19000	405	15.04	6081	798	0.00	0	495	0.18	90	689	0.79	544	689	0.92	634	1178
FOR 20000	415	15.04	6247	827	0.00	0	510	0.18	93	706	0.79	557	706	0.92	650	1207

WATER STORAGE	POINTING QTY	RATE	COST	CORE WALL STEEL QTY	RATE	COST	TOTAL B/WALL	RING BEAM CONCRETE QTY	RATE	COST	STEEL QTY	RATE	COST	TOTAL	QTY	RATE	COST	TOTAL COST	COST PER GALL
FOR 5000	[illegible]	[illegible]	289	[illegible]	[illegible]	5444	[illegible]	[illegible]	[illegible]	[illegible]	189	6.58	1254	2802	[illegible]	[illegible]	[illegible]		4.91
FOR 6000	391	0.75	294	813	6.58	5363	8422	104	17.65	1827	207	6.58	1352	3179	[illegible]	[illegible]	[illegible]		4.51
FOR 7000	417	0.75	314	975	6.58	6351	10086	110	17.65	1946	224	6.58	1460	3386	50	[illegible]	[illegible]		4.21
FOR 8000	453	0.75	339	1052	6.58	6870	10855	119	17.65	2103	239	6.58	1557	3662	56	[illegible]	[illegible]		4.05
FOR 9000	476	0.75	358	1112	6.58	7259	11470	126	17.65	2224	252	6.58	1645	3869	61	9.90	[illegible]		3.85
FOR 10000	502	0.75	376	1171	6.58	7648	12084	133	17.65	2343	266	6.58	1734	4077	65	[illegible]	[illegible]		3.70
FOR 11000	527	0.75	397	1251	6.58	8036	12889	140	17.65	2462	279	6.58	1822	4284	71	[illegible]	[illegible]		3.58
FOR 12000	544	0.75	410	1270	6.58	8296	13109	144	17.65	2542	288	6.58	1880	4422	73	[illegible]	[illegible]		3.40
FOR 13000	570	0.75	429	1330	6.58	8683	13728	201	17.65	3548	302	6.58	1974	5521	80	9.10	794	4283	3.30
FOR 14000	595	0.75	448	1390	6.58	9075	14337	210	17.65	3707	316	6.58	2062	5769	84	9.90	832	4528	3.23
FOR 15000	612	0.75	461	1429	6.58	9333	14747	216	17.65	3812	325	6.58	2121	5933	90	9.90	891	4688	3.13
FOR 16000	629	0.75	474	1469	6.58	9592	15157	222	17.65	3918	334	6.58	2180	6098	94	9.90	931	4862	3.04
FOR 17000	655	0.75	493	1528	6.58	9981	15771	231	17.65	4077	347	6.58	2269	6345	100	9.90	992	5118	3.01
FOR 18000	672	0.75	506	1568	6.58	10240	16181	237	17.65	4183	356	6.58	2327	6510	105	9.90	1084	5283	2.94
FOR 19000	689	0.75	518	1608	6.58	10499	16580	243	17.65	4289	365	6.58	2384	6675	109	9.90	1077	5438	2.87
FOR 20000	706	0.75	531	1648	6.58	10759	17000	249	17.63	4395	374	6.58	2443	6840	113	9.90	1121	[illegible]	2.82

LENGTH / BREADTH RATIO 1.5 : 1

WATER STORAGE	INTERNAL DIM	EARTH WORK QTY	RATE	COST	LEAN CONCRETE QTY	RATE	COST	BASE SLAB STEEL QTY	RATE	COST	TOTAL COST	TOP SLAB CONCRETE QTY	RATE	COST	TOP SLAB STEEL QTY	RATE	COST	TOTAL COST
FOR 5000 7.50	8.50 12.75	378	8.69	4956	51	17.65	956	163	6.58	1065	2021	91	21.05	1925	430	6.58	2863	4787
FOR 6000 7.50	9.25 14.00	621	8.69	5425	65	17.65	1143	196	6.58	1275	2415	104	21.05	2184	488	6.58	3253	5437
FOR 7000 7.50	10.00 15.00	671	8.69	5851	75	17.65	1324	226	6.58	1474	2798	115	21.05	2421	554	6.58	3619	6030
FOR 8000 7.50	10.75 16.00	731	8.69	6329	86	17.65	1518	259	6.58	1690	3208	128	21.05	2690	613	6.58	4006	6696
FOR 9000 7.50	11.50 16.75	758	8.69	6589	96	17.65	1700	290	6.58	1895	3595	139	21.05	2926	668	6.58	4360	7286
FOR 10000 7.50	12.00 18.00	803	8.69	6977	108	17.65	1906	325	6.58	2122	4029	152	21.05	3200	730	6.58	4764	7944
FOR 11000 7.50	12.50 19.00	845	8.69	7347	119	17.65	2096	357	6.58	2334	4430	164	21.05	3445	786	6.58	5130	8575
FOR 12000 7.50	13.25 19.50	879	8.69	7638	129	17.65	2280	389	6.58	2539	4819	175	21.05	3676	838	6.58	5473	9149
FOR 13000 7.50	13.75 20.25	912	8.69	7930	139	17.65	2457	419	6.58	2736	5193	185	21.05	3899	651	6.58	4251	8150
FOR 14000 7.50	14.25 21.00	946	8.69	8222	150	17.65	2641	450	6.58	2941	5581	196	21.05	4129	692	6.58	4519	8649
FOR 15000 7.50	14.75 21.75	979	8.69	8513	160	17.65	2831	485	6.58	3152	5984	207	21.05	4366	734	6.58	4795	9161
FOR 16000 7.50	15.25 22.50	1013	8.69	8805	172	17.63	3028	516	6.58	3372	6400	219	21.05	4609	777	6.58	5076	9685
FOR 17000 7.50	15.75 23.25	1047	8.69	9096	183	17.65	3232	551	6.58	3598	6830	231	21.05	4859	821	6.58	5363	10222
FOR 18000 7.50	16.00 24.00	1075	8.69	9339	192	17.63	3389	578	6.58	3773	7162	240	21.05	5053	853	6.58	5580	10634
FOR 19000 7.50	16.50 24.75	1107	8.69	9621	204	17.65	3604	615	6.58	4013	7617	252	21.05	5315	887	6.58	5800	11115
FOR 20000 7.50	17.00 25.25	1134	8.69	9854	215	17.63	3788	646	6.58	4218	8006	263	21.05	5536	937	6.58	6121	11651

WATER STORAGE	CONCRETE QTY	RATE	COST	LABOUR QTY	RATE	COST	EXCAVATION QTY	RATE	COST	PLASTERING QTY	RATE	COST	PLASTERING QTY	RATE	COST	TOTAL COST
FOR 5000	213	15.04	3196	347	0.00	0	207	0.18	38	361	0.79	285	361	0.92	333	618
FOR 6000	233	15.04	3497	380	0.00	0	232	0.18	42	385	0.79	312	385	0.92	364	676
FOR 7000	250	15.04	3760	414	0.00	0	255	0.18	47	425	0.79	334	425	0.92	392	727
FOR 8000	268	15.04	4023	450	0.00	0	278	0.18	51	455	0.79	359	453	0.92	419	778
FOR 9000	283	15.04	4249	485	0.00	0	299	0.18	55	480	0.79	379	480	0.92	443	822
FOR 10000	300	15.04	4512	520	0.00	0	323	0.18	59	510	0.79	403	510	0.92	470	873
FOR 11000	315	15.04	4738	554	0.00	0	344	0.18	63	536	0.79	423	536	0.92	494	916
FOR 12000	328	15.04	4926	584	0.00	0	363	0.18	66	557	0.79	440	557	0.92	513	953
FOR 13000	340	15.04	5114	614	0.00	0	382	0.18	70	578	0.79	456	578	0.92	533	989
FOR 14000	353	15.04	5302	645	0.00	0	401	0.18	73	599	0.79	473	599	0.92	552	1025
FOR 15000	363	15.04	5460	677	0.00	0	420	0.18	77	621	0.79	490	621	0.92	572	1062
FOR 16000	378	15.04	5678	709	0.00	0	440	0.18	81	642	0.79	507	642	0.92	591	1098
FOR 17000	390	15.04	5866	742	0.00	0	461	0.18	84	663	0.79	523	663	0.92	611	1134
FOR 18000	400	15.04	6016	768	0.00	0	477	0.18	87	680	0.79	537	680	0.92	627	1163
FOR 19000	413	15.04	6204	802	0.00	0	490	0.18	91	701	0.79	554	701	0.92	644	1209
FOR 20000	423	15.04	6354	851	0.00	0	515	0.18	94	718	0.79	567	718	0.92	662	1229

WATER STORAGE	POINTING QTY	RATE	COST	CORE WALL STEEL QTY	RATE	COST	TOTAL B/WALL	RING BEAM CONCRETE QTY	RATE	COST	STEEL QTY	RATE	COST	TOTAL	QTY	RATE	COST	TOTAL COST	COST PER GALL
FOR 5000	361	0.75	272	844	6.58	5509	9705	98	17.65	1686	181	6.58	1249	2807	39	9.90	[illegible]	2978	4.91
FOR 6000	385	0.75	290	925	6.58	6037	9534	105	17.65	1847	209	6.58	1366	3213	45	9.90	[illegible]	3402	4.50
FOR 7000	425	0.75	320	993	6.58	6481	10241	113	17.65	1986	225	6.58	1469	3455	50	9.90	[illegible]	[illegible]	4.23
FOR 8000	455	0.75	342	1062	6.58	6855	10958	120	17.65	2125	241	6.58	1572	3697	54	9.90	549	3237	4.05
FOR 9000	480	0.75	362	1127	6.58	7354	11572	127	17.65	2244	254	6.58	1659	3904	60	9.90	597	3478	3.86
FOR 10000	510	0.75	384	1191	6.58	7777	12280	135	17.65	2383	270	6.58	1763	4146	68	9.90	[illegible]	3739	3.74
FOR 11000	536	0.75	403	1251	6.58	8166	12901	142	17.65	2502	284	6.58	1851	4353	71	9.90	704	3948	3.42
FOR 12000	557	0.75	419	1300	6.58	8490	13416	147	17.65	2601	295	6.58	1925	4526	76	9.90	750	4137	3.40
FOR 13000	578	0.75	435	1350	6.58	8814	13928	204	17.65	3601	307	6.58	2003	5604	80	9.90	[illegible]	4505	3.31
FOR 14000	599	0.75	451	1399	6.58	9130	14440	212	17.65	3758	316	6.58	2077	5810	85	9.90	845	4504	3.22
FOR 15000	621	0.75	467	1448	6.58	9462	14952	219	17.65	3863	329	6.58	2150	6014	90	9.90	[illegible]	4712	3.14
FOR 16000	642	0.75	483	1499	6.58	9786	15464	227	17.63	3998	341	6.58	2224	6222	95	9.90	940	4917	3.07
FOR 17000	663	0.75	499	1548	6.58	10110	15976	234	17.65	4130	352	6.58	2298	6428	100	9.90	990	5120	3.02
FOR 18000	680	0.75	512	1588	6.58	10370	16386	240	17.65	4236	361	6.58	2357	6593	104	9.90	1029	5269	2.94
FOR 19000	701	0.75	528	1650	6.58	10694	16858	248	17.65	4368	372	6.58	2430	6799	109	9.90	1082	5508	2.89
FOR 20000	718	0.75	541	1677	6.58	10953	17307	254	17.65	4474	381	6.58	2489	6964	114	9.90	1126	5677	2.84

LENGTH / BREADTH RATIO 2 : 1

WATER STORAGE RESERVOIR — COST ESTIMATE
(AT 0% PREMIUM ON COMPOSITE SCHEDULE OF RATES 1979)
RCC / BRICK MASONRY 5000 – 20000 GALLONS

Water capacity (gal) / height	Internal dim. (ft)	Brick work rate per cft Qty	Rate	Cost	Base slab concrete per cft Qty	Rate	Cost	Base slab steel per kg Qty	Rate	Cost	Total cost
FOR 5000 7.50	[illegible]	384	8.69	3073	53	17.63	943	161	6.53	1050	1993
FOR 6000 7.50	[illegible]	644	8.69	5598	64	17.63	1130	193	6.53	1258	2387
FOR 7000 7.50	[illegible]	698	8.69	6064	75	17.65	1322	227	6.53	1485	2813
FOR 8000 7.50	[illegible]	745	8.69	6472	86	17.63	1510	259	6.53	1692	3202
FOR 9000 7.50	[illegible]	785	8.69	6822	96	17.63	1699	290	6.53	1892	3590
FOR 10000 7.50	[illegible]	832	8.69	7230	108	17.65	1900	324	6.53	2115	4015
FOR 11000 7.50	[illegible]	845	8.69	7347	119	17.63	2096	357	6.53	2334	4430
FOR 12000 7.50	[illegible]	912	8.69	7930	129	17.63	2283	389	6.53	2543	4826
FOR 13000 7.50	[illegible]	944	8.69	8202	140	17.63	2462	420	6.53	2742	5204
FOR 14000 7.50	[illegible]	986	8.69	8571	150	17.65	2649	452	6.53	2949	5598
FOR 15000 7.50	[illegible]	1020	8.69	8863	161	17.65	2841	484	6.53	3163	6005
FOR 16000 7.50	[illegible]	1053	8.69	9154	172	17.65	3040	518	6.53	3385	6425
FOR 17000 7.50	[illegible]	1087	8.69	9446	182	17.63	3217	548	6.53	3582	6798
FOR 18000 7.50	[illegible]	1114	8.69	9679	199	17.63	[illegible]	579	6.53	3783	7181
FOR 19000 7.50	[illegible]	1147	8.69	9971	203	17.63	3584	611	6.53	3991	7575
FOR 20000 7.50	[illegible]	1174	8.69	10201	214	17.63	3773	644	6.53	4208	7979

Water capacity (gal)	Roof slab concrete per cft Qty	Rate	Cost	Roof slab steel per kg Qty	Rate	Cost	Total cost	Wall concrete per cft Qty	Rate	Cost	Land cost per sqft Area	Rate	Cost	Excavation cost per 100 cft Qty	Rate	Cost
FOR 5000	92	21.05	1929	440	6.53	2872	4802	219	15.04	3271	345	0.00	0	210	0.18	38
FOR 6000	104	21.05	2200	502	6.53	3275	5475	240	15.04	3610	384	0.00	0	237	0.18	43
FOR 7000	118	21.05	2477	563	6.53	3686	6163	280	15.04	3810	425	0.00	0	262	0.18	48
FOR 8000	129	21.05	2721	620	6.53	4051	6771	278	15.04	4174	457	0.00	0	284	0.18	52
FOR 9000	141	21.05	2965	676	6.53	4415	7380	295	15.04	4399	491	0.00	0	306	0.18	56
FOR 10000	153	21.05	3231	737	6.53	4811	8042	310	15.04	4662	527	0.00	0	329	0.18	60
FOR 11000	164	21.05	3445	786	6.53	5130	8575	315	15.04	4738	554	0.00	0	344	0.18	63
FOR 12000	177	21.05	3727	850	6.53	5549	9276	340	15.04	5114	595	0.00	0	372	0.18	68
FOR 13000	188	21.05	3952	647	6.53	4226	8178	353	15.04	5302	625	0.00	0	391	0.18	72
FOR 14000	199	21.05	4194	687	6.53	4488	8682	368	15.04	5527	658	0.00	0	412	0.18	75
FOR 15000	211	21.05	4433	730	6.53	4765	9198	380	15.04	5715	690	0.00	0	432	0.18	79
FOR 16000	222	21.05	4678	770	6.53	5030	9709	393	15.04	5905	723	0.00	0	452	0.18	83
FOR 17000	233	21.05	4902	811	6.53	5298	10194	405	15.04	6091	753	0.00	0	470	0.18	86
FOR 18000	240	21.05	5116	847	6.53	5537	10653	415	15.04	6242	781	0.00	0	488	0.18	89
FOR 19000	254	21.05	5352	905	6.53	5895	11247	428	15.04	6430	812	0.00	0	507	0.18	93
FOR 20000	263	21.05	5580	924	6.53	6034	11613	437	15.04	6580	842	0.00	0	525	0.18	96

Water capacity (gal)	Plastering cost per 100 sqft Qty	Rate	Cost	Plastering cost per 100 sqft Qty	Rate	Cost	Total cost	Pointing cost per 100 sqft Qty	Rate	Cost	Wall steel per kg Qty	Rate	Cost	Total cost
FOR 5000	370	0.79	292	370	0.92	341	655	370	0.75	278	865	6.53	5650	8508.7
FOR 6000	408	0.79	322	408	0.92	376	698	408	0.75	307	952	6.53	6222	9831.4
FOR 7000	442	0.79	349	442	0.92	407	756	442	0.75	332	1032	6.53	6740	10631
FOR 8000	472	0.79	372	472	0.92	435	807	472	0.75	355	1102	6.53	7194	11368
FOR 9000	497	0.79	393	497	0.92	458	851	497	0.75	374	1162	6.53	7585	11982
FOR 10000	527	0.79	416	527	0.92	486	902	527	0.75	397	1232	6.53	8056	12689
FOR 11000	536	0.79	425	536	0.92	493	916	536	0.75	403	1251	6.53	8166	12804
FOR 12000	578	0.79	456	578	0.92	533	989	578	0.75	435	1350	6.53	8814	13928
FOR 13000	599	0.79	473	599	0.92	552	1025	599	0.75	451	1399	6.53	9138	14440
FOR 14000	625	0.79	493	625	0.92	576	1069	625	0.75	470	1459	6.53	9527	15054
FOR 15000	646	0.79	510	646	0.92	595	1105	646	0.75	486	1509	6.53	9851	15566
FOR 16000	667	0.79	527	667	0.92	615	1142	667	0.75	502	1558	6.53	10175	16078
FOR 17000	689	0.79	544	689	0.92	634	1178	689	0.75	518	1608	6.53	10497	16580
FOR 18000	706	0.79	557	706	0.92	650	1207	706	0.75	531	1648	6.53	10759	17000
FOR 19000	727	0.79	574	727	0.92	670	1243	727	0.75	547	1697	6.53	11085	17512
FOR 20000	744	0.79	587	744	0.92	685	1273	744	0.75	560	1737	6.53	11342	17922

Water capacity (gal)	Concrete per cft Qty	Rate	Cost	Steel per kg Qty	Rate	Cost	Total	[illegible] Qty	Rate	Cost	Total cost	Cost per gal
FOR 5000	98	17.63	1727	196	6.53	1279	3006	40	9.50	[illegible]	[illegible]	[illegible]
FOR 6000	108	17.63	1906	216	6.53	1410	3317	45	9.50	[illegible]	[illegible]	[illegible]
FOR 7000	117	17.65	2065	234	6.53	1528	3593	51	9.50	[illegible]	[illegible]	[illegible]
FOR 8000	125	17.65	2206	250	6.53	1633	3835	56	9.50	537	[illegible]	[illegible]
FOR 9000	132	17.63	2329	263	6.53	1719	4042	61	9.50	607	35705	[illegible]
FOR 10000	140	17.65	2462	279	6.53	1822	4284	67	9.50	[illegible]	[illegible]	3.85
FOR 11000	142	17.63	2502	284	6.53	1851	4353	71	9.50	704	39685	3.61
FOR 12000	153	17.65	2700	306	6.53	1998	4697	77	9.50	[illegible]	[illegible]	3.38
FOR 13000	212	17.63	3733	318	6.53	2077	5810	82	9.50	809	44220	3.40
FOR 14000	221	17.63	3892	332	6.53	2165	6057	87	9.50	858	46435	3.32
FOR 15000	228	17.63	4024	343	6.53	2239	6264	92	9.50	907	48473	3.23
FOR 16000	234	17.65	4157	354	6.53	2313	6469	97	9.50	957	50520	3.16
FOR 17000	243	17.63	4289	365	6.53	2384	6673	101	9.50	1002	52489	3.09
FOR 18000	249	17.63	4395	374	6.53	2443	6840	106	9.50	1046	54225	3.01
FOR 19000	257	17.63	4527	386	6.53	2519	7046	110	9.50	1085	55857	2.94
FOR 20000	263	17.65	4635	395	6.53	2576	7211	115	9.50	1139	57865	2.90