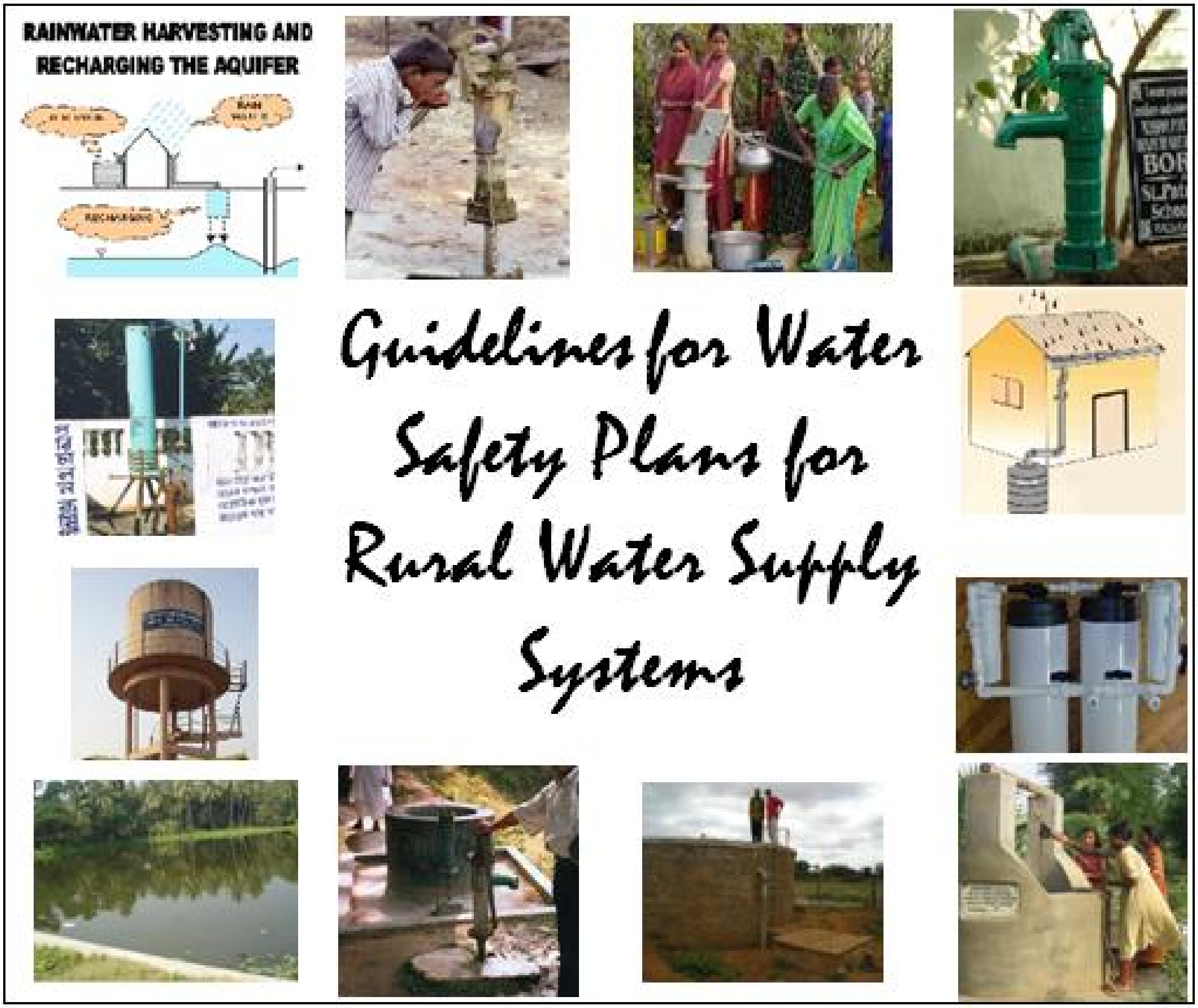

Sulabh International Academy
of Environmental Sanitation,

Supported by WHO, India

"*Guidelines for Water Safety Plans for Rural Water Supply Systems*"

Study Sponsored by

World Health Organization

Study Conducted by

Sulabh International Academy of Environmental Sanitation

Chief Patron

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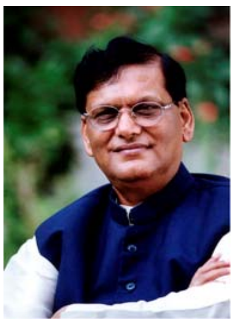
"Development of Guidelines for Water Safety Plans for Rural Water Supply Systems"



Dated: 28th Nov. 2009

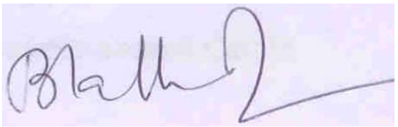
Dr. Bindeshwar Pathak,
Chancellor, SIAES and
Founder, SISSO

Foreword

Sulabh has been working for the promotion of Environmental Sanitation in the country for the last four decades. We are committed to the fulfillment of the dream of Mahatma Gandhi to build a society free from the evils of untouchability and social discrimination. Abolishing the dehumanizing system of manual scavenging of night soil from the community is the basic precondition and primary step towards that end. Sulabh developed the two-pit pour flush toilets – an affordable, user-friendly model of human excreta disposal – which ensure hundred percent safety against environmental pollution and does not require manual handling. Today, there are more than a million household Sulabh Souchalayas in the country and more than 6000 public toilet complexes based on Sulabh technologies. All together more than 10 million people in the country are using Sulabh Souchalayas.

It is in this context that I express my deepest gratitude and sincere thanks to WHO, India for entrusting the task of **"Development of Guidelines for Water Safety Plans in the Rural Areas"** to Sulabh International Academy of Environmental sanitation during 2009-2010. The study was supported by a group of nationally and internationally reputed experts and adequately reviewed by distinguished professional and sector leaders. I feel very happy that SIAES with support from WHO could make contribution for the implementation of the National Rural Drinking Water Programme (NRDWP) Guidelines of Govt. of India and I hope that this document would help the key stakeholders, to provide safe drinking water to the rural communities of the country.

I congratulate Prof. K.J. Nath, Team leader and the Members of the Expert and Review Group for successfully completing the documentation and once again extend my grateful thanks to Dr. Salim J. Habayeb and Mr. A.K. Sengupta of WHO India.



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Chancellor, SIAES and Founder, SISSO

Sulabh International Academy of Enviorenmental Sanitation
Palam, New Delhi

"Development of Guidelines for Water Safety Plans for Rural Water Supply Systems"

Dated: 28th Nov. 2009

Prof. Kumar Jyoti Nath
Vice Chancellor, SIAES and
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Preface

During the last decades, starting with the International decade of Water Supply and Sanitation (1981-1990), substantial investments have been made by the Central and State Govts., In India for the improvement of community water supply in the rural areas of the country. Unfortunately, however, this is not reflected in the community health scenario. There is no significant reduction in the morbidities related to water and sanitation related diseases particularly the diarrheal infections. The primary reason for the health benefits not being commensurate with the investments made in community water supply sector is the neglect of water quality. Till 80s and 90s, even the rudimentary facilities of the water quality and surveillance were not available for the rural communities. Though in recent years, the facilities for monitoring and surveillance of water quality in the rural areas have expanded significantly under various national programmes, the approach and structure of the same leave many questions, unanswered. Traditionally the approach to water quality and safety management in India has relied on endpoint testing of drinking water as it leaves the system. Often a few samples are collected from the source, treatment plant or the distribution system, but there is no comprehensive system of identification of contamination risks and hazards thoroughly in the entire system from the catchment to the consumer. The problem with "end product testing" is that the results are too little and too late for preventive action.

The traditional and existing concepts of a good water supply management which is being practiced largely in most urban and also rural water supply systems in the country might include some of the components of the water safety plan which WHO is trying to promote in the developing countries, but they mostly do not include hazard identification and risk assessment and management based on a health based target. The Water Safety Plan is essentially a framework of hazard identification, risk assessment and risk management including the control measures, monitoring and incidental and emergency plans. It is also required that the associated documentation for each system should be included in the same. The water supplier is the key player in the WSP, but other stakeholders including the consumers have equally significant roles.

The revised National Rural Drinking Water Programme (NRDWP) Guidelines 2009-2012 issued by Rajiv Gandhi National Drinking Water Mission, Department of Drinking Water Supply has shifted the focus from 'source development and installation of water supply system for providing drinking water supply to rural household' to focus on development of 'village security plan' which also includes village safety plan before taking up planning & installation of water supply system to ensure provision of safe and adequate water supply to each rural household at a convenient location on a sustainable basis. Basically it envisages provision of drinking water as a part of the overall water resource management and safety plan.
In the above context water safety issues play an important role for sustainable water supply in the rural habitations in the country. The water safety aims at keeping not only surveillance to all unit operations in water supply but also provides guidelines with do's and don'ts for operation, maintenance, keeping the system free from pollutional threat, minimization of unaccounted for water (UFW), scope of peoples participation and sustainability of the system.

For the first time in independent India, policy support, in principle has been obtained for institutionalizing WSP approach under the revised NRDWP. Now, it is of utmost importance that along with adequate funding support and appropriate technology development, capacity building is undertaken in various organizations in the rural water supply chain, i.e, State level, District level, Block level and Grass root level. The present document which WHO has entrusted the Sulabh International Academy of Environmental Sanitation (SIAES) addresses the above issues. The document which is developed with contributions by a group of nationally and internationally reputed experts and reviewed by experienced professionals include comprehensive guidelines for various rural water supply systems which are presently being practiced in the rural areas of the country. We hope the document would be useful for the professional and various stakeholders in the rural water supply chain and it would be useful as a support document for the revised NRDWP.

Prof. Kumar Jyoti Nath
Team Leader

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Chapter-I

"Introduction and Background"

Introduction

1.1 WATER SAFETY PLAN: CONCEPT AND OBJECTIVES

The delivery of safe drinking water is vital for protecting public health and of promoting

more secure livelihoods in a country. Very often, however, assessment of water safety particularly in the context of rural communities in India is limited to occasional tests of water quality and insufficient attention is paid to the proactive management of water safety. The traditional approach to water quality and safety management has relied on the testing of drinking water either as it leaves the treatment works or at selected points, either within the distribution system or at consumer taps. This is what is referred to as 'end-product testing'. The problem with this approach is that the results are too little and too late for preventive action. Improving the management of water safety, adopting appropriate quality assurance procedures is increasingly in the priority agenda.

The World Health Organization (WHO), in their Guidelines for Drinking-water Quality (2004) concludes that end-product testing is not sufficient to guarantee safe drinking water to consumers. Instead, WHO recommends planning and implementation of effective WSP for ensuring safe drinking water.

The advantage of WSP over end-product testing is, WSP concentrate on ensuring , that, the processes involved in delivering safe drinking water are operated properly and are under full control at all times. In addition WSP also address the issues of providing an organized and structured system to minimize the chance of failure through oversight or lapse of management. The process should help to increases the consistency with which safe water can be supplied and provide contingency plans to respond to system failures or unforeseeable hazardous events.

Developing and implementing of WSP of a water supply system is based largely upon Hazard Analysis and Critical Control Point (HACCP) approach. The approach include –

- understanding of the system,
- systematic and detailed assessment and prioritization of hazards and associate risk
- putting appropriate control measures in place to reduce risks to an acceptable level
- monitoring of barriers or control measures.

In the revision of their Guidelines for Drinking water quality, the World Health Organization (WHO) identified five key components that are required to deliver safe drinking water (WHO, 2004; Davison et al., 2004).

- The establishment of health-based targets for microbial and chemical quality of water,

- A system assessment to determine whether the water supply chain from catchment to consumer can deliver safe drinking water at the point of consumption,

- Monitoring of identified control measures within the water supply chain that provide assurance of safety,

- Management plans documenting the system assessment and monitoring and which describe the actions to be taken during normal operation and incident conditions to secure water safety,

- Independent public health surveillance of water safety.

It is well understood that the overall responsibility to achieve the goal for delivering safe drinking water to the rural community cannot be borne by a single agency or sector, rather an integrated approach is the key factor. Steps (ii) to (iv) inclusive constitute what is called a Water Safety Plan (WSP). It should be the responsibility of the nodal organization to prepare, implement and evaluate the WSP. The establishment of health based targets and surveillance are more typically the responsibility of the health sector. (Havelaar et al., 2003; Howard 2002; WHO, 1997; WHO; 2004). However, depending on the institutional set up prevailing in the concerned state or districts, the system may vary.

1.2 Rural Water Supply Scenario in India: Safety and Quality Issues

Rural India has about 800 million people residing in about 1.6 million habitations spread over **15** diverse ecological regions. Meeting the drinking water needs of such a large population can be a daunting task. The non-uniformity in level of awareness, socio-economic development, education, poverty, practices and rituals and water availability as well as wide variations in water quality add to the complexity of the task. As per estimation, couple of years back, around **25** million Indians are affected by water-borne diseases annually, around 700,000 are estimated to die, mostly children under 5, of water, sanitation and hygiene related diseases and 73 million working days are lost due to water-borne diseases each year.

There is no such thing as naturally pure water. In nature all water contains some impurities. As water flows in streams collects in lakes and filter through layer of soil and rock in the ground, it dissolves or absorbs the substances that it touches. Some of these substances are harmless. But presence of certain chemical parameters beyond tolerance limit or presence of pathogenic organisms in water render it unsuitable for drinking. Water also gets contaminated during handling, treatment and transportation in the public distribution system. Drinking water safety is a vital public health issue. Many types of infectious diseases can be transmitted through the consumption of water tainted with bacteria, parasites, viruses or chemicals.

India has witnessed significant improvement in rural water supply with increasing coverage of areas and a large volume of financial resources made available. Technology options for rural water supply depend on sources, water quality, extent and magnitude of necessary treatment etc. Again, while surface water treatment systems aim at removal of suspended and colloidal matter and microbial contaminants, the ground water treatments are necessary for removal of specific contaminants like arsenic, excess of fluoride, nitrate, excess hardness, iron etc. The upgradation of coastal/estuarine water to convert it as per drinking water quality requires desalination technology.

The drinking water supplied to the consumers must reach them safe and potable. Accordingly all water supply systems must have a water safety plan in place. These include source protection, appropriate intake, application of water treatment process and optimal operation and maintenance, rational distribution system, water quality monitoring and surveillance, etc. for surface water treatment. In case of ground water supply emphasis need to be given on appropriate aquifer selection, design of bore well, pumping arrangement, specific yield, distribution, maintenance, water quality monitoring and surveillance etc. In case of spot sources (Tube wells with hand pump attachment) issues relating to platform, drainage, safe distance from pollutional sources, local priming during summer etc. need to be addressed so as to maintain safe water supply to the villages from safe sources.

The revised National Rural Drinking Water Programme (NRDWP) Guidelines 2009-2012 issued by Rajiv Gandhi National Drinking Water Mission, Department of Drinking Water Supply has shifted the focus from 'source development and installation of water supply system for providing drinking water supply to rural household' to focus on development of 'village security plan' which also includes village safety plan before taking up planning & installation of water supply system to ensure provision of safe and adequate water supply to each rural household at a convenient location on a sustainable basis. Basically it envisages provision of drinking water as a part of the overall water resource management and safety plan.

In the above context water safety issues play an important role for sustainable water supply in the rural habitations in the country. The water safety aims at keeping not only surveillance to all unit operations in water supply but also provides guidelines with do's and don'ts for operation, maintenance, keeping the system free from pollutional threat, minimization of unaccounted for water (UFW), scope of peoples participation and sustainability of the system.

1.3 CRITICAL CONSTRAINTS AND KEY CHALLENGES:

Given the demographic and socio-economic character, ecological and hydrogeological diversities, of rural India and the institutional and infrastructural capacities of rural water supply service sector, planning and implementation of a comprehensive Water Safety Plan for the rural water supply systems is a huge challenge. Key constraints and concerns include the following:-

(i) *Limited data availability*

Basic data in respect of catchment and source water quality and also various components of water transmission, distribution, storage and house hold handling in the rural areas is difficult to be obtained. Assessment of risks from chemical and microbial contamination of the system from catchment to consumer end becomes difficult in absence of regular sanitary inspection data and information.

(ii) *Unplanned development*

Limitations in regulatory institutions and enforcement mechanism have resulted in unplanned development and fragmented responsibility which make it difficult to locate water supply lines and hazards to the same.

(iii) *Sanitation*

Poor status of rural sanitation including facilities for human excreta disposal drainage and solid waste management, and also open defecation in many areas increases the risk of faecal contamination of the system in the rural areas.

(iv) *System Knowledge*

Because of lack of culture and expertise in community water supply management in most of the village level organizations in the rural areas, much of the information of the piped network may not be available due to poor record keeping or lack of post construction documentation.

(v) *Equipment/Human resource availability*

If the time of setting up health based standards for appropriate water quality parameters, both microbial and chemical, we should carefully consider the availability of resources as well as infrastructure such as laboratories, skilled manpower, technical expertise, etc. The planned WSP for achieving the same, must also address these problems, including capacity building and resource mobilization.

1.4 Rural Water Supply Systems:

In the pre-independence era during 30s and 40s most rural communities depended on dug wells and ponds as also rivers and canals for meeting their domestic water needs including drinking, cooking, bathing, washing, etc. However, as most of these sources were grossly contaminated with pathogenic micro-organisms, the communicable disease burden in terms of diarrhea, cholera, typhoid, hepatitis, worm infection, etc were huge and epidemics of diarrheal diseases were frequent. Infant mortality rate was very high, more than 150. After independence, the National Govt. launched a strong campaign for providing hand pump operated tube wells for supplying bacteriologically safe ground water to the rural community. Presently more than 85% of the rural communities receive their water supply from ground water sources. In recent years however, problems of chemical contamination of ground water sources, like arsenic, fluoride, nitrate, salinity etc have added a new dimension to the rural water supply problem. In many states, increasing number of rural communities are being supplied from piped water supply systems with appropriate treatment for improving water quality both microbially and chemically.

In the above context, the present document has discussed planning and implementation of water safety plan for the following rural water supply systems which are being used in varying extent by the rural communities in different regions of the country.

i) Dug well based rural water supply system
ii) Pond based rural water supply system with appropriate treatment and rain water harvesting system through surface storage
iii) Bore well based rural water supply system
iv) Roof top rain water harvesting system
v) Ground water recharge system
vi) Gravity fed water supply systems for rural communities particularly in the hilly areas.
vii) Arsenic removal systems for ground water based schemes
viii) Fluoride removal systems for ground water based schemes
ix) Iron removal systems for rural schemes
x) Disinfection systems for rural schemes
xi) Pump and tank systems for single village.
xii) Piped water supply systems with appropriate treatment for multiple villages.

Developing and implementing of Water Safety Plan for all the above systems, broadly adapting hazard analysis and critical control approach, include, -

- Understanding of the system
- Systematic and detailed assessment and prioritization and hazard and associated risks
- Putting appropriate control measures in place to reduce risks to an acceptable level.
- Monitoring of barriers or control measures and verification and validation of the same.

This guideline is prepared with a aim to provide practical guidance to the key stakeholders, project managers, workers and consumers at different levels, for evolving situation specific good practices for planning and implementation of WSP approach within the broad guideline of the water security plan proposed by Govt. of India.

Guidelines for Water Safety Plan in the rural areas

Chapter-2

"Institutional Framework for implementing water safety plans in rural India"

Institutional Framework for implementing water safety plans in rural India

2.1 Introduction

The Govt. of India has recently published a new framework for implementation of rural water supply for the period 2008-12 which has suggested a paradigm shift in approach. Salient features of the guidelines are mentioned below:

a) Ensure permanent drinking water security in rural area

b) Stress on ensuring drinking water security for all in the community in place of present norm of water supply based on per capita basis.

c) To reduce disease burden and improve quality of life, it has been decided that the water supplied for drinking and cooking should be of high quality as per the potable standards. This emphasizes the need to establish quality assurance programmes for water supply to reduce potential risk of water contamination, integrating it with the National Rural Water Quality Monitoring & Surveillance Programme.

d) Convergence of National Rural Employment Guarantee Scheme programme for construction of new ponds and rejuvenation of the old ponds

e) Maintenance cost of all water supply systems should have an inbuilt component of cross-subsidy to ensure that the economically backward groups are not deprived of this basic minimum needs

f) Shift from the conventional litres per capita per day to the norms of securing drinking water security for all in the community, based on the felt need of the community.

g) Installation of a water supply system in a habitation does not confer on it, the status of a fully covered habitation unless every household in the habitation has been fully covered with potable water in sufficient quantity and of adequate quality.

h) The States should transfer the programme to the Panchayeti Raj Institutions (PRI) particularly to the Gram Panchayats to enable the community to plan, implement and manage their own water supply systems.

The New Policy approach, provide necessary scope and opportunity for the Rural Water Supply Management at villages, block, district and state level, to plan and implement Water Safety Plan and include the basic components of the same, in the rural water supply projects.

2.2 Institutional Mechanism at the State, District, Block/Village Level

Provision of water and sanitation is a state subject. Thus, all programmes related to drinking water supply are implemented by the states. As per 73rd amendment of the Indian constitution, most of the rural development programmes including provision of water supply and sanitation in rural areas is now implemented by the three-tier Panchayet system (Rural local govt.). As per rules of business, in almost all the states, PHED or the equivalent autonomous board, is the nodal department for rural water supply in rural areas. PHED develops plan and liaison with the Department of Drinking Water Supply under the Ministry of Rural Development, Government of India. To meet various types of activities like; coverage, sustainability, water quality etc, the required funds are shared by both the GOI and the State Governments from the funds allocated under National Rural Water Supply Programme (NRWSP). All states are also required to provide drinking water facilities in all the rural schools and ICDS centres from fund available under NRWSP. A part of this work should also be accomplished through the funds provided by the Twelfth Finance Commission.

Under the NRWSP, the issue of Water Quality Monitoring and Surveillance has also been given a lot of importance. It has been proposed to develop data from household level to link it with the database at the Mission Level to ensure drinking water security at the household level. Stress has also been given on MIS (computerization of data at sub-divisional level and to define the location of all rural drinking water sources with the help of GPS). To facilitate implementation of all IEC and HRD related activities, 100% grant-in-aid support has been provided to the states to establish Communication and Capacity Development Unit (CCDU). Besides all these, stress has been given by the GOI for R&D as well as Programme & Project Monitoring & Evaluation.

Considering drinking water a public good, importance has been given for involvement of the community to develop its own village water security plan taking into consideration, the present water availability, reliability and its different usage and equity. To ensure this, different types of bodies are to be formed at various levels. While at village level, Village Water and Sanitation Committees (VWSC) are to be formed, at district level, District Water and Sanitation Mission (DWSM) is to be formed. At state level, State Water and Sanitation Mission (SWSM) should be constituted to prepare broad state specific policy and programme implementation framework to enable the Panchayati Raj Institutions (PRIs) and community organizations play their roles effectively.

There are different types in designated Panchayat bodies for water and sanitation related matters. At the District level in the Zilla Parishad or Zilla Panchayet (ZP), there is one standing committee on water, sanitation and health related matters headed by the Chairman of that committee. In this committee, other elected representatives of the ZP (from ruling as well as opposition parties) and some other ZP officials are also inducted. The Executive Engineer, PHED and the Chief Medical Officer of Health (CMOH) are also members of this committee. The EE, PHED provides all technical inputs and guidance to the committee in implementing various activities. Similar standing committee is also there at Block or Taluka level. While at ZP level, the Additional or Chief Executive Officer is responsible for implementation, at block level; the Block Development Officer (BDO) being the Executive Officer of the block, is responsible for implementation of the programme. One Sub-Assistant Engineer (SAE, RWS) assists the BDO in implementing water and sanitation related activities. At Gram Panchayat (GP) level, the Pradhan or the Gram Panchayet President is responsible for all such activities. One sub-committee on Education and Health is also there at GP level headed by a Coordinator to guide the Gram Pradhan in implementing water supply related activities. One technical person is also now posted in each of the GP to assist the Gram Panchayat to implement different development programmes including water and sanitation.

Besides all these committees at different levels, there is also Village Water and Sanitation Committee (VWSC) at village level which is responsible for all water and sanitation related matters. This dedicated team is responsible for implementation, subsequent follow up actions and maintenance of all water supply schemes in the village. The committee receives support and other assistances from the member of the Gram Sansad (PRI at booth level), SAE, RWS attached to the Block Office; Mechanic of PHED attached to the Block office; the technical person engaged at Gram Panchayat level, chemist of the concerned water testing laboratory, facilitator of water quality surveillance programme in the GP (sample collector) etc.

2.3 Roles and Responsibilities of Rural Institutions for Implementation of WSP

From the foregoing discussions it is evident that the revised National Rural Drinking Water Programme (NRDWP), Guidelines 2009-2012, issued by the Rajib Gandhi Drinking Water Mission, Department of Drinking Water Supply, Govt. of India, has largely integrated the concerns of Water Safety and Security as conceptualized under the WHO, Water Safety Plan. To plan and implement a comprehensive WSP in all the rural water supply schemes, it is now required that –

(i) All the existing rural institutions are firmly committed to the concept of WSP, - health based targets/risks and hazard analysis/operational control/preventive measures/sanitary inspection/ quality surveillance, etc.

(ii) Required additional financial resource is granted to the executing agencies.

(iii) Required capacity building and training in terms of additional manpower, laboratories, testing kits, etc, are undertaken.

(iv) An effective co-ordination mechanism is developed between PRI organizations and Health & PHE Department, at the state, district, block and village level for implementing WSP.

The process of development, implementation and maintenance of a rural WSP though, is primarily the responsibility of the Lead Implementing (LI) Agency associated with the water supply programme, but requires support and involvement from a number of partner and regulatory organizations. Clear support from all stakeholders particularly of user's group is imperative for successfully putting WSP for rural water safety programme into practice. Supports from appropriate authorities are also required –

- To secure manpower and financial resources
- To obtain support for changes in working practices
- To get commitment from all management levels
- To increase acceptance of operational staff

Initial step of the WSP process should therefore include:

- Identify the organization, who should take lead in the WSP process, in the rural setting
- Gain commitment of participation and support, from other partner key organizations in the WSP process as per need

Frame work for implementation of NRDWM along with providing requisite policy support for institutionalizing WSP as an integral component of Water Security Plan , suggests constitution of Water and Sanitation Support Organization (WSSO) under State Water and Sanitation Mission (SWSM).Suggested roles and responsibilities of WSSO include, to assist various level functionaries including community level actors to prepare water security plan for their water supply scheme.

WSSO need to prepare broad state specific policy and guide-line to enable the PRIs and community organizations to play their role effectively in the context of planning and implementation of WSP approach, facilitating the process of preparation of Comprehensive Water Security Action Plan (CWSAP) for the state.

Planning and implementation of District Water Security Plan(DWSP) which is to be prepared based on individuals Village Water Security Plans developed for the villages of the districts is the responsibility District Water and Sanitation Mission (DWSM)/Zilla Parishad at the district level.

The main objective of the CWSAP is to provide a definite direction to the programme, and also to ensure regular monitoring of the progress made by the respective State's Goal towards achieving drinking water security to every rural household by 2012. Effective implementation of WSP for rural water supply schemes would facilitate the process.

2.4 Policy Support for Mobilization of fund for WSP

For the first time in India policy support, in principle, has been obtained for institutionalizing WSP approach under the revised National Rural Water Supply Programme. Now, along with encouragement and guidance from appropriate authorities for developing and implementing WSP in practice at various levels in the rural water supply schemes, requisite financial support is a must and this issue needs to be addressed at the outset.

Sanitary inspection, water quality testing, data-management, additional manpower deployment etc. need substantial fund .In the Rural Water Supply(RWS) programme, due to acute scarcity of fund, carrying out routine O&M of the created assets and taking up bare minimum necessary rejuvenation and rehabilitation of work has often became a serious problem, water sector of India getting blame as sector of 'build neglect and rebuild'. Specific policy guidance for mobilizing resources for putting WSP into practice should be put into place. Possibility of utilizing fund available for various activities viz. the National Rural Drinking Water Quality Monitoring and Surveillance Programme, water quality surveillance under National Rural Health Mission, 12th Finance Commission etc, for WSP activities may be explored. Along with requisite fund, a degree of change of organizational work culture and mindset of professionals as well as community will also be required for adapting and implementing WSP effectively.

2.5 Formation of WSP Teams

Figure 1 depicts the responsibilities of various level institutions in the context of planning and implementation of WSP. We do not suggest creation of new institutions for implementation of WSP, rather strengthening of the existing institutions with additional manpower, laboratory infrastructure, etc, would be desirable. However as indicated in Fig. 1 at the scheme level, it might be required to have a support team for overseeing the implementation of WSP.

2.5.1 Scheme Specific WSP Support Teams

A comprehensive water safety plan should be in place during the planning of any rural water supply system. In this regard it is quite justified to form a core team for the whole state for preparation and planning of WSP for various rural water supply schemes. In India, it is a common practice to engage consultancy agencies for planning and design of water supply systems. But very few consultancy agencies in India in the private sector have adequate experience in planning a comprehensive water safety plan. Hence, prudent thinking and capacity building approaches are needed before engaging outside agencies for preparation of WSP. State CCDUs could be entrusted with this task. As far as the implementation of WSP, in the operation and management of water supply schemes are concerned the existing institutions in the PHED, P&RD and other related organizations should be involved and here also lot of effort is required for appropriate capacity building.

Level	Institutional Mechanism	Responsibility/Function
State level	Water and Sanitation Support Organisation(WSSO) to be created Under State Water and Sanitation Mission (SWSM)	Formulation of State specific policy and guide-line as required facilitating process of WSP in the state. Preparation of Comprehensive Water Security Action Plan Committing fund for WSP activities Monitoring & Supervision of WSP related activities in the state
District Level	District Water & Sanitation Mission (DWSM)/ Zilla Parishadh	Planning and implementation of District Water Security Plan(DWSP) .Develop District Resource Pool(DRP),which should include experience and expert personal who will be in a position to render their expertise to the WSP teams of the individual scheme Channelizing fund
Village Level	Village Water and Sanitation Committee(VWSC) / Pani Samiti, to work with close coordination or in convergence with Village Health And Sanitation Committee (VHSC) of NRHM	Planning, implementation and, of water supply scheme for village for achieving health based targets focus on water quality
Scheme Level	Water Safety Plan (WSP) Team	Planning , implementation documentation etc. of WSP

Figure 1

Responsibilities of Various Level Institutions In The Context Of Planning & Implementation Of WSP

- Depending on the extent, magnitude and population coverage of the RWS project, the scheme level team could be at the village, block or district level.

- Depending on the size of a water supply organisation, and where organizations are resp onsible
  for multiple systems, it may be necessary to have multiple WSP working groups, which r eport

- to a central team. The usefulness of this arrangement of this arrangement needs to be assessed at the commencement of the process but may include:

- A core team;

- Subordinate working groups that undertake particular aspects of the WSP, such as a 'catchment', 'source water', 'treatment' and 'distribution system' ,

- External team members and reviewers (incorporating government agents and independent experts).

The Public Health Engg. Dept. (PHED), is the nodal Dept. for implementing major rural water supply systems involving large water treatment plants and multiple village transmission cum distribution systems. PHED is also responsible for water quality monitoring and surveillance at the state, district and block level. Panchayeti Raj organizations (PRI) are responsible for operation and maintenance of spot sources and also village level distribution systems. In some of the states like West Bengal, where water quality monitoring and surveillance is also supported by NGO run laboratories, the same are under the control of P&RDD.

In view of the above, the following WSP Support Teams are suggested at various levels.

WSP Teams at various levels

Level	Members of the WSP Team	Remarks
State	Chief Engineer /Officer-in-Charge (Water Quality Management); Superintendent Engineer in charge of State Monitoring Cell; Chief Chemist / Senior Consultant / Lab Coordinators; Chairmen, Conveners of Water Quality related Advisory Bodies wherever applicable./Health Dept., Experts	The team should address the broad water quality concerns and water safety risks in the State-wide perspective.
Multiple Block/Multiple District Treatment Plant/ District and Water Supply Schemes	Executive Engineer in Charge of the water treatment plant supplying water to the multiple village system; Chief Chemist/Lab. In Charge; Mechanical/ Electrical Engineers-in-Charge of Intake works and pumping; Officer-in-Charge of the Treatment Plant; District Medical Officer and one/two external experts. President Zilla Parishad/Shabhadhipati, Zilla Parishad	This team is primarily responsible for hazard monitoring and risk assessment in the treatment plants operation & maintenance. Quality monitoring maintenance and management of water treatment plant are the primary concerns of this team. In case of any critical problem, needing the support of State level team, the matter should be referred to them.
Block / Zonal Reservoirs and Trunk mains and Distribution Systems	Depending on the length and extent of the truck mains and the no. of zonal reservoirs, there could be no. of such water safety teams at the block levels. The members include concerned Assistant Engineers, Block Development Officer, Block Medical Officer, Chemist in charge of concerned laboratories. President of Block/Taluka Panchayet Shabhapati of Panchayet Samities as the case may be. Sub-Assistant Engineer, RWS.	This team's primary responsibility would be the operation & maintenance of the truck main including leak detection, and the upkeep of the zonal reservoirs and ensuring that residual chorine is maintained at the desired level. The committee at the block level should be in constant contact and co-ordination with the higher level committees.

Gram Panchayet (GP) Distribution Household Systems/hand pump/Dug well Village level, Water Supply Schemes	Gram Panchayet functionary in charge of rural water supply and sanitation, Sub-Assistant Engineer, RWS. One elected member of the GP, Laboratory staff from the nearest Laboratory, Community representative, Anganwadi workers, teachers of local school/colleges.	This committee's primary responsibility is to monitor the quality of water at the street stand post and also in the household. Periodic sanitary inspection of the distribution systems including street stand posts and household plumbing's system should also be taken up. The risk posed by human excreta and waste disposal system should also be assessed and taken up to the higher level committees if required.

* The various water safety plans committees mentioned above should function in conjunction and coordination with existing institutions under the revised National Rural Water supply Guideline as indicated in Figure 1.

Guidelines for Water Safety Plan in the rural areas

Chapter-3

"Gravity Fed Water Supply System in the Hilly Area"

"Gravity Fed Water Supply System in the Hilly Area"

1. Introduction

Availing the advantage of topography in the hilly area, water is conveyed from its source to the consumer end by gravity force in a Gravity Fed Water Supply (GFWS) system. GFWS system is one of the most popular means of providing water supply in all the hilly states of North Eastern Region (NER), Uttaranchal, Himachal Pradesh, J&K etc. As in GFWs system no recurring cost for energy is involved, the system is cost effective.

GFWS system like other systems of water supply, also exposed to the risk of contamination of different type and degree, depending upon site conditions and other variable. Properly planned and implemented Water Safety Plan(WSP) considered to be an effective quality assurance tool having the potentiality to ensure supply of safe water from GFWS up to consumer end . Objective of WSP is to reduce the potential risk of contamination of water supply system adopting a comprehensive risk assessment and risk management approach to all the steps in a water supply chain from catchment to consumer.

In developing WSP for GFWS system, to the extent possible, preference should be on, streamlining and upgrading, the current practice of the water quality management if any. WSP approach should be simple, user friendly, having flexibility to improve as and when new information and experience becomes available.

2. Process Description for GFWS system

Putting appropriate control measures in place in HACCP approach of WSP need realistic risk assessment for identifying and analysing potential hazards.

One of the important requirements of such system assessment process is to develop understanding regarding the process, covering the whole system from the catchment to the end point of supply, along water quality requirements at various steps. To identify where the system is vulnerable to hazardous events, and who need to be responsible for control measures also important.

Schematic Flow diagram of a typical GFWS System is given in Fig. 1

Format for capturing information related with Process Description for GFWS system may be seen in the table below.

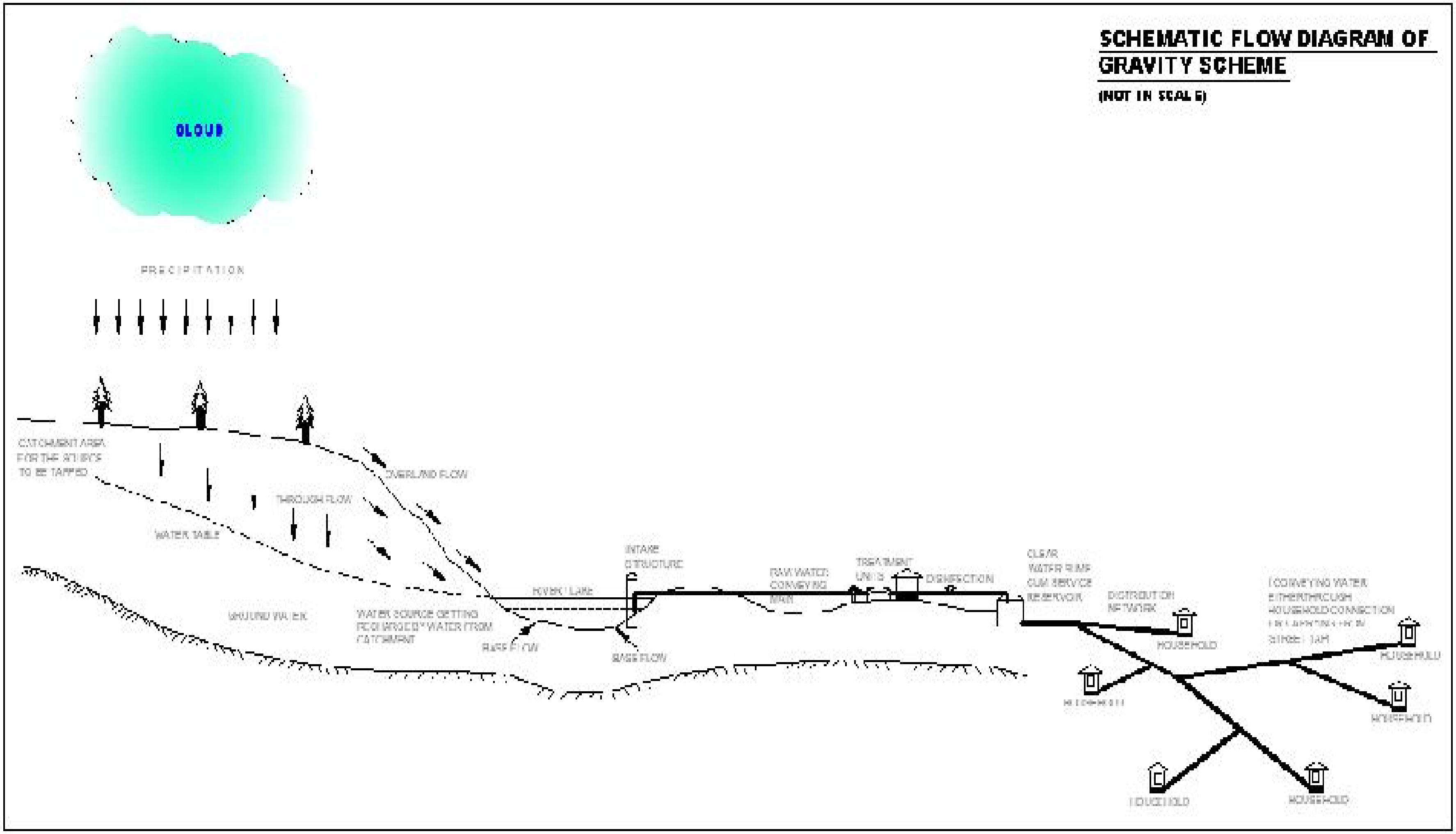


Table 1 – Format for capturing information related with Process Description for GFWS system

Components in the process of water supply	Water quality requirements	Description with particular reference to vulnerability to hazard	Responsibility for control measures
Source Centred Catchment Area Management(SCCAM) If extension of the water project is foreseen, water catchment areas should be identified that may be used in the future and possibly can already be included in the SCCAM Protecting catchment from any potential hazardous events, which may affect raw water quality at source conserving and increasing the water retaining capacity in the catchment area	Recharging of water source should not be cause of contamination. Preventing causes of turbidity in the raw water due soil erosion	Insanitary activities in the catchment area of human and animal may cause chemical and bacteriological contamination as well as high turbidity of water at source due to leaching soil erosion etc.	Lead Implementing (LI)& Partner Agencies & Community
Source Protection Source of GFWS may be any one of the following or combination of two or more a)Spring b) Stream c) Impounding reservoir d) River e) Any other(Specify)	Quality of water to be tapped need to be according to treatment plant capability, preventing step in source contamination can save unnecessary expenditure , of treating the same	Competing demand of water for other purpose viz. irrigation , hydroelectric etc. drinking water requirement should get preference . Flooding of source may increase turbidity, contamination etc. Trespassing of human and animal may cause various degree of contamination	LI & Partner Agencies & Community
Intake Structure	Same as source	Damage of intake structure, may cause leaching of contamination and water leakage , Back up storage at intake may help in mitigation of draught situation Trespassing may contaminate water at intake	Agencies & Community

Raw Water Conveying main	Same as source & intake	Any leakage may expose to risk of contamination	LI Agencies & Community
Treatment Unit	Treatment unit should be capable of treating undesirable contaminants from raw water and prevent re-contamination in the process of treatment Treated water quality should conform to the standard specified in BIS10500	Poor operational practice may lead to large-scale contamination and increased public health risks In-adequate O&M fund may effect proper O&M of Treatment unit compromising preventing steps against contamination, Chemicals used if any during treatment process, should be free from contamination Trespassing to be avoided	LI Agencies & Community
Clear Water Service Reservoir & disinfection	Water quality should conform to the standard specified in BIS10500 Post-chlorination to maintain residual chlorine at delivery point	Prevent possibility of recontamination, due to poor condition of clear water reservoir	LI Agencies & Community
Distribution Net-Work	Water quality should conform to the standard specified in BIS10500 At the delivery point specified residual chlorine to be maintained	Leakage combined with low pressure ,damage pipes and fittings may cause the risk of contamination	LI Agencies & Community
Water Collection Conveying Storage &Use at House-hold	Water quality should be fit for the purpose of intended use	Possibility of microbiological contamination from collection point of distribution net-work and point of use is wide-spread and often significant	User community

3. Technology description including Sanitary map of the water catchment

Brief technology description of the GFWS which should include design criteria adopted for various component of the scheme , specification of material used , sanitary map of the water catchment, source protection etc. management process at various level, WQ test requirements etc considered very much important information for planning and implementation of WSP

While providing technology description it is also desirable to provide certain general information about the scheme as shown below

General Information about the GFWS scheme

- Name of the Habitation/Habitations served by the GFWS
- Name of Census Village with code no served by the GFWS
- Year of Commission of the scheme-
- Design period of the scheme
- Design capacity of the scheme-
- No of House-holds presently served by the scheme - SC
  ST
  General
  Total
- House-holds no projected for ensuring house-hold water security up to specified design period by scheme
- Whether there is any proposal/possibility of future augmentation of the scheme
- Whether House Holds served by the scheme have access to any other water supply system Yes/No
- If yes brief note about the alternative system
- About Health Data availability of community (from NRHM)

Format for providing information related with Technology Description etc. may be seen in Table 2

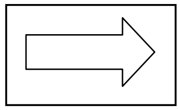
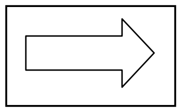
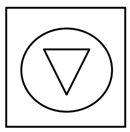
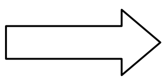
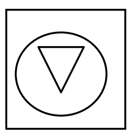
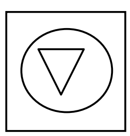
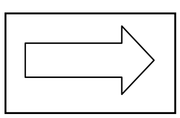
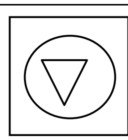
Table 2 Format for providing information related with Technology Description etc.

Component/ Process	Information to be provided	Water Quality testing requirements	Management Process		Document to be prepared /provided
			Present	Improvement suggested	
Source Centred Catchment Area Management	a)Land use and coverage pattern of catchment with particular focus on lessen contaminants, soil erosion and sedimentation control, b)Whether any extension of the water project is foreseen, if yes water catchment areas should be identified that may be used in the future	Skeleton facility of water testing should be available in the TPU For selected chem. and bact. parameter, water testing in sub.div /PHC lab.	Except ad-hoc inspection By VWSC member nothing specific	More scientific Sanitary inspection, involving land user of the catchment, enhancing their awareness	Sanitary map of catchment

	c) Whether any significant or minor change is expected in land use, coverage either in short term or long term, also need to be assessed				
Protection of water source	a)Water availability of source during different session of the year b) What are the other purpose for which water from the source are in use(competitive use) c) Water quality indicating any specific water quality problem need specific attention d) whether water source get flooded or damaged during, heavy rain?	Testing for pH, turbidity etc. may be done in TPU lab, regularly for selected chem. parameter &bact.(monthly) in lab	Time to time inspection by field level operating staff	Contingency plan to be prepared for addressing problem of flood etc.	Water discharge record for sufficient period of time
Intake Structure	Accessibility of intake-structure for O&M purpose Dimensions of intake-structure, Details about screening device	Same as case of water source	Time to time inspection by field level operating staff	Preventing trespassing of unauthorised personnel or animal erecting fencing Preparing preventive maintenance schedule	Drawing and specification of Intake structure including grit or screen
Raw water conveying main	Diameter, length, specification of pipe material, quality of laying any leakage in the pipe		Inspection by field level operating staff	Preventing steps against damage of the pipe line	Lay-out drawing of Pipes
Treatment Plant Unit (TPU)	The capacity of the TPU indicating quantity and contaminants(Physical, chemical, bacteriological) and the range for tackling which TP designed . The units of the plant including their design parameter, specification of construction etc.	Testing for pH, turbidity etc. may be done in TPU lab, regularly , for selected chem. parameter &bact.(monthly) in lab	O&M by departmentally engage minimally trained operators WQM not at all adequate	Operators to be trained, WQM to be strengthen	Detailed drawing of the treatment plant- showing all the operating valves etc.
Clear Water Reservoir (CWR) & Disinfection	Capacity of the CWR, Number of compartments, positions of inlet, out-let material for construction. Whether CWR is adequately leakage proof and covered, general condition of the CWR Disinfection process ,along with contact period	Water testing for selected chem. parameter &bact.(monthly) in lab. Testing of bleaching powder for Chlorine content etc.	Operation by departmentally engage minimally trained operators	Cleaning of CWR should be done much more regularly. Trespassing of un authorise person should be strictly prohibited to avoid re-contamination	Detailed drawing of the CWR,

Distribution net-work	Pipe material, dia, length age etc, Details of the specials used in the distribution etc.	Regular residual Chlorine testing, by field testing kits	Operated by departmentally engage minimally trained operators No preventive maintenance	Regular flushing and disinfection of distribution net-work Preventive maintenance	Lay-out drawing of distribution net work, showing valve chambers, Vulnerable sections etc.
Collecting ,carrying, storing and use of water by users	Knowledge Attitude &Practice(KAP) of the user related with water handling etc.	Monitoring of bacteriological quality of water at house-hold level	Nothing effective in existence	Community need to be mobilised and effective Community Based Water Quality Monitoring & Surveillance must be put into place	Action Plan regarding implementation of Behavioural Change Communication

4. Format for capturing information related with process flow with symbol for GFWS system

Indicating steps of process flow with symbol	Description
	Catchment - recharging source Inspection required
	Source- Transportation Inspection required
	Intake structure-Storing ,Transportation Inspection
	Raw water conveying main- Transportation
	Treatment- Inspection and Operation
	Clear-water-reservoir and disinfection- Storage, inspection and operation
	Distribution- net work- Transportation and Inspection
	Collecting ,carrying, storing and use of water by users

Please refer to the schematic Flow sheet of GFWS system in Figure 1.

5. Hazards Analysis & Risk Prioritization

It is the most important activity of WSP process .Steps expected to be worked through, are:

- Identify the hazardous events that can result in hazards gaining entry to the GFWS system
- Determine the risk potential of each hazardous event

- Identify the control measures currently in place;
- Suggest any additional control measures required

Typical challenges

- Since a risk assessment provides a 'point in time' picture of the system, the risk assessment should be reviewed on a regular basis in order not to miss new hazards and hazardous events.
- Uncertainty in assessment of risks due to unavailability of data, poor knowledge of activities within the water supply chain and their relative contribution to the risk generated by the hazard or hazardous event.
- Properly defining likelihood and consequence with sufficient detail to avoid subjective assessments and to enable consistency
- Risk mitigation practices may be a)Pro-active ,b) Reactive c)Emergency or combination of two or more
- Need of development of emergency response plan is critical.

In GFWS system, a number of hazardous events may occur at any one step, it is important to decide whether any of these events present a significant risk and need to be for action. A risk assessment process is therefore required to prioritise the risks.

Various methods are available for risk prioritisation. An example of semi-quantitative risk prioritisation approach for GFWS is presented. The best way of carrying this out is to draw up a simple table and systematically record all potential hazardous events and associated type of hazards.

To avoid being too subjective it will be of crucial importance to provide indicative rating as shown in Table-II to both likely hood of occurrence and consequence/impact in advance.

TABLE-3

Indicative rating of 'Likely hood' and 'Severity' for Risk Prioritisation

Level	**Descriptor**	**Rating (indicative) in numerical terms**
Likely hood of occurrence category		
A	Almost Certain	5
B	Likely	4
C	Moderate	3
D	Unlikely	2
E	Rare	1
'Severity' ,*category*		
A	Insignificant	No detectable impact (1)
B	Minor	Aesthetic impact causing dissatisfaction (2)
C	Moderate	Major aesthetic impact possibly resulting in use of alternative sources (3)
D	Major	Morbidity expected from consuming water (4)
E	Catastrophic	Mortality expected from consuming water (5)

For each event, 'Risk rating' is calculated by multiplying indicative rating of 'Likelihood' by 'Severity', as shown in Table 3

Information capture format for hazards events & risk prioritisation (semi-quantitative method) are depicted below

Table-4 Information capture format for hazards events & risk prioritisation of catchment (semi-quantitative method)

Activity/process Step	Hazardous events and Type	Risk Prioritisation (semi-quantitative method)			Existing control measures	Additional control measures propose
		in category of *Likely-hood*	in category of *consequence/ impact*	Risk rating		
Meteorology and weather patterns	*a) Soil erosion in the catchment area due to heavy rainfall* i)disruption and damage of water-supply system a)cause of increased turbidity probability of bacteriological contamination also high *b) long spell of dry period* In adequacy of discharge in source Hazard Type- Microbial Physical	a)Moderate (3) b) Moderate (3)	a)Major(4) b)Major(4)	3 x 4 =12 3x4 =12	Taking up ad-hoc restoration and damage repairing work No effective control in existence	Taking up permanent nature of preventive measures against soil erosion. Promoting activities to enhance Water retention capacity of soil
Human and animal activities In the catchment areas	Fire-wood collection, latrine and other construction activities cause of Hazard Hazard Type- Microbial	Moderate (3)	Moderate(3)	3x3 = 9	Ad-hoc approach, no systematic effective control measures not in place	Fencing off area to prevent problem of trespassing

Land use/cover pattern/Shifting Cultivation/ any quarrying and mining activities	Use of fertilizer and pesticide in agriculture contaminate sub-soil water Hazard Type- Microbial Chemical	Moderate (3)	Major (4)	3x4 = 12	Ad-hoc approach, no systematic effective control measures not in Place	Initiate discussion with land owner

Information capture format for hazards events & risk prioritisation of water source & intake (semi-quantitative method)

Activity/ process Step	**Hazardous events and type**	**Risk Prioritisation (semi-quantitative method)**			**Existing control measures**	**Additional control measures propose**
		in category of Likely-hood	**in category of consequence /impact**	**Risk rating**		
Flooding of water source due to heavy Rainfall	Damage of water source, disruption of water supply, High turbidity Hazard Type- Microbial Physical	Moderate(3)	Moderate (3)	3 X 3 = 9	Ad-hoc emergency measures for restoration of scheme	Coding of source for better data management, diversion of surface water flow and preventing flooding of water source
Open access for people and animals at source	Probability of getting water contaminated Hazard Type- Microbial	Likely (4)	Moderate (3)	4x3 = 12	Displaying sign-board preventing trespassing not very much effective	Strict control to prevent trespassing. Providing fencing may be provided

Inventory of point discharge viz. domestic/industrial waste effecting water quality at source	Possibility of getting raw water contaminated Hazard Type- Microbial Chemical	Moderate(3)	Moderate (3)	3x 3 = 9	Occasional ground inspection upstream , without any effective follow up	Strengthen ground inspection to ascertain that there is no danger of contamination, Effective follow up in case of
Trespassing of un authorise personal and animals at in-take	Possibility of contamination is high Hazard Type- Microbial	Moderate (3)	Moderate (3)	3 x 3= 9	Nothing specific	Provide fencing around intake to prevent trespassing
Intake arrangement	Controlling turbidity in drinking water supplies is important for both health and aesthetic reasons Hazard Type- Physical	Moderate (3)	Minor (2)	3 x2 = 6	Screen broken manual cleaning of debris time to time	Screen or a structure of some kind to be re-installed to hold back debris, with arrangements of periodic cleaning

Table 5: Information capture format for hazards events & risk prioritisation of TPU and CWR (semi-quantitative method)

Activity/process Step	Hazardous events and type	Risk Prioritisation (semi-quantitative method)			Existing control measures	Additional control measures propose
		in category of Likely-hood	in category of consequence /impact	Risk rating		
Faulty design, poor quality of workmanship of TPU	In-adequacy of treatment process, may fail to remove contamination Causing, health hazard Hazard Type- Physical Chemical Microbial	Likely (4)	Major(4)	4 x 4 = 16	Taking up ad-hoc corrective measures only as reactive basis	Review the design and construction of existing TPU systematically, identify the gap, Taking up both short term and long term corrective measures
Lack of adequate skill personal and constrain of requisite fund for O&M	Poor operational practice and in-adequate O&M may cause various contamination Hazard Type- Physical Chemical Microbial	Likely (4)	Major (4)	4x 4 =16	No specific control measures in existence	Strengthening communication and capacity building initiatives augment resources for O&M through cost sharing from community
Temporary by passing of water TPU due to break-down of TPU or for attending major repair works	May lead to large-scale contamination and increased public health risk Hazard Type- Physical Chemical Microbial	Moderate (3)	Major (4)	3 X 4 = 12	No specific control measures in existence	More stress on Preventive maintenance

Impurities or contaminants present in the chemicals , utilize for treatment purpose	May induce contamination. In water Hazard Type- Chemical Microbial	Unlikely (2)	Moderate (3)	3 x2 = 6	Attempt is made to procure chemical from reliable, tests	Routine checking of the chemicals to be used in treatment process In laboratory to confirm the chemicals are free from contaminants
No proper hygienic measure taken during manual routine cleaning of CWR	Probability of getting re-contamination is very high Hazard Type- Physical Chemical Microbial	Moderate (3)	Moderate (3)	3 X3 = 9	No serious efforts of tackling problem	Inspect CWR regularly and clean at desired frequency adopting necessary hygienic steps
Leakage , damage, of CWR in-adequate cover	Possibility of contamination is very high Hazard Type- Physical Chemical Microbial	Moderate (3)	Moderate (3)	3 x3 = 9	No effective steps for mitigation of problem for constraints of funds	Leakage , damage etc. of CWR to be attended promptly. Problem of fund, to be addressed on priority basis
Improper disinfection -chemicals used for disinfection not as specified. Contact time not adequate etc. Disinfection not done regularly	Effective disinfection is the most vital requirement for ensuring water safety, with-out which water may continue to remain hazardous or prone to the risk of hazard. Hazard Type Microbial	Moderate (3)	Moderate (3)	3 X3 = 9	Time to time supervision of disinfection activities carried out, follow-up action not proper.	Regular testing of disinfectant to be used, to be carried out. Strict supervision should be in place to ensure dosing in correct quantity allowing adequate contact time

Table- 6 Information capture form for *hazards events & risk prioritisation of* distribution net-work and water handling and use at house-hold level(semi-quantitative method)

Activity/process Step	Hazardous events And type	Risk Prioritisation (semi-quantitative method)			Existing control measures	Additional control measures propose
		in category of Likely-hood	in category of consequence/impact	Risk rating		
Leakage/damage /pressure drop of distribution net-work (both for pipes and valves) Attending pipe repair works without maintaining hygienic practice	Leaks in the distribution may be both in visible or non visible form hazardous contaminants from outside may get entry to the distribution net work through leakage/opening etc. contaminating water Hazard Type- Physical Chemical Microbial	Likely(4)	Major(4)	4 X 4 = 16	Attending the major defects as and when possible, no methodical approach	Proper monitoring for timely detection of Leakage/damage /pressure drop etc. Attending detected shortcomings promptly Maintaining adequate inventories of pipes and fittings to attend quick repair
Un authorize operation of distribution with vested interest	Possibility of getting distribution net-work damaged and consequently get contaminated Hazard Type- Physical Chemical Microbial	Moderate(3)	Moderate (3)	3 X 3 = 9	Inspection in limited scale by operating staff to prevent un-authorize operation	Community should be empowered to prevent un-authorise operation expected to provide better results

Faulty design of distribution , poor construction/laying of distribution quality and age of pipes and valves, faulty operation etc.	Any failure in tackling distribution issues in time and efficiently may cause more complicated hazard problem in future Hazard Type- Physical Chemical Microbial	Likely (4)	Major (4)	4 x 4 = 16	Initiating corrective measures ad-hoc basis	To address the issue intervention to be initiated developing proper Action Plan, phasing the activities according to availability of fund.
Corrosion of metallic pipe material in the distribution system	Release of metals into the water may cause undesirable aesthetic and health effect Hazard Type- Physical Chemical	Moderate(3)	Moderate (3)	3 X 3 = 9	No effective mitigation practice in place	Regular flushing and disinfecting of pipes, if feasible pipes may be replaced
Deposition of sedimentation in the distribution system over time	Sedimentation may reduce water carrying capacity and drop of pressure, risk of recontamination of water is also high Hazard Type- Physical Chemical Microbial	Moderate(3)	Minor (2)	3 X 2 = 6	Flushing of distribution system time to time	More effective steps required to minimise access of turbid water to distribution system

Water Collection Conveying Storage &Use at House-hold	Water may become re-contaminated at any point between collection from distribution, storing serving/consuming/ handling due to incorrect practices Hazard Type- Physical Chemical Microbial	Likely(4)	Major (4)	4 x 4 = 16	Dissemination of information among house-hold regarding the need of hygienic practice in collection ,storing handling etc	Thrust on effective implementation of Total Sanitation &Campaign (TSC) to eliminate source of contamination, thrust on behavioural change communication

6. Operational monitoring schedules & Control measures

In WSP process operational monitoring is the act of conducting a planned sequence of observations or measurements, to assess whether the control measures applied at a point in the system are achieving their objectives. Effective monitoring relies on establishing:

- What will be monitored;
- How it will be monitored;
- When it will be monitored;
- Where it will be monitored;
- Who will do the monitoring

For some control measures, it may be necessary to also define 'critical limits' outside of which confidence in water safety would be lost. Deviations from these critical limits usually require corrective actions. Corrective actions should be specific wherever possible, including assigning responsibilities for carrying out the corrective actions

'Monitoring' may also comprise verification and validation which is dealt separately in Table-7, a suggestive format for capturing Operational Monitoring Schedule etc. is presented

Table 7: Information capture format for Operational Monitoring Schedule etc.

Process Step	Parameter to be monitored	Monitoring Process		Critical limit	Corrective Actions	
Source Centred Catchment Area Management	Land use ,coverage pattern, undesirable activities by human and animal whether any significant or minor change is expected in land use, coverage either in short term or long term,	What	Land use and coverage of catchment	No latrines, no waste dumps or no fertiliser for agriculture use , no shifting cultivation .Forest burning	What	Preventing undesirable activities in the catchment area
		How	Proper inspection of catchment		How	Taking up the issue with concern department as well as dialogue with land users
		When	Monthly		When	As soon as detected
		Where	Demarcated catchment area of the source			
		Who	Member of the WSP team and VWSC member		Who	WSP team & community
Protection of Surface/ Sub surface water source	Quality and quantity of water as well as preventive measures against damage of water source from natural calamities (flood, etc) or human and animal activities	What	Testing of water quality on selected parameter, Ascertaining discharge of the source of water , as well as physical safety of the source	Physical, chemical and bacteriological contamination should be within limit of treating capacity of Treatment Plant. Quantity of water should be sufficient to meet requirement	What	Preventing contaminated discharge at the upstream of the tapping point of the source. Promoting water conservation measures

		How	Water quality testing at laboratory, Measuring discharge Physical inspection of site,	Protection measures against prevention of damage should be adequate	How	Taking up the issue with polluter Dialogue with stake-holders
		When	Monthly Twice		When	As a continuous process
		Where	At source		Who	WSP team member, &VWSC members
		Who	Water sample collection sending for testing to lab J AL SURAKSHAK Discharge measurement and inspection by operational Staff.			
Intake Structure	Any interruption of water flow water loss due to damage of structure	What	Ensuring cleaning and repair works taken up to the structure according to the need	Deposition of debris and sediments preventing flow of raw water to the system Damage of structure may effect in retaining water, consequently causing wastage	What	Mobilising community along with operational staff in cleaning and repair work of intake
		How	Inspection		How	Motivating community
		When	Periodical & during high rainfall		When	Regularly interacting with community
		Where	At intake point		Who	WSP team member,

		Who	Operating Staff & WSP team member			&VWSC members
Raw Water conveying main &TPU	Any disruption of raw water conveying main Performance of functioning of TPU	What	No leakage/damage by human or animal/washing away by flood etc. of pipes	Raw water flow below the design requirement Treated water not conforming to BIS standard	What	Taking up protective measures to prevent any unintended damage of Raw water conveying main Address the identified deficiencies in treatment process
		How	a)Close inspection b)Water quality testing		How	Taking up the activities with proper investigation and planning
		When	Inspection every week under normal circumstances, in case of emergency immediately		When	Immediately after the problem is detected and situation goes beyond control
		Where	Along the raw water conveying main		Who	Lead Implementing Agency
		Who	Operational staff and WSP team members			

C WR & Disinfection	Water quality Hygienic environment of clear water reservoir Effectiveness of disinfection	What	Water quality of CWR to be tested Leakage , proper cover of CWR Quality of disinfectant used	Water quality should not indicate any type of hazard No Source having potentiality to contaminate water at CWR should exist No deviation in quality of chemical used for disinfection from the standard specified and contact time should be adequate	What	Regular cleaning of CWR maintaining hygienic practices Possible source of contamination around CWR to be eliminated Quality of chemicals used for disinfection need to be verified Dosing of disinfectant in requisite quantity allowing requisite contact time to be ensured
		How	Lab. Tests of water quality and chemicals used for disinfectant Water tightness tests of CWR		How	Strengthening Supervision and quality control measures Imparting training to the operating staff regarding

						proper disinfection
		When	Weekly		When	Continuous Process
		Where	At CWR		Who	WSP team member and VWSC functionaries
		Who	Jalsurakshak ASHA			
Distribution net-work	Steps taken to minimise water-loss in distribution effective Consumer receiving safe water from distribution	What	Leakage both hidden and exposed, residual head and pressure at different delivery end	Loss of water during distribution should not be more than 20% Residual head at tail end should not be less than 6meter Residual Chlorine at the tail end should not be less than 0.2mg/litre	What	Attending distribution leakage /flushing/replacement work most promptly observing hygienic practices Avoiding any un authorise operation of distribution
		How	By inspection and residual chlorine by field testing kits		How	Maintaining proper super vision and inventory of materials
		When	Weekly		When	Continuous process
		Where	Distribution net work			
		Who	Jalsurakshak ASHA Operating Staff		Who	WSP team member VWSC functionaries, Operating staff

Water Collection Conveying Storage &Use at House-hold	Hygienic water handling practices of the user	What	Practices during collection, transportation and storage of water by user	Water collection, transport and storage to be hygienic Water supply should be capable meeting Health Based Target	What	Changing water related Knowledge, Attitude & Practices(KAP)
	Health Data of Community	How	Observing the practices of user community		How	Inter-personal behavioural change communication
		When	Regularly		When	Regularly

7. Supporting Programme,

Supporting Programmes are those activities that indirectly support water safety, they are also essential for proper operation of the control measures. Supporting Programmes cover a range of activities including communication and capacity development, preventive maintenance and hygiene and sanitation as well as legal aspects such as a programme for understanding the organisation's compliance

Suggestive format for capture of Supporting Programmes is provided in Table 8.

Table 8: Information capture format of Supporting Programmes that could be included in the WSP (not exhaustive)

Programme	Purpose	Examples
Communication & Capacity Development	Success of effective planning and implementation of WSP to a great extent depend upon the awareness and commitment of the stake-holders which need to be enhanced Skill of the operating staff is most important.	• Developing Information Education Communication (IEC) material to enhance the effective participation of various level stake-holders • Organising training for upgrading skill of operating staff
Strengthening Laboratory infrastructure	In-adequate laboratory facilities is one of the major constraints in planning and implementation of WSP in practice.	• Manning the existing laboratories with qualified skilled personnel • Setting up of new laboratories at Sub-div level

		• Net-working with PHC Lab
Calibration	To ensure that critical limit set for monitoring is reliable and of acceptable accuracy.	• Calibration schedules. • Self-calibrating equipment.
Preventive maintenance	To ensure that malfunctions of important processes are minimised and storages and assets are in good working order.	• Putting in practice effective preventive maintenance programme • Adequate inventory of spare material /parts to be kept to attend the repair
Hygiene and sanitation	To prevent personnel involve in operation and equipment as well as chemicals from inducing hazards to the water.	• Hygienic code of conduct of personnel involved in the regular operation must be put into practice • Strict cleanliness to be maintained • Proper methodology to be developed to ensure chemicals used in various process free from contamination
Improving cost recovery from user community	Putting WSP into practice need resource , sharing of cost by user will help in augmenting resources	• Evolving effective affordable cost-sharing mechanism
Attending consumer complain/suggestion	Enhancing consumer confidence level regarding reliability of the system	• Regular dialogue with user group
Research & Development	Planning and implementation of WSP is a new approach. Findings of Action Research having relevant with no doubt can help in improving the system	

8. Verification Schedule

Establishing procedures to verify that the water safety plan is working effectively and will meet the health-based targets is a vital requirement WSP approach. Such verification broadly may involves two activities that are undertaken together to provide a body of evidence that the WSP is working effectively and will meet the desired objective

- Water quality monitoring; and
- Auditing of operational activities.

Verification should also include checking that consumers are satisfied with the water supplied. It is important that consumers are using the safe, managed water supply rather than less safe alternatives.

In Table 9, Information capture format for verification may be seen

Table 9: Information capture format for verification

Activity	Description	Frequency	Responsible Party	Records
Effectiveness of WSP process in achieving health based target	Analyse Health Data of community maintained by NRHM Water analysis reports	Every three months	WSP team, VWSC and NRHM	Health Data of community served maintained by ASHA (NRHM) Water analysis reports
Adequacy of Sanitary Inspection Measures	Review Sanitary inspection form , whether have the scope to include all the potential hazard of the catchment area	Every six months	WSP team VWSC	Sanitary Inspection format
Accuracy of Laboratory Testing	Results of percentage of sample tested may be verified by testing in Referral Lab.	5% of the sample tested as a part of WSP activity	Jalsurakhak, ASHA	Data of Water Quality Analysis carried out both as routine as well as in Referral Lab.
Assessment of Impact of advocacy programme on behavioural change of user's community	Structural Observation of the water related practices of the community	Random sampling of HH and user community	ASHA /grass root worker of LI Agency, Partner Agency, NGO etc.	IEC material produce for the purpose
Auditing status of the Water Security of the user HH. Checking satisfaction level of the user of	Situation study, meeting and interacting with community, Visit to HH to ascertain ground realities	On regular basis	Subject Expert/ ASHA /grass root worker of LI Agency, Partner Agency, NGO etc.	Evaluation Report etc.

the system Verifying users are not using alternative unsafe source rejecting the system				

9. Validation Schedule to ascertain system capability

Validation involves obtaining evidence that the activities taken up supporting the WSP is correct and that the operation of the water supply in accordance with the WSP will be able to achieve the desired health-based targets. Validation normally includes more exclusive and intensive monitoring than routine operational monitoring.

Validation schedule need to be so prepared, that such exercise in a position to ascertain that the overall system design and operation is capable of consistently delivering water of the specified quality to meet the health-based targets

A suggestive format provided in Table10.

Table10: I**nformation capture format for validation**

Item Validated	**Hazardous Events**	**Validation Schedule**	**Comments**
Source Centred Catchment Area Management process	Microbial Contamination getting detected in water –source	Combined analysis of water quality and sanitary inspection data from verification to assess whether protection measures in catchment have been effective and identify the gap and validate the management process	It may often be more efficient to invest in preventive processes within the catchment than to invest in major treatment infrastructure to manage a hazard.
Chlorine residual critical limit values	Non reduction of water –borne diseases burden among the user in-spit-of maintaining residual chlorine 0.1mg/litre	Co-relating residual chlorine and nature of diseases burden, critical limit of residual chlorine may considered to be increased	Disinfection is only one defence against disease. Every effort should be made to protect water sources from contamination
Advocacy approach adopted for ensuring	Water for drinking and cooking getting re-	Critically revisit the advocacy approach, focus more on inter-	Behavioural change is a slow process.

behavioural change among community towards better hygienic practices in water handling	contaminated during carrying , storing and use at the house-hold level	personal communication using youth as change agent	

10. Action Plan for Improvement

When the assessment of the drinking-water system indicate that existing practices and technologies of GFWS system not adequate to ensure drinking-water safety, as a part of full planning and implementation of WSP plan. An action plan for in-corpora ting corrective measures for addressing the in-adequacy need to be developed which may include both short-term and long-term programmes.

Realistic assessment of fund requirement for implementation of improvement plans and careful prioritization of issues in accord with the outcomes of risk assessment also need to be done . Implementation of plans should be monitored to confirm that improvements have been made according to action plan and are effective.

A suggestive format for incorporating information related with Action Plan for Improvement in the WSP plan as discussed presented below

Table11: information capture format. for Action Plan for Improvement (Indicative)

Issues identified for requirement of improvement	**Approach to be adopted for carrying out improvement**	**Short term/long term**	**Time frame for implementation**	**Approximate fund requirement**	**Responsible for improvement**	**Degree of priority**
Control and management of forest and Jhum fire at the catchment area	Supplement community effort facilitate community governance	Long term	No definite time frame		LI and Partner Agency, VWSC	High Priority
Protecting source from flooding	Providing drainage and barrier channel for diversion of flood	Short term	SiX Months	Rs 2lakhs	LI Agency	Priority Medium
Treatment Process unable to remove turbidity to	Renovate the TPU for improving turbidity	Long term	Nine months	Rs1.5 lakhs	LI Agency	Priority Medium

desire extent due to lesser detention period of sedimentation tank	removal efficiency					
Water losses during distribution too high	Replacing damage pipes etc.	Short term	Three months	Rs 1lakhs	LI Agency	High Priority

Chapter-4

"Water Safety Plan for Dug well Based Rural Water Supply System"

Water Safety Plan for Dug well Based Rural Water Supply System

1. Introduction

Dug wells provide a cheap and low-tech solution to accessing groundwater in rural locations, with a high degree of community participation. Dug wells have been successfully excavated to 60m. Dug wells are cheap and low tech (compared to drilling) as they use mostly hand labour for construction. Dug wells have low operational and maintenance costs. Dug wells are traditional abstraction methods and are readily accepted by the community. The construction of dug wells can incorporate a high degree of community participation (e.g. pre-fabrication of earthen/concrete rings). Generally diameter varies from 1.5m to 2m for individual households and small communities. Bigger diameter ranging from 3m to 10m or even more is in use for bigger communities as well as for irrigation purposes. Since most dug wells exploit shallow aquifers, the well may be susceptible to yield fluctuations and possible surface contamination. In view of this dug well has limited use. These wells are generally used where alternative safe water is not available particularly in rocky terrain and where ground water in deeper aquifer is contaminated due to presence of toxic chemicals such as arsenic, fluoride etc.

Water is collected from the dug wells manually using rope and buckets or using hand pumps and power pumps depending on yield, availability of power etc.

2. Water Supply Process Description

(a) Source: The rain water percolates through the soil pores and is deposited as ground water. This water is generally free from suspended particles. However, chances of chemical contamination are there if ground strata through which the rain water is percolating contains soluble chemicals. Chances of bacteriological contamination are also very high. This water is collected traditionally by constructing Dug Well. Water is generally lifted either by bucket fitted with rope or through hand pump fixed over a platform constructed over the well. When the yield is high and electrical power is available power pump is also used.

(b) Treatment: Dug wells can often supply drinking water at a very low cost, but because impurities from the surface easily reach dug wells, a greater risk of contamination occurs for these wells when they are compared to deeper tube wells. Dug wells are relatively easy to contaminate, and dug wells are unreliable. Basically water of dug well is not treated except disinfection. Disinfection is accomplished by adding chlorine depending on the demand. Usually bleaching powder is used as the source of chlorine. Pot chlorination is generally adopted for dug wells. Most of the bacteria, viruses, parasites, and fungi that contaminate well water come from fecal material from humans and other animals. Common bacterial contaminants include E. coli, Salmonella, Shigella, and Campylobacter jejuni. Common viral contaminants include norovirus, sapovirus, rotavirus, enteroviruses, and hepatitis A and E. Parasites include Giardia lamblia, Cryptosporidium, Cyclospora, and microsporidia

(c) Transportation: On lifting of water from the Dug well it is collected in earthen or metal pitchers which are carried by the villagers to their respective homes and finally stored in the kitchen/ dining in a bigger pitcher (Jala) for consumption.

(d) Water Quality Requirements: The quality of the water must satisfy the quality standard prescribed by the BIS as stipulated under BIS/CPHEEO/WHO guidelines. The following chemical water quality parameters viz, pH, turbidity, iron, chloride, fluoride, chloride, hardness, arsenic will be tested as prescribed by the Government of India in addition to the bacteriological analysis. All chemical testing to be undertaken at least once in a year and bacteriological test once in 3 months (GOI Guideline).

(e) Handling of water at House Holds: Special care has to be taken to see that water do not get contaminated at household level. A good practice of hand washing before touching the pitchers must be adopted. Besides, the containers shall always be kept covered and a cup fitted with a handle shall be used for lifting water from the containers. Practice of regular washing of the containers shall be advocated. As a precautionary measure it is desirable to adopt home chlorination to guard against possible contamination during storage and handling at house hold level.

4. Water Supply use Details along with Consumer Needs:

The Dug well water is intended for use in the homes for:

- Drinking
- Cooking including cleansing of vegetables and food grains
- Cleansing of utensils and crockery
- Cleansing of clothes
- Bathing
- Feeding of domestic animals

The water shall meet the drinking water quality criteria. It shall be free from any unpleasant taste, odour and colour. It shall be safe and free from any chemical and bacteriological contamination. The quality of water shall be monitored periodically in respect of the following parameters, as per Govt. of India guideline.

- pH
- turbidity
- iron
- chloride
- fluoride
- chloride
- hardness and
- arsenic
- Baceriological

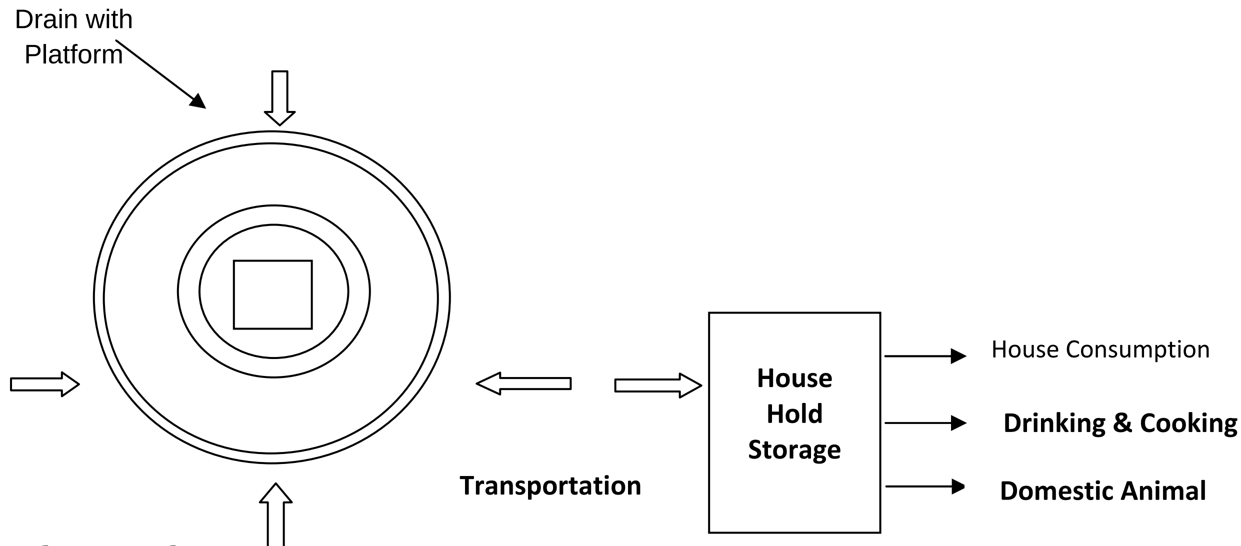
5. Technology description including sanitary map of the water catchments:

During construction of the dug well the following points are to be considered:

- Location of dug well: It shall be located on a high and dry land available within the village away from the latrines. Preferably it shall be located centrally for easy access of the villagers. A minimum safe distance of 10 metres shall be maintained from the latrines /waste dumps to prevent microbial contamination. However, in case of adverse hydrogeological situations like rocky formations / lime stone, etc, special protection measures are to be taken in consultation with specialists.
- Depth of well must be below the water table of the area in summer season. This will prevent drying up of the well in summer and ensure supply of water throughout the year.
- There shall be one parapet round the well to prevent direct entry of water in the well.
- There shall be a well built platform round the well with drainage facility for proper disposal of used water and rain water.
- It is better to provide a cover on the dug well to prevent entry of fallen leaves and other materials which contaminate the water of dug well. The drawal of water from the dug well may be done with the help of a hand pump installed over the platform.
- The common practice is to draw water from dug well with the help of a bucket attached to the rope. The rope is taken through a pulley fixed on the centre of the well.
- The dug well shall be so located that there is no latrine within a radius of 10 metre. Also there shall be no waste or cow dung dumping yard close to the dug well.
- There shall be one village level caretaker who will ensure periodic chlorination at desired dose to keep the well free from bacteriological contamination.
- The block level laboratory shall ensure periodic collection of water sample, its testing and reporting the result to ensure corrective action, if required.
- The laboratory shall also conduct sanitary survey, preparation of map and suggest action for preventive action to avoid any contamination.

Suggested format for sanitary survey for Dug well is given in Table 1

6. Flow Diagram with symbol



Underground Seepage Water

7. Hazard Analysis

The most important activity of the WSP team is identification of the hazards and prioritization of the identified risks. Risks are prioritized in terms of their likely impact on the safety of the system. Through the risk assessment process it is possible to decide whether any modification is required to achieve the water quality targets. The existing control measures are documented and uncontrolled risks are evaluated. Proposed additional control measures to be suggested to achieve water quality targets.

The risk assessment process may involve a quantitative or semi-quantitative approach. This helps the WSP team to calculate a priority score for each identified hazard. The following table may be utilized for the purpose.

Level	Descriptor	Rating (indicative) in numerical terms
'Likely hood of occurrence' category		
A	Almost Certain	5
B	Likely	4
C	Moderate	3
D	Unlikely	2
E	Rare	1
'Severity' Category		
A	Insignificant	No detectable impact - 1
B	Minor	Aesthetic Impact Causing Dissatisfaction - 2
C	Moderate	Major Aesthetic Impact - 3
D	Major	Morbidity expected from consuming water - 4
E	Catastrophic	Mortality expected from consuming water - 5

For each event risk rating is calculated by multiplying indicative rating of 'Likelihood' by severity.

It is essential to know what is hazard and hazardous events? How risk associate with hazard to be assessed? These are indicated below:

- Hazards are defined as: Physical, biological, chemical or radiological agents that can cause harm to public health.Hazards may be present or may originate throughout the water supply chain from catchments to consumer

- Hazardous events are defined as: An event that introduces hazards to, or fails to remove them from, the water supply.

- The risk associated with each hazard may be assessed, by identifying the likelihood of occurrence and evaluating the severity of consequences if the hazard occurred. The potential impact on public health is the most important consideration, but other factors such as aesthetic effects, continuity and adequacy of supplies, and utility reputation should also be considered.

Hazard event

In case of dug well the followings has been identified as hazard events which needs proper attention to ensure safety of the water:

- Direct entry of contaminated water in the well
- Contamination due to damage to lining
- Accumulation of contaminated water due to poor drainage arrangements
- Contamination from the buckets
- Contamination due to naturally occurring chemicals
- Leaching of chemicals
- Leaching of Microbial contamination

Broad control measures to be adopted for the above mentioned events are:

- Proper construction of well including parapet wall, cover, apron and drainage
- Proper sealing of lining with good mortar
- Extension of drains to a nearby nullah or ditch
- Installation of hand pump
- Discard the source and select one without chemical contamination
- Hazardous chemicals shall not be dumped near the dug well
- Increase length of travel to prevent contamination

For each of the above hazard event cause of the event, hazard type or risk involved, control measures required to be adopted for prevention of the hazards in respect of Dug well are indicated in the Table 2.

8. Operational Monitoring Schedule

The operational monitoring schedule in a WSP includes monitoring of control measures and corrective actions necessary when operational targets are not met. It is an important aspect of WSP implementation. It is implemented to ensure that any deviation from the required performance is rapidly detected. Factors considered for establishing the monitoring programs are:

- What will be monitored?
- How the monitoring be done?
- Where the monitoring be done?
- When the monitoring be done?
- Who will carry out monitoring?

If it is observed during monitoring that the critical limits have been exceeded then corrective actions are to be taken. The following factors are considered:

- What action is to be taken
- How the action is to be taken
- When action is to be taken
- Who will take the action

For some control measures, it may be necessary to define 'critical limits' outside of which confidence in water safety would be lost. Deviations from these critical limits usually require corrective actions. Corrective action shall be specific assigning the responsibilities for carrying out the corrective action.

Operational monitoring schedule for Dug well is given in Table 3.

9. Verification Schedule

To ensure that the WSP is functioning properly it is essential to have a process of verification. Usually verification involves the following activities:

- Compliance monitoring
- Auditing of operational activities
- Consumer satisfaction

Verification helps to understand whether the system is capable of delivering water of specified quality and appropriate corrective actions in case of failures. To verify that the water safety plan is working effectively and will meet the health-based targets is a vital requirement of WSP approach. Such verification broadly may involve two activities that are undertaken together to provide a body of evidence that the WSP is working effectively:

- Water quality monitoring; and
- Auditing of operational activities.

Verification should also include checking that consumers are satisfied with the water supplied.

Activity wise proposed verification schedule for Dug well is given in Table 4.

10. Validation Schedule

It is desirable to take up validation monitoring to determine whether the system is performing as assumed during system assessment and operation of water supply in accordance with the with the WSP will be able to achieve the desired health- based targets. Validation normally includes more exclusive and intensive monitoring than routine operational monitoring.

The validation practice helps in identifying the short comings and suggests corrective actions to be taken. The suggested format of validation schedule is given in Table 5.

11. Improvement Action Plan

For making the WSP a success, it is necessary to have an inbuilt improvement plan which can neutralize the risk involved at various stages.

Starting from Catchments to Consumer, existing techniques can be modified if need be, provided records of construction, operation and maintenance of the Water Supply system based on surface water storage are systematically kept and judicially analyzed.

Catchments characteristics being the primary requisite of WSP, protection of its water quality aspects and scope for storage of requisite quality of water have to be studied continuously. For augmentation of water availability, ground water recharging if feasible can be resorted to.

Storage and handling of water, similarly, can be improved by generating well designed awareness generation techniques. Contamination of water sources can be better identified by deploying more sophisticated analytical techniques, if such situation arises

Above issues have been identified for Dug well and actions required to be taken for their improvement are indicated in Table 6.

TABLE 1

Format for Sanitary Survey of Dug Well

1. Location:
2. Code No
3. Date of survey:
4. Water sample collected: Yes / No

Specific Diagnostic Information of Survey

Sl No	Item	Risk	
		Yes	No
1	* Is there a latrine within 10 m* of the dug well		
2	Is the nearest latrine uphill of the well		
3	Is there any source of pollution within 10 m of the Dug well (e.g animal breeding, industry, waste dump etc.)		
4	Is the drainage faulty allowing ponding within 2 m of the well		
5	Is the drainage channel cracked, broken or need repair		
6	Is the fence missing		
7	Is the platform less than 1 m wide		
8	Does the spilt water collect in the apron		
9	Are there cracks in the cement platform		
10	Is the hand pump defective and needs repair		
11	Is the well cover insanitary		
	Total score of Risks =		
	Risk score: ** 9-11 = Very High, 6-8 = High, 3-5 = Medium, 0-3 = Low		
	Results and Recommendations:		
	The following important points of risk were noted:		
	Signature of Inspector		
Comments			

* Applicable for fine sand & clay soil. Expert advice required for adverse hydrogeological conditions.

** Suggestive: WSP teams and local experts could have their own standard and norms for identifying hazard events and indicating their risk-score.

Table 2: Hazard Analysis

Process Step	Hazardous Event	Hazard Type	Risk Prioritization (Semi Quantitative Method)			Control Measures	Additional Control Measures
			In category of Likely-hood	In category of consequence /impact	Risk Rating		
Well Construction	Ingress of contaminated surface water directly into well as lining stops at ground level	Construction	Moderate (3)	Major (4)	3 x 4 = 12	Extend lining up to a height of 0.9 m	
	Ingress of contaminants due to poor construction or damage to lining	Construction	Moderate (3)	Minor (2)	3 x 2 = 6	Repair the leaky and damaged joints	
Catchments around Dug Well	Leaching of organic matters from organic waste damps	Microbial	Unlikely (2)	Catastrophic (5)	2 x 5 = 10	Locate waste dumps at least 10 m away from dug well	
	Leaching of faecal matters from human and animal wastes	Microbial	Moderate (3)	Major (4)	3 x 4 = 12	Locate toilet and animal pen at least 10 m away from dug well	Chlorinate the dug well periodically with bleaching powder
	Leaching of naturally occurring chemicals in sub soil strata	Chemical	Minor (2)	Major (4)	2 x 4 = 8	Discard a well having chemical contamination beyond permissible limit	
Dug well	Contamination from the use of in sanitary bucket and rope	Microbial	Moderate (3)	Major (4)	3 x 4 = 12	Ensure use of dedicated set of bucket and rope for lifting water. The bucket shall always be kept on a raised platform	The bucket shall be cleaned and disinfected daily

	Contamination due to inundation during flood	Microbial	Minor (2)	Major (4)	2 x 4 = 8	The platform shall be adequately raised and well lining shall be above the flood level and adequate drainage to prevent water logging.	Post flood super-Chlorinate
	Contamination due to use of poor quality water for priming of hand pumps attached to a dug well	Microbial/ Chemical	Moderate (3)	Major (4)	3 x 4 = 12	Leaky sheet valve to be replaced immediately on detection. In emergency use only good quality water for priming.	
Transportation of water	Contamination due to dust if water container is not properly covered during transportation	Microbial/ Others	Moderate (3)	Major (4)	3 x 4 = 12	Ensure covering the container.	The carrying container shall be cleaned before use.
Storage and Handling of water	Contamination due to use of unclean utensil and/or hand for drawing water from storage tank (Jala)	Microbial/ Others	Moderate (3)	Major (4)	3 x 4 = 12	Water shall be taken out from the storage tank using a cup fitted with a handle.	Make it a habit to wash hands before touching the water pitcher or storage tank.
	Contamination by dust particles or domestic animals for not covering the storage tank	Microbial/ Others	Moderate (3)	Major (4)	3 x 4 = 12	Storage tank shall always be kept covered.	Regular washing of storage tank to be practiced

Table 3: Operational Monitoring Schedule

Process Step	Performance Indicators	Monitoring Process		Critical Limit	Corrective Action		Supporting Programme
Catchments around Dug Well	Waste Dumping, Toilet etc. close to dug well	What	Presence of waste dump, latrine etc around dug well	No latrine, animal pen, waste dump etc. within 10 m radius of dug well	What	Re-sitting of the units	IEC activities
		How	Sanitary inspection		How	Applying GP Rules	
		Where	Within 10 m radius of dug well		When	Immediately on identification	
		When	Once in every six months		Who	Member of GP	
		Who	Chemist of NGO Lab				
Dug Well	Quality of water of the dug well	What	Test quality of water	Water quality must satisfy the standard set forth in Water Supply Manual of GOI	What	Unsafe wells shall be marked	Educate villagers through group meetings and IEC activities
		How	Laboratory test		How	Through routine testing as per GOI guidelines	
		Where	At source		When	Immediately on detection	
		When	During commissioning and periodically at least once in a year		Who	SAE PHED / Chemist of NGO Laboratory	
		Who	Concerned Laboratory				
	Condition of well lining and drainage around dug well	What	Prevention of leakage through lining and inundation	Lining and drains are in good condition	What	Sealing of damaged lining and repairs of drains/ platform	
		How	Sanitary inspection		How	Using cement mortar	
		Where	Dug well lining and platform / drain		When	Immediately on detection	
		When	Once in every six months		Who	SAE PHED placed at Block level	
		Who	Chemist of NGO Lab				
	Disinfection of Dug well	What	Disinfection using bleaching soln.	Smell of chlorine	What	Chlorine dose as fixed by Lab	Training by laboratory on disinfection
		How	Using field test kit		How	By pot chlorination	
		Where	At Dug well		When	Twice in a week	
		When	Daily		Who	Caretaker	
		Who	Caretaker				

Hand Pump	Maintenance of Pump	What	Checking operation of pump	Pump seat valve is leaking	What	Repairing of pump	
		How	By operating the pump		How	By replacement of seat valve	
		Where	At Dug well site		When	Immediately on detection	
		When	Monthly		Who	Mechanic PHED	
		Who	Mechanic PHED				
Storage and Handling	Contamination during handling and storage	What	Hygiene practice during collection, transport and storage	Water collection, transportation and storage is hygienic	What	Key hygiene messages	Educate villagers through group meetings and IEC activities and school children as a part of curricula
		How	Through inspection at all levels		How	Hygiene education and practice at schools and IEC activities	
		Where	At dug well site and households		When	Regular activity	
		When	Weekly		Who	Member of GP	
		Who	Member of GP				

Table 4: Surveillances and Verification Schedule

Activity	Description	Frequency	Responsible Party	Records
Sanitary Survey	Sanitary survey will be done as per GOI guidelines	Twice in a year	Chemist of NGO Lab	NGO Laboratory and GP Office
Water Quality Monitoring	Monitoring of quality of water for physical, chemical and biological quality as per GOI guidelines	Twice in a year	Chemist of NGO Lab	NGO Laboratory and GP Office
Effectiveness of Water Safety Plan	Monthly Meeting of the Water and Sanitation Committee shall discuss the WSP involving the District Water & Sanitation Cell, PHED and BMOH and meet the Community.	Field visit and discussion with the Communities to be done as frequently as possible. Gap shall not exceed 3 months.	Gram Panchayat	GP office

Impact Assessment of Advocacy Programme	Verification of water related practices of the Community	Random Sampling	Chemist of NGO Lab / GP Office Staff	IEC Material Produced (NGO Laboratory and GP Office)
Checking Satisfaction level of the User Community	Visit to House Holds and meeting at GP Office	Quarterly	Panchayat / GP Office	Survey Report (GP Office)

Table 5: Validation Schedule

Process Step	Hazardous Event	Validation	Comments
Catchments	Leaching of organic matters, faecal matters and naturally occurring minerals.	Verification of water quality analysis data and sanitary inspection records to assess whether the protection measures are effective.	
Dug well	Bacteriological contamination of well water	Study analysis of water quality results, sanitary inspection data, dug well repair records etc for assessment of effectiveness of WSP	
	Effectiveness of chlorination in dug well	Study records of disinfection by chlorination, analysis of tests records of residual chlorine etc to assess the effectiveness of chlorination. In addition study health records, particularly of diarrhea disease.	
	Presence of any toxic chemicals e.g. arsenic, fluoride etc		
Hand pump	Introduction of contamination through hand pump	Study records of hand pump repair	
Transportation	Introduction of contamination during transportation	Survey and local enquiry	
Storage and handling	Contamination due handling and storage	Survey and local enquiry	

Table 6: Improvement Action Plan

Issue Identified	Approach to be adopted for carrying out improvement	Time frame for implementation	Responsibility	Fund Requirement	Type of Plan	Degree of Priority
Sanitary protection of dug well	Provide 1m wide platform sloped away from the well with proper drainage facility	Within 6 months	Gram Panchayat		Short Term	High Priority
Maintenance of dug well	Routine yearly maintenance of dug well including platform and drain to be introduced involving community	Within 6 months	Gram Panchayat		Short Term	High Priority
Chemical contamination	Testing of water quality immediately on construction	Twice in a year	NGO Laboratories		Short Term	High Priority
Maintenance of Hand pump	Periodic maintenance of hand pump including seat valve	Immediate on detection	Mechanic of PHED		Short Term	High Priority
Chlorination	Regular chlorination of pond water with bleaching powder	Within 6 months	Gram Panchayat		Short Term	High Priority
Safe water handling	Introduction of hygiene education in primary schools and IEC activities e.g. hand washing, washing of water container, safe handling during storage etc	Within 6 months	School teacher, NGO and GP Member		Short Term	High Priority

N.B. Requirement of fund as per estimate to be indicated in Column 5

Chapter-5

"Bore-well based rural water supply systems (Hand Pump Operated)"

Bore-well based rural water supply systems

(Hand Pump Operated)

1.0 Introduction

In India, approximately 85% of rural habitations are dependent on ground water. Borewells are sunk to draw water from different aquifers as per water availability and quality. The borewells are fitted with either hand pumps or power pumps. It is a most common scenario in India that villagers are provided with groundwater through hand pump attached borewells (Tube wells) as public water supply system. The tubewells are installed in the villages under rural water supply programme. The borewell water (hand pump attached) quality should conform to drinking water quality standard. The availability of ground water from borewell must meet the demand of the consumers throughout the year. But one can see that tubewells remain to be overcrowded in many villages and the situation gets worsened in some villages where tubewells become non-functional. There could be risk of contaminations in groundwater and sources of these contaminations could be natural or anthropogenic. The groundwater protection as well as conservation is a necessity in areas where rural people are dependent on it.

Safety of drinking water supply for spot sources need to be achieved through the use of a comprehensive risk assessment and risk management approach that encompass all steps to ensure safe water to the consumers. Accordingly, Water Safety Plans are to be conceptualized, developed, institutionalized and operated to ensure secured and safe drinking water supply to the villagers. The primary objective of a WSP in ensuring good drinking water supply practice are the minimization of contamination of source waters, the reduction or removal of contamination through treatment processes and the prevention of contamination during storage, transfer or carriage and handling of drinking water.

In groundwater supply through spot sources, WSP need to be adopted to keep the tubewells free from contamination. The WSP is to be framed considering the following:

- Risk of groundwater contamination from natural sources.
- Risk of groundwater contamination from anthropogenic sources.
- Hydro-geology
- Identification of pollutional sources.
- Pollutional travel
- Pollutional risk from casual and uncared approach.
- Preventive maintenance.
- Curative action.

2.0. Water supply process description:

In India, groundwater is a major source of drinking water supply in the rural areas. Groundwater is renewable through natural recharging mechanism. Groundwater table fluctuation in an aquifer occurs according to groundwater recharge. However, if abstraction and recharge mismatch with over-drawal of groundwater, then water table may fall as we are experiencing in several places of the country. A total ground water resource for water table aquifer is the sum of annual recharge and potential recharge in shallow water table and water logged areas. The quantum of groundwater available for development is usually restricted to long term average recharge of the aquifer and is 100% dependable source of supply.

The subsurface water sources include springs, wells and galleries. The wells may be shallow or deep. Shallow wells may be of dug well type, sunk or built, of the bored type or of the driven type. They are of utility in abstracting limited quantity of water from shallow pervious layers, overlying the first impermeable layer.

Deep wells are taken into pervious layer below the first impermeable stratum. They can be of the sunk well type or the bored or drilled type. They are of utility in abstracting comparatively larger supplies from different pervious layers below the first impervious layer. Because of the longer travel of groundwater to reach pervious layer below the top impermeable layers, deep wells yield a safer supply than shallow wells.

The shallow tubewell, also called a driven well, is sunk in various ways depending upon its size, depth of well and nature of material encountered. Bored wells are tubular wells drilled into permeable layers to facilitate abstraction of groundwater through suitable strainers inserted into the well extending over the required range or ranges of the water-bearing strata. There are a variety of methods for drilling such wells through different soils and for providing suitable strainers with a gravel shrouding where necessary. For bored wells , the hydraulic rotary method and the percussion method of drilling such wells through hard soils are popular. For soft soils, the hydraulic jet method, the reverse rotary recirculation method and the sludge method are commonly used. Wells in soft soils must be cased throughout. When bored in rock, it is necessary to case the well at least through the soft upper strata to prevent caving. In providing the strainer arrangement whereby water is admitted and sand or gravel extended, it is desirable to make the openings of the strainer as large as practicable in order to reduce friction, while at the same time preventing entrance of any considerable amount of sand.

The well is fitted with pump. Normally, for supply through spot sources hand pumps are fitted with tubewells. The selection of hand pumps is dependent on water table, operation, maintenance, etc. Hand pump fitted borewells (Tubewells) are very common as spot sources of water supply in rural areas of the country. Different types of hand pumps are used depending on the depth of water table in the well, e.g. Mark-II, Mark-III, Mark-IV, Tara pump, No : 6 H.P. etc, The borewells are to be disinfected after commissioning for supply of water to the consumers. The hand pump fitted borewells must have cemented platform and proper drainage system. All borewells must be sanitary sealed to prevent entry of contamination through the annular spaces around the borewells.

The locations of hand pumps attached tubewells are selected on assessing the accessibility of the source to the consumers. The hand pumps normally draw 12 to 16 ltrs of groundwater per minute. Beneficiaries collect water from the tubewells and bring the same in containers to their respective premises. The water is available in the tubewell as long as water level remains above minimum required level for pumping. There are risks of contamination in tubewell water from anthropogenic or natural sources. It is advised that tube wells should be located 10 m away from latrine pits/waste dumps. In adverse hydrogeological situations like rocky formations, lime stones etc, experts should be consulted. The tubewell water needs regular quality monitoring to ensure safe water availability to the consumers. Consumers store water in the residential houses to meet the daily need. Where water supply sources are tubewell often villagers use contaminated surface water for bathing, washing, etc.

3.0 Format for capturing information related to process

Description should be in lined with the Table-1 in Chapter – 3

4.0 Ground Water Treatment Requirement & Household Handling

Groundwater normally is not treated by the consumers. However, groundwater treatment is necessary when bacterial contamination or chemical contaminations are present in water. Following are the treatment requirement in case water quality does not conform to Drinking Water Standards (BIS10500:1991).

- Disinfection
- Excess fluoride removal
- Arsenic removal
- Nitrate removal
- Iron removal
- Reduction of Hardness
- Reduction of Total dissolved solids

Water is generally kept in containers. The shape of the containers may vary and the variation of containers could be seen from place to place and region to region. Again, container quality also varies according to cost. The containers are often handled non-hygienically. Instead pouring out from containers, glasses are dipped in the containers and as a result the drinking water gets contaminated. Often water is brought in containers having no cover. Hence, there could be chances of post contamination of drinking water during carriage as well as household handling. The water safety plan as referred above could ensure water security to consumer through preventive measures and risk coverage. But unless household hygiene of water handling and storage is improved, re-contamination could take place.

The water supply system through spot sources must ensure drinking water security for all in the community. Basic minimum need at the household level for drinking and cooking and also the needs for cattle and other similar needs are to be met. Water supply for drinking and cooking should maintain high quality as per the prescribed potable water standards and for other household and animal needs, the water should be of acceptable standard.

5.0 Technology description including sanitary map of the water catchment (Design criteria, material specification, source protection, management of the process at various level, WQ test requirement and other design data as per needs).

Vertically drilled wells:

The minimum depth of a well is determined by the depth necessary to reach and penetrate, for an optimum distance, the water bearing stratum allowing a margin for dry seasons for storage and for such draw-down as may be necessary to secure the required yield.

Because of the smaller diameters and the possibility to access deeper and thus well protected aquifers, the concept of drilled vertical wells still prevail today. Vertical wells can be adapted to a variety of geological, hydrological, and technical settings, leading to a large variability in construction.

Deeper aquifers often encounter reducing hydro-chemical conditions and thus elevated concentrations of iron, manganese and sulphides.Contact with oxygen and mixing in long screen promotes the precipitation of mineral phases which may clog the well.

In consolidated rocks, the well is often simply an open borehole equipped with a pump. Sometimes soil and weathered semi consolidated upper parts of the aquifer need to be stabilized by a casing-and backfilling of the annulus, while the aquifer remains uncased. The tubing is divided into perforated parts (screen) which take in the groundwater and non-perforated parts (casing) intended to seal off non-aquiferous formation or zones of undesirable water quality. The remaining space between the tubing and the borehole wall (annulus) is filled with permeable material (filter or gravel pack) around the screen and with impermeable material (bentonite, cement, etc.) around the casing.

Preventive Maintenance:

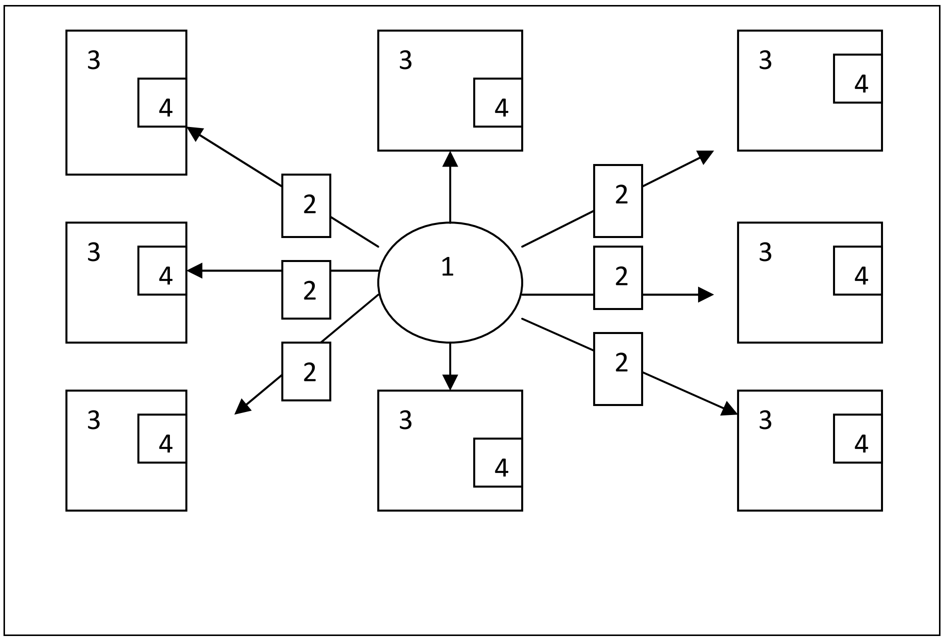
According to available data the specific capacity of wells should be measured at regular intervals either monthly or bi-monthly and it should be compared with the original specific capacity. As soon as 10 to 15 % decrease in specific capacity is observed steps should be taken to determine the cause and accordingly corrective measures should be taken.

Map of the village slowing the bore well is a necessity towards achieving water security to the consumers. The map will highlight all sources of ground water contamination, risk associated with the pollution level etc. The map will also address presence or absence of platform, drainage system etc.

Format for providing information related to technology description should be in line with the Table-2 in Chapter-3

6.0 Flow diagram with –Symbol

Water supply system from spot sources is presented through line diagram



1. Bore well fitted with-hand Pump(Tube Well).
2. Manual carriage of water containers after collection from hand pump.
3. Residential houses.
4. Home Storage.

7.0 Hazard Analysis and Risk Prioritization

- It is the most important activity of WSP process. Steps expected to be worked through, are :
- Identify the hazardous events that can result in risk to Bore-well based (Hand pump operated) water supply system.
- Determine the risk potential of each hazardous event.
- Identify the control measures currently in place.
- Suggest any additional control measures required.

Technical Challenges :

- Since a risk assessment provides a 'point in time' picture of the system, the risk assessment should be reviewed on a regular basis in order not to ignore new hazards and hazardous events.
- Uncertainty in assessment of risks due to unavailability of data, poor knowledge of activities within the water supply chain and their relative contribution to the risk generated by the hazard or hazardous event.
- Properly defining likelihood and consequence with sufficient detail to avoid subjective assessments and to enable consistency.
- Risk mitigation practices may be (a) pro-active, (b) Reactive, (c) Emergency or Combination of two or more.
- Need of development of emergency response plan.

In bore-well based (Hand pump operated) water supply system a number of hazardous events may occur. It is essential to decide whether any of these events causes significant risk and need for preventive action.

Various methods are available for risk prioritization. A example of semi-quantitative risk prioritization approach for borewell based (Hand pump operated) water supply is presented. The best way of carrying this act is to draw up a simple table and systematically record all potential hazardous events and associated type of hazards.

To avoid being too subjective it will be of appropriate to provide indicative rating (as given in Chapter 3 on Gravity Feed Water Supply System)

For each event, 'Risk Rating' is calculated by multiplying 'Indicative Rating of Likelihood' by 'Severity' as done in case of Gravity Feed Water Supply System (Chapter-3)

Table-1. Information Capture format for hazard events and risk prioritization of catchment (semi quantitative method) for Bore Wells.

Activity / Process Step	**Hazardous events and type**	**Risk Prioritization (semi quantitative method)**			**Existing Control Measures**	**Additional Control measures proposed**
		In category of Likelihood	***In Category of Consequence / Impact***	***Risk Rating***		
Meteorolog y and Weather	a) Ground water recharging	a) Moderate (3)	a) Major (4)	3 x 4 = 12	Only natural recharging	Catchment development and

Activity / Process Step	Hazardous events and type	Risk Prioritization (semi quantitative method)			Existing Control Measures	Additional Control measures proposed
		In category of Likelihood	*In Category of Consequence / Impact*	*Risk Rating*		
Pattern	lesser due to lesser rainfall b) Depletion of water table	b) Moderate (3)	b) Major (4)	3 x 4 = 12	Legislation for application	construction of structures for more recharging Strict compliance of regulation
	c) Flood	c) Moderate (3)	c) Catastrophic (5)	3 x 5 = 15	of statutory regulation on bore-well installation Supply of potable water by tanker, pouch, etc.	Adoption of programme for disaster preparedness with infrastructure development and capacity building.
Different anthropogenic activities in the catchment areas	a) Pollution travel from latrine pit, waste dump b) Priming of hand pump with contaminated water	a) Unlikely (2) b) Unlikely (2)	a) Major (4) b) Major (4)	2 x 4 = 8 2 x 4 = 8	Keeping distances from pollutional sources No effective control in existence	Carrying soil type wise pollutional travel study and ascertaining pollutional travel. Prevention through awareness and motivation.
Land use / Cover Pattern Cultivation etc.	Use of fertilizer and pesticides contaminate sub-soil water	Unlikely (2)	Major (4)	2 x 4 = 8	No effective control measures	Controlled use of fertilizer and pesticide. Awareness and motivation campaign.

Table-2. Information Capture format for hazard events and risk prioritization of hand pump attached bore-well (semi-quantitative method)

Activity / Process Step	Hazardous events and type	Risk Prioritization (semi quantitative method)			Existing Control Measures	Additional Control measures proposed
		In category of Likelihood	***In Category of Consequence / Impact***	***Risk Rating***		
Faulty design, poor quality of workmanship of Bore-well construction	Inadequacy of pumped water, reduced yield	Moderate (3)	Major (4)	3 x 4 = 12	Taking up ad-hoc corrective measures	Review the design, rejuvenation of bore-well, re-boring with corrective design.
Flooding of area causing inundation of hand pump	a) Disrupting of water supply b) Contamination of bore-well	a) Likely (4) b) Likely (4)	a) Major (4) b) Major (4)	4 x 4 = 16 4 x 4 = 16	Ad hoc, emergency measure Inadequate effort for disinfection	Disaster preparedness, alternative safe water supply. Undertaking disinfection of all bore-wells, Training for preparedness
Structural deficiency / damage	a) Absence of platform and lead drain b) Absence of sanitary sealing	a) Unlikely (2) b) Likely (4)	a) Major (4) b) Moderate (3)	2 x 4 = 8 4 x 3 = 12	Mostly included in work schedule Mostly unattended	Community motivation for providing platform and lead drain Training of plumbers and technicians for sanitary sealing.
Treatment for removal of certain contaminants	a) Natural toxic chemical from geological sources causing unpotable water	b) Moderate (3)	b) Major (4)	3 x 4 = 12	a) No effective control in existence	Regular monitoring, and surveillance
	b) Non-	Moderate	Moderate (3)	3 x 3 = 9	b) No	Regular

Activity / Process Step	Hazardous events and type	Risk Prioritization (semi quantitative method)			Existing Control Measures	Additional Control measures proposed
		In category of Likelihood	***In Category of Consequence / Impact***	***Risk Rating***		
	functioning of Treatment plant c) Media exhausted d) Lack of O&M	(3) Moderate (3) Likely (4)	 Major (4) Major (4)	 3 x 4 = 12 4 x 4 = 16	effective control c) Ineffective d) Ad hoc approach	monitoring, involvement of beneficiaries Regular monitoring and surveillance Strict vigilance, capacity building, involvement of community

Table-3. Information Capture format for hazard events and risk prioritization of water handling and use at consumers premises

Activity / Process Step	Hazardous events and type	Risk Prioritization (semi quantitative method)			Existing Control Measures	Additional Control measures proposed
		In category of Likelihood	***In Category of Consequence / Impact***	***Risk Rating***		
Water collection, conveying, storage and use at household level	Water may become re-contaminated at any point between collection, conveying, storing, handling and consuming due to incorrect practices	Likely (4)	Major (4)	4 x 4 = 16	Dissemination of information among household regarding the need of hygienic practice during collection, storage, handling, etc.	Thrust on effective implementation of Total Sanitation Campaign (TSC) to eliminate source of contamination, thrust on behavioral change, consumer education, improvement in personal hygiene.

8.0 Operational monitoring schedules

In WSP process operational monitoring is the act of conducting a planned sequence of observations or measurements, to assess whether the control measures applied at a point in the system are achieving their objectives. Effective monitoring relies on establishing:

- What will be monitored?
- How it will be monitored?
- When it will be monitored?
- Where it will be monitored?
- Who will do the monitoring?

For some control measures, it may be necessary also to define 'Critical limits' beyond which confidence in water safety would be lost. Deviation from these critical limits usually requires corrective actions. Corrective actions should be specific wherever possible, including assigning responsibilities for carrying out the corrective actions.

'Monitoring' may also comprise verification and validation which are dealt separately. In example 8A, a suggestive format for capturing operational monitoring schedule etc. is presented.

Table-4, Information Capture format for Operational Monitoring Schedule etc.

Process Step	Parameter to be Monitored	Critical Limit	Corrective Actions		
Source Centred Catchment Area Management	Land use coverage pattern, Undesirable activities	Land use and coverage of catchment	No latrines and waste dump in close proximity, no fertilizer and insecticides and pesticides use in close proximity	What	Preventing undesirable activities in the catchment area
		Proper inspection of catchment Once in a year or as required		How	Taking up issue with concern department, dialogue with the community, awareness generation
		Monthly		When	As soon as detected
		Member of the WSP team & VWSC members		Who	WSP team and community
Protection of ground water	Quality of water at regular	Testing of water quality	Physical and chemical	What	Preventing contamination by

Process Step	Parameter to be Monitored	Critical Limit	Corrective Actions		
aquifer from contamination due to natural or anthropogenic cause	interval Every six months (Pre and Post monsoon)	on selected parameter and comparing with BIS (10500)	parameters should be within max. acceptable limit as per BIS. If alternative water sources are not available, Parameters should be within max. permissible limit as per BIS. Free from Bacteriological contamination.		keeping toilet pit, waste pit etc. at safe distance from bore-well.
		Water quality testing in approved laboratories		How	Awareness motivation training and framing guidelines
		Fortnightly / monthly or regularly Hand pump water		When	As a continuous process
		Water sample collection by trained personnel and analysis by trained chemist and technician		Who	WSP team members and VWSC members
Bore-well and hand-pump operation	Any interruption of pumping of water from aquifer, change of yield, depletion of water table, damage of hand pump and accessories	Monitoring rate of pumping, yield at regular interval, depth of water table at regular interval. Ensuring repairing work and replacement of damaged parts	Standard yield according to type of hand pumps. Max. Permissible Limit of draw-down. Damage of hand pump or any parts	What	Training and motivating personnel for proper monitoring
		Inspection		How	Motivating VWSC Committee
		Periodical and during monitoring		When	Regularly interacting with community
				Who	WSP team members and VWSC members
Water collection, conveying	Hygienic water handling practices of the	Practices during collection,	Collection, transportation and storage to	What	Changing water related Knowledge, Attitude and

Process Step	Parameter to be Monitored	Critical Limit	Corrective Actions		
storage and use at household	user	transportation and storage of water by users	be hygienic, well protected. Water should be capable of meeting health based target and quality must conform to BIS standard		Practice (KAP). Household disinfection.
	Health data of the community	Observing the practices of user community		How	Behaviourial change, better practice, training
		Regularly		When	Regularly
		At household level		Who	ASHA, VWSC, etc.

Supporting Programme :

Supporting programmes are those activities that indirectly support water safety. These are also essential for proper operation of the control measure. Supporting programmes cover a range of activities including communication and capacity development, preventive maintenance, hygiene education and sanitation as well as legal aspects. Suggestive format for capture of supporting programme is provided in Table-5.

Table-5, Information Capture format of Supportive Programmes that could be included in the WSP (not exhaustive)

Programme	Purpose	Example
Communication and capacity development	Success of effective planning and implementation of WSP to a great extent depend upon awareness, motivation and commitment of stakeholders which need to be evaluated. Skill of the operating staff is most important.	• Development of IEC material to enhance the effective participation of various level stakeholders. • Organising training for upgrading skill of user community.
Strengthening Laboratory Infrastructure	Inadequate laboratory facilities is one of the major constraints in planning and implementation of WSP in practice	• Manning the existing laboratories with qualified skilled personnel. • Setting up new laboratories at Block level. • Networking of rural laboratories.
Calibration	To ensure that critical limit set for monitoring is reliable and of acceptable accuracy	• Calibration schedule. • Calibrating equipment.
Preventive Maintenance	To ensure that malfunctioning of hand pump bore-well are minimized	• Putting in practice effective preventive maintenance programme. • Adequate inventory of spare parts to be kept to attend the repair.

Hygiene and Sanitation	To prevent contamination of water	• Strict cleanliness. • Hygiene practice.
Attending consumer complain / suggestion	Enhancing consumer confidence level regarding reliability of system of water supply from spot sources	• Regular dialogue with user group.

9.0 Verification schedule

Establishing procedure to verify that the water supply plan is working effectively and will meet the health based targets is a vital requirement of WSP approach. Such verification broadly may involve two activities that are undertaken together to provide a picture of evidence that the WSP is working effectively and will meet the desired objective:

- Water quality monitoring
- Auditing of operational activities.

Verification should also include the checking that consumers are satisfied with the water supplied. It is important that consumers are using the safely managed water supply rather than less safe alternatives.

Table-6, Information Capture format for Verification

Activity	Description	Frequency*	Responsible Agency	Records
Effectiveness of WSP Process in achieving health based target	Analyse health data of community maintained by NFHM. Water analysis report	Yearly	WSP team, VWSC and NRHM	Health data of community maintained by ASHA (NRHM). Water analysis report.
Performance evaluation of hand pump attached bore-wells	Study related to yield, water quality, depletion of water table, dry period if any etc.	Half yearly	WSP team, VWSC, G.P. level team, Expertise to be hired.	Data and information related to well performance
Sanitary Survey	Identification of pollutional source and distance, survey of platform, lead drain, risk of conveyance, storage, etc. and review the information	Yearly	WSP team, GP level working group	Sanitary inspection format and data

Water quality testing	Water quantity testing and verification from referral laboratory	Quarterly	Rural laboratory engaged in WQMs programme	Data of water quality analysis carried out as routine and verification from laboratory
Preventive Maintenance	Safe-guarding water source from pollution and verification from water quality testing	Half yearly	WSP team, GP level working group / VWSC	Salient information of Bore-well
Curative action	Corrective measure and verification through observation and measurement	As and when necessary	GP level working group / VWSC	Recording action for corrections.

* Incase of emergency of natural calamities or epidemics

10.0 Validation schedule to ascertain system capacity

Validation involves obtaining evidence that activities taken up supporting the WSP is correct and that the operation of the water supply in accordance with the WSP will be able to achieve the desired health based targets. Validation normally includes more extensive and intensive monitoring than routine operational monitoring.

Validation schedule need to be so prepared, that such exercise in a position to ascertain that the overall system design and operation is capable of consistently delivering water of the special quality to meet the health based targets. A suggestive format is provided in Table-7

Table-7, Information Capture format for Validation

Item Validated	Hazardous Events	Validation Schedule	Comments
Behaviour of aquifer as sustainable source	Reduction of yield, depletion of water table, disruption water availability, dry bore-well	Regular monitoring of all relevant components to verify whether all precautionary measures have been undertaken to achieve sustainable ground water source.	It is of utmost importance to ascertain geology, lithology and ground water abstraction system of the area.
Protection of bore-well from anthropogenic and natural	Bacteriological and chemical contamination of ground water	Sanitary survey format examination and scrutiny and also assessment of preventive and remedial measures.	General guidelines for protecting bore-wells from anthropogenic and

contamination		Appropriate aquifer selection and verification from water quality testing records,	natural pollution need to be followed strictly.
Advocacy approach adopted for ensuring behavioural change among community towards better hygienic practices in water handling.	Water for drinking getting contaminated during carriage, storage and handling at household level.	Critically revisit the advocacy approach, focus more on awareness and sensitization, stress on using IEC material for better communication.	Behavioural change with corrective approach.

11.0 Action Plan for Improvement

When the assessment of drinking water system indicates that existing practices and technologies of bore-well based (hand pump operated) rural water supply system are not adequate to ensure drinking water safety, as a part of full planning and implementation of WSP, an action plan for incorporating corrective measures for addressing the inadequacy need to be developed. Implementation of plans should be monitored to confirm that improvements have been made according to action plan and are effective.

A suggestive format for incorporating information related with action plan for improvement of WSP is presented below.

Table-8. Information Capture format for Action Plan for Improvement.

Issues identified for requirement of improvement	**Approach to be adopted for carrying out improvement**	**Short Term / Long Term**	**Time frame for Implementation**	**Approx. Fund Requirement**	**Responsible for Improvement**	**Degree of Priority**
Selection of appropriate aquifer	Study of Lithology and Hydro-geology	Long term	No definite time frame	To be assessed as per local situation	PHED or Relevant Departments	High Priority
Sanitary Sealing	Selection of low cost material and simple technology	Long Term	Within the time frame of construction	Rs.10,000/- per Bore-well	Implementing Agency	High Priority
Aquifer Sealing	Selection of material and method to protect leaching of chemical (geological) contaminants from upper aquifer to lower aquifer	Long Term	Within the time frame of construction	Rs.20,000/- per Bore-well	Implementing Agency	High Priority

Protection from Pollutional Travel	Deficiency identification and correction measures	Long Term	Fortnight	Rs.1000/- per Bore-well	GP level team / VWSC	High priority
Disinfection	Routine or as required on the basis of water quality test report	Short Term	One day	Rs.50/- per Bore-Well	GP level team, VWSC	High Priority

Chapter-6

"Pond Based Rural Water Supply Systems with appropriate Treatment and Rain Water Harvesting Systems through Surface Storage"

Water Safety Plan for Pond Based Rural Water Supply Systems with appropriate Treatment and Rain Water Harvesting Systems through Surface Storage

1. Introduction

The pond based water supply system is generally used in costal areas where surface water and in many case the ground water is saline and unfit for human consumption. Protected deep pond with high embankment is constructed. Runoff from roof top of school building or office building is diverted to collect rain water during rainy season. High embankment prevents entry of saline water particularly during natural calamity. The pond water is generally treated in horizontal roughing filters or slow sand filter beds and collected in a sump. Water from the sump is pumped to the consumer. Type and capacity of pump depends on the size of the community, availability of power etc. The water is chlorinated before pumping to kill pathogenic bacteria.

Rain water harvesting for storage of water can provide an eco-friendly, affordable, adoptable and acceptable method for augmenting availability of water. The traditional wisdom of our people in rain water harvesting being practiced since the dawn of civilization needs to be refined through scientific approach with due focus on innovative technologies of water harvesting, conservation & augmentation. The initiatives of the Government to usher in a participatory approach involving the communities can only bring the desired results. These storages also serves as ponds.

2. Water Supply Process Description

(f) Source: Protected pond water serves as the source of supply for pond based system. Generally it receives rain water and solely depends on it. It collects both direct rainfall as well as runoff from the roof top of nearby school/ office buildings. Technique of rain water harvesting may be adopted as to create a sustainable pond water source.

(g) Treatment: The pond water may contain turbidity. There may be also odour problem. The pond water needs to be filtered to remove suspended solids. The water is generally passed through a horizontal roughing filter followed by slow sand filtration to remove suspended solids. The filtered water is collected in a sump. In the process some bacteria is also killed. However, there may be growth of algae in the pond which may clog the filter bed. Growth of algae may also attract contamination from toxins released by it. Algal growth may be controlled through adequate dose of chlorine or copper sulphate. The filtered water is also required to be chlorinated to kill residual bacteria, if any. The dose of chlorine depends on the chlorine demand which may be worked out through laboratory test. Usually bleaching powder is used as the source of chlorine.

(h) Transportation: The treated water from the sump can be supplied to the community either by gravity if the terrain condition is suitable or can be pumped. Generally power pump is used for the purpose. However, hand pump is where power supply is not available. In case of hand pump the water is collected in earthen or metal pitchers which are carried by the villagers to their respective homes and finally stored in the kitchen/ dining in a bigger pitcher (Jala) for consumption. When water is supplied to a bigger community a power pump is used for supply through a net work of pipe lines through street stand posts. The villagers collect water in earthen or metal pitchers and are taken to their respective homes and finally stored in the kitchen/ dining in a bigger pitcher (Jala) for consumption.

(i) Water Quality Requirements: The quality of the water must satisfy the quality standard prescribed by the BIS or Manual on Water Supply and Treatment published by the Ministry of Works and Housing. The chemical parameters like pH, turbidity, iron, manganese, arsenic, chloride, fluoride, hardness, silica etc should be tested in addition to the bacteriological analysis of water. At least once in a year the chemical and bacteriological quality of drinking water should be tested and monitored periodically during water supply period.

(j) Handling of water at House Holds: To ensure safety of drinking water special needs to be taken to see that water do not get contaminated even at household level. A good practice of hand washing before touching the pitchers must be adopted. Besides, the containers shall always be kept covered and a cup fitted with a handle shall be used for lifting water from the containers. Practice of regular washing of the containers shall be practiced. As a precautionary measure it is desirable to adopt home chlorination to guard against possible contamination during storage and handling at house hold level.

3. Technology description including sanitary map of the water catchments:

The following techniques can be deployed, depending upon availability and sustainability of terrain conditions, catchment's characteristics, rainfall distribution etc.

1) Tanka/ Kund/ Kundi
2) Percolation Tanks
3) Check Dams
4) Pond/ Tank
5) Gabian Structure
6) Sub-surface dykes/ Underground Bandharas

1) Tanka/ Kund/ Kundi: Tanka is generally circular in shape, having 3-4m in diameter, constructed in stone masonary having 20-60 cum capacity to suit individual households. Larger ones of 6m diameter and 200 cum capacity are built for village communities. A strip of land of 12m width around the Tanka is usually treated to increase the rain water collection. The following points need to be considered:

- The selected area should be cleared of all vegetation i.e., grass, shrubs, bushes etc.
- Since the rainwater flows over gently sloping (3 to 4% slope) sandy terrain, very little sediment flows into the tank.
- Requires constant vigil during the rainy season to prevent activities within the catchment area which may contaminate stored water.
- Requires pre-monsoon cleaning of the Tanka and the catchment.
- The system is not useful in areas with steep slopes and where land surface has clayey soil.

2) Percolation tanks: Percolation tanks are artificially created surface water bodies, submerging a land area with adequate permeability to facilitate sufficient percolation of impounded surface run-off to recharge the ground water. The percolation tank is more or less similar to check dams or nala bund with a fairly storage reservoir. A tank can be located either across small streams or in uncultivated land adjoining streams through excavation and providing a delivery canal connecting the tank and the stream. To use these tanks efficiently, the points to be considered are:

- Submergence area should be uncultivated as far as possible
- It is advisable to have the percolation tank in a good/ average catchment according to Stranger's Table for classification.
- Rainfall pattern on long term evaluation needs to be studied so that the percolation tank gets filled up during monsoon.
- Soils in the catchment area should be of light sandy type to avoid silting up of the tank bed.
- Location of the tank should preferably be downstream of run-off zone.
- The catchment area of small tanks should be 3-4 sq km and for larger tanks 5-8 sq km.

3) Check Dams/ Nala Bunds: Check dams are constructed across small streams having gentle slope. In order to avoid scouring from excess run off, water cushions are provided at downstream side. A series of small bunds or weirs are made across selected nala sections to impede the flow of surface water in the stream channel which is retained in pervious soil surface/ rock surface for a longer period. Nala bunds are constructed across bigger streams of second order in areas having gentler slopes which acts like a mini percolation tank.

The following conditions need to be considered for constructing Check dams/ Nala bunds:

- The total catchment area should normally be between 40 to 10 hectares and the rainfall in the catchment should be less than 1000m.
- The width of the nala bed should be 5-15 m and the depth should not be less than 1 m.
- Dams should be built at sites that can produce a relatively high depth of surface area so as to minimize evaporation losses.
- Rocky surfaces underneath should not be fractured or cracked, which may cause leakage of water in deeper levels.
- Dam foundation must be of solid impermeable rock with no soil layer or fracture lines.
- Preferably dams should be located along the edges of depressions or directly across the lower ends of deep gullies into the rock.

5) Pond/ Tank: Where there is a feasibility to build a pond of a desired size to meet the water requirements of the community, it is necessary to work out the water requirements for various needs as also to determine the catchment area above the pond site, from where the monsoon run off would be available to fill the pond. Care should be taken to decide on the alignment and height of earthen bund and the location and size of the spillway to evacuate the

surplus monsoon discharge. The storage capacity should be at least double the total requirement to take care of evaporation and seepage losses.

To ensure better performance of pond based water supply, the following points need to be considered:

- Depth of the pond should be below the lowest water table (average during the lean period) for sustainability of water supply
- Preparation of earth fill material with optimum moisture needed
- Placement and compaction of earth in layers are to be provided
- Provision may be made for irrigation outlet and spillway
- The slopes should be trimmed to correct angle
- Protection of upstream and downstream slopes may be made
- Embankment round the pond should be made to prevent direct entry of water in the pond
- Maintenance requirements like prevention of surface erosion, wave action, damage by cattle and human beings etc should be strictly complied with

6) Gabian Structure: It is commonly constructed across small stream to conserve stream flows with practically no submergence beyond stream course. Locally available boulders stored in a steel wire mesh and tied up in the form of rectangular blocks is put across the stream to make it as a small dam by anchoring it to the stream banks. The silt content of stream water in due course is deposited in the interstices of the boulders to make it less permeable. However, these structures, although can impound stream flow its sustainability needs constant monitoring as it is prone to leakage.

7) Ground Water Dams/ Sub-surface Dykes/ Underground Bandharas: a ground water dam is a sub-surface barrier across stream which retards the natural ground water flow of the system and stores water below ground surface or above to meet the demands during the period of moisture stress. It arrests the flow of ground water out of the sub-basin and increases the storage within the aquifer which helps in raising the water level in upstream part of ground water dam. Ground water dam in conjunction with Check dam ensures better water availability to the community. However, shallow ground water has a risk of contamination from seepage of surface pollutants.

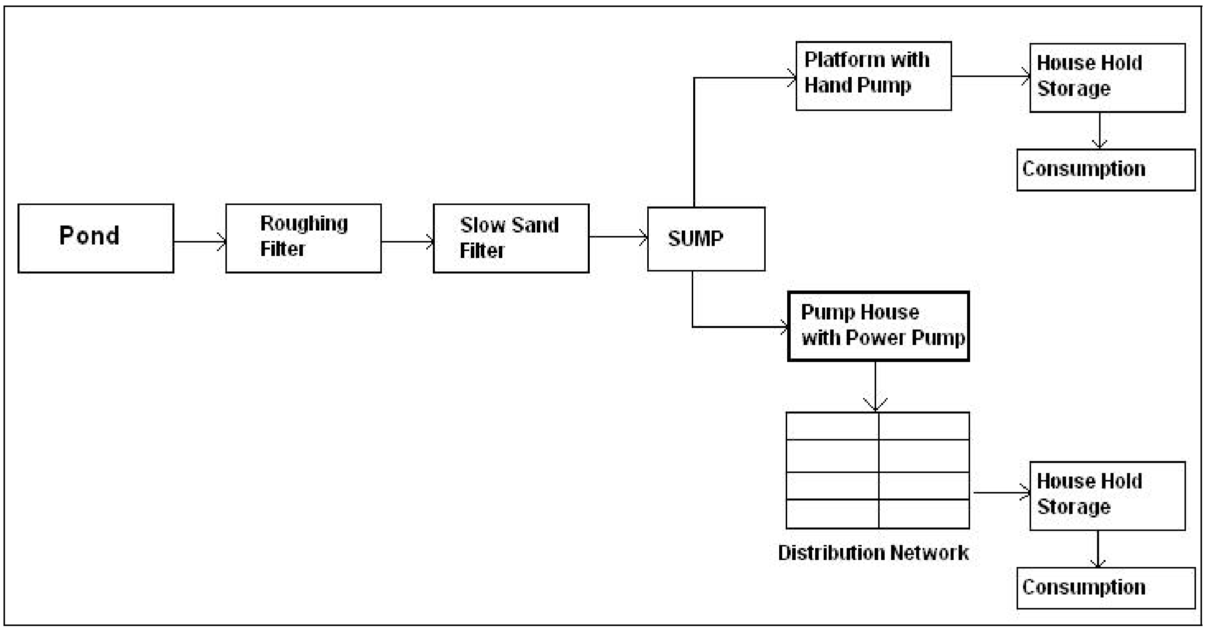
<u>Pre-cautions to use surface storage as water supply system:</u>

- No open defecation in/ near the river bed upstream and in the catchments area.
- Bathing/ laundry in the upstream of Check Dam has to be checked
- There must be no pit-latrines on the bank upstream as also in the catchments area from where water is diverted to surface storage
- Use of pesticides/ chemicals upstream of the dam site and in the catchments area have to be avoided
- Regular maintenance towards down-stream gravity out-take needs to be performed

Water harvesting in village and community ponds, water storage through construction of check dams, nala bunds, and contour bunds can provide sustainable water sources for the household and community needs. However, it is equally important that effective steps should be taken to transport collected and treated water from the catchment to the consumers keeping due importance to hazard free safe supply to the consumers. In one hand, the harvested water should be made contamination free and safe for human consumption. On the other, the water distribution system from catchment to consumer should be hastle-fee, should not be contaminated during transportation of water and should be completely safe to use by the consumers. Only by ensuring these, it will be possible to make sustainable safe water supply to the households and communities.

(Incorporate sanitary survey format and catchments map showing location of pond and other facilities.) Table-1

6. Flow Diagram with Symbol



7. Hazard Analysis

The most important activity of the WSP team is identification of the hazards and prioritization of the identified risks. Risks are prioritized in terms of their likely impact on the safety of the system. Through the risk assessment process it is possible to decide whether any modification is required to achieve the water quality targets. The existing control measures are documented and uncontrolled risks are evaluated. Proposed additional control measures to be suggested to achieve water quality targets.

The risk assessment process may involve a quantitative or semi-quantitative approach. This helps the WSP team to calculate a priority score for each identified hazard.

The following table may be utilized for the purpose.

Level	Descriptor	Rating (indicative) in numerical terms
'Likely hood of occurrence' category		
A	Almost Certain	5
B	Likely	4
C	Moderate	3
D	Unlikely	2
E	Rare	1
'Severity' Category		
A	Insignificant	No detectable impact - 1
B	Minor	Aesthetic Impact Causing Dissatisfaction - 2
C	Moderate	Major Aesthetic Impact - 3
D	Major	Morbidity expected from consuming water - 4
E	Catastrophic	Mortality expected from consuming water - 5

For each event risk rating is calculated by multiplying indicative rating of 'Likelihood' by severity.

It is essential to know what is hazard and hazardous events? How risk associate with hazard to be assessed? These are indicated below:

- Hazards are defined as: Physical, biological, chemical or radiological agents that can cause harm to public health.Hazards may be present or may originate throughout the water supply chain from catchments to consumer

- Hazardous events are defined as: An event that introduces hazards to, or fails to remove them from, the water supply.

- The risk associated with each hazard may be assessed, by identifying the likelihood of occurrence and evaluating the severity of consequences if the hazard occurred. The potential impact on public health is the most important consideration, but other factors such as aesthetic effects, continuity and adequacy of supplies, and utility reputation should also be considered.

Hazard event

In case of pond based system the followings has been identified as hazard events which needs proper attention to ensure safety of the water:

- Direct entry of surface runoff in pond / RWHS
- Breaching of embankments in Nala Bunds and Check Dams
- Bursting of check dams due to very large water flow in the stream
- Contamination due to other activities such as bathing, washing clothes and utensils, use by animals etc.
- Accumulation of contaminated water due to poor drainage arrangements near the water collection platform.
- Fish Farming
- Leaching of Microbial contamination
- Falling Leaves
- Direct Discharge to pond
- Drying and Clogging of Filter bed used for water purification
- Contamination due to large scale open defecation in catchments area
- Contamination during Transport

- Contamination during Storage and Handling
- Lack of effective maintenance of both water storage and water distribution system

Broad control measures to be adopted for the above mentioned events are:

- Proper construction of embankment around the pond / RWHS storage reservoir and construction of platform with drainage facilities.
- Direct discharge to pond/ storage reservoir to be stopped
- Waste materials/Hazardous chemicals shall not be dumped or toilet constructed near the dug well
- Stop open defecation in catchments area
- Fish Farming to be stopped
- Carrying containers to be covered
- Hygiene to be practiced
- Proper maintenance of the system is to be ensured

For each of the above hazard event cause of the event, hazard type or risk involved, control measures required to be adopted for prevention of the hazards are indicated in the Table 2.

8. Operational Monitoring Schedule

The operational monitoring schedule includes monitoring of control measures and corrective actions necessary when operational targets are not met. It is an important aspect of WSP implementation. It is implemented to ensure that any deviation from the required performance is rapidly detected. Factors considered for establishing the monitoring programs are:

- What will be monitored?
- How the monitoring be done?
- Where the monitoring be done?
- When the monitoring be done?
- Who will carry out monitoring?

If it is observed during monitoring that the critical limits have been exceeded then corrective actions are to be taken. The following factors are considered:

- What action is to be taken
- How the action is to be taken
- When action is to be taken
- Who will take the action

Operational monitoring schedule for pond / storage tank based system is given in Table 3.

9. Verification Schedule

To ensure that the WSP is functioning properly it is essential to have a process of verification. Usually verification involves the following activities:

- Compliance monitoring
- Auditing of operational activities
- Consumer satisfaction

Verification helps to understand whether the system is capable of delivering water of specified quality and appropriate corrective actions in case of failures. Activity wise proposed verification schedule is given in Table 4.

10. Validation Schedule

It is desirable to take up validation monitoring to determine whether the system is performing as assumed during system assessment and operation of water supply in accordance with the with the WSP will be able to achieve the desired health- based targets. Validation normally includes more exclusive and intensive monitoring than routine operational monitoring.

The validation practice helps in identifying the short comings and suggests corrective actions to be taken. The suggested format of validation schedule is given in Table 5.

11. Improvement Action Plan

For making the WSP a success, it is necessary to have an inbuilt improvement plan which can neutralize the risk involved at various stages.

Starting from Catchments to Consumer existing techniques can be modified if need be, provided records of construction, operation and maintenance of the Water Supply system based on surface water storage are systematically kept and judicially analyzed.

Catchments characteristics being the primary requisite of WSP, protection of its water quality aspects and scope for storage of requisite quality of water have to be studied continuously. For augmentation of water availability, ground water recharging if feasible can be resorted to.

The storage reservoir - its material of Construction, maintenance requirement can demand improvement of techniques. It is possible to reduce silt deposition of the reservoir by adopting forestation measures / soil erosion measures in the catchments area.

The Distribution System can also be improved suitably depending upon the requirements and sometimes by replacing the materials for distribution pipe/ pumps etc.

Storage and handling of water, similarly, can be improved by generating well designed awareness generation techniques. Contamination of water sources can be better identified by deploying more sophisticated analytical techniques, if such situation arises

An action plan for incorporating corrective measures for addressing the shortcomings are developed for implementation in immediate phase as well as long term basis. Realistic assessment of fund requirement for implementation of improvement plans and careful prioritization the different items of work are essential.

Above issues have been identified and actions required to be taken for their improvement are indicated in Table 6.

Table 2: Hazard Analysis

Process Step	Hazardous Event	Hazard Type	Risk prioritization (Semi Quantitative Method)			Control Measures	Additional Control Measures
			In Category of Likelihood	In Category of Consequence/ impact	Risk Rating		
Pond/ RWHS Construction	Ingress of contaminated surface run-off	Construction	Moderate (3)	Moderate (3)	3 x 3 = 9	Construct 1 m high embankment around the pond.	Surroundings may be sloped away from pond embankment
	Breaching of embankments in Nala Bunds/ Check Dams	Construction	Unlikely (2)	Catastrophic (5)	2 x 5 =10	Proper maintenance of Bunds/ Dams	
	Bursting of Check Dams due huge water flow in Stream	Construction	Rare (1)	Catastrophic (5)	1 x 5 = 5	Arrangement of diversion of excess flow, if possible	
Catchments around Pond / RWHS	Leaching of organic matters from organic waste damps	Microbial	Unlikely (2)	Catastrophic (5)	2 x 5 =10	Locate waste damps at least 10 m away from pond embankment	
	Leaching of faecal matters from human and animal wastes	Microbial	Moderate (3)	Catastrophic (5)	3 x 5 =15	Locate toilet and animal pen at least 10 m away from pond embankment	Chlorinate the water after treatment with bleaching powder
Pond / RWHS water	Washing of utensils and clothes, bathing and swimming	Microbial	Unlikely (2)	Catastrophic (5)	2 x 5 =10	Pond to be reserved for exclusive use of drinking purpose	Fencing may be provided along the embankment
	Direct discharge of wastes from adjoining houses	Microbial	Unlikely (2)	Catastrophic (5)	2 x 5 =10	All such connections to be plugged	In case of large no of connections intercepting sewers may be laid for diversion of all waste water
	Fish Farming	Microbial	Moderate (3)	Catastrophic (5)	3 x 5 =15	Fish farming to be prohibited	Cultivation on a limited scale to be done which thrive on bacteria.
	Falling leaves from trees around pond	Chemical/ odor	Moderate (3)	Minor (2)	3 x 2 = 6	Avoid leafy trees and prevent extension of branches inside pond	Periodic removal of leaves particularly during winter
Roughing Filter and Slow Sand Filter	Excess inflow of suspended matters due to damage of the strainer and reduced flow due to clogging of filter	Turbidity	Moderate (3)	Minor (2)	3 x 2 = 6	Repair of damaged strainer and regular cleaning of strainer	Regular inspection
	Drying up of filter media	Microbial	Moderate (3)	Catastrophic (5)	3 x 5 =15	Ensure sufficient head of water above sand bed	Training of operator
	Filter clogging	Microbial/ Physical	Moderate (3)	Catastrophic (5)	3 x 5 =15	Scraping and replacement of filter sand at regular interval	Training of operator
	Contamination due to use of poor quality water for priming of hand pumps attached to the sump	Microbial/ Chemical depending on quality of water used	Moderate (3)	Moderate (3)	3 x 3 = 9	Leaky sheet valve to be replaced immediately on detection. In emergency use only good quality water for priming.	Training of operator
	Leaky tap	Wastage of water	Moderate (3)	Insignificant (1)	3 x 1 = 3	Repair / Replace leaky tap	Training of operator

Process Step	Hazardous Event	Hazard Type	Risk prioritization (Semi Quantitative Method)			Control Measures	Additional Control Measures
			In Category of Likelihood	In Category of Consequence/ impact	Risk Rating		
Transportation of water	Contamination if water container is not properly covered during transportation	Microbial/ Others	Moderate (3)	Catastrophic (5)	3 x 5 =15	Ensure covering of the container.	The carrying container shall be cleaned before use.
Storage and Handling of water	Contamination due to use of unclean utensil and/or hand for drawing water from storage tank (Jala)	Microbial/ Others	Moderate (3)	Moderate (3)	3 x 3 = 9	Water shall be taken out from the storage tank using a cup fitted with a handle.	Make it a habit to wash hands before touching the water pitcher or storage tank.
	Contamination by dust particles or domestic animals for not covering the storage tank	Microbial/ Others	Moderate (3)	Minor (2)	3 x 2 = 6	Storage tank shall always be kept covered.	Regular washing of storage tank to be practiced

Table 3: Operational Monitoring Schedule

Process Step	Performance Indicators	Monitoring		Critical Limit	Corrective Action		Supporting Programme
Catchments around Pond / RWHS	Waste Dumping, Toilet etc. close to pond	What	Presence of waste dump, latrine etc around pond	No latrine, animal pen, waste dump etc. within 10 m from the pond embankment	What	Stop dumping of all types of waste materials & relocate Toilet	Educate villagers through group meetings and IEC activities
		How	Sanitary inspection		How	Applying GP Rules	
		Where	Within 10 m of embankment		When	Immediately on identification	
		When	Once in every six months		Who	Member of GP	
		Who	Chemist of NGO Lab				
Water Storage Pond / RWHS	Quality of water of the pond	What	Test quality of water	Water quality must satisfy the standard set forth in Water Supply Manual of GOI	What	Proper dosing of Disinfectant	
		How	Laboratory test		How	Through routine testing as per GOI guidelines	
		Where	At source/ Treated water sump		When	Regularly	
		When	During commissioning and periodically at least once in a year		Who	SAE PHED / Chemist of NGO Laboratory	
		Who	Concerned Laboratory				
	Protection and Proper use of pond	What	Fencing of pond / Use of pond	Fence damaged / Use of pond for other activities	What	Fence pond/ Stop other activities	Educate villagers through group meetings and IEC activities
		How	Sanitary inspection		How	Routine repairing / Educate people	
		Where	Area around pond / Use of pond		When	Immediately on detection	
		When	Monthly		Who	Village Water & Sanitation Committee (VWSC)	
		Who	Operator / Chemist of NGO Lab				
	Presence of Algae	What	Algal growth	Occurrence of blooms	What	Reduce nutrient flow	Operator Training
		How	Visual inspection		How	By stopping Fish Farming	
		Where	At Pond		When	Within 2 Weeks	
		When	Monthly		Who	VWSC / Operator	
		Who	Operator				
	Insufficient Quantity of water	What	Depth of pond	Water level goes below the entry level of Roughing Filter Unit	What	Excavate pond	Educate villagers through meetings and IEC activities to consume less water during emergency
		How	Visual inspection / Measurement		How	Engaging labour	
		Where	At pond		When	Within 1 Year	
		When	Weekly during dry season		Who	VWSC	
		Who	Operator				
Purification by Roughing / Slow Sand Filter	Condition of Sand Filter Bed	What	Head of Water over Sand Filter	No water over Sand Filter Bed	What	Repair / Re-install the constant head device	Training of Operator
		How	Inspection of Filter / Flow rate		How	Repairing	
		Where	At Filter		When	Immediately on detection	
		When	Weekly		Who	Operator	
		Who	Operator				
	Filter Clogging	What	Rate of Flow of Filter	Water level touches over flow pipe	What	Clean the filter bed	Training of Operator
		How	Height of water over filter bed		How	Scraping the top sand layer	
		Where	At Filter		When	Immediately on detection	
		When	Daily		Who	Operator	
		Who	Operator				

Process Step	Performance Indicators	Monitoring		Critical Limit	Corrective Action		Supporting Programme
Purification by Roughing / Slow Sand Filter	Filter Condition	What	Filter bed depth, cracks etc	Filter bed depth less than 0.3 m	What	Remove sand refill properly	Training of Operator
		How	Top of Sand above minimum mark		How	As per order of PHED/ ZP / GP	
		Where	At Filter		When	Immediately on detection	
		When	Monthly		Who	Operator	
		Who	SAE PHED				
Hand Pump	Maintenance of Pump	What	Checking operation of pump	Pump seat valve is leaking or pump is out of order	What	Repairing of pump	Training of Operator
		How	By operating the pump		How	By replacement of seat valve / bucket etc	
		Where	At site		When	Immediately on detection	
		When	Monthly		Who	Mechanic PHED	
		Who	Mechanic PHED				
Distribution System / Tap etc for bigger scheme	Condition of Distribution System etc	What	Any leakage in Distribution system	Bursting in the main	What	Repairing of burst	Training of Operator
		How	Visual inspection		How	Engaging agency	
		Where	Along the distribution network		When	Immediately on detection	
		When	Weekly		Who	PHED / ZP / GP	
		Who	Operator				
Storage and Handling	Contamination during handling and storage	What	Hygiene practice during collection, transport and storage	Water collection, transportation and storage is hygienic	What	Key hygiene messages	Educate villagers through group meetings and IEC activities and school children as a part of curricula
		How	Through inspection at all levels		How	Hygiene education and practice at schools and IEC activities	
		Where	At water collection site and households		When	Regular activity	
		When	Weekly		Who	Member of GP	
		Who	Member of GP				

Table 4: Surveillances and Verification Schedule

Activity	Description	Frequency	Responsible Party	Records
Sanitary Survey	Sanitary survey will be done as per GOI guidelines	Twice in a year	Chemist of NGO Lab	Sanitary Inspection format (NGO Laboratory and GP Office)
Functioning of Civil and Mechanical Items	Survey of the created Water Supply systems	Twice in a year	Maintenance Authority – SAE, PHE, Panchayat Samity, Minor Irrigation Engineer, Hydro-Geologist	O&M Card of Pond/ RWHS (Block / GP Office / Minor Irrigation / SWID)
Water Quality Monitoring	Monitoring of quality of water for physical, chemical and biological quality as per GOI guidelines	Twice in a year	Chemist of NGO Lab	Water Quality Report Card (NGO Laboratory and GP Office)
Effectiveness of Water Safety Plan	Monthly Meeting of the Water and Sanitation Committee shall discuss the WSP involving the District Water & Sanitation Cell, PHED and BMOH and meet the Community.	Field visit and discussion with the Communities to be done as frequently as possible. Gap shall not exceed 3 months.	Gram Panchayat	Health Data card and Water Quality Report Card (Health Center, NGO Laboratory and GP Office)
Impact Assessment of Advocacy Programme	Verification of water related practices of the Community	Random Sampling	Chemist of NGO Lab / GP Office Staff	IEC Material Produced (NGO Laboratory and GP Office)
Checking Satisfaction level of the User Community	Visit to House Holds and meeting at GP Office	Quarterly	Panchayat / GP Office	Survey Report (GP Office)

Table 5: Validation Schedule

Process Step	Hazardous Event	Validation Schedule	Comments
Catchments	Leaching of organic matters, faecal matters	Verification of water quality analysis data and sanitary inspection records to assess whether the protection measures are effective.	
Pond	Bacteriological contamination of pond water	Study analysis of water quality results, sanitary inspection data etc for assessment of effectiveness of WSP	
	Effectiveness of chlorination in pond	Study records of disinfection by chlorination, analysis of tests records of residual chlorine etc to assess the effectiveness of chlorination. In addition study health records, particularly of diarrhea disease.	
Hand pump	Introduction of contamination through hand pump	Study records of hand pump repair	
Transportation	Introduction of contamination during transportation	Survey and local enquiry	
Storage and handling	Contamination due handling and storage	Survey and local enquiry	

Table 6: Improvement Action Plan

Issue Identified	Approach to be adopted for carrying out improvement	Time frame for implementation	Responsibility	Fund Requirement	Type of Plan	Degree of Priority
Sanitary protection of pond / RWHS	(a) IEC activities on pond protection, embankment protection and exclusive use of pond for drinking water purpose.	Within 6 months	PHED/ ZP / Gram Panchayat and NGO involved in IEC activities.		Short Term	High Priority
	(b) Fencing around Pond / RWHS	Within 2 Years	PHED/ ZP / Gram Panchayat		Long Term	Medium Priority
Operation and Maintenance of pond / RWHS and filter unit	Preparation of Manual on Operation of Filter Unit and pond maintenance	Within 6 months	PHED and Gram Panchayat		Short Term	High Priority
Chemical contamination	Testing of water quality immediately on construction	Twice in a year	NGO Laboratories		Short Term	High Priority
Maintenance of Hand pump	Periodic maintenance of hand pump including seat valve	Immediate on detection	Mechanic of PHED		Short Term	High Priority
Chlorination	Regular chlorination of pond water with bleaching powder	Within 6 months	Gram Panchayat		Short Term	High Priority
Safe water handling	Introduction of hygiene education in primary schools and IEC activities e.g. hand washing, washing of water container, safe handling during storage etc	Within 6 months	School teacher, NGO and GP Member		Short Term	High Priority

N.B. Requirement of fund as per estimate to be indicated in Column 5

Table 1

SANITARY SURVEY FOR THE ASSESSMENT OF RISKS OF CONTAMINATION OF DRINKING WATER SOURCES

I. Type of facility : **RAIN WATER TANK CATCHMENT**

General information :

i. Location : Village ....
: Gram Panchayat ....
: District ....

ii. Code No. ..../........................../..........................

iii. Water authority/Panchayat Pradhan/Community Representative Signature ....

iv. Date of visit ....

v. Is water sample taken?..........................Sample No.......................... Water Quality Acceptable/Rejectable

II. Specific Diagnostic Information	**Risk** Yes	No
1. Is there any contamination of the roof catchment area? (e.g. plants, dirt or excreta)	•	•
2. Are the guttering channels which collect water dirty?	•	•
3. Is there any deficiency in the filter box at the tank inlet? (e.gs. lacks fine gravel)	•	•
4. Is there any other point of entry to the tank which is not properly covered?	•	•
5. Is there any defect in the walls or top of the tank (e.g. cracks), which could let water in?	•	•
6. Is the tap leaking or other wise defective?	•	•
7. Is the floor under the tap defective or dirty?	•	•
8. Is the water collection area inadequately drained?	•	•
9. Is there any source of pollution around the tank or water collection area? e.g. excreta.	•	•
10. Is the water bucket left in such a position that it may be contaminated?	•	•

Total Score of risks ..../10

Contamination risk score: 9-10=V, high; 6-8=high; 3-5= intermediate; 0-2= low

Number of 'YES' to be counted

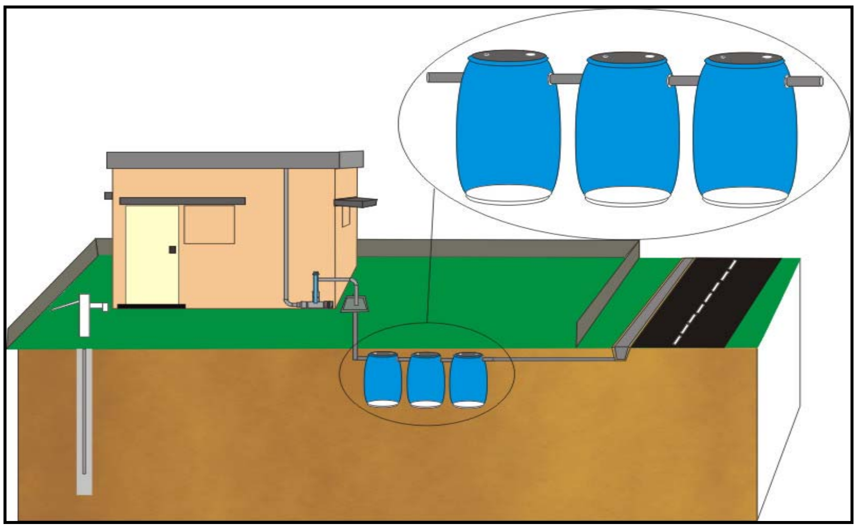
III. Results and recommendations:

The following important points of risk (serially from the top) were noted : and the authority advised on remedial action

(list nos 1-10)

Signature of Investigator ....

Chapter-8



"Ground Water Recharging Systems"

Ground Water Recharging Systems

1. Introduction:

To tackle the twin problems of de-saturation of aquifer zones and consequent deterioration of ground water quality, there is an urgent need to augment the ground water resources through suitable management interventions to provide sustainability and protection. There are several urban areas in the country, mostly dependent on ground water resources for water supply systems where situation has been further aggravated with the rapid pace of urbanization and potable drinking water supply in those urban complexes has become a major threat for its sustainability. The stress on ground water system has increased tremendously resulting in steep water level declines in and around those cities.

Natural replenishment of ground water reservoir is a slow process and is often unable to keep pace with the excessive and continued exploitation of ground water. Artificial recharge efforts are basically aimed at augmentation of the natural movement of surface water mainly derived from rain water into ground water reservoir through appropriate techniques. Artificial recharge projects are generally designed to replenish ground water resources in depleted aquifers and to conserve water for future use. Other objectives include control of saline water ingress, control of land subsidence etc.

Among the various advantages of ground water recharge, the important ones are: negligible evaporation losses, quality improvement by infiltration through the permeable media, higher biological purity, rising of ground water level, energy saving due to reduction in suction and delivery head as a result of rise in water levels. Rain water is the main source of recharge into ground water. Other important sources are seepage from tanks/ponds, canals, streams and man-made reservoirs by constructing check dam, contour bunds, earthen bunds, sub-surface dyke/ Ground water dam etc.

To ensure water security in the community where primarily ground water resources are used, recharging to ground water can provide an effective means for water protection and sustainability.

2. Water Supply Process Description

Ground water recharging schemes will essentially involve the following components:

i) Assessment of source water: Insitu precipitation in the water shed/catchment, surface water bodies by impoundment, treated municipal wastes etc may be source of water for recharging. However, proper physical, chemical and biological qualities of source water have to be assured before recharging.

ii) Planning of Recharge Structures: Planning of artificial recharge schemes involves the formulation of a suitable plan, under characteristic specific natural condition of the area, to augment the natural ground water recharge. The planning should be aimed at a) preparation of layout plan showing locations of proposed structure and source water conveyance system. b) Determination of the number of structures required for recharge. c) Identification of locations of proposed structures and d) preparation of design specifications and drawings.

iii) Finalizations of specific techniques and designs: Depending upon the need, availability of source water, sub-surface storage capacity of the aquifers and hydrogeological frame work of the aquifer system, specific technique for ground water recharging may be arrived at.

iv) Monitoring and Impact assessment: It is essential to assess the efficacy of the structures constructed for artificial recharge which helps in identification of cost effective recharge mechanism for optimal recharge into the ground water system. Impact assessment will require monitoring of recharge structures, ground water regime, change in water supply and water quality.

v) Financial and economical evaluation: It is a critical parameter to be ascertained before finalizing decision to implement any artificial recharge scheme. Economic and financial viability of the scheme have to be established. Benefits to be accrued from such scheme needs to be accounted for in order to decide the social acceptability of the scheme.

vi) Operation and Maintenance: Periodic maintenance of recharge structures is required as infiltration capacity reduces because of silting, chemical precipitation and accumulation of organic matter. Preventive maintenance of recharge structures is also needed to forestall major repair or replacement of its different components.

3. Technology Description including sanitary Map of Water Catchments:

Various techniques involved for artificial recharging to ground water can be described as

I. Direct Methods.

A) Surface Spreading Techniques
- Flooding
- Ditch and Furrows
- Recharge Basins
- Run-off Conservation Structures

i) Bench Terracing

ii) Contour Bunds and contour Trenches.

iii) Gully Plugs, Nala Bunds, Check Dams.

iv) Percolation Ponds.

B) Sub-surface Techniques
- Injection Wells (Recharge Wells)
- Gravity Head Recharge Wells
- Recharge Pits and Shafts
- Existing Dugwells and Tubewells

II Indirect Methods

C) Induced Recharge from surface water sources.
D) Aquifer Modification by Bore Blasting and Hydro-fracturing.

III Combination Methods

E) Ground Water Conservation Structures like Subsurface Dyke (Bandharas) /Ground Water Dam.

F) Fracture Sealing Cementation.

A combination of Surface and Sub-surface Techniques can also be taken up under favorable terrain and hydrogeological conditions.

Information capture report for water supply process and technology should be in line with the Table 2 and Table 2 of Chapter 3.

I. Direct Methods

A. Surface Spreading Techniques- The basic objective of this technique is to increase the contact area and residence time of surface water over the soil to enhance infiltration and to augment the ground water storage in phreatic aquifers. Adjacent to rivers or irrigation canals, where water levels remain deep even after monsoons and where sufficient non- committed surface water supplies are available, flooding technique can be taken up for recharging. Ditch and Furrows method involves construction of shallow, flat- bottomed and closely spaced ditches and furrows to provide maximum water contact area for recharge from stream or canal water source. Recharge Basins are constructed parallel to ephemeral or intermittent streams, canals or other surface water bodies and are either excavated or are enclosed by dykes and levees. Run-off Conservation Structures are created commonly by bench terracing, contour bunds, gully plugs, nala bunds, check dams and percolation ponds.

B. Sub-surface Techniques- The most common methods used for recharging involve diversion of water from catchments including Roof-top catchment through a) Injection Wells or Recharge Wells b) Recharge Pits and Shafts c) Dug Well/ Tube Well d) Borehole flooding and e) Natural openings and cavities. (see Figure 1)

II. Indirect Methods

The most common methods are induced recharge from surface water sources and aquifer modification techniques. Induced recharge can be effect by pumping water from an aquifer, hydraulically connected with surface water bodies. Under favourable

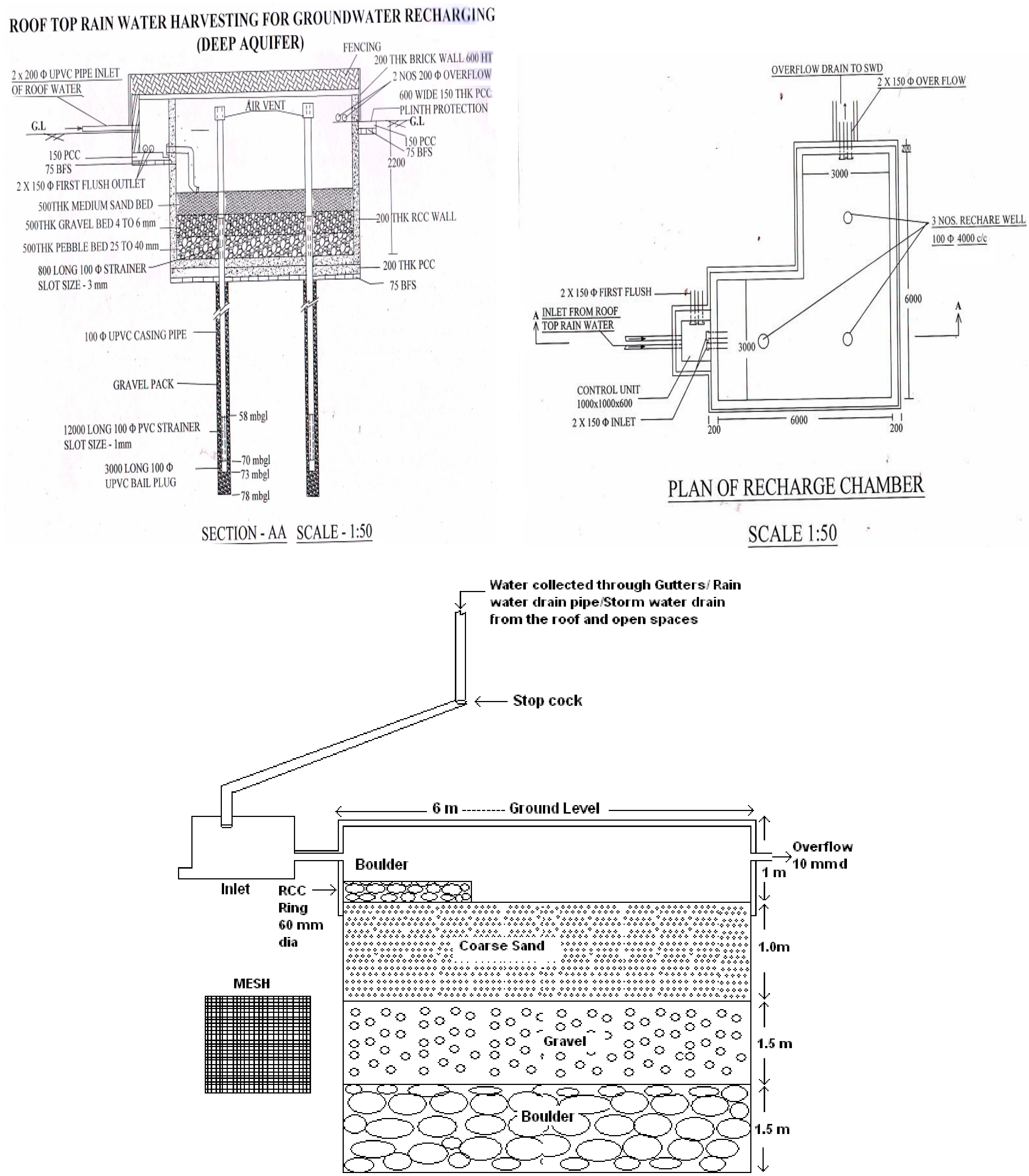


Figure 1: Plan and Layout of Recharge Pit for Shallow Aquifer

Hydrogeological conditions, induced recharge can be effective for improvement of water quality also.

III. Combination Method: Commonly adopted combination methods include recharge basins with shafts, percolation ponds with recharge pits or shafts etc. The known techniques of ground water conservation are a) Ground Water Dam/ Sub-surface dyke/underground 'Bandharas' and b) Fracture sealing Cementation techniques which help in improvement of water supply system.

4. Hazard Analysis:

Possible Hazards:

- Source water for recharging can be contaminated by faeces in the catchment area.
- Breeding of insect vectors inside stored/ impounded water
- Source water for recharging can be polluted by air pollution from factories, industries, mining etc which influence the chemical quality of water vapour in atmosphere
- Source water may carry dust, debris, organic matter from bird droppings, rotten tree leaves, seeds, algae etc.
- Open defecation by human beings and animals in the proximity of source water from which recharging is done can also contribute pollution.
- Filtration Chamber required for transmitting clean water can be clogged
- Leakage in the Filtration Chamber adjacent to sanitary system or sewerage lines
- Clogging of Strainers in the recharge wells
- Lack of sufficient 'head'(water table or piezometric) can prevent recharging in case of gravity head recharge wells
- Excessive recharging without consideration of water level of the area can result into water logging

The above hazard events can be controlled by adopting the following measures:

- Rain water tanks/reservoirs should be designed to protect the water from contamination by leaves, dust, insects, vermin and other sources like industrial and agricultural pollutants
- Incoming water to be used for recharging should be filtered or screened
- The area surrounding Artificial Recharge Structure should be kept in good sanitary condition, fenced off to prevent animal fouling the area
- In case of Roof-top catchment for source water, 'first-flush system should be provided to drain out first two to three showers
- Slow sand filtration will remove any harmful organism
- Adding chlorine in appropriately measured quantity will disinfect the water
- 'SODIS' (Solar Disinfections) may be tried at convenient places
- Chemical & bacteriological contamination of source water during the collection and storage processes can be prevented effectively by proper

and regular maintenance of the Recharging System including Filtration Chamber

- Clogging of strainer (filter) of the Recharge Well can be removed both by mechanical surging by sending compressed air/ or by charging chemicals
- Hazards encountered at different stages i.e., storage of water in the catchment, filtration process and recharging process can be minimized by effective maintenance arrangements by suitably trained maintenance personnel.

Table -1, Hazard Analysis:

Process Set up	Hazardous Event	Hazard Type	Risk Prioritization			Control Measures
			In category of Livelihood	In category of Consequence/Impact	Risk Rating	
Source Water	Can be contaminated by faeces in the catchment ever	Microbial	Moderate (3)	Moderate (3)	9	Avoid such areas. Awareness to be generated amongst the people to prevent such happenings
	Breeding of insects vectors inside stored/impounded water	Microbial	Moderate (3)	Moderate (3)	9	Impounded water in Roof top Rain water harvesting should be covered. In other recharge systems periodic cleaning and maintenance is required
	May carry dust, debris, organic matters	Microbial	Unlikely (2)	Moderate (3)	6	First flush system should be provided. Maintenance before and after on set of monsoons needed.
	Open defecation by human beings and animals in the proximity of source water can contribute pollution	Microbial/ Physical	Moderate (3)	Moderate (3)	9	Awareness amongst the beneficiaries needs to be guaranteed. Periodic field checking needed.
Filtration chamber	Can develop clogging	Construction	Unlikely (2)	Moderate (3)	6	Filtration chamber should be suitably designed. Filtration media should be properly washed and cleaned before use.
	Leakage in the Filtration chamber adjacent sanitary system/sewerage lines	Construction	Rare (1)	Catastrophic (5)	5	Care should be taken in the civil construction so that such hazard does not occur. Periodic monitoring of the chamber needed.
Strainer of Recharge wells	Clogging of strainer may hamper recharge capacity	Construction	Unlikely (2)	Moderate (3)	6	PVC/Stainless strainer should be used when quality of formation water is brackish.
	Improper construction of recharge well will reduce recharge capabilities	Construction	Moderate (3)	Moderate (3)	9	Well should be constructed tapping the aquifer only. Precise delineation of aquifer by electrical logging of bore hole will be helpful.

Transportati on of water	Contamination hazard during initial spells of rains	Microbial/Ph ysical	Moderate (3)	Moderate (3)	9	First flush system should be used to avoid such menace. The upper part of filtration chamber comprising coarse sands may be replaced before rainy season, if needed.
	Pollution effect during transportation of water used for recharging	Microbial	Unlikely (2)	Moderate (3)	6	Addition of chlorine in measured quantity, use of "SODIS" (Solar Disinfection may be helpful)

5. Operational Monitoring Schedule

Surface structures such as percolation ponds, check dam, impounded water by contour bunds, Cement Plugs etc need to be monitored at regular interval to assess the actual storage created in the structures, period of impounding, rate of percolation and siltation problems. For sub-surface structures, the intake water supplied to the structures is measured by appropriate measuring devices such as flow meters and 'V' notches. Daily records of such measurements help quantify the amount for recharge purpose. The 'Roof-top catchment' needs to be cleaned before on set monsoons. Regular maintenance need of the roof-top catchment before and after monsoons is required. Periodical checking of conditions of Recharge Well as regards filling up of the well by silty materials, clogging of slots of strainer filter etc. should be done to ensure proper functioning of the recharge well. Water Level monitoring adjacent to the recharging system helps in studying the effect of artificial recharge on the natural ground water system.

Table-2, Operational Monitoring Schedule

Process Step	Critical Limit	Monitoring	Corrective Action
A. Source Water from Catchment	1) Waste dumping, open defecation and latrine activities irrigational activities causing contamination of water 2) Roof-top catchment with falling of leaves, bird dropping, accumulation of silt and debris. Maintenance of gutters, down-pipes etc.	1) Identification of waste dump, latrine activities, sanitary inspection, application of fertilizer etc. Monitoring should be done preferably on monthly basis 2) Cleaning before onset of monsoon and after monsoon is over. 3) Condition of gutter, down pipe etc At least two times in a year.	1) Directives from local bodies to stop such activities, educate villagers through IEC activities 2) Proper monitoring and regular cleaning can get rid of the hazard. For Roof-top catchment water, provision of first flush system will ensure that contaminated water is not diverted to Filtration Chamber
B. Filtration Chamber.	Clogging of slow-sand filter, effectiveness of out flow pipe, provided in Filtration Chamber, replacement of upper layer of filter materials contaminated after operation.	1) Regular maintenance and replacement of materials as and when required. 2) Leakage in the filtration chamber, if any. At least twice in a year before and after monsoon.	Once the need for corrective action is established after monitoring, replacement of defective materials will ensure better functioning of the system

Process Step	Critical Limit	Monitoring	Corrective Action
C. Recharging Device	Clogging of strainer/ filter, deposition of silty materials inside the recharge device like Pit, Shaft and Well etc.	Identification of clogging effect from examination of filtration rate, identification of filled up materials by measuring the depth of wells. Frequency of monitoring at least twice before and after monsoon.	Once the hazards are identified from monitoring, it can be cleaned by mechanical surging and or/by compressed air and if necessary by charging appropriate chemicals.
D. Water Level Monitoring	Impact on water level of the ground water regime adjacent to Ground Water Recharging Device.	Monitoring of water levels during planning stage of artificial recharge Projects. Monitoring of water level subsequent to recharging on a monthly basis through a network of observation wells.	The behaviour of water table/piezometric head profile collected from network of observation well data can clearly establish the efficacy of the recharge scheme. In case any deviation is observed, the reasons for the same should be identified and necessary remedial measures be taken up.

6. Verification Schedule

Verification in primarily done to determine the capability of the system in delivering the objectives for which the system was created. The verification at the level of its operational activities, records of monitoring of the various facets of the system at different stages and satisfaction of the beneficiaries should be done which will ultimately help in taking corrective steps as and when required.

For effective verification, the following schedule may be maintained

Table-3, Verification Schedule

Activity	Description	Frequency	Responsibility of The Personnel
A. Constructional Aspects of the System.	Civil and mechanical components involved in the System to assess the effectively of the System.	Twice in a year (before and after recharge in pre-monsoon and post monsoon period.)	SAE, PHED, Representative of Irrigation and Ground Water Departments, and Panchayat functionary responsible for the Project.

Activity	Description	Frequency	Responsibility of The Personnel
B. Measurements.	a) Flow rate, duration and quality of source water. b) Inflow and out flow of the water in Filtration chamber. c) Recharge rate and depth to water in recharge structures. d) Thickness and composition of surface clogging layer when the recharge structure is dry. e) Precipitation and evaporation from surface ponds. f) Depth to water and quality of ground water in the area adjoining recharge system in operation	During recharge period of monsoon months (4months) on a monthly basis.	Technician, Hydrogeologist and Irrigation Engineer Records should be maintained at G.P.Level.
C. Social Aspects related to satisfaction of Consumers.	Finding out whether overall ground water availability in dug wells/tube wells have improved after recharging to ground water done through the system.	In post-monsoon period, especially from January to May, on monthly basis.	Technician under the supervision of SAE and co-ordination of Beneficiaries representative

7. Validation Schedule

When the recharge system is in operation, systematic appraisal is required to assess the performance of the System to find out the deficiency and to suggest appropriate measures to overcome the shortcomings identified from the validation activity. Such validation activity may be scheduled as under:

Table-4, Validation Schedule

Process Step.	Hazardous Events.	Validation.
A. Catchments.	Leaching of organic matter, faecal matters, chemical and other pollutants from municipal, agricultural and industrial activities.	Verification of water quality and sanitary inspection records, Analysis of records and rectification work carried out to assess whether intervention made was sufficient to rectify the system.
B. Water Storage and Recharge System.	Siltation of storage reservoir, Rupture of civil construction, Replacement need of various components involved in the system	Verification of maintenance records of civil and mechanical items based on which periodic corrective actions were taken. Necessary to establish the validity of such rectifications in improving the performance of the system
C. Clogging of the Recharge System.	Clogging effect of suspended matter, reduction in infiltration capacity, encrustation on slot opening of Recharge Well, Filling of Dug Well and Tube Well used for recharging	Verification of scraping of surface layer clogged by deposition of silt and suspended solids. Verification of depth of recharge well to gauge the thickness of filled up materials etc which will suggest suitable measures to be taken up for Rehabilitation of the system.

8. Improvement Action Plan

In order to make the Recharge Project sustainable which will essentially help to make WSP a success, it is essential to have an inbuilt improvement plan which will offset the risk involved at various stages of operation and functioning of the system.

The potential problems expected to be encountered in Recharge Project mostly relates to the source water availability and its quality. The soil structure and biological activity which takes place consequent to recharge operations may also develop some problem. A major requirement for source water in Recharge Project is that water should be silt-free. Silt is the un-dissolved solid matter comprising clay particles, organic matter and fine particles of silica and calcite. This suspended matter clogs the soil by the filling up the interstices of the soil and by depositing a layer of mud on the surface. The clogging effect by suspended matter may be minimized by

1) periodical removing of the mud cake and scraping of the surface layer, 2) providing a filter bed having lower permeability than that of the underlying soil strata which needs to be replaced periodically, 3) adding organic matter or chemicals to the uppermost layer and 4) planting grasse cover over the surface Bore Wells which are much more prone to silting than spreading grounds, need periodic re-development by mechanical means and pumping.

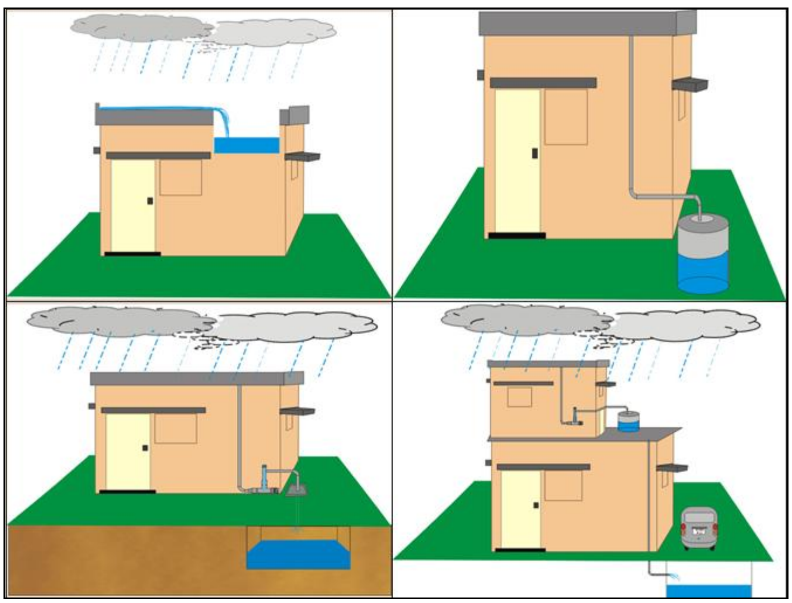
The close vicinity of spreading basis to populated and industrial areas may create environmental hazards when uncontrolled and untreated contaminants may enter into the Recharge System. Again, artificial recharge designed to raise ground water level can cause substantial damage due to inundation of basement of buildings. Seepage of saline water into fresh water system can be another potential problem. While making Recharge Scheme for augmentation of water supply, these aspects need to be looked into carefully and innovative improvement plan to arrest such menace should be kept ready. Lining of the Recharge Area may be required in some cases.

Various chemical processes like adsorption, ion-exchange, oxidation and dissolution may take place during the process of artificial recharge Iron oxyhydroxide and organic flocks adsorbed on aquifer particles may reduce the permeability. Acidization may help in the improvement of the permeability.

If the recharge water is chemically and physically compatible with the ground water to be recharged, the effectiveness of the recharge operations increases. When biodegradable matter is present in the injected water, sealing of the well may occur rapidly. Pre-treatment through slow sand filter and chlorination may prevent the growth of bacteria and maintenance of residual chlorine level of 1-2 mg/ l in the recharge well may minimize the biological clogging.

The Artificial Recharge Scheme can augment water availability scenario in an area to a considerable extent through participatory approach, backed by sound technical and scientific knowledge transferred in the grass-root level by the concerned government agencies. A proper vigilance on the operations, systematic maintenance practice and urge for improvement of the System as ground situation demands, can add to a better sustainability of the Ground Water Recharge System.

Chapter-8



"Roof top Rain water Harvesting System"

ROOF TOP RAIN-WATER HARVESTING SYSTEM

A. Introduction

The basic source of water is precipitation in the form of rain or snow. Rain feeds surface water, ground water and the eco-system. Rainfall can be collected by everybody at any place for their own use. Rain water harvesting simply means collecting rainfall, storing in reservoir and keeping it clean for use during non-rainy days. The technology being so simple can be efficiently practiced by everyone in their own place or at a place where water is needed. Rainfall comes for short duration and goes, making most of the year dry without rain. In India we receive rainfall mainly during the monsoon period and the remaining months are without rain. The dry period without rain being long, the rainfall during the rainy season need storage to last the dry period. Operation and maintenance of roof rain water harvesting scheme is simple and very cheap. Maintenance can be effectively done by the family having members with normal common sense. But, construction of good and sufficient big storage reservoir is rather costly.

The Government playing a supportive role in providing the capital cost of roof rain water harvesting system the people themselves can manage the maintenance and operation of the water supply system. In roof rain water harvesting system the burden of incurring heavy expenditure for maintenance from the State Revenue can be relieved by the people. In heavy rainfall areas of North East India, Himalayan foot hills and coastal areas roof rain water harvesting system, if properly done, can be the best option for sustainable drinking water supply system.

B. Water supply process description

Roof of buildings are used as catchments for collecting rainfall. On sloping roof rain water flows to the down direction which is collected by making rain gutter of suitable material. Water collected in the gutter is allowed to flow into a reservoir where water is stored. In flat roof building the roof finishing is given a gradient to facilitate rainfall to flow towards the corner from where the water can be collected through pipe which is joined to the reservoir. Roof being impervious there is no water absorption and the entire rainfall can be harvested. Thatch roof is not convenient for rain water harvesting.

At the entry of the reservoir a simple screen or filtering arrangement to prevent undesirable material entering the storage is required to be made. The piping system from the roof to the reservoir is provided with an arrangement to flushed out the first shower of rainfall which is normally dirty.

The water reservoir may be over ground or underground. Every reservoir must be provided with arrangement to drain off water completely for occasional cleaning of the reservoir required for maintenance. It must have a suitable cover to prevent entry of insects and dirt. Under-ground reservoir need water lifting device which may be manual or mechanically operated. Over-ground reservoir is provided with water tap for drawing water. Families with better financial position normally has over head reservoir for connecting the house internal plumbing for use in the kitchen and toilets.

C. Water Supply use detail along with consumer needs

Roof rain water harvesting system is primarily for domestic water supply. As rain passes through the atmosphere traces of impurities are absorbed by rainfall which normally is negligible in rural areas where air pollution is not much. Properly maintained roof catchments and reservoir give water clean enough for normal domestic uses such as cooking, washing and cleaning. However bacterial contamination can take place in the reservoir after long storage. To ensure safety rainwater storage must be given occasional chlorine treatment at an interval of at least once in a month. Water needed for direct consumption like drinking, however, require domestic disinfection like filtration, boiling or solar disinfection (SODIS) to eliminate bacterial contamination in drinking water.

Quantity of water from roof rain water harvesting depends on the size of roof catchments and the annual rainfall. In heavy rainfall areas even a small house can feed enough water for domestic consumption. In the NE India the average rainfall is about 2200 mm per annum; a small house of 15m x 5m can supply water :-

15 x 5 x 2.2 = 165 cum. = 165000 litre/year

For a family of 8 persons, this is –

$$\frac{165000}{365 \times 8} = 56.5 \text{ lpcd}$$

Till recently, the Government of India norms of rural water supply used to be 40 lpcd. [(lpcd) = Litre per capita per day].

Roof rain water harvesting can be used for domestic animals, horticulture and ground water recharge. For such inferior water use ground tank storage can be used. Mosquito breeding is always a nuisance, as such chlorine treatment is necessary at regular interval.

D. <u>Technology description including sanitation</u>

In rooftop rain water harvesting system roof is the catchment from where rainfall is captured. On sloping roof rain gutter fixed on the eave collect the rainfall which is taken through pipe to the water reservoir. On flat Roof the roof surface finishing is given a slight slope to allow rain water to flow in one direction which is taken through piping system to the reservoir. In monsoon areas the roof is normally dirty during the long dry season which makes the first shower dirty which need to be thrown away. The piping system from the roof to the reservoir is made in such a way to facilitate flushing out of the water without entering the reservoir. This can be done by closing the entry valve and opening the flushing valve. When the water is clean the flushing valve is closed and water is led into the reservoir. A system of screening or filtration is build at the entry of reservoir to prevent fallen leaves, birds dropping and other dirty materials.

Design parameters :

Q = AF

Where Q = is the quantity of water harvested

A = area of catchment

F = average annual rainfall

Example :- Size of roof 15m x 5m in a locality having annual rainfall of 2200 mm / Per annum.

Quantity of water :

$$Q = 15 \times 5 \times \frac{2200}{100} = 165 \text{ cum.}$$

That is 165 x 1000 = 1,65,000 litres.

Specification:-

I. Catchment:- Flat roof are normally of reinforce concrete with top water proof finishing. The top finishing is given a slope of 1:72 slope to facilitate rain water collection. Slope roof are either Galvanized Corrugated Iron Sheet or Steel. Rain gutter made from galvanized iron sheet or plastic rain gutter attached on the edge of roof collect rainfall and a piping system joined the gutter with the reservoir.

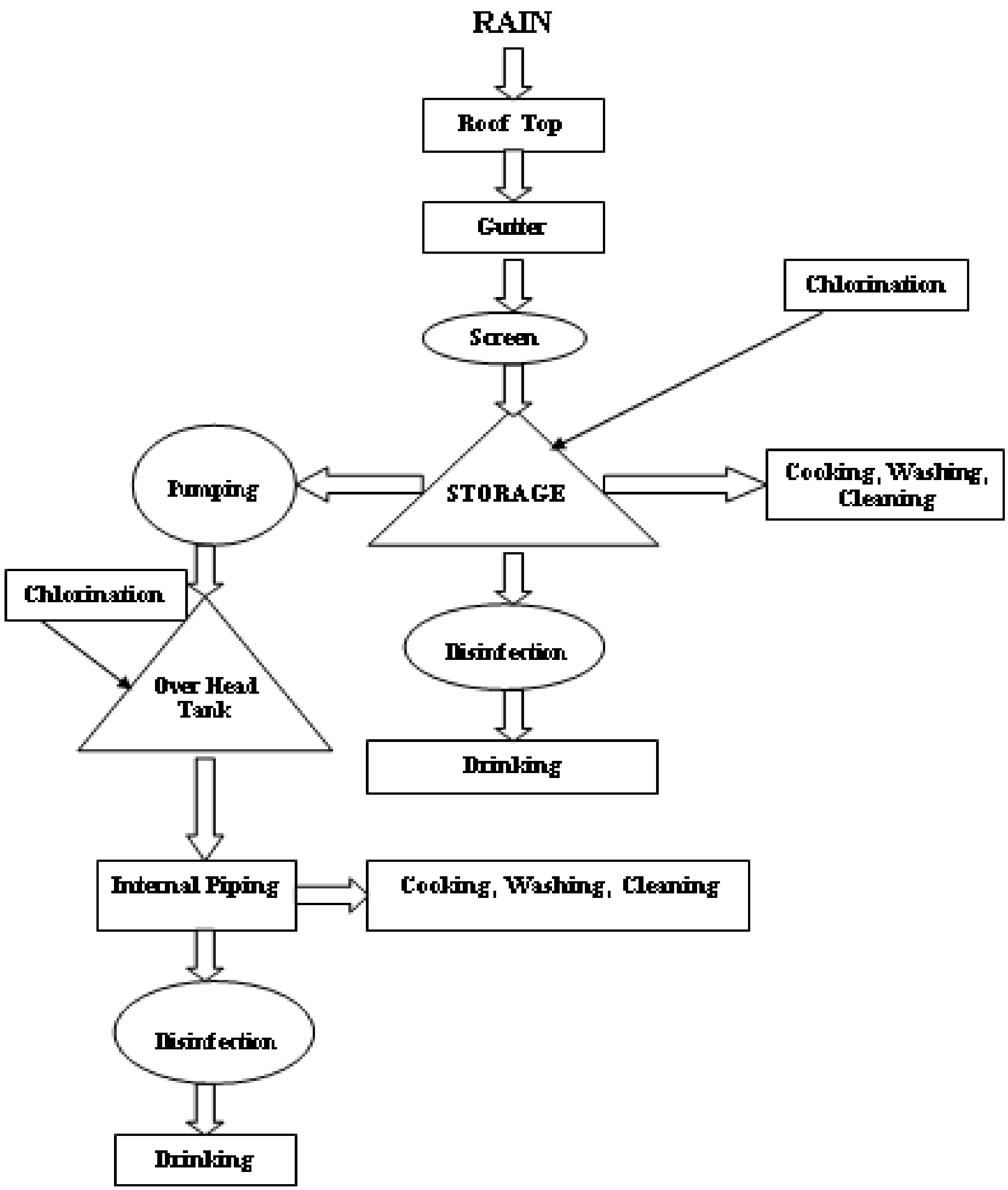
II. Reservoir:- Normally reservoir are made of RCC, Ferro-Cement, Steel or Masonry. Small capacity

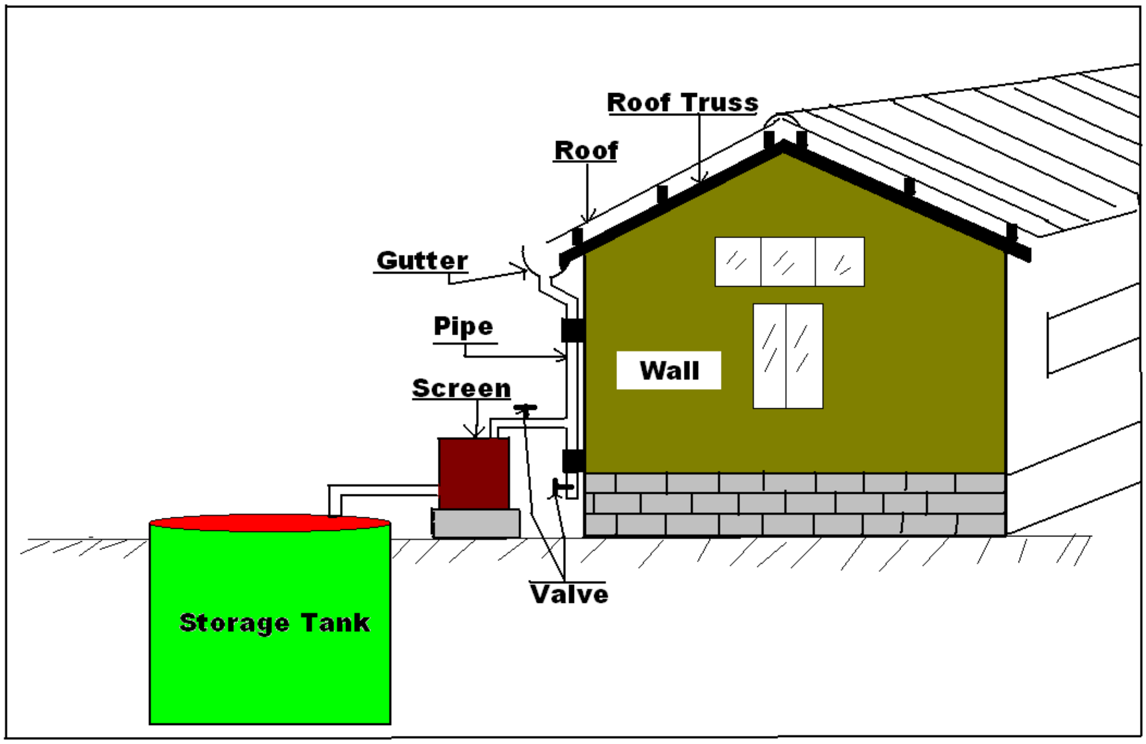
tank may also be of plastic tank. The reservoir must have ventilation and proper cover to prevent entry of insects and mosquito. In high rise building and multi storied building the top floor can be conveniently used as storage of water. This facilitate water supply to the consumer by gravity to the plumping system.

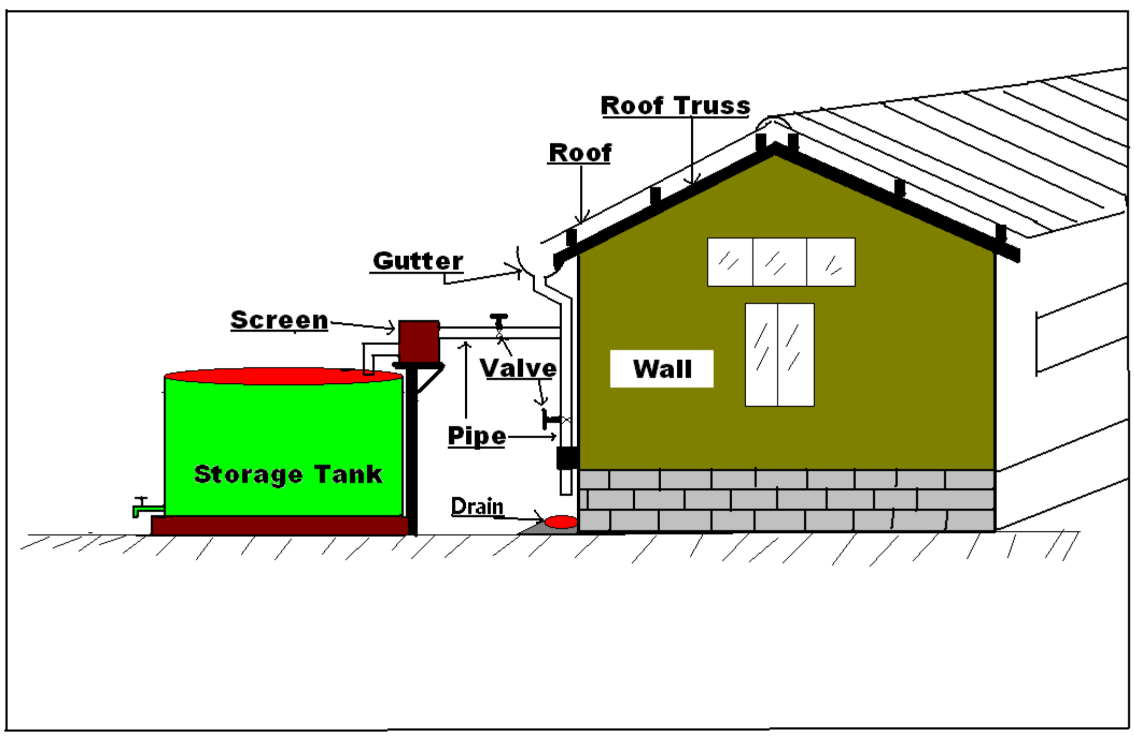
Ground tank need lifting of water to the overhead reservoir by mechanical pumping system. At the bottom of the reservoir a drain pipe is necessary to be provided for occasional emptying and cleaning of tank. Drain pipe and over flow pipe must be connected to proper drainage in the ground for sanitation and prevention of soil erosion.

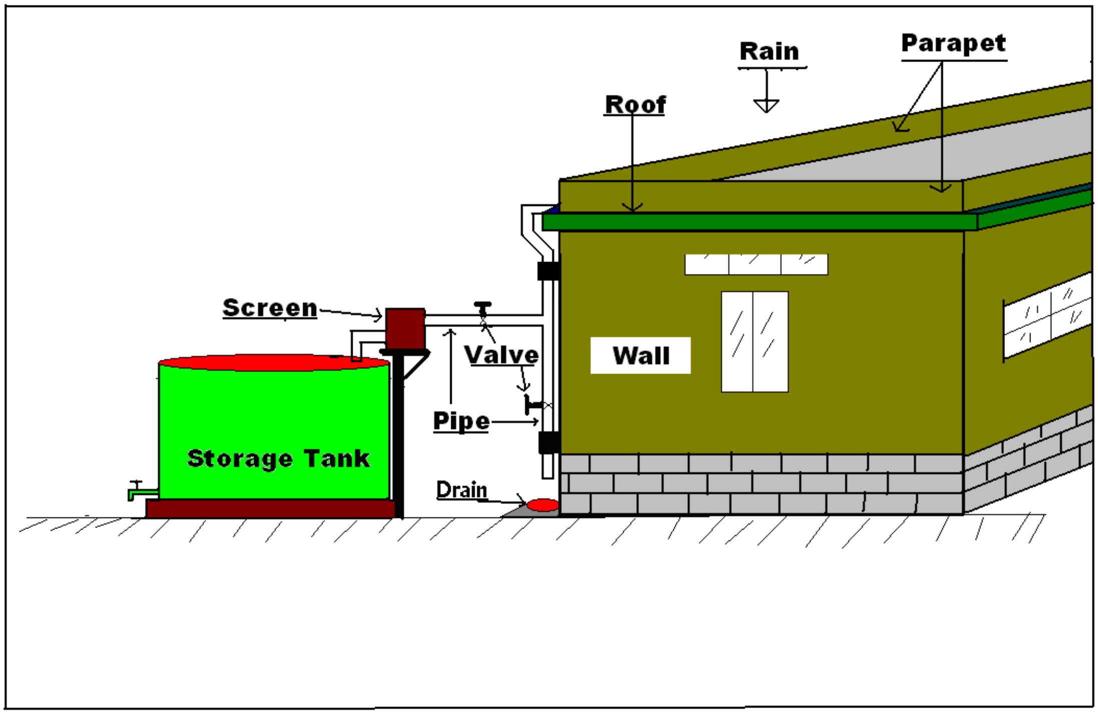
Flow Diagram with symbols

ROOF TOP RAIN WATER HARVESTING SYSTEM




Roof Truss
Roof
Gutter
Pipe
Screen
Wall
Storage Tank
Valve


Roof Truss
Roof
Gutter
Screen
Valve
Wall
Pipe
Storage Tank
Drain



E. Hazard analysis:

Quality of water depends very much on cleanliness of the roof catchment and rain gutter. In built up areas and industrial areas regular cleaning is required. In spite of regular cleaning of roof, there is bound to be dust, birds dropping and leaves on the roof. Flushing out of the first rainfall is very important to flush out rainfall carrying atmospheric pollution and dirt on the roof. Cleaning of the screen and the rain gutter at regular interval during rainy season by the house owner or staff of maintenance must be ensured.

During the dry season the roof, rain gutter, piping system, screen, valves and fitting must be thoroughly inspected. Repair whenever necessary should be done before onset of rain. Inspection of insect nest and cobweb is very vital. Roof must not be used for drying of food grains or cloths. The reservoir is meant for long storage of water and great care is required to prevent entry of any insect or dirt. Even though regular cleaning of the tank is desirable but it is very difficult in practice. Cleaning the bottom of tank need complete emptying which is possible only when the entire water is used up.

Rain water is normally free from chemical impurities but bacteriological contamination can take place. Regular doze of Chlorine/Bleaching Powder may be applied at least once a month. Rain water is normally fit for all types of domestic use. Water for direct consumption that is drinking should however be treated domestically by SODIS or boiling to remove any possible bacterial contamination.

The starting of monsoon always bring cyclonic storm and hail storm. During such occasion unusual damage to the roof, rain gutter, piping system and even reservoir can take place. Fallen trees and branches of trees can disturbed rain water harvesting system. Such emergencies are very prevalent in the monsoon areas. Emergent action to repair the damage by heavy storm is always unavoidable. In such cases extra expenditure and labour is always required. Heavy rainfall and cyclonic storm invariably caused flooding in the plain areas and landslide in hilly areas. Proper drainage system and sanitation of the surrounding areas are very important.

Information capture Formats for hazard events and risk prioritization for roof catchments, water conveyance and household level are given in Table 1, 2 and 3.

(A) HAZARD ANALYSIS: Roof Rain Water Harvesting

Table- 1, Information capture format for hazards events & risk prioritization of Roof catchment and water conveyance.

Activity/ Process Step	Hazardous events and type	Risk prioritization			Existing control measures	Additional control measures propose
		In category of Likely hood	In category of consequence / impact	Risk rating		
Meteorology, weather pattern, fallen leaves & dust	i)Long spell of dry period, inadequate rainfall ii) Leaves or dusts falling on roof iii) Flush out of first rain	Moderate (3) Major (4) Moderate (3)	Major (4) Moderate (3) Moderate (3)	3 x 4 = 12 4 x 3 = 12 3 x 3 = 9	No effective control in existence Regular inspection and cleaning Inspection	Afforestation of surrounding country
Human, Animal, Birds activities on the roof and rain gutter	i) construction activities , human walking on roof ii) Animal and bird dropping	Moderate (3) Moderate (3)	Moderate (3) Moderate (3)	3 x 3 = 9 3 x 3 = 9	Daily Cleaning Daily Cleaning	Nil Nil

Table-2, Information capture format for hazards events & risk prioritization of Rain Water Reservoir and disinfection.

Activity/ Process Step	Hazardous events and type	Risk prioritization			Existing control measures	Additional control measures propose
		In category of Likely hood	In category of consequenc e / impact	Risk rating		
No proper hygienic measure taken during manual cleaning of Reservoir	Probability of getting recontaminatio n - Physical, chemical and microbial	Moderate (3)	Moderate (3)	3 x 3 = 9	No serious effort in tackling problem	Inspection regularly & cleaning at desired frequency taking hygienic steps

Leakage, damage of reservoir and inadequate cover	Possibility of contamination high - Physical, chemical and microbial	Moderate (3)	Moderate (3)	3 x 3 = 9	No effective steps for mitigation of problem. Due to constraints of fund.	Reservoir repair to be attend properly. Problem of fund to be address on priority.
Impurities or contaminants present in chemicals used for disinfection of water	May induce contamination of water. Hazard type: Chemical microbial	Unlikely (3)	Moderate (3)	2 x 3 = 6	Attempt to procure chemical from reliable source test.	Routine checking in laboratory to confirm chemicals and free from contaminants
Improper disinfection, chemicals used not as specified. Contact time not adequate. Disinfection not done regularly	For ensuring water safety without which water may continue to remain or from to risk of hazard. Type: Microbial	Moderate (3)	Moderate (3)	3 x 3 = 9	Time to time supper vision of disinfection activities carried out. Follow up action not proper.	Regular testing of disinfectant to be used, to be carried out. Strict supper-vision should be done to ensure correct dosing and allowing adequate contact time.

Table- 3, Water handling and uses at household level, drainage and sanitation of Roof Rain water harvesting.

Activity/ Process Step	**Hazardous events and type**	**Risk prioritization**			**Existing control**	**Additional control measures propose**
		In category of Likely hood	**In category of consequence / impact**	**Risk rating**		
Water collection, conveying, storage and use at household	Water may become re-contaminated at any point between collection from reservoir, storing, serving, handling, consuming due to incorrect practices. Hazard type: Physical	Likely (4)	Major (4)	4 x 4 = 16	Dissemination of information in every household regarding hygienic practice in collection, handling, storing, serving, etc.	Thrust on effective implementation of Total Sanitation Campaign (TSC) to eliminate source of contamination. Thrust on behavioral change and communication.

	Chemical microbial					
Sanitation and drainage of area surrounding rain water reservoir and house.	Water stagnation and lack of drainage creating insanitary condition. Hazard type: Physical microbial	Likely (4)	Moderate (3)	4 x 3 = 12	Regular inspection and cleaning of drainage system	-Ditto-

F. <u>Operational monitoring:</u>

Normal operation and monitoring of roof rain water harvesting is looked after by the house owner. The house owner, the family members and their staff are required to be trained to be fully aware of the detailed operational maintenance of the various items of roof rain water harvesting system such as regular cleaning of the roof, the rain gutters, the screen, the reservoir cover, the reservoir ventilation, the piping system including the valves and drainage. Opening of the valve to flush out the first rainfall is very important as the first shower of rainfall is dirty and should not be allowed to enter into the reservoir. As soon as the rainwater is clean, water should be let into the reservoir by closing the flush out valve and opening the valve to the reservoir.

The work of regular cleaning as mentioned above must be done invariably during the dry period and after cyclonic storm. To avoid water stagnation the surrounding drains and sanitation must be attended to by the members of the family. Sometimes this may be required to be repeated during the rainy season.

Regular chlorine treatment of the water in the reservoir is urgent, to remove bacterial contamination which may developed during long storage. This may be done by the house owner and their staff. The laboratory staff of the Government or municipality should also have regular inspection to see that chlorine treatment is done properly. In order to ensure proper mixing of chlorine inside the reservoir the water must be properly stirred by mechanical or manual stirring. Water sample should be tested in the State laboratory as often as possible at least at an interval of every quarter.

Control and prevention of vector breeding should be ensured by providing appropriate mosquito proof netting. Cleaning and disinfection of roof catchment, conveyor pipe and reservoirs should be undertaken periodically.

Water for drinking needs proper disinfection. Members of the household and their staff must thoroughly understand the urgency. Disinfections by boiling or by SODIS or by domestic filtration must be done regularly. In addition the State laboratory staff also must check the quality of drinking water to ensure safety. In actual practice there is a tendency of neglecting the duties of quality assurance on the part of water management staff and members of family. A good and efficient system of maintenance and monitoring is very urgent. Information capture format for operational monitoring is given in Table-4.

G. <u>Verification :</u>

The physical maintenance of the roof rain water supply system and quality control is normally done by the household and their employees. The family is primarily responsible for the quality control of water and safety. Capacity building of all the members of the family and their employees is very urgent in safe guarding the water. The operational monitoring schedule mentioned in **F** must be ensured at the family level; which should also be inspected and supervised regularly by the Government functionaries responsible for water supply. Information capture format for verification is given in Table-5.

H. <u>Validation schedule :</u>

Roof rain water harvesting system is subjected to a number of hazards which may affect the water supply system. The hazards which can affect the system need to be attended promptly to ensure safety of the water supply system. Information capture format for validation is given in Table-6.

I. <u>Improvement action plan :</u>

Rooftop rain water harvesting system is one of the best option for sustainable water supply system in heavy rainfall areas particularly in rural areas where atmospheric pollution is less. Awareness and capacity building of everyone, every family, the entire community and the Government is very important. Rain water harvesting can effectively be applied everywhere and can be handled be even ordinary people in their own premises.

After the infrastructures are in place, maintenance and operation can be done by the household without Government assistance. Substantial Government revenue can be saved by the people in maintaining water supply and the community can also be relieved from Government interference.

Reservoir for storing water is costly and it is the most vulnerable item for endangering the water safety. Water reservoir made of plastic and steel sheets are easily damage by cyclonic storm. RCC reservoir proved to be the strongest and best as reservoir which can withstand most of the hazards. But construction of RCC is difficult and costly. It is desirable if RCC reservoir is used for improvement of the roof rain water supply system. Information capture format for Improvement action plan is given in Table-7.

(B) OPERATIONAL MONITORING – Roof Rain Water Harvesting

Table-4, Information capture format for operational monitoring schedule, etc.

Process Step	**Parameter to be monitored**	**Monitoring Process**		**Critical limit**	**Corrective Actions**	
Roof catchment and water conveyance to reservoir	Condition of roof, rain gutter, screen structure and cleanliness for efficient and hygienic functioning	What	Ensuring cleaning and repair of any defects.	No activity on the roof. Damage to structures	What	Preventing undesirable activity
		How	Inspection		How	Educate owner family member.
		When	Periodical and after heavy rain and Cyclone		When	Continuously
		Where	Roof and water conveyance		Who	WSP team and house owner
		Who	Owner family, WSP members.			

Rain water reservoir and disinfection	Water quality: Effectiveness of disinfection: Hygienic environment.	What	Test water quality, Leakage, proper cover of reservoir, quality of disinfectant used.	No hazard indication Chemical used for disinfection to conform specified standard	What	Regular cleaning of CWR maintaining hygienic practices. Possible source of contamination around CWR to be eliminated. Quality of chemicals used for disinfection need to be verified. Dosing of disinfectant in requisite quantity allowing requisite contact time to be ensured.
		How	Laboratory test, water tightness test		How	Strengthening Supper vision and quality control measures Imparting training to the operating staff regarding proper disinfection
		When	Monthly		When	Continuous process
		Where	At reservoir		Who	WSP team member and VWSC functionaries
		Who	Village water committee , WSP team and family			
Water handling and used at household	Hygienic water handling practices of water. Health data of family	What	Practices during collection, transportation and storage of water by user	Water collection, transport and storage to be hygienic Water supply should be capable meeting Health Based Target	What	Changing water related Knowledge, Attitude and Practices (KAP)
		How	Observing the practices of user community		How	Inter-personal behavioral change communication
		When	Regularly		When	Regularly
		Where	At HH & Community		Who	ASHA

(C) VERIFICATION – Roof Rain Water Harvesting

Table-5, Information capture format for verification.

Activity	Description	Frequency	Responsible Party	Records
Effectiveness of WSP process in achieving Health Based Target	Analyze Health Data of Community maintained by NRHM. Water analysis reports	Every three months	WSP team, VWSC and NRHM	Health Data of Community maintained by ASHA (NRHM) Water analysis reports
Adequacy of Sanitary Inspection measures	Review sanitary inspection form, whether have the scope to include all the potential hazard of the roof catchment.	Every six months	WSP team, VWSC	Sanitary inspection format
Accuracy of Laboratory Testing	Results of percentage of sample tested may be verified by testing in Referral Lab.	5% of the sample tested as a part of WSP activity	Jalsurakhak, ASHA	Data of water quality analysis carried out both as routine as well as in referral Lab.
Assessment of Impact of advocacy programme on behavioral change of user's community	Structural Observation of the water related practices of the community.	Random sampling of HH and user community	ASHA / grass root worker of LI Agency, Partner Agency, NGO, etc.	IEC material produce for the purpose
Auditing status of Water Security of the user HH. Checking satisfaction level of the users of the system. Verifying users are not using alternative unsafe source	Situation study, meeting and interacting with community, visit to HH to ascertain ground realities.	On regular basis	Subject expert / ASHA / grass root worker of LI Agency, Partner Agency, NGO, etc.	Evaluation report, etc.

(D) VALIDATION – Roof Rain Water Harvesting

Table-6, Information capture format for validation.

Item validated	Hazardous Events	Validation Schedule	Comments
Roof catchment management process	Chemical and microbial contamination in water	Combine analysis of water quality and sanitary inspection data from verification to assess whether protection measures in roof catchment have been effective and identify gap and validate the management process.	Prevention is always better than corrective actions.
Chlorine residual critical limit values	Non reduction of water borne diseases among the user in-spite of maintaining residual chlorine 0.1 mg/ltr	Co-relating residual chlorine and nature of diseases burden, critical limit of residual chlorine may considered to be increased.	Disinfection is only one defense against disease. Every effort should be made to protect water from contamination.
Advocacy approach adopted for ensuring behavioral change among community towards better hygienic practices in water handling.	Water for drinking and cooking getting re-contaminated during carrying, storing and use at the household level	Critically revisit the advocacy approach, focus more on inter-personal communication using Youth as change agent	Behavioral change is a slow process

(E) ACTION PLAN FOR IMPROVEMENT: Roof Rain Water Harvesting

Table-7, Information capture format for Action Plan for Improvement (Indication)

Issues identification for requirement of Improvement	**Approach to be adopted for carrying out improvement**	**Short term / Long term**	**Time frame for implementation**	**Approx. fund requirement**	**Responsible for improvement**	**Degree of priority**
Mass awareness of Rain as a renewable basic water source and behavioral change of people	Massive campaign at all levels of the society	Long term	No definite time frame		LI and Partner Agency	High Priority
Control of air pollution and improvement of forest managements	Supplement community effort. Facilitate community and industries	Long term	No definite time frame		LI and Partner Agencies and industries	High Priority

Dos and DONTs in maintenance of Roof top rain water harvesting system:

(A) Dos:

i) During dry season have thorough inspection of the roof, rain gutter, piping system, screen, ventilation and cover of reservoir, inside and outside the reservoir, all fittings and attend repair whenever necessary.
ii) Clean the roof surface, gutter, reservoir and all the fittings during the dry season, just before monsoon rain and during the monsoon period and when necessary.

iii) Apply Chlorine / Bleaching Powder to the water in the reservoir periodically, as determined by water testing.

iv) Water for drinking water must be dis-infected to remove bacteria either by boiling or SODIS or domestic filter daily.

v) Drainage and Sanitation around the reservoir and house must be ensured during rainy season.

vi) Keep the flush out valve open during the dry season to remove the first rain.

(B) DONTs:

i) Roof made of thatch and asbestos should not be used for roof rain water supply.

ii) Do not use roof for drying food grains and cloths.

iii) Do not drink water which is not properly infected.

iv) Do not keep the water reservoir without proper cover.

Chapter-9

“WSP – Water Disinfection”

Water Disinfection

1. Introduction:

The disinfection of potable water and wastewater provides a degree of protection from contact with pathogenic organisms including those causing cholera, polio, typhoid, hepatitis and a number of other bacterial, viral and parasitic diseases. Disinfection is a process where a significant percentage of pathogenic organisms are killed or controlled. As an individual pathogenic organism can be difficult to detect in a large volume of water or wastewater, disinfection efficacy is most often measured using "indicator organisms" that coexist in high quantities where pathogens are present. The most common indicator organism used in the evaluation of drinking water is Total Coliform (TC) or Faecal Coliform (FC), unless there is a reason to focus on a specific pathogen.

Disinfection is usually the final stage in the water treatment process in order to limit the effects of organic material, suspended solids and other contaminants. The primary methods used for the disinfection of water in very small (25-500 people) and small (501-3,300 people) treatment systems are ozone, ultraviolet irradiation (UV) and chlorine. There are numerous alternative disinfection processes that have been less widely used in small and very small water treatment systems, including chlorine dioxide, potassium permanganate, chloramines and peroxone (ozone/hydrogen peroxide). In India, the most widely used disinfectant for drinking water is Chlorine or Bleaching Powder. Most rural systems use the same.

2. Water Disinfection Methods

Physical methods

This category is represented by techniques employing such physical principles for disinfection as UV radiation, ultrasound, ultra filtration, reverse osmosis, heating, freezing, and ionizing radiation. Disinfecting small quantities of water by pasteurizing with heat or solar energy is a technology with some potential, but requires further development. The recently developed method for water disinfection by direct exposure to solar radiation may also be used.

Chemical methods

Chemical methods depend mostly on selected chemicals with oxidizing and biocide properties. Their practical applications range from removing undesirable constituents to disinfecting water supplies, wastewater treatment effluent, or industrial waters. The most commonly used chemicals include ozone, chlorine and some of its compounds, potassium permanganate, and hydrogen peroxide.

<u>Chlorination</u>

The use of chlorine and some of its derivatives will continue as an integral part of the disinfection process in water and wastewater treatment. This also applies to developing countries, where this mode of disinfection is fairly well established.

Alternative disinfecting agents such as chlorine dioxide, UV light, and UV light in conjunction with hydrogen peroxide are being considered. However, the formation of mutagens and carcinogens in chlorinated waters and wastewaters can be abolished or minimized by modifying the unit processes. The potential health impacts that are yet to be clearly discerned and the toxicity to aquatic life resulting from discharged *chlorinated effluent do not seem to outweigh the public health benefits derived from chlorination practices.*

Household methods

There are many situations where individuals or families would need to resort to simple and effective methods for drinking-water disinfection. These include the following:

- *Catastrophic conditions leading to displacement (earthquakes, floods, hurricanes, wars, or civil disturbances);*
- *Emergencies arising from flourishing waterborne diseases; and*
- *Resident populations and foreigners at risk in endemic areas with unsafe water supplies.*

Physical methods (boiling or the use of ceramic filters), chemical methods (chlorine compounds in solution or tablet form, e.g., sodium hypochlorite solutions, calcium hypochlorite tablets, organic chlorine compounds, iodine solution, and organic iodine compounds) and others have been recommended for such cases.

None of these methods is entirely free from practical problems that could induce users to revert to untreated water. Fuel wood, for instance, for boiling is no longer a tenable practice, particularly in areas where it is absent or being depleted. Besides, the flat taste of boiled water discourages some consumers. The diverse types of ceramic filters have a wide range of pore sizes and present difficulties in selection. They suffer frequent clogging of the ceramic candles and often leak through disguised fine cracks. Proprietary halogen preparations frequently lead to consumer complaints and rejection because of the undesirable tastes and odors imparted to the water. It is especially so if high doses are applied inadvertently or as required in cases of heavily polluted waters. Relief agencies are often trapped in a dilemma by the requirements for importing and distributing, in addition to shortages, cost acceptability, and expiry dates. These issues encourage attempts to resolve them through the development of practical and effective techniques, simple enough to be applied by individuals or households.

3. Disinfection mechanism

Disinfection commonly takes place because of cell wall corrosion in the cells of microorganisms, or changes in cell permeability, protoplasm or enzyme activity (because of a structural change in enzymes). These disturbances in cell activity cause microorganisms to no longer be able to multiply. This will cause the microorganisms to die out. Oxidizing disinfectants also demolish organic matter in the water, causing a lack of nutrients.

4. Technology Description:

The processes of disinfection for different disinfectants have been tabulated below:

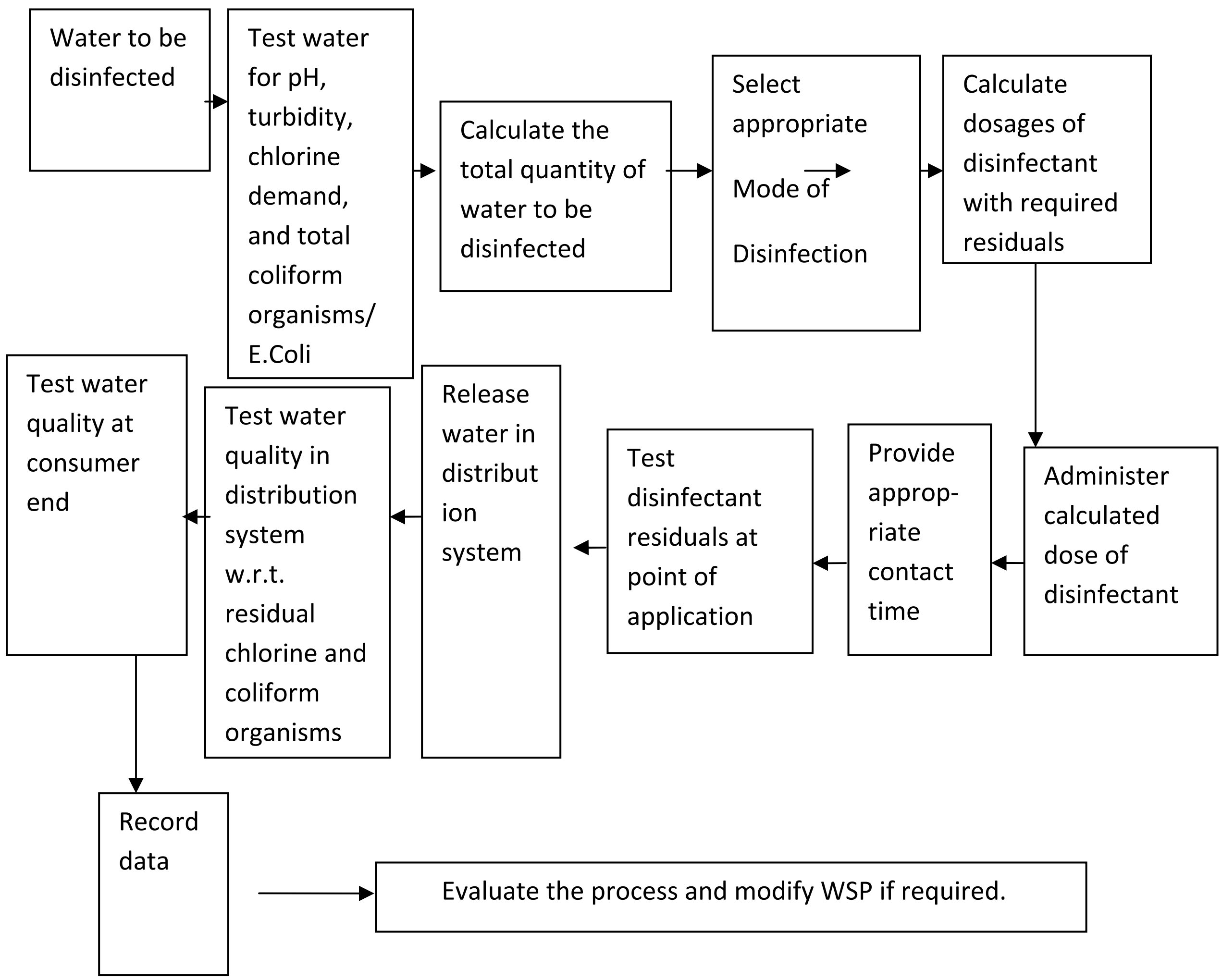
Sl.No	Disinfectant	Basic information	Advantages	Limitations	Process	Equipments
1	Chlorine Gas	At normal pressures, elemental chlorine is a toxic, yellow-green gas, and is liquid at high pressures.	Chlorine is very effective for removing almost all microbial pathogens and is appropriate as both a primary and secondary disinfectant.	Chlorine is a dangerous gas that is lethal at concentrations as low as 0.1 percent air by volume.	Chlorine gas is released from a liquid chlorine cylinder by a pressure reducing and flow control valve operating at a pressure less than atmospheric. The gas is led to an injector in the water supply pipe where highly pressurized water is passed through a venturi orifice creating a vacuum that draws the chlorine into the water stream. Adequate mixing and contact time must be provided after injection to ensure complete disinfection of pathogens. It may be necessary to control the pH of the water.	A basic system consists of a chlorine cylinder, a cylinder-mounted chlorine gas vacuum regulator, a chlorine gas injector, and a contact tank or pipe.

Sl.No	Disinfectant	Basic information	Advantages	Limitations	Process	Equipments
2	Sodium hypochlorite solution	Sodium hypochlorite is available as a solution in concentrations of 5 to 15 percent chlorine, but is more expensive than chlorine gas (as available chlorine).	Sodium hypochlorite is easier to handle than gaseous chlorine or calcium hypochlorite.	Sodium hypochlorite is very corrosive and should be stored with care and kept away from equipment that can be damaged by corrosion. Hypochlorite solutions decompose and should not be stored for more than one month. It must be stored in a cool, dark, dry area.	Sodium hypochlorite solution is diluted with water in a mixing/holding tank. The diluted solution is injected by a chemical pump into the water supply pipe at a controlled rate. Adequate mixing and contact time must be provided.	A basic liquid chlorination system, or hypochlorinator, includes two metering pumps (one serving as a standby), a solution tank, a diffuser (to inject the solution into the water), and tubing.
3	Bleaching Powder (Calcium hypochlorite)	Calcium hypochlorite is a white solid that contains 65 percent available chlorine and dissolves easily in water.	When packaged, calcium hypochlorite is very stable, allowing a year's supply to be bought at one time.	Calcium hypochlorite is a corrosive material with a strong odor that requires proper handling. It must be kept away from organic materials such as wood, cloth, and petroleum products. Reactions between calcium hypochlorite and organic material can generate enough heat to cause a fire or explosion. Calcium hypochlorite readily absorbs moisture, forming chlorine gas. Therefore, shipping containers must be emptied completely or carefully resealed	Calcium hypochlorite may be dissolved in a mixing/holding tank and injected in the same manner as sodium hypochlorite. Alternatively, where the pressure can be lowered to atmospheric, such as at a storage tank, tablets of hypochlorite can be directly dissolved in the free flowing water by a proprietary device that provides flow-proportional chlorination with gravity feed of the tablets.	The equipment used to mix the solution and inject it into the water is the same as that for sodium hypochlorite. Solutions of 1 or 2 percent available chlorine can be delivered by a diaphragm-type, chemical feed/ metering pump or by tablet chlorinator.

Sl.No	Disinfectant	Basic information	Advantages	Limitations	Process	Equipments
4	Chloramines	Chloramines are formed when water containing ammonia is chlorinated or when ammonia is added to water containing chlorine (hypochlorite or hypochlorous acid).	An effective bactericide that produces fewer disinfection by-products, chloramine is generated onsite. Usually, chloramines-forming reactions are 99 percent complete within a few minutes.	Chloramine is a weak disinfectant. It is much less effective against viruses or protozoa than free chlorine. Chloramine is appropriate for use as a secondary disinfectant to prevent bacterial re growth in a distribution system. Nitrogen trichloride appears to be the only detrimental reaction. It may be harmful to humans and imparts a disagreeable taste and odor to the water. The use of the proper amounts of each chemical reactant will avoid its production.	Chlorine (gaseous solution or sodium hypochlorite) is injected into the supply main followed immediately by injection of ammonia (gaseous solution or as ammonium hydroxide). As before, adequate mixing and contact time must be provided. The mix of products produced when water, chlorine, and ammonia are combined depends on the ratio of chlorine to ammonia and the pH of the water. Chlorine-to-ammonia ratios of 5:1 should not be exceeded. If the pH drops below 5, some nitrogen trichloride may be formed.	The generation of chloramines requires the same equipment as chlorination (gaseous or aqueous hypochlorination), plus equipment for adding ammonia (gaseous or aqueous).
5	Ozone	Ozone, an allotrope of oxygen having 3 atoms to each molecule, is a powerful oxidizing and disinfecting agent. It is formed by passing dry air through a system of high voltage Electrodes.	Requiring shorter contact time and dosage than chlorine, ozone is widely used as a primary disinfectant in many parts of the world—but is relatively new to the U.S. Ozone does not directly produce halogenated organic materials unless a bromide ion is present.	Ozone gas is unstable and must be generated onsite. A secondary disinfectant, usually chlorine, is required because ozone does not maintain an adequate residual in water.	The major elements of an ozonation system are: • air preparation or oxygen feed; • electrical power supply; • ozone generation—usually using a corona discharge cell consisting of two electrodes; • ozone contact chamber; and • ozone exhaust gas destruction.	Ozonation equipment includes air preparation equipment; an ozone generator, contactor, destruction unit; and instrumentation and controls.

Sl.No	Disinfectant	Basic information	Advantages	Limitations	Process	Equipments
6	Ultraviolet	Ultraviolet (UV) radiation is generated by a special lamp. When it penetrates the cell wall of an organism, the cell's genetic material is disrupted and the cell is unable to reproduce.	UV radiation effectively destroys bacteria and viruses. As with ozone, a secondary disinfectant must be used to prevent re growth of microorganisms. UV radiation can be attractive primary disinfectant for small systems because: • it is readily available, • it produces no known toxic residuals, • it requires short contact times, and • the equipment is easy to operate and maintain.	UV radiation may not inactivate *Giardia lamblia* or *Cryptosporidium* cysts, and should be used only by groundwater systems not directly influenced by surface water—where there is virtually no risk of protozoan cyst contamination. UV radiation is unsuitable for water with high levels of suspended solids, turbidity, color, or soluble organic matter. These materials can react with or absorb the UV radiation, reducing the disinfection performance.	The effectiveness of UV radiation disinfection depends on the energy dose absorbed by the organism, measured as the product of the lamp's intensity (the rate at which photons are delivered to the target) and the time of exposure. If the energy dosage is not high enough, the organism's genetic material might only be damaged instead of destroyed. To provide a safety factor, the dosage should be higher than needed to meet disinfection requirements.	UV lamps and a reactor. No chemical oxidant required; therefore, microorganisms can be killed without generating by-products of chemical oxidation or halogenation.

Flow chart for water disinfection:



5. Hazard analysis with reference to the water to be disinfected:

- Quality of water: The physical, chemical and bacteriological quality of water is to be ascertained before proceeding to disinfection. For effective chlorination it is necessary that pH should be below 8 as the formation of hypochlorus acid and hypochlorite ion takes place below this pH and both of them are responsible for disinfection. The water should also be turbidity free as turbidity shields micro organisms and they are not killed.

- Storage of water: The reservoir where the water is to be disinfected should not be located in a low lying area. There should be no leakages and the structure should not be in a damaged condition. There should be good sanitary environment around the reservoir.

Control measures: If structure of reservoir is damaged, get it repaired. Maintain sanitary conditions around the reservoir. Review treatment process for pH, turbidity and coliform organisms. Improve process if required. Clean reservoirs at regular interval.

System assessment part 2 – Disinfection:

As discussed earlier, chlorination is the only method of disinfection which is being practiced at most of water supply schemes in India. For preparation of a plan for chlorination, following information is required:

Quantity of water to be disinfected: The total volume of water in a reservoir is first calculated by multiplying length, breadth and height of water in meters for a rectangular storage tank and by formula 3.14×r2×h, where r is the radius of the cylindrical structured reservoir and h is the height of water.

If there is regular inflow of water in the reservoir, it should also be considered while calculating the doses of disinfectants.

Chlorine demand of water: Find out total chlorine demand of the un chlorinated water in the laboratory by applying varying doses of chlorine to a known volume of raw water. After a contact period of 30 minutes, determine the residual chlorine in each of the test samples and plot a graph between the dose of chlorine applied and the residual chlorine observed after a contact period of 30 minutes. It is also known as break point chlorination. The amount of chlorine added beyond this demand will be the residual chlorine.

Mode of chlorination: Identify the most suitable mode of chlorination for the water supply scheme. The chlorination could be done by chlorine gas, sodium hypochlorite solution or bleaching powder. Chlorine gas which is available in one ton and 50 kg cylinders is suitable for large and medium type water supply schemes. Electro chlorinators could also be used for on site preparation of hypochlorite solution by electrolysis of sodium chloride solution. Also identify the dosing system for chlorination of water in a reservoir or on line chlorination where a pressure pump will be required to inject the disinfectant in the charged pipe line.

Hazard analysis with reference to chlorination: The risk assessment with reference to chlorination involves following parameters:

- Quality of the disinfectant. The chemicals used for chlorination of water supply should follow the minimum quality requirements as mentioned by the Bureau of Indian Standards for chlorine gas, sodium hypochlorite and bleaching powder. Also find out the % available chlorine and stability in the sodium hypochlorite solution and bleaching powder.
- Storage of chemicals: The chemicals used for chlorination should be stored in a dry, well ventilated and spacious place. These chemicals should not be placed with other chemicals used in water treatment especially ferric alum.

- The dosing equipments such as chlorinators for chlorine gas and dosing plants for hypochlorite solution and bleaching powder should be in working order. Faulty or non operational equipments may result in serious hazards.

Corrective measures:

- Conduct regular inspections of the chemicals used for chlorination to ensure quality.
- Provide proper storage of these chemicals.
- Chlorination units should be equipped with all necessary safety measures such as neutralization tank with lime for the leaking chlorine cylinder, masks, gloves, first aid box, etc.
- Monitor the doses of chemicals at regular interval to ensure that correct doses are being administered.
- Ensure that the dosing nozzles are not choked particularly with bleaching powder dosing unit.

Information format for Hazard events and risks associated during water disinfection process

Process/ Activity	Hazardous events	Risks associated	Corrective measures	Additional control measures
To ascertain the quality of water to be disinfected	May not confirm to the minimum water quality requirement with respect to pH, turbidity and organic matter.	Water will not be disinfected affectively as turbidity may shield bacteria. Large dosages of disinfectant will be required.	Review water treatment process and ensure that the pH of the treated water is less than 8 and it is turbidity free.	Periodic testing of water quality with respect to temperature, pH, turbidity and total coliform organisms/ E.Coli.
Storage of water (Reservoir)	1. Damaged Structure. - Leakages in walls 2. Wrong site selection: -Low lying area -Unsanitary environment around reservoir	Intrusion of contamination from external sources may result in deterioration of water quality thus affecting disinfection process.	1. Repair damaged structures. 2. Create sanitary conditions around reservoir by filling of low lying area and cleaning the surroundings. 3. Periodic cleaning of reservoir at regular interval	1. Regular maintenance of the structure. 2. Protect the area by constructing boundary wall or wire fencing to restrict unwanted entry. 3. Involve community in maintaining sanitary conditions around the reservoirs by generating awareness among them on importance of water quality, sanitation and hygiene. 4. Periodic testing of water.
Disinfectant Quality	Poor quality of disinfectant: -Low % of available chlorine -Low stability - Presence of impurities	- Disinfection capacity is reduced resulting in large quantity requirement and unnecessary increase in cost. - Unwanted impurities may result in deterioration of water quality.	- Inspect the material before procurement. It should confirm to the minimum requirement (BIS Standards)	Periodic testing of disinfectant for available chlorine %, stability and impurities.

Process/ Activity	Hazardous events	Risks associated	Corrective measures	Additional control measures
Storage of disinfectants	-Liquid chlorine storage. -Bleaching powder and sodium hypochlorite storage. -Storage of sufficient quantity of disinfectants.	- Leakage in liquid chlorine cylinder may cause health risks to the surrounding community. -Improper storage of bleaching powder may result in fire in the store. - Insufficient quantity of disinfectant will hamper disinfection process.	- Large capacity chlorine gas cylinders should not be installed in thickly populated areas. - A lime neutralization tank should be available near liquid chlorine cylinder. - Gas cylinder should be installed at a place with direct emergency access to outside air and fitted with an exhaust fan ventilation system. - All safety regulations must be observed. Self contained breathing apparatus and a chlorine repair kit should be available whining a reasonable time frame and/ or distance. - Bleaching powder should be stored at a dry well ventilated room in stakes at sufficient distance apart and sufficient from ceiling for free movement of air. - Bleaching powder and other disinfectants should not be stored along with other chemicals particularly alum.	Periodic inspection of stores by WSP team.

* In the above table, the hazardous event and risk associated with the same, has been described in a subjective manner, however, it is preferable that the WSP team should quantify and prioritize the risk as shown in Chapter-3.

6. **Operational Monitoring:**

1. Ensure that correct doses of chemicals are being administered.
2. Ensure that proper contact period (30 minutes) has been provided before supplying the water.
3. Ensure that sufficient quantity of chemicals is available in the store.
4. Check % available chlorine in sodium hypochlorite solution and in bleaching powder.
5. Examine water samples at regular interval for residual chlorine at source of supply and at different points of distribution system.
6. Ensure dose of chlorine at source such that at least 0.2 mg/L of residual chlorine is present at tail end in ordinary days and 0.5 mg/L during epidemics.
7. Examine water samples for total coli form organisms and E.Coli frequently to ensure bacteriological safe water supply.

Information capture format for Operational Monitoring

Process/ Activity	Monitoring parameter	Monitoring process	Corrective steps
Water to be disinfected	Water quality: - pH, turbidity, temperature, total coliform organisms,/ E.Coli	- Daily water testing for these parameters at treatment plant laboratory.	Communicate the results to treatment plant in charge for necessary measures to improve treated water quality.
Storage of water (Reservoir)	External contamination	-Sanitary survey - Regular maintenance of structure	- Maintain sanitary and hygienic conditions around treatment plants. -Involve community. - Immediate repairs of leakages/ damages.
Material Inspection	Quality of the disinfectant	Test for % available disinfectant, stability and other impurities	Replace the material if does not confirm to specifications.
Disinfectant dosages	Conduct chlorine demand test	Administer dose of disinfectant so as to maintain a residual of chlorine 0.2 mg/L at tail end at normal times and 0.5 mg/L during epidemics. -Ensure a contact period of at least 30 minutes before supply.	- Increase disinfectant dose if required. - Conduct test for residual chlorine at identified points in distribution system. - Repair/ remove leakages in distribution system.
Water quality at house hold level	Check residual chlorine at consumer end.	Collect samples for total coliform organisms and residual chlorine checking from distribution system and consumer house holds. No. of samples and frequency should be as per BIS drinking water standards; 10500.	Increase dose of disinfectant if required. Conduct sanitary survey. Repair leakages / damages in pipeline network.

Management and Communication:

1. Ensure that corrective actions are implemented without any delay.
2. Consumer complaints are attended immediately.
3. Review the processes of chlorination from time to time.
4. Modify the safety plan if so required.
5. Maintain proper records such as log books for the quantity of water chlorinated, amount of chemicals used, residual chlorine data at regular interval, bacteriological examination reports, raw water quality reports and the chlorine demand, etc.
6. Review cases of water borne diseases in the community.

7. Validation and verification:

1. Prepare plan for a detailed inspection right from process to the consumer end.
2. Conduct sanitary and water borne disease cases survey to assess the disinfection process.
3. Document all the related data for future planning and verification.

Verification Schedule
Establishing procedure to verify that the water safety plan for disinfection is working effectively and meeting the desired health-based targets is a vital requirement for WSP approach. Such verification broadly involves two activities that are undertaken together to provide a body of evidence that the WSP is working effectively and will meet the desired objective.

- Water quality monitoring; and
- Auditing of operational activities.

Verification should also include checking that consumers are satisfied with the quality of water supplied. It is important that consumers are using the safe, managed water supply rather than less safe alternatives.

Information capture format for verification

Activity	Description	Frequency	Agency Responsible	Records
Effectiveness of WSP process in achieving health based target	-Analysis of health data of community maintained by NRHM. -Review Water analysis reports for chemical and bacteriological examinations	Every three months	WSP team, VWSC and NRHM	-Health data of community served maintained by ASHA (NRHM) -Water analysis data maintained by NRHM, block and district water testing laboratories.
Adequacy of Sanitary Inspection Measures	-Review Sanitary inspection form (Does it include all the potential hazards of the catchment area).	Every six months	WSP team, VWSC	Sanitary Inspection format
Accuracy of Laboratory Testing of water samples	Results of percentage of sample tested may be verified by testing in Referral Lab.	5% of the sample tested as a part of WSP activity	Jalsurakshak under NRDWQM&SP, ASHA	Data of Water Quality Analysis carried out both as routine at block and district level laboratories as well as in Referral Lab.
Assessment of Impact of advocacy programme on behavioural change of user's community	Structural Observation of the water related practices of the community	Random sampling of households and user community	ASHA /grass root worker, Partner Agency, NGO etc.	IEC material produced for the purpose
Auditing status of the Water Security of the user HH. Checking satisfaction level of the user of the system and also verifying that users are not consuming alternative unsafe source rejecting the system.	Situation study, meeting and interacting with community, Visit to HH to ascertain ground realities.	On regular basis	Subject Expert/ ASHA /grass root worker, Partner Agency, NGO etc.	Evaluation Report

Validation Schedule to ascertain system capability:

Validation involves obtaining evidence that the activities taken up supporting the WSP is correct and that the operation of the water supply in accordance with the WSP will be able to achieve the desired health-based targets. Validation normally includes more exclusive and intensive monitoring than routine operational monitoring.

Information capture format for validation

Item Validated	Hazardous Events	Validation Schedule	Comments
Source Centred Catchment Area Management process	Microbial Contamination getting detected in water –source	Combined analysis of water quality and sanitary inspection data from verification to assess whether protection measures in catchment have been effective and identify the gap and validate the management process	It may often be more efficient to invest in preventive processes within the catchment than to invest in major treatment infrastructure to manage a hazard.
Chlorine residual critical limit values	Non reduction of water –borne diseases burden among the user in spite of maintaining residual chlorine 0.2mg/L	Co-relating residual chlorine and nature of diseases burden, critical limit of residual chlorine may considered to be increased	Disinfection is only one defence against disease. Every effort should be made to protect water sources from contamination
Advocacy approach adopted for ensuring behavioural change among community towards better hygienic practices in water handling	Water for drinking and cooking getting re-contaminated during carrying , storing and use at the house-hold level	Critically revisit the advocacy approach, focus more on inter-personal communication using youth as change agent	Behavioural change is a slow process.

7. Action Plan for Improvement

When the assessment of the drinking-water system indicate that existing practices and technologies of disinfection system are not adequate to ensure drinking-water safety, as a part of full planning and implementation of WSP plan, an action plan to incorporate corrective measures for addressing the in-adequacy need to be developed which may include both short-term and long-term programmes.

Realistic assessment of fund requirement for implementation of improvement plans and careful prioritization of issues in accordance with the outcomes of risk assessment also need to be done. Implementation of plans should be monitored to confirm that improvements have been made according to action plan and are effective.

Information capture format for Action Plan for Improvement

Issues identified for improvement	Approach to be adopted for carrying out improvement		Time frame for implementation	Responsible for improvement	
Control and management of the source and its surroundings	Supplement community effort facilitate community governance	Long term	No definite time frame	VWSC WSP team, PHED	High Priority
Protecting source from flooding and external contamination	Providing drainage and barrier channel for diversion of flood	Short term	SiX Months	Community, PRI, WSP team, VWSC	Priority Medium
Treatment Process unable to remove turbidity to desire extent	Renovate the treatment plant for improving turbidity removal efficiency		Nine months	VWSC / WSP team / PHED	Priority Medium
Disinfectant dosing equipments damaged	Replacing damage units / parts, etc.	Short term	Three months	VWSC / PHED	High Priority
Inadequate laboratory testing facilities	Supplement equipments, chemicals and conduct refresher courses for training to staff.	Long term	Every year	PHED	High priority

Guidelines for Water Safety Plan in the rural areas

Chapter-10

"Water safety plan for arsenic removal plants"

Water safety plan for arsenic removal plants

1. INTRODUCTION

Naturally occurring inorganic may cause in some places problem in ground water. If inorganic is toxic and present beyond permissible limit in water then these may cause severe sufferings on the health of the consumers. Inorganic arsenic can occur in the environment in several forms but in natural waters, and thus in drinking water, it is mostly found as trivalent arsenite [As (III)] or pentavalent arsenate [As (V)]. Inorganic arsenic is a documented carcinogen (WHO 1993). The symptoms of chronic arsenic poisoning include various types of dermatological lesions, skin pigmentation, muscular weakness, liver disorder, paralysis of lower limbs etc. Long term exposure to arsenic via drinking water could cause cancer of the skin, lungs, urinary bladder, and kidney.

Arsenic can be removed from ground water by employing different methods. Arsenic removal units (ARU) could be hand pump attached or these could be attached with power pump fitted borewells. Domestic arsenic removal units could also serve as POU treatment in the house.

Selection of appropriate technology for arsenic removal need to be done through meticulous assessment of the technology & operational process, characteristics and availability of the media, regeneration or replacement of media after exhaustion, sludge disposal problems and other risks associated with the operational & monitoring of the plant. Sustainability of the ARU need to be judged through field performance of the unit and acceptability of the user-community. In case of domestic filters or those attached to spot sources for arsenic removal, attention need to be paid on the capacity building and institutional development for extending support services to the community so that user-groups could get benefit from the use of the household or community arsenic removal units.

The water safety plan for Arsenic Removal Unit would be useful not only for the agency or operational group but also for the beneficiaries or consumers. The WSP document would be useful for the team who would be formed at Gram Panchayat (GP), Block level to oversee the functioning of hand pump attached arsenic removal units. The document would also be useful to the agencies who would be operating the centralized arsenic removal units attached with power pump fitted deep bore wells and treated water distributed through piped network to the consumers. The document would also be useful for appropriate use of domestic units for arsenic removal. WSP procedures described in this chapter should be read in conjunction with chapter 5 (Bore well) and chapter 13 (Pump and Tank system).

2. WATER SUPPLY PROCESS DESCRIPTION

In arsenic affected areas, there could be risk of presence of arsenic water in the following type of water supply:

a) Water supply through hand-pump attached borewells (spot sources).
b) Piped water supply from power-pump fitted deep borewells.

In the above context, arsenic removal units (ARU) are installed for supplying arsenic-safe water. The villagers could get arsenic safe water from ARU as per following systems:

i. Pumping of arsenic contaminated ground water, removal of arsenic through installed ARU and delivering the arsenic-safe water by piped water supply system.

   Following are the salient characteristics of Arsenic Safe Water Supply.

a) The deep bore-well water is contaminated with arsenic
b) The ARU aims to function as per design and remove arsenic to conform to the maximum desirable limit of BIS.
c) The pumping rate of power-pump is normally between 20000 and 45000 lits/hr.
d) ARU may function under the principle of co-precipitation adsorption, ion-exchange, membrane filtration etc. The ARU is cleaned through backwashing or down washing but the arsenic contaminated water is stored for separation of arsenic rich iron particles to avoid environmental pollution. Media regeneration / replacement is done when required.
e) The treated water is supplied to the consumer through pipelines. Disinfection by chlorination is done to take care post contamination in the pipeline. The residual chlorine of maximum 0.2 mg/l is maintained at the consumer point.
f) The ARU is operated either departmentally (PHED) or by engaging private agencies.
g) Water quality is monitored regularly for raw water, treated water and supply water at consumer taps.

ii. Pumping of arsenic contaminated ground water and removing arsenic through hand pump attached ARU. Following are the salient characteristics of the water supply system using ARU fitted with hand-pump attached borewells.

a) The borewell water is contaminated with arsenic.
b) The ARU aims to function as per design and remove arsenic to conform to the maximum desirable limit of BIS.
c) The pumping rate of hand-pump is normally between 12 lit/min and 16 lits/min.
d) The ARU may produce arsenic safe water between 500 lits/hr and 800 lits/hr.
e) The ARU is cleaned or backwashed media when required or replaced.
f) In case of arsenic removal by co-precipitation, the sludge is stored in small reservoirs to avoid environmental pollution.
g) Normally user-groups operate and maintain the ARU. The user-groups are properly trained for operation and maintenance.
h) Consumers may contribute money for maintenance of ARU,
i) Water quality is monitored at certain interval.

iii. Removal of arsenic by using household ARU. The following are the characteristics of the water supply system using ARU at consumer point.

a) The water purification capacity of ARU may vary between 5 lits/hr and 10 lits/hr.
b) Users are trained for operation and maintenance of ARU.
c) Supporting capacity is generated at Block level for media regeneration and replacement for ARU, availability of chemicals, candle replacement etc.
d) Regular water quality testing is carried out to ascertain drinking water quality at consumer end.
e) Awareness, sensitization and motivation campaign is organized in the arsenic affected areas to popularize the use of domestic ARU.

4. WATER SUPPLY USE DETAILS ALONG WITH CONSUMER NEEDS

The water supply system must ensure drinking water security for all the communities. Basic minimum need at household level for drinking and cooking and other similar needs are to be met. Water supply for drinking and cooking should maintain high quality as per the prescribed drinking water standard framed by BIS. Health based target setting approach is to be undertaken to address total exposure of an individual to pollute and moves from reliance on end product testing of water quality to risk assessment and risk management of water supplies.

Normally arsenic safe water must fulfill the consumer demand for drinking and cooking. This requirement has been estimated between 8 and 10 litres per capita per day. The water supply must be according to demand and satisfaction of the consumers. The security and safety of water from arsenic removal units are to be ensured to all consumers. It is necessary to address capacity building for rendering support to the consumers for ARU-media management.

5. TECHNOLOGY DESCRIPTION

Arsenic can be removed from ground water by the application of following methodologies :

- Co-precipitation
- Adsorption
- Ion-Exchange
- Reverse Osmosis

Arsenic occurs in aquatic environment in tri-valent (Arsenite) or pentavalent (Arsenate) form and these forms are considered to be most important in selecting removal methodology. It has been reported that arsenite is more likely to be found in anaerobic ground water compared to arsenate. In India both the species of arsenic are found in ground water.

Water treatment with coagulants such as aluminium alum ($Al_2(SO_4)_3.18H_2O$), Ferric chloride ($FeCl_3$) and Ferric sulphate ($Fe_2(SO_4)_3. 7H_2O$) are effective in removing arsenic from water. Ferric salts have been found to be more effective over a wider range of pH. In both the methods arsenite need to be oxidized to arsenate by application of oxidants, because pentavalent arsenic can be more effectively removed than trivalent arsenic in co-precipitation process. In co-precipitation process chlorine solution (bleaching powder / sodium hypochlorite / calcium hypochlorite) is added followed by the addition of ferric alum or ferric chloride or ferric sulphate. Both rapid and slow mixing are necessary for coagulation and flocculation. The pH is maintained between 7.0 and 8.0. During the flocculation process all kinds of micro-particles and negatively charged ions are attached to the flocs by electrostatic attachment. Arsenic is also adsorbed onto coagulated flocs. The floc particles are allowed to get completely settled. The supernatant is then filtered to get arsenic-safe drinking water.

Several sorptive media have been reported to remove arsenic from water. These are activated alumina, activated carbon, iron and manganese coated sand, kaolinite clay, hydrated ferric oxide, activated bauxite, titanium oxide, silicon oxide and many natural and synthetic media. The efficiency of sorptive media depend on the use of oxidizing agent to aid to sorption of arsenic. Activated alumina, Al_2O_3 having good sorptive surface is an effective medium for arsenic removal. Packed column of activated alumina is manufactured in ARU. Regeneration of saturated alumina is carried out by using 4% caustic soda and 2% sulphuric acid. The activated alumina needs replacement after 4 regenerations.

Granular ferric hydroxide is used in ARU. The unit requires iron removal as pre-treatment to avoid clogging of filter bed. Many sorptive media are used for removal of arsenic under different commercial names which are patented in several countries. Sometimes the constituents of sorptive media (patented) are not disclosed by the manufacturers of ARU. So, availability of those sorptive media is restricted which being used in ARU and there could be risk of running the ARU if such potential sorptive media is not available from the media manufacturers.

In ion-exchange process, synthetic resins are used with well defined ion-exchange capacity. The process is normally used for removal of specific undesirable cation or anion from water. As the resin becomes exhausted it needs to be regenerated. The arsenic removal capacity is dependent on sulphate and nitrate contents of raw water as sulphate and nitrate are exchanged before arsenic. The ion-exchange process is les dependent on pH of water. The efficiency of ion-exchange process is radically improved by pre-oxidation of arsenite to arsenate.

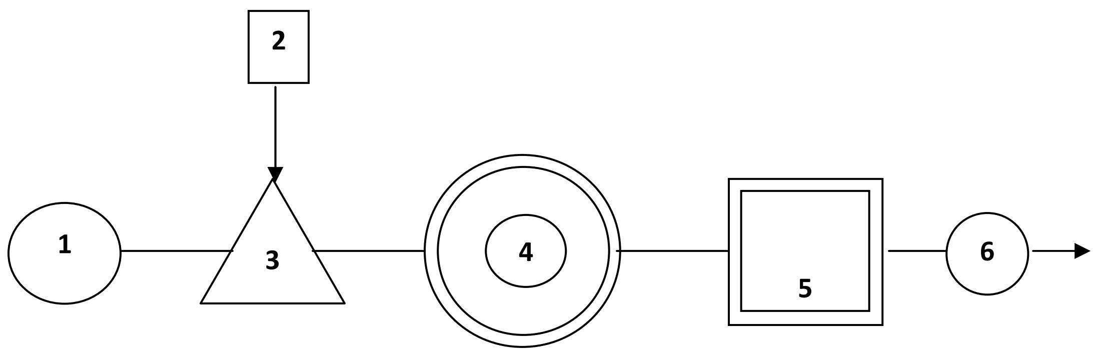
Membrane techniques like reverse osmosis, nano-filtration and electro- dialysis are capable of removing all kinds dissolved solids including arsenic from water.

6. FLOW DIAGRAM WITH SYMBOLS

The flow diagram of different components of various technologies are furnished below

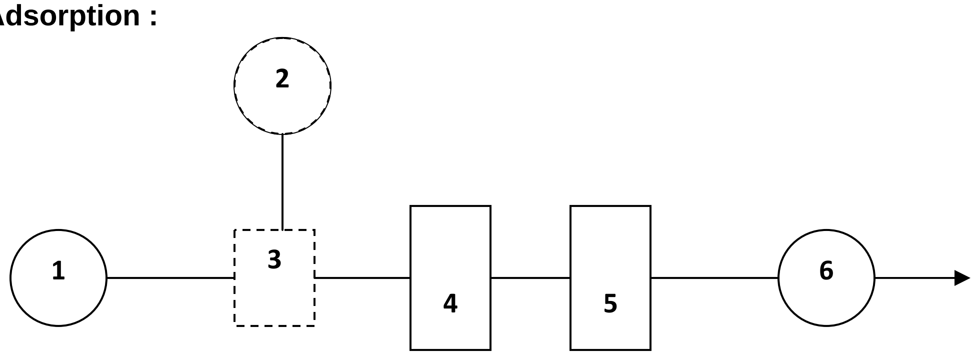
A. Co-precipitation :

Piped water supply from ARU fitted with power-pump attached deep bore well.



1. Arsenic contaminated ground water
2. Chemical tank
3. Flash mixer / Baffled chamber
4. Clariflocculator (Mechanized / Non-mechanized)
5. Filter (Upflow / Downflow)
6. Arsenic-safe water reservoir.

B. Adsorption :



1. Arsenic contaminated ground water
2. Chemical tank (optional) / Aeration (optional)
3. Mixing Unit (optional)
4. Iron elimination filter
5. Arsenic adsorption column
6. Arsenic-safe water reservoir.

7. HAZARDOUS ANALYSIS AND RISK PRIORITIZATION

It is the most important activity of WSP process. Steps expected to be worked through are:

- Identify the hazardous events that can result in risk to Arsenic removal / treatment system.
- Identify the control measures currently in place.
- Suggest any additional control measures.

Typical Challenges:

- Since a risk assessment provides a 'point in time' picture of the system, the risk assessment should be reviewed on a regular basis in order not to ignore new hazards and hazardous events.
- Uncertainty in assessment of risks due to unavailability of data, poor knowledge of activities within the water supply chain and their relative contribution to the risk generated by the hazard or hazardous event.
- Properly defining likelihood and consequence with sufficient detail to avoid subjective assessments and to enable consistency.
- Risk mitigation practices may be (a) pro-active, (b) Reactive, (c) Emergency or Combination of two or more.
- Need of development of emergency response plan.

In arsenic removal plant / unit based water supply system a number of hazardous events may occur. It is essential to decide whether any of these events causes significant risk and need for preventive action.

Various methods are available for risk prioritization. A example of semi-quantitative risk prioritization approach for ARU based water supply water supply is presented. The best way of carrying this act is to draw up a simple table and systematically record all potential hazardous events and associated type of hazards.

To avoid being too subjective it will be of appropriate to provide indicative rating as shown in Table – I to both likelihood of occurrence and impact in advance.

Table – I: Indicative rating of 'Likelihood' and 'Severity' for Risk Prioritization

Level	Description	Rating (indicative) in numerical terms
Likelihood of occurrence category		
A	Almost certain	5
B	Likely	4
C	Moderate	3
D	Unlikely	2
E	Rare	1
'Severity' Category		
A	Insignificant	No detectable impact (1)
B	Minor	Aesthetic impact causing dissatisfaction (2)
C	Moderate	Major aesthetic impact (3)
D	Major	Morbidity expected from consuming water (4)
E	Catastrophic	Mortality expected from consuming water (5)

For each event, 'Risk Rating' is calculated by multiplying 'Indicative Rating of Likelihood' by 'Severity' as shown in Table – 1.

In Table – 2, Information Capture format for hazard events and risk prioritization (semi-quantitative method) has been highlighted.

Table – 2. Information Capture format for hazard events and risk prioritization of Arsenic Removal Unit (semi quantitative method)

Activity / Process Step	Hazardous events and type	Risk Prioritization (semi quantitative method)			Existing Control Measures	Additional Control measures proposed
		In category of Likeli-hood	In Category of Consequ-ence / Impact	Risk Rating		
Sludge formation during arsenic removal process	Contamination of surface water, soil and also health hazards	Likely (4)	Major (4)	4 x 4 = 16	Storage in U/G chamber	Proper sludge collection, storage, treatment and disposal.
Backwashing of ARU to remove clogging	Contamination of surface water bodies, soil and also deleterious effect on public health	Like (4)	Major (4)	4 x 4 = 16	Flow through drain and storage in ditch	Controlled collection and storage. Solids separation, treatment and disposal.
Media adsorption capacity exhausted during operation	Risk of drinking arsenic contaminated water	Almost certain (5)	Major (4)	5 x 4 = 20	Water quality testing. Regeneration of media, if feasible; otherwise replacement.	Regular water quality monitoring. Capacity building for media regeneration. Media replacement when required.
Decline in performance of ARU	Risk of drinking arsenic contaminated water	Like (4)	Major (4)	4 x 4 = 16	No effective control	Assessment of performance through quality monitoring.
Arsenic removal unit and functioning	Fluctuation in water quality with increase in arsenic contamination	Unlikely (2)	Major (4)	2 x 4 = 8	Nothing specific	Water quality testing. Adjustment in chemical addition or media management
	Inappropriate or insufficient	Unlikely (2)	Minor (2)	2 x 2 = 4	Nothing specific	Water quality testing.

Activity / Process Step	Hazardous events and type	Risk Prioritization (semi quantitative method)			Existing Control Measures	Additional Control measures proposed
		In category of Likeli-hood	In Category of Consequ-ence / Impact	Risk Rating		
	treatment process					Modification in treatment process for upgradation.
	Sub-standard quality of sorptive and exchange media or lesser quantum of media used. Quicker exhaustion of sorption and exchange capacity media.	Moderate (3)	Moderate (3)	3 x 3 = 9	No effective step to mitigate the problem	Quality control during manufacturing of ARU. Replacement of media. Water quality monitoring.
	Process control failure, Power failure	Moderate (3)	Moderate (3)	3 x 3 = 9	Nothing specific	Introduction of sensor system. Alternative power source. Operational monitoring.
	Substandard quality of chemical for Co-precipitation process	Moderate (3)	Major (4)	3 x 4 = 12	Nothing specific	Quality control. Testing of chemical. Proper specification for procurement.

8. OPERATIONAL MONITORING SCHEDULES

In WSP process operational monitoring is the act of conducting a planned sequence of observations or measurements, to assess whether the control measures applied at a point in the system are achieving their objectives. Effective monitoring relies on establishing:

- What will be monitored?
- How it will be monitored?
- When it will be monitored?
- Where it will be monitored?

- Who will do the monitoring?

For some control measures, it may be necessary also to define ‘Critical limits’ beyond which confidence in water safety would be lost. Deviation from these critical limits usually require corrective actions. Corrective actions should be specific wherever possible, including assigning responsibilities for carrying out the corrective actions.

‘Monitoring’ may also comprise verification and validation which are dealt separately. In Table – 3, a suggestive format for capturing operational monitoring schedule etc. is presented.

Table – 3, Information Capture format for Operational Monitoring Schedule etc.

Process Step	Parameter to be Monitored	Monitoring Process		Critical Limit	Corrective Actions	
Rate of water treatment in ARU in decreasing trend	Rate of flow (output)	What	Flow measurement	Output (flow) as per ARU capacity	What	Head loss monitoring
		How	Flow meter reading		How	Cleaning of ARU
		When	Daily *		When	As required
		Who	VWSC		Who	VWSC / Community
Clogging of ARU due to iron	Rate of flow (output)	What	Flow measurement	Output (flow) as per ARU capacity	What	Flow Measurement
		How	Flow meter reading		How	Cleaning of ARU
		When	Daily		Who	VWSC / Community
		Who	VWSC			
Treatment fails to remove arsenic and also fails to conform to BIS standard (acceptable) in case of adsorption and ion-exchange process	Arsenic and other routine parameters	What	Water quality testing	Arsenic in treated water not more than 10 ppb	What	Treatment improvement
		How	Laboratory analysis		How	Process adjustment
		When	Weekly/ Once month		When	As and when required
		Who	Laboratories set up for WQMS		Who	WSP / WSC
Treatment fails to remove arsenic and also fails to conform to BIS (acceptable) in case of Co-precipitation process	Arsenic and other routine parameters	What	Water quality testing	Arsenic in treated water not more than 10 ppb	What	Treatment improvement
		How	Laboratory analysis		How	Introduction of both chemical and proper dose
		When	Weekly/ Once month		When	As and when required
		Who	Laboratories set up for WQMS		Who	WSP / VWSC

* Once in a month for small plants

9. Supporting Programme:

Supporting programmes are those activities that indirectly support water safety. These are also essential for proper operation of the control measure. Supporting programmes cover a range of activities including communication and capacity development, preventive maintenance, hygiene education and sanitation as well as legal aspects. Suggestive format for capture of supporting programme is provided in Table – 4.

Table – 4. Information Capture format of Supportive Programmes that could be included in the WSP (not exhaustive)

Programme	Purpose	Example
Communication and capacity development	Success of effective planning and implementation of WSP to a great extent depend upon awareness, motivation and commitment of stakeholders which need to be evaluated. Skill of the operating staff is most important.	• Development of IEC material to enhance the effective participation of various level stakeholders. • Organizing training for upgrading skill of user community.
Strengthening Laboratory Infrastructure	Inadequate laboratory facilities is one of the major constraints in planning and implementation of WSP in practice	• Manning the existing laboratories with qualified skilled personnel. • Setting up new laboratories at Block level. • Networking of rural laboratories.
Calibration	To ensure that critical limit set for monitoring is reliable and of acceptable accuracy	• Calibration schedule. • Calibrating equipment.
Preventive Maintenance	To ensure that malfunctioning of hand pump bore-well are minimized	• Putting in practice effective preventive maintenance programme. • Adequate inventory of spare parts to be kept to attend the repair.
Hygiene and Sanitation	To prevent contamination of water	• Strict cleanliness. • Hygiene practice.
Attending consumer complain / suggestion	Enhancing consumer confidence level regarding reliability of system of water supply from spot sources	• Regular dialogue with user group.

10. VERIFICATION SCHEDULE

Establishing procedure to verify that the water supply plan is working effectively and will meet the health based targets is a vital requirement of WSP approach. Such verification broadly may involve two activities that are undertaken together to provide a picture of evidence that the WSP is working effectively and will meet the desired objective :

- Water quality monitoring
- Auditing of operational activities.

The verification schedule should include checking of sludge treatment and disposal, disposal of back-wash water, media regeneration and replacement.

Verification should also include the checking that consumers are satisfied with the water supplied. It is important that consumers are using the safely managed water supply rather than less safe alternatives.

Table – 5. Information Capture format for Verification

Activity	Description	Frequency	Responsible Agency	Records
Performance evaluation of ARU	Verification and checking of rate of treatment, daily output, water quality etc.	Quarterly	G.P. level working group. WSP team. Expertise to be hired	Data recording from field monitoring, water quality analysis report
Sludge management	Verification and checking of sludge storage, treatment and disposal	Quarterly	G.P. level working group. WSP team, External Expert	Documentation of sludge management system
Wash-Water Disposal	Verification of wash-water storage and disposal system, risk from disposal, risk of spread of hazard and also secondary contamination from wash-water	Quarterly	G.P. level working group. WSP team, External Expert	Documentation of wash-water disposal system, Supportive water quality analysis.
Media regeneration or replacement	Verification of media treatment for regeneration when required and replacement with new media when regeneration is not feasible	Half yearly	WSP team, External Expert	Documentation of media regeneration or replacement for the ARU
Community involvement and management	Assessment of extent and magnitude of community participation in O&M of hand pump attached ARU and also examining popularity of household ARU	Half yearly	WSP team. External Expert	Documentation of components of community involvement and management.
Capacity building for extension of support for ARU management	Verify the development of institutional capacity for rendering support services	Yearly	WSP team, External Expert	Documentation of all components of capacity building and support services.

11. VALIDATION SCHEDULE TO ASCERTAIN SYSTEM CAPACITY

Validation involves obtaining evidence that activities taken up supporting the WSP is correct and that the operation of the water supply in accordance with the WSP will be able to achieve the desired health based targets. Validation normally includes more extensive and intensive monitoring than routine operational monitoring.

Validation schedule need to be so prepared, that such exercise in a position to ascertain that the overall system design and operation is capable of consistently delivering water of the special quality to meet the health based targets. A suggestive format is provided in Table – 6.

Table – 6. Information Capture format for Validation

Item Validated	Hazardous Events	Validation Schedule	Comments
Performance evaluation of ARU	Presence of arsenic contamination in treated water, reduction in rate of treatment	Regular monitoring of all relevant components for assessment of ARU performance	It is utmost important as optimum performance ensures Arsenic-safe water to the consumers.
Sludge management	Arsenic rich sludge may re-contaminate water, soil, crop, etc.	Meticulous monitoring to validate the sludge management system at regular interval.	It is essential to check risk from sludge management.
Wash-water disposal	Wash-water containing higher proportion of arsenic may cause environmental and health problem.	Monitoring at regular interval to oversee the wash-water storage and disposal system maintaining environmental safeguard.	The monitoring and checking are vital as deficiency in management system may cause environmental pollution.
Media regeneration and replacement	Arsenic removal unit performance depends on media regeneration and replacement	Overseeing and monitoring regularly the media regeneration facility and performance and also replacement of media at proper time	Media plays an important role for arsenic removal and so, regeneration and replacement are two essential components of proper management.

12. ACTION PLAN FOR IMPROVEMENT

When the assessment of arsenic removal based drinking water supply system indicates that existing technologies and performances of ARU are not adequate to ensure drinking water safety, as a part of full planning and implementation of WSP, an action plan for incorporating corrective measures for addressing the inadequacy need to be developed. Implementation of plans should be monitored to confirm that improvements have been made according to action plan and are effective.

A suggestive format for incorporating information related with action plan for improvement of WSP is presented below.

Table – 7. Information Capture format for Action Plan for Improvement.

Issues identified for requirement of improve-ment	Approach to be adopted for carrying out improve-ment	Short Term / Long Term	Time frame for Implementa-tion	Approx. Fund Require-ment	Responsi-ble for Improve-ment	Degree of Priority
Implement measures to control arsenic	Performance monitoring of ATU	Short Term	No definite time frame	No additional fund	PHED or Relevant Departme nts or	High Priority

Issues identified for requirement of improve-ment	Approach to be adopted for carrying out improve-ment	Short Term / Long Term	Time frame for Implementa-tion	Approx. Fund Require-ment	Responsi-ble for Improve-ment	Degree of Priority
contamination related risks due to deficiency in the performance of ATU.					VWSC	
Assessing the water supply to determine whether it is able to meet health based target	Water quality testing and curative action	Short Term	No definite time frame	No additional fund	PHED or Relevant Departments or VWSC	High Priority
Sludge and Media management	Capacity building, training and motivation	Long Term	One month	Affordable contribution from beneficiaries	PHED or Relevant Departments or VWSC	High priority
Awareness and Motivation of villagers	Organising different interactive sessions using IEC materials	Long Term	One month	Rs.5000/- per G.P.	GP level team, VWSC	High Priority

Guidelines for Water Safety Plan in the rural areas

Chapter-11

"WSP – Defluoridation"

WSP – Defluoridation

1. Introduction

Fluoride is found in all waters in some concentrations. Sea water contains about 1mg/L while rivers, lakes and ground water generally exhibit concentrations of less than 0.5mg/L. However, much higher concentrations can occur. High fluoride concentrations are expected in ground waters from calcium poor aquifers and in areas where fluoride bearing minerals are common. Waters with high concentrations of fluoride may also occur in geographical belts associated with sediments of marine origin in mountainous areas, volcanic rocks and granites & gneissic rocks. Many of the lakes in East African Rift system have extremely high fluoride concentrations.

2. Fluoride and human health risks

Approximately 75-90% of ingested fluoride is absorbed. Nearly 40% of ingested fluoride is absorbed from the stomach as HF. Fluoride not absorbed in the stomach is absorbed in the intestine. High concentrations of cat ions that form insoluble complexes with fluoride, such as calcium, magnesium and aluminum can markedly decrease gastrointestinal fluoride absorption.

Once absorbed in the blood, it is readily distributed throughout the body, resulting in accumulation of fluoride in calcium rich areas such as the bone. Fluoride is excreted via urine, faeces and sweat.

Fluoride in small quantity (0.5 mg/L) is beneficial to teeth as it prevents dental carries while beyond the tolerance limit of human body it causes:

Skeletal fluorosis (affecting bones). The usual symptoms are pain in the neck, back joints and rigidity in joints and restricted movement of cervical and lumbar spine, knee and pelvic joints and shoulder joints.

Dental fluorosis (affecting teeth). It occurs in children during the development stages when teeth are exposed to fluoride. The discoloration of teeth progresses from white to yellow to brown and finally to black. The discoloration may be in spots or as streaks invariably horizontal in orientation.

Non-skeletal fluorosis (affecting soft tissues). Investigations on soft tissue involvement in fluorosis have been reported to cause adverse affect on skeletal muscle, Erythrocytes, Gastro-intestinal mucosa, Ligaments, Thyroid gland, etc.

Limit of fluoride in drinking water

In setting a national standard for fluoride concentration in drinking water, it is particularly important to consider climatic condition and volumes of water intake. BIS:10500 has prescribed a maximum permissible limit of 1.5 mg/L in drinking water.

3. Removal of excessive fluoride:

Occurrence of fluoride at excessive levels in drinking-water in countries is a serious problem. Its detection demands analytical grade chemicals and laboratory equipment and skills. Similarly, the prevention of fluorosis through management of drinking-water is a difficult task, which requires favourable conditions combining knowledge, motivation, prioritization, discipline and technical and organizational support. Many filter media and several water treatment methods are known to remove fluoride from water. However, many initiatives on defluoridation of water have resulted in frustration and failure (COWI, 1998). Therefore, in any attempt to mitigate fluoride contamination for an affected community, the provision of safe, low fluoride water from alternative sources, either as an alternative source or for blending, should be investigated as the first option. In cases where alternative sources are not available, defluoridation of water is the only measure remaining to prevent fluorosis. However, there are several different defluoridation methods. What may work in one community may not work in another.. What may be appropriate at a certain time and stage of urbanization may not be at another. It is therefore most important to select an appropriate defluoridation method carefully if a sustainable solution to a fluorosis problem is to be achieved. Potentially available and acceptable processes and materials are:

Bone charcoal ;Contact precipitation ; Clay ; Activated alumina ; Calcium chloride ; Monosodium phosphate ; Nalgonda ; etc. Advanced treatment technologies, e.g. reverse osmosis, electro dialysis and Distillation, etc. may also be used for removing excess fluoride.

Defluoridation of drinking-water is technically feasible at point-of-use (at the Tap), for small communities of users (e.g. wellhead application) and for large drinking water supplies. Activated alumina and reverse osmosis are the most common technologies. Activated alumina can concurrently remove other anions, such as arsenate. Reverse osmosis achieves significant removal of virtually all dissolved contaminants.

Method Characterization:

Fluoride removal treatment plant design should account for the required storage of water and filter columns, as used for bone charcoal. Activated alumina and clay, are often fed intermittently. Thus there will be a need for a pre-storage container and a control of flow rate in order to ensure a minimum contact time. Batch units, as in the Nalgonda technique, are often fed once a day. In both cases a separate clean water container would be useful or even essential.

Even in situations where water is supplied through piped schemes, the decentralized solution may be more advantageous. This is because there is no need to remove the fluoride from water that is not consumed, i.e. used for cooking or drinking, and water demand for all uses is often more than 10 times the water needed for drinking and cooking. Defluoridation of the total amount of water used would, therefore, be more costly and possibly unaffordable for the Community or the household. Unnecessary removal of fluoride from water would result in accumulation of unnecessarily large amounts of toxic sludge. This is likely to create an environmental disposal problem?

Media and process

Defluoridation processes can be categorized into three main groups:

- Bone charcoal, activated alumina and clay resemble sorption media, preferably packed in columns to be used for a period of operation. Sorption processes result in saturated columns to be renewed or regenerated..

- Aluminum sulfate and lime in the Nalgonda technique, polyaluminium chloride, lime and similar compounds act as co-precipitation chemicals to be added daily and in batches. Precipitation techniques produce certain amount of sludge every day.

- Calcium and phosphate compounds are the so-called contact precipitation chemicals to be added to the water upstream of a catalytic filter bed. In contact precipitation there is no sludge and no saturation of the bed, only the accumulation of the precipitate in the bed.

Bone charcoal

Bone charcoal is a blackish, porous, granular material. The major components of bone charcoal are calcium phosphate 57–80 per cent, calcium carbonate 6–10 per cent, and activated carbon 7–10 per cent. In contact with water bone charcoal has the specific ability to take up fluoride from water.

Contact precipitation

Contact precipitation is a technique by which fluoride is removed from the water through addition of calcium and phosphate compounds and then bringing the water in contact with an already saturated bone charcoal medium

Nalgonda

The Nalgonda process was adapted and developed in India by the National Environmental Engineering Research Institute (NEERI) and developed to be used at both the community or household levels. The process is aluminium sulfate based coagulation-flocculation sedimentation, where the dosage is designed to ensure fluoride removal from the water. Aluminium sulfate, $Al2\ (SO4)3\ 18H2O$, is dissolved and added to the water under efficient stirring in order to ensure initial complete mixing. Aluminium hydroxide micro-flocs are produced rapidly and gathered into larger easily settling flocs. Thereafter the mixture is allowed to settle. During this flocculation process many kinds of micro-particles and negatively charged ions including fluoride are partially removed by electrostatic attachment to the flocs. Compared with normal drinking-water flocculation, a much larger dosage of aluminium sulfate is normally required in the defluoridation process. As the aluminium sulfate solution is acidic, simultaneous addition of lime is often needed to ensure neutral pH in the treated water and complete precipitation of aluminium. Surplus lime is used as a weighting agent, i.e. to facilitate more complete settling. The treated water can be decanted.

Activated alumina

Activated alumina is aluminium oxide (Al_2O_3) grains prepared to have a sorptive surface. When the water passes through a packed column of activated alumina, pollutants and other components in the water are adsorbed onto the surface of the grains. Eventually the column becomes saturated: first at its upstream zone and later, as more water is passed through, the saturated zone moves down stream with the column eventually becoming totally saturated.

Regeneration

Regeneration of the saturated alumina is carried out by exposing the medium to 4 per cent caustic soda (NaOH) either in batch or by flow through the column, resulting in a few Bed Volumes of caustic wastewater contaminated with fluoride. Residual caustic soda is then washed out and the medium is neutralized with a 2 % sulfuric acid rinse. During this process about 5–10 per cent of the alumina is lost, and the capacity of the remaining medium is reduced by 30–40 per cent. After 3–4 regenerations the medium has to be replaced. Alternatively, in order to avoid on-site regeneration, the saturated alumina can be recycled to a dealer, who can adjust the capacity of the activated alumina to the desired value by using an appropriate mixture of fresh and regenerated media. Where the process is operated at domestic level, the regeneration cannot be left to the users. Instead, a central chemical store is set up in each village, where the users can get the regeneration done along with motivation and encouragement to continue the fluorosis prevention. Regeneration may result in the presence of aluminum at a concentration greater than 0.2 mg l^{-1} if the pH is not readjusted to normal.

Clay

Clay is an earthy sedimentary material composed mainly of fine particles of hydrous aluminum silicates and other minerals and impurities. Clay is fine-textured, plastic when moist, retains its shape when dried and sinters hard when fired. These properties are utilized in manufacture of pottery, brick and tile. Both clay powder and fired clay are capable of sorption of fluoride as well as other pollutants from water.

Evaluation and selection of method

The above reporting on the methods of defluoridation reveals that there is not a universal method which is appropriate under all social, financial, economic, environmental and technical conditions. None of the methods has been implemented successfully at a large scale in many parts of the world. This is quite remarkable, especially when taking into consideration the fact that several defluoridation methods have been studied in detail and even reported as appropriate methods, for a number of years.

4. Water safety plan for defluoridation of drinking water

As mentioned earlier, high concentrations of fluoride in ground water have been reported in many states in the country. The water safety plan of a water supply in such areas shall take care of the fluoride problem in the area based on the availability of surface water source in the vicinity, the overall water quality in the area and average rain fall. In case the water quality in the area is having high concentrations of fluoride along with high concentrations of other parameters also, then the priority of options could be as:

- Scheme based on alternate surface source available in the vicinity
- Installation of desalination plant
- Rain water harvesting

If the water quality in the area is potable except fluoride, then water safety plan may include defluoridation for the water supply scheme. Further, if only few sources are affected with fluoride and other fluoride free sources are also available, then the drinking water requirement should be fulfilled from safe sources and other requirements could be met from other sources having fluoride.

5. Hazard analysis:

Raw water quality:

1. If other parameters are also above the maximum permissible limits along with fluoride, go for alternate surface source available in the vicinity and is economically viable. If no alternate surface source is available, go for desalination plant.
2. If only fluoride is beyond permissible limits, then go for the other safe source for drinking and cooking purposes and other sources with high fluoride could be used for bathing, washing, cleaning, etc.
3. Domestic defluoridation units may be used in the house holds dependant on a particular source.
4. If all the sources in the village are fluoride affected, go for community based unit which may be GLR attached or HP attached.

Quality of Defluridating Media

1. Whether as per desired specifications.
2. Describe fluoride up take capacity

Regeneration process:

1. Quality of chemicals used for regeneration.
2. Describe equipments other articles required for regeneration
3. Describe safety arrangements such as first aid box, gloves, etc.

Disposal of sludge:

1. Identify the quantity of sludge generated,
2. Identify the sludge neutralization process.
3. Describe final disposal of the sludge.

Disposal of the exhausted Defluoridating media which can not be regenerated:

1. Describe the total quantity of media to be disposed.
2. Identify the suitable location for disposal.
3. Identify if it can be used for other industrial requirements.

Corrective measures:

Water Quality:
1. Blending of water of different sources based on water quality report.
2. Use of rain water for drinking and cooking.
3. Use of safe source for drinking and cooking.
4. Use of surface water if available in the vicinity of the village.
5. Promote ground water recharge.

Quality of Defluoridating media:

1. Use duly inspected material only.
2. Check fluoride uptake capacity of media of different batches.

Regeneration of defluoridating media:

1. The operator handling regeneration process should be well trained.
2. Good quality chemicals should only be used.
3. Establish regeneration centre for domestic defluoridation units.
4. Make all arrangements for onsite regeneration of media at community based DF units.
5. Wash the regenerated media with enough water to bring pH of water to 6.5
6. Give proper contact period.

Disposal of sludge:

1. Collect the waste water and sludge generated during regeneration process in a settling tank.
2. Neutralize the waste effluent with lime. Ensure that pH of the effluent is >7.
3. Dry the sludge.
4. Dispose at a suitable place like construction of road or building. May also be used in brick manufacturing.

Disposal of exhausted defluoridating media:

1. Collect the media which can not be regenerated further from various DF units.
2. Dispose the media at a suitable place from where it could not percolate in the ground.

Table-1, Information format for Hazards events and risk associated

Process/Activity	Hazardous events	Risks associated	Corrective measures	Additional control measures
Raw water quality	Multiple quality problem	Adverse effects on human health	-Go for alternate safe water source -Install desalination plant	Periodic testing of water quality by block /district level laboratory
	Single water quality problem of excess fluoride	Dental fluorosis/ Skeletal fluorosis/ Non skeletal fluorosis	Install defluoridation plant	Periodic testing of water quality by block /district level laboratory
Defluoridation unit	Poor quality of defluoridating media	-Reduced defluoridating capacity -Deterioration of water quality	-Inspect material before procurement -It should confirm to desired specifications -Periodic testing of media	
	Regeneration/ replenishment of defluoridating media	Poor treated water quality	Timely regeneration/ replenishment of media	Test water quality at periodic intervals
	Disposal of Sludge	Contamination of surrounding surface/ ground water	- Collect the sludge in a collecting chamber - Neutralize the sludge -Dry -Dispose off at a suitable place	Periodic inspections by district level authorities
	Disposal of exhausted media	Contamination of surrounding surface/ ground water	- Explore reuse possibilities of the media -Dispose off at a suitable place	Periodic inspections by district level authorities

6. Operational Monitoring:

1. Check raw water quality for fluoride concentration.
2. Calculate the requirement of treated water for drinking and cooking.
3. Check quality of defluoridating media before use.
4. Based on fluoride content and treated water requirement, identify the approximate time period when regeneration will be required.
5. Test for fluoride in treated water at regular interval. Increase frequency of testing of treated water when the media is expected to be exhausted.
6. Keep sufficient media in store for replacement.
7. Chemicals required for regeneration should always be readily available.
8. Check for pH, SO4, alkalinity and residual alumina after regeneration of media.

Table-2, Information capture format for operational monitoring

Process/ Activity	Monitoring parameter	Monitoring process/ plan	Corrective measures
Raw water quality	- Test water for pH, total alkalinity, fluoride, total dissolved solids, sulphates	Test water samples from all sources of the water supply scheme once a month	
Defluoridating media	Quality of the defluoridating media	-Inspect material before procurement -Periodic testing of the media for uptake capacity at block/ district level laboratory	Replace media if required
Treated water	Quality of treated water	Daily testing of treated water for pH and fluoride	-Adjust dosages of chemicals as per chemical analysis report - Regenerate the media if required - Replace media if required - Increase frequency of water testing when it is expected to be near exhaustion.
Regeneration of adsorbents (DF media)	-Quality of chemicals used for regeneration -Regeneration process -Availability of chemicals	-Ensure quality of the chemicals used for regeneration -Ensure that regeneration process is being followed as suggested -Ensure that sufficient quantity of required chemicals is available in store	-Impart training to the plant operators.
Treated water quality	Check treated water quality after regeneration	Analyst water samples for pH, fluoride, sulphates and residual adsorbent (mostly aluminum as most of the defluoridation adsorbents are aluminum based materials	Repeat regeneration process

Management and Communication:

1. Keep proper records for the quantity of media used.
2. Keep records for various chemicals consumed in regeneration.
3. Keep records of the defluoridating media replaced.
4. Total quantity of water treated,
5. Raw water quality.

6. Treated water quality.
7. Sludge disposed.
8. Chemicals required for neutralization of the waste effluent.
9. Take corrective measures in time and record the same.
10. Conduct inspections at regular interval to validate the DF process and verify the results of treated water.

7. Validation and verification

1. Prepare plan for a detailed inspection right from process to the consumer end.
2. Conduct sanitary and fluorosis cases survey to assess the defluoridation process.
3. Document all the related data for future planning and verification.

Verification Schedule

Establishing procedure to verify that the water safety plan for defluoridation is working effectively and meeting the desired health-based targets is a vital requirement for WSP approach. Such verification broadly involves two activities that are undertaken together to provide a body of evidence that the WSP is working effectively and will meet the desired objective.

- Water quality monitoring; and
- Auditing of operational activities.

Verification should also include checking that consumers are satisfied with the quality of water supplied. It is important that consumers are using the safe, managed water supply rather than less safe alternatives.

Table-3, Information capture format for verification

Activity	Description	Frequency	Agency Responsible	Records
Effectiveness of WSP process in achieving health based target	-Analysis of health data of community maintained by NRHM. -Review Water analysis reports for chemical examinations particularly fluoride concentration.	Every three months	WSP team, VWSC and NRHM	-Health data of community served maintained by ASHA (NRHM) -Water analysis data maintained by NRHM, block and district water testing laboratories.
Adequacy of Sanitary Inspection Measures	-Review Sanitary inspection form (Does it include all the potential hazards of the catchment area).	Every six months	WSP team, VWSC	Sanitary Inspection format
Accuracy of Laboratory Testing of water samples	Results of percentage of sample tested may be verified by testing in Referral Lab.	5% of the sample tested as a part of WSP activity	Jalsurakshak, ASHA	Data of Water Quality Analysis carried out both as routine at block and district level laboratories as well as in Referral Lab.

Assessment of Impact of advocacy programme on behavioural change of user's community	Structural Observation of the water related practices of the community	Random sampling of house holds and user community	ASHA /grass root worker, Partner Agency, NGO etc.	IEC material produced for the purpose
Auditing status of the Water Security of the user HH. Checking satisfaction level of the user of the system and also Verifying that users are not consuming alternative unsafe source rejecting the system.	Situation study, meeting and interacting with community, Visit to HH to ascertain ground realities.	On regular basis	Subject Expert/ ASHA /grass root worker, Partner Agency, NGO etc.	Evaluation Report

Validation Schedule to ascertain system capability

Validation involves obtaining evidence that the activities taken up supporting the WSP is correct and that the operation of the water supply in accordance with the WSP will be able to achieve the desired health-based targets. Validation normally includes more exclusive and intensive monitoring than routine operational monitoring.

Table-4, Information capture format for validation

Item Validated	Hazardous Events	Validation Schedule	Comments
Source Centred Catchment Area Management process	Chemical Contamination getting detected in water –source	Combined analysis of water quality and sanitary inspection data from verification to assess whether protection measures in catchment have been effective and identify the gap and validate the management process	It may often be more efficient to invest in preventive processes within the catchment than to invest in major treatment infrastructure to manage a hazard.
Fluoride concentration in treated water	Non reduction of fluorosis burden among the users	Co-relating the treated water quality and dietary habits of the users	Defluoridation of water is the main control measure to combat flurosis.
Advocacy approach adopted for ensuring behavioural change among community towards defluridation	Water for drinking and cooking is defluridated	Critically revisit the advocacy approach, focus more on inter-personal communication using youth as change agent	Behavioural change is a slow process.

8. Action Plan for Improvement

When the assessment of the drinking-water system indicate that existing practices and technologies of defluridation system are not adequate to ensure drinking-water safety, as a part of full planning and implementation of WSP plan, an action plan to incorporate corrective measures for addressing the in-adequacy need to be developed which may include both short-term and long-term programmes.

Realistic assessment of fund requirement for implementation of improvement plans and careful prioritization of issues in accordance with the outcomes of risk assessment also need to be done. Implementation of plans should be monitored to confirm that improvements have been made according to action plan and are effective.

Table-5, Information capture format for Action Plan for Improvement

Issues identified for improvement	Approach to be adopted for carrying out improvement	Short term/long term	Time frame for implementation	Responsible for improvement	Degree of priority
Control and management of the source and its surroundings	Supplement community effort facilitate community governance	Long term	No definite time frame	VWSC WSP team, PHED	High Priority
Protecting source from flooding and external contamination	Providing drainage and barrier channel for diversion of flood	Short term	Six Months	Community, PRI, WSP team, VWSC	Priority Medium
Treatment Process unable to remove fluoride to a desire extent	Renovate the treatment plant for improving fluoride removal efficiency	Long term	Nine months	VWSC / WSP team / PHED	Priority Medium
Inadequate laboratory testing facilities	Supplement equipments, chemicals and conduct refresher courses for training to staff.	Long term	Every year	PHED	High priority

Guidelines for Water Safety Plan in the rural areas

Chapter-12

"WSP – Iron Removal System for Drinking Water Supply"

(For Technical and Professional Manager)

Iron Removal System for Drinking Water Supply

(For Technical and Professional Manager)

1. Introduction

Iron is one of the earth's most plentiful resources, making up at least five percent of earth's crust. Rainfall seeping through the soil dissolves iron and carries into natural water .Iron compounds present in natural water in diverse form and concentration.
In ground water source, iron generally present in water in two forms either in soluble ferrous iron or in -soluble ferric iron form . Water containing ferrous iron is clear and colourless as iron is completely in dissolved state and when exposed to air, a reddish brown substance begins to form.

In shallow wells or in surface water, iron may be present wholly or partially combined with the organic matter. Although this kind of iron can be colour-less some-time it is also found to be yellow or brown. Iron some time exists in iron with certain kind of bacteria known as iron bacteria. Iron bacteria consume iron to survive and leave a reddish brown or yellow slime that can clog plumbing and offensive odour

Presence of iron in drinking water though not a health hazard, but it cause taste, staining and accumulation problem, because of which water with excess iron people do not accept and prefer to use even unsafe available surface source . Maximum desirable and permissible limit of iron in drinking water is 0.3mg/litre and 1.0mg/litre respectively Scientifically designed Iron Removal Plant (IRP) are in use in domestic water supply system for removing iron in excess of permissible limit, Depending upon the system, capacity and nature of the scheme, for the purpose of this document IRP broadly classified in three Types

- IRP fitted with bigger community scheme, having deep tube well as source with energy driven pump, distribution net-work etc. (may be referred here-after as IRP Type A)

- IRP for smaller community scheme having tube-well as source fitted with Hand Pump (HP) without any distribution etc. (may be referred here-after as IRP Type B)

- Domestic iron-removal filters for house-hold level (may be referred here-after as IRP Type C) (Figure 1 and Figure 2)

As each types of IRP mentioned above is exposed to the risk of various degree of contamination due to different situational factors ,ensuring water safety while processing through IRP is most challenging task. Properly planned and implemented Water Safety Plan (WSP) considered to be an effective quality assurance tool having the potentiality to ensure supply of safe water from
WSP is based on a comprehensive risk assessment and risk management approach to all the steps in a water supply chain from catchment to consumer where IRP is one of the vital component of the chain system Planning and implementation of WSP for IRP need to be put into practice fitting in with appropriate forward and backward linkage with specific water supply chain.WSP for IRP in isolation may not serve desire purpose

Some of the other technologies which are in use for iron removal for drinking water purpose are:

Ion –exchange process may be applicable for iron removal if the iron is present in reduced state and in a soluble form in the raw water. The ion-exchange process percolates water through bead like spherical resin material. The material used should have adsorption ability as well as ion –exchange ability. Zeolite The Ion-exchange process is a reversible inter-change of ions between a solid ion-exchange medium and a solution. Air should be excluded from the system to prevent deposition of colloidal oxides on the ion exchange material. Therefore air lifts, open tanks or pneumatic tanks should not used preceding in the ion exchange. The exhausted bed of ion exchange material to be regenerated with salt solution.
In general the technology of Ion-exchange for water purification including iron-removal which are in use were patented/branded. The organisation responsible for developing /marketing technology need to provide guidance user for developing WSP.

Ozonation - Ozone is a powerful oxidizer and can be used effectively for iron removal .An Ozone generator which may be available in many design and sizes is used to make Ozone that is then fed by pump or by an air injector into the water stream to convert ferrous iron into ferric iron. This is followed by a contact time tank and then by a catalytic medium or inert multilayered filter for removal of the ferric iron.

Oxidizing Filtration Media

Using certain oxidant material viz. Greensand, Bir, Pyrolox as filter media can help in iron removal. Some of the characteristics of such oxidant material are as follows-
Greensand- Greensand is a processed material consisting of nodular grains of the zeolite mineral glanconite. The material is coated with manganese oxide. The ion-exchange properties of the glanconite facilitates the bonding of the coating . This coating is maintained through regeneration with potassium permanaganate. One of the most common chemical oxidant having relatively high capacity for iron removal and can operate at high flow rates with moderate backwash requirements
Birm- acts as a catalyst to promote the reaction between the oxygen and dissolved iron in the water. It requires no regeneration but needs relatively high level of dissolved oxygen and works best at the PH above 6.8

Pyrolox- a natural ore that oxidizes and then filters the resulting in soluble iron. It does not need to regenerate needs back-wash

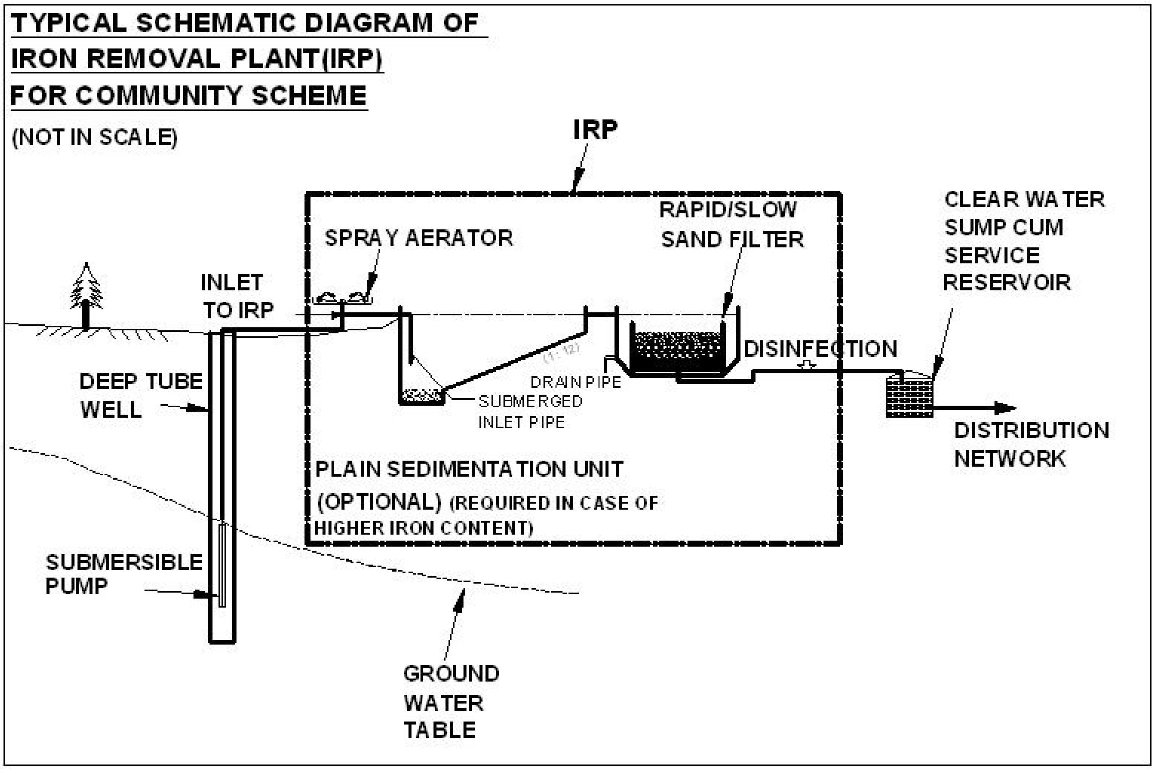


Figure-1

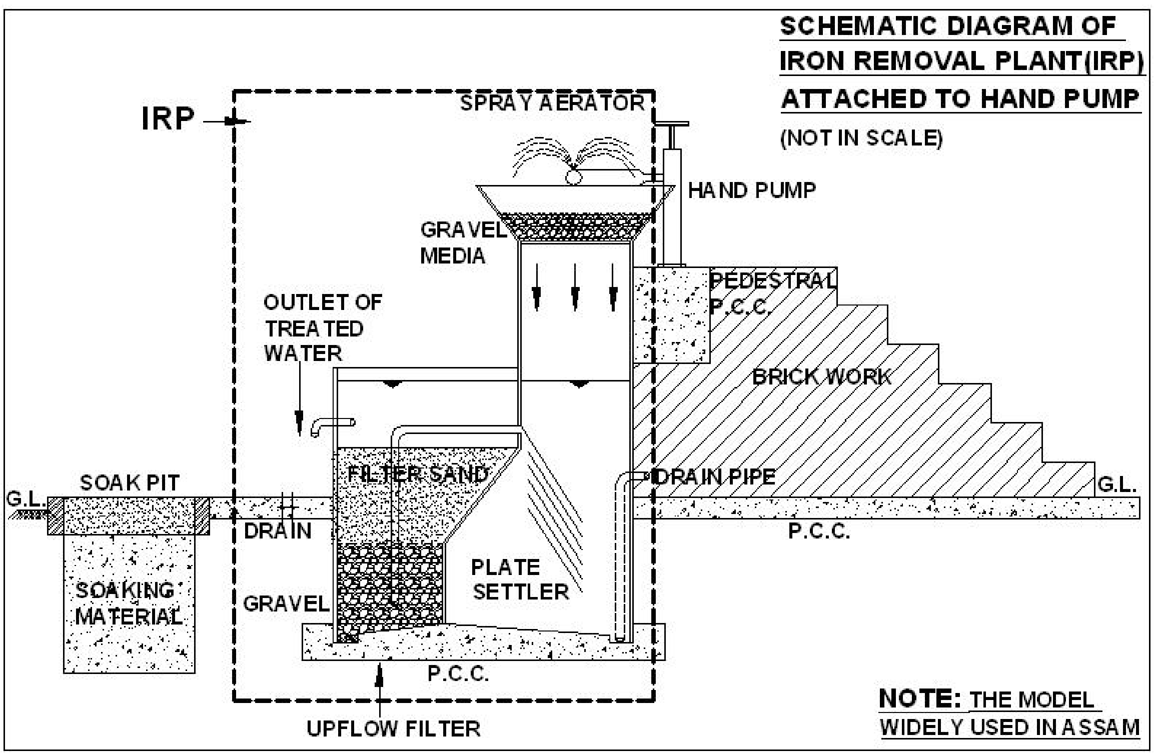


Figure-2

2. Process Description of IRP

Developing and implementing of WSP for IRP, proposed to be based largely upon Hazard Analysis and Critical Control Point(HACCP) approach. In HACCP approach putting appropriate control measures in place need realistic risk assessment identifying and analysing potential hazard . One of the important requirement for carrying out such system assessment process is to develop understanding regarding the process involve in IRP, covering the whole system from the inlet- system of water to IRP to the out-let system of water from IRP, along with water quality requirements at various steps. Identifying where the system is vulnerable to hazardous events, and who need to be responsible for control measures is also important.

In general water entering an IRP should be free from contamination other than iron, which to be removed WSP of IRP need to ensure during while removing iron efficiently, the risk of contamination from other sources get minimized. Many of the IRPs are complex arrays of pipes, filter media, valves etc. therefore the risks of contamination are not always very easily identified.

Tentative format for capturing information related to Process description for Type A & Type B IRP provided in Table- 1

Table- 1, Format for capturing information related to Process description of Type A & Type B IRP

Code	Components in the process of water supply	Water quality requirements	Description with particular reference to vulnerability to hazard	Responsibility for control measures
IR1	Inlet water to IRP	Should be free from turbidity microbial, and chemical contamination other than iron of specified range PH should be within the prescribed range	Contamination other than iron of the range which can be treated in IRP adversely effect the treatment process. Access of microbial contamination to IRP may contaminate IRP system . Rate of flow of water and pH if not as per design requirements will hamper the treatment process	Operational staff engaged in O&M of IRP & community
IR2	Aeration system Aeration is the process of bringing water and air into intimate contact. Aerator fall broadly into two general categories. They either introduce air into the water or water into the air. For Type A IRP aerator may be Cascade Aerators Cone Aerator Spray aerator	Iron present in water is oxidized through atmospheric oxygen, Should be free from bacteriological and physical and chemical contamination other iron of specified range which cannot be treated in IRP	In-addition to contamination if any induced through inlet water, un-roofed chamber may allow birds to congregate and defecate introducing pathogens to water. Array of pipes and valves exposed to the risk of hazard particularly microbial contamination unhygienic practices of personnel engaged in O& M , may also have the potentiality of hazard	Operational staff engaged in O&M of IRP & community

	For Type B IRP generally Spray aerator is used A pressure aerator commonly used in pressure filtration . The air is injected and allowed to stream into the water as a fine bubble, causing the iron to be readily oxidized.			
IR3	Initial Sedimentation Generally occurs in aeration chamber prior to flow to sedimentation chamber or filter units	In the aeration chamber floor ,a percentage of precipitated iron get settled . Water quality should be free from , undesirable contaminants	Problem of risk of bacteriological contamination is as same aeration chamber, Precipitate settled iron need regular cleaning	Operational staff engaged in O&M of IRP & community
IR4	Final Sedimentation before filtration Generally plain sedimentation preferred ,without any addition of chemicals	Water quality should be free from , undesirable contaminants	Settled precipitate , if not removed regularly , will be cause of hazard	Operational staff engaged in O&M of IRP & community
IR5	Filtration Filter generally used both Type A & Type B ,IRP are Rapid sand filter, Slow sand filter Up flow filter Etc,	Water quality should be free from any undesirable contaminants	In-adequate design and. poor operational practice may lead to large-scale contamination and increased public health risks Most commonly reported problem filter cracks permitting short circuiting may cause contamination	Personnel having expertise on IRP Operational staff engaged in O&M of IRP & community
IR6	Washing of filters a) Back Wash system For Type A IRP back-washing may be done by pumping treated water, or pushing water from elevated reservoir For Type B IRP back-washing done diverting water from HP b)Washing by Scrapping sand from filter top and replacing with washed sand	Water utilized for back-wash, Should free –from turbidity any chemical and bacteriological contamination	The most common reason for filter failure in IRP Type A and Type B due to absence of its proper washing. Microbial and other contamination of water used for back washing/ washing of filter media may cause contamination Unhygienic operating practices during washing may cause hazard	Operational staff engaged in O&M of IRP & community

IR7	Out let water from IRP	Water quality should be safe and acceptable for drinking, cooking, washing and other domestic purposes	In case of presence of any contamination other than iron. It will be difficult to achieve health target In case of presence of iron, in excess of permissible limit, and in-adequate flow user may reject the source and go for alternate available unsafe source	Operational staff engaged in O&M of IRP & community

In case of Type C IRP (Domestic Filter) care need to be taken, that water put in the filter free from turbidity microbial, and chemical contamination other than iron of the range which can be tackled by filter. At the HH level adopting proper hygienic practice it need to be ensured that filter does not get any contamination , particularly microbial. Outlet water from Type C IRP will indicate, how the filter is effective

Water Supply use details along with consumer needs

Safety requirements of water vary depending upon its end use, WSP plan may therefore include statement related with Intended use , Treatment need, House-hold handling use etc. as shown in Table- 2.

Table- 2, Format for providing information related with Intended use treatment need and House-hold handling (Type A & Type B) for IRP

Intended Use	Treatment need	House-Hold- Handling
Water obtained from IRP intended for use at the House-hold level for drinking and cooking.	iron beyond permissible limit removed, processing it through appropriate IRP Water should be free from microbial and other contaminants	Water consume at rural house-hold, many of such houses are kattcha and not very hygienic A number of users have to, carry water for drinking & cooking along with other use from out-side street taps, for Type A IRP and from out-let of Type B IRP in container that are not always hygienically safe, , water storing and use at HH level not also very much safe from microbial contamination.
For bathing , washing clothes, washing for utensils etc.	In case of presence of iron beyond permissible limit iron to be removed, processing it through appropriate IRP	Storing and handling of water used for washing utensils need care for avoiding bacteriological contamination, no major specific care need for the use of other purposes

For Type C IRP water used primarily for drinking and in certain cases for cooking at HH level.

Putting water in IRP free from microbial contaminants and careful handling of filter to keep the filter free from bacteriological contamination most vital

3. Technology Description

Brief technology description of the IRP which should include design criteria adopted for various component of the system , specification of material used , . management process at various level, WQ test requirements etc considered very much important information for planning and implementation of WSP
While capturing technology description for Type A & Type B IRP it is also desirable to provide certain general information about the scheme where IRP is in use below

General Information about the scheme where IRP is in use

- Name of the Habitation/Habitations served by the scheme
- Name of Census Village with code no served by the scheme
- Year of Commission of the scheme-
- Year of Commission of IRP
- Design period of the scheme
- Design capacity of the scheme-
- No of House-holds presently served by the IRP - SC
  ST
  General
  Total
- House-holds nos projected for ensuring house-hold water security up to specified design period by scheme/IRP
- Whether there is any proposal/possibility of future augmentation of the scheme/IRP
- Whether House Holds served by the scheme/IRP have access to any other water supply system : Yes/No

- If yes brief note about the alternative system
- About Health Data availability of the community (from NRHM)

Format for providing information related with Technology Description etc. may be seen in Table- 3.

Table- 3, Suggestive format for capturing information related with Technology Description etc. for Type A & Type B IRP

Component/Process	Information to be provided	Water Quality testing requirements	Management Process		Document to be prepared /provided
			Present	Improvement suggested	
Inlet water to IRP	Water Quality and Quantity Average down time of the source	Lab testing of water in lab regarding turbidity ,PH iron content, bacteriological and other relevant parameter	Type A IRP operator and VWSC Type B IRP Care-taker and user group	Streamlining water quality testing facilities Improving data management	water quality testing reports of different periods Seasonal variation record of water table
Aeration system (including initial	Type of Aerator, various parameter for which IRP design viz. specified, rate of	Lab testing regarding turbidity ,PH iron content	Type A IRP operator and VWSC	Supervision By VWSC for Type A IRP and by user group	Detailed drawing of Aeration system showing piping details (where ever

settlement of iron precipitation)	flow, iron content pH etc. Specification of material used for pipes / chamber etc.	bacteriological and other relevant parameter	Type B IRP Care-taker and user group	for Type B IRP to be strengthen	required)along with , preventive and hygienic operational requirements
Sedimentation Chamber	Design parameter viz detention time , surface area, depth etc. No of chambers Specification of material used for pipes , civil construction etc.	Testing of water in lab turbidity ,iron content bacteriological and other relevant parameter	Type A IRP operator and VWSC Type B IRP Care-taker and user group	Supervision By VWSC for Type A IRP and by user group for Type B IRP to be strengthen	Detailed drawing of Sedimentation showing piping details (where ever required)along with , preventive and hygienic operational requirements
Filtration Unit	Type of Filter, description of process, dimensions, no of units Design parameter, filter media details,(grain size, depth etc.) specification of material	Lab testing of iron content bacteriological & other relevant parameter	Type A IRP operator and VWSC Type B IRP Care-taker and user group	In case of requirement, opinion from expert may be sought .Proper supervision on quality of functioning of filter	Detailed drawing of filtration unit showing piping details along with , preventive and hygienic operational requirements
Back washing/washing system of filter media	Methodology of washing adopted, in case of back-wash ,whether compressed air used . Back wash water container details	Testing of water in lab regarding turbidity ,iron content &bacteriological Etc.	Type A IRP operator and VWSC Type B IRP Care-taker and user group	Strengthen supervision mechanism	In case of back washing, detailed drawing of the back wash including piping details preventive and hygienic operational requirements
Out-let water from IRP	Brief details about out –let arrangement For Type A IRP, whether the supply is intermittent or continuous Out-let water leading to any CWR For Type B IRP to what extent the user have to make extra pumping of HP	Testing of water in lab regarding iron content bacteriological etc.	Nothing specific	Ensuring involvement of Jalsurakhak/ASHA	Water quality report. Health data of user community

For Type C IRP domestic filters available in the market or to manufacturer, tackle problem of iron adopting various principles. Ascertaining effectiveness, limitation as well as maintenance requirements to ensure safe drinking water from water is must.

4. Construction of Flow Diagram with symbol

It is important to capture the elements of the water supply system in sufficient detail to enable the accurate assessment of risks and identification of control measures constructing flow diagram with symbol. The objectives of this step are therefore:

- Conceptually understand the water supply process through building a flow diagram;

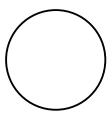
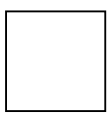
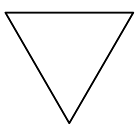
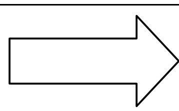
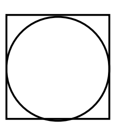
- Identify the linkages, water flow direction in the water supply process.

- A good conceptual flow diagram greatly facilitates the identification of hazards, risks and controls as it allows:

    - Identification of pathways by which hazards can be transferred to consumers; and
    - Identification of "critical control points" on the flow diagram

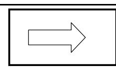
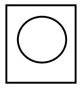
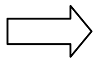
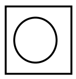
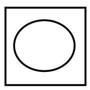
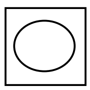
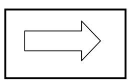
In Table I Process flow diagram symbols with brief definition presented

FIGURE- 3
Process flow diagram symbols with brief definition

Flow Diagram Symbol	Definition of Symbol
	Operation: Indicates when there is an operation or group of operations that result in intentional change in the water.
	Inspection: Represents an inspection or decision. Eg. water supply is examined or is verified.
	Storage: Where water is stored.
	Transport: Occurs when the water is moved from one place to another.
	Combined activity: Indicates activities performed either concurrently or by the same operator at the same location. Any combination of symbols may be used. Example shown indicates a combined operation and inspection.

Using the symbols of Table I information related with process flow with symbol for Type A& Type B, IRP may be captured in the format as shown in Figure 4.

Figure 4 : Format for capturing information related with process flow with symbol for Type A & Type B IRP system

Indicating steps of process flow with symbol	Description
	Inlet water to IRP- Transportation and Inspection
	Aeration system- Inspection and Operation
	Initial Sedimentation- Transportation
	Sedimentation Chamber- Inspection and operation
	Filtration unit - Inspection and Operation
	Back-washing unit-Inspection and Operation
	Out-let water from IRP- Inspection and transmission

5. Hazards Analysis & Risk Prioritization

It is the most important activity of WSP process .Steps expected to be worked through, are:

- Identify the hazardous events that can result in hazards gaining entry to the GFWS system
- Determine the risk potential of each hazardous event
- Identify the control measures currently in place;
- Suggest any additional control measures required

Typical challenges

- Since a risk assessment provides a ‘point in time’ picture of the system, the risk assessment should be reviewed on a regular basis in order not to miss new hazards and hazardous events.
- Uncertainty in assessment of risks due to unavailability of data, poor knowledge of activities within the water supply chain and their relative contribution to the risk generated by the hazard or hazardous event.
- Risk mitigation practices may be a)Pro-active ,b) Reactive c)Emergency or combination of two or more
- Need of development of emergency response plan is critical

For both Type A & Type B IRP a simplified risk prioritization process, drawing on the team’s judgment may be carried out.

In this process risks may be ranked as 'significant', 'uncertain', or 'insignificant', based on an assessment of the hazards/hazardous events at each step in the process. In Table II definition of descriptors for use in simple risk prioritization is provided

Table-4, Definition of descriptors for use in simple risk prioritization

Descriptor	Meaning	Comments
Significant	Clearly a priority	The risk should be considered further to determine whether additional control measures are required and whether a particular process step should be elevated . It is necessary to validate existing control measures before defining whether additional control measures are required.
Uncertain	Unsure if the event is or is not a significant risk	The risk may require further studies to understand if the event is really a significant risk or not.
Insignificant	Clearly not a priority	The risk need to be described and documented and will be revisited in future years as part of the WSP rolling review.

Suggestive information capture format for simplified risk prioritization process of IRP Type A & Type B provided in Table 5.

Table 5, Information capture format for simplified risk prioritization process of Type A & Type B IRP (Suggestive)

Activity/ process Step	Hazardous events and Hazard Type	Risk Prioritisation	Existing control measures Existing control measures	Additional control measures propose
Inlet water quality and quantity	a)Detection of microbial contaminants water Hazard Type Microbial b)Detection of chemical and physical contaminants which cannot be treated in the IRP or likely to interfere in the process of treatment Hazard Type Physical Chemical c)Quantity of flow less than design, due to problem of source Hazard Type Physical No flow due to break down of the source Hazard Type Physical & Microbial	a)Significant b)Uncertain c) Significant	a)Time to time water testing with H2S strip, Not effective follow-up b)No effective control c)No effective control d)No effective control	a)Testing in lab. Initiate Prompt follow up action to prevent microbial contamination b)Need of initiating effective steps to control, properly diagnosing the reason c)Adequate measures for source sustainability

		d)Significant		need to be initiated d)Adequate measures for source sustainability by ensuring preventive maintenance During idle item, preventive measures to be taken so that no microbial contamination get induced in the IRP system Whenever IRP to be re-started after idle time, the system need to be disinfected thoroughly Particularly in case of IRP Type B prior to installation of IRP reliability of source need to be ascertained
Aeration system (including initial settlement of iron precipitation)	a)In open roof aeration systems induction of contamination carried by bird, air Hazard type Physical Chemical Microbial b)Unhygienic operational practice may induce Hazard Hazard type Physical Microbial etc. c)In-adequacy in the aeration arrangement Hazard type Physical Chemical	a)Uncertain b)Significant c)Significant	a)To avoid bird hazard in some cases, aeration chamber covered with net b)No specific action for improvement c) No specific action for improvement	a)Examine whether any other effective steps can be taken to minimise bird nuisance etc. b)Imparting appropriate training to the operating staff, to improve the operational efficiency & hygienic practices c)Action plan to be prepared to modify aeration arrangements to suit the requirements
Sedimentation Chamber	a)If the settled deposition not cleaned at regular interval, it may interfere with proper functioning of sedimentation and cause of hazard	a) Significant	a)Sedimentation chamber cleaned occasionally	a)Proper supervision should be kept to ensure regular hygienic cleaning

	Hazard type Physical Chemical Microbial b)In-adequacy in detention period, surface area, depth, etc. sludge disposal ,inlet-outlet arrangements etc. Hazard type Physical Chemical Microbial	b) Uncertain	b) No Specific action for improvement	of sedimentation b)Scope of modification to be explored and incorporated
Filtration Unit	a)Design and construction in-adequacy of the unit Hazard type Physical Chemical Microbial b)Poor O& M as well as un-hygienic practices in operation Hazard type Physical Chemical Microbial c)Crack in filter media, causing short circuiting contamination Hazard Type Physical Chemical	a) Significant b) Significant c) Uncertain	a) Addressing the short-comings in ad-hoc manner b) Instruction issued to operating staff time to time for ensuring better O&M and hygienic practices c) Preventing to keep filter dry	a)As a long term measures necessary corrective modification to be in-corporated ,scientifically investigating the gap, b) Need better supervision, effective back-up of training support Need better supervision
Back washing/washing system of filter media	a)Any deficiency in quality, quantity pressure head etc. may hamper in proper washing of filter media resulting clogging causing hazard Hazard Type Physical Chemical Microbial b)For slow sand filter washing if adequate care is not taken to avoid unhygienic practices chances of getting contamination induce very high Hazard Type Physical Chemical Microbial	a)Significant b)Significant	a) No specific measures for improvements b) Instructions issued to the operating staff regarding proper and hygienic washing of slow sand filter	a)Remodelling back-washing system for incorporating back washing efficiency preventing possibility of recontamination b)Supervision and imparting proper training to the operating functionaries
Out-let water from IRP	Quantity and quality of water adequate, safe and acceptable			

6. Operational monitoring schedules & Control measures

In WSP process operational monitoring is the act of conducting a planned sequence of observations or measurements, to assess whether the control measures applied at a point in the system are achieving their objectives. Effective monitoring relies on establishing:

- What will be monitored;
- How it will be monitored;
- When it will be monitored;
- Where it will be monitored;
- Who will do the monitoring

For some control measures, it may be necessary to also define 'critical limits' outside of which confidence in water safety would be lost. Deviations from these critical limits usually require corrective actions. Corrective actions should be specific wherever possible, including assigning responsibilities for carrying out the corrective actions. In Table 6, a suggestive format for capturing Operational Monitoring Schedule etc. is presented

Table 6, Information capture format for Operational Monitoring Schedule etc. for Type A & Type B IRP

Process Step	Parameter to be monitored	Monitoring Process		Critical Limit	Corrective actions	
Inlet water to IRP	Water quality on selected parameter, ascertaining rate of flow	What	Testing of water quality on selected parameter, Ascertaining rate of flow Ascertaining discharge of the source of	No microbial contamination is permitted, no physical and chemical contamination other than iron of specfied range is permitted	What	Source of microbial contamination to be detected and eliminated provision of treatment any other chemical contaminants if required may be made

		How	Lab. Testing for water quality and measurement of flow observing standard method		How	Sanitary inspection of deep tube-well in case of Type A IRP , in case of Type B IRP in addition to sanitary inspection ensure plat-form around HP , modify design of IRP (if required),to take care of any other chemical contaminants detected
		When	Monthly twice for Type A IRP, Once in three months Type B IRP		When	Immediately after detction
		where	At the in-let point of IRP		Who	VWSC,/ Pani Samiti members LI Agency Type A IRP, for Type B IRP user's committee etc
		Who	Operating staff for Type A IRP, care taker for Type B IRP			
Aeration system	Hygienic operation & Effective functioning of the unit	What	No congregate and defecation birds pipes and valves are clean, strict hygienic standard maintained by personnel engaged in operation, no clogging etc. in the pipes nozzle etc	Defecation by birds , un-hygienic practices of the operating staff, unclean pipes etc should not introduce pathogenic contamination	What	Preventing bird nuisance. maintaining hygienic practices and cleanliness
		How	Inspection		How	Eliminate the cause which can attract birds ,motivating grass root operator to improve hygienic practices and cleanliness
		When	Regularly		When	Regularly
		where	Aeration Chamber		who	VWSC,/ Pani Samiti members LI Agency Type A IRP, for Type B IRP user's committee etc
		Who	VWSC member for Type A IRP, User group for Type B IRP			

Sedimentation Chamber	Water quality including microbial contamination, proper Operation & Maintenance of the unit	What	Testing of water quality on selected parameter, Ascertaining regular cleaning of precipited iron etc. deposited in the chamber, inlet out let arrangement functioning properly Ascertaining discharge of the source of	No microbial contamination is permitted, sludge deposition , inlet-outlet arrangement etc. should not effect the desired performance of settlement	What	source of microbial contamination if any to be detected and elimination , regularity in sludge removal to be maintained ,hygienic Operation &Maintenance to be ensured
		How	Lab. Testing for water quality , inspection of sludge removal and inlet-outlet arrangements etc.		How	Inspection, preventive steps to eliminate the possibility contamination , motivating grass root operator to improve hygienic practices , regular removal of deposited sludge etc.
		When	Every month in Type A IRP and once in three months in Type B IRP		When	At regular interval
		where	Sedimentation Chamber		who	Functionaries of VWSC for Type A IRP. User group for Type B IRPF
		Who	VWSC member for Type A IRP, User group for Type B IRP			
Filtration Unit	Water quality including microbial contamination ,proper and hygienic Operation & Maintenance of the unit etc	What	Testing of water-quality on selected parameter including microbial, adequacy of design and performance ,maintenance of hygienic practices, regularity in washing of filter media	No microbial contamination can be permitted. back washing/ washing of filter media at regular interval extremely important. If filter media get clogged , the iron precipitates may	What	source of microbial contamination if any to be detected and elimination , regularity in back washing/washing to be maintained, hygienic Operation &Maintenance to be ensured

		How	Lab.testing of water quality and structural observation on functioning of filter	penetrates through the filter-bed and appear in the treated water.	How	Strengthening preventive steps to eliminate potential source of contamination, imparting training to field level operating staff for hygienic and better O&M
		When	Monthly twice for Type A IRP, Once in three months Type B IRP		When	As and when required both for Type A & Type B IRP
		where	Filter Unit		who	Functionaries of VWSC and Operating Staff for Type A IRP. User group and care taker for Type B IRP
		Who	Operating staff for Type A IRP, care taker for Type B IRP			
Back Washing / Washing system of filter	Quality , quantity and pressure head of water for back washing . Hygienic maintenance for washing by scrapping	What	Ensuring quality of back-washing water, particularly regarding microbial contamination, adequacy of quantity and pressure head of water during back wash. Maintenance of hygienic practices during scrapping and replacement of sand	Microbial contamination of back wash water will contaminate filter .Un-hygienic practice during filter wash also may contaminate .Inadequate back -wash with lesser quantity and inadequate pressure, will not be able to serve the due purpose	What	Source of microbial contamination to be detected and eliminated , adequate water pressure and quantity for back-washing to be ensured, Hygienic operation standard to be maintained
		How	Lab testing of water, structural observation		How	Strengthening preventive steps to eliminate potential source of contamination, imparting training to field level operating staff for hygienic and better O&M . If required necessary modification in back-washing arrangement may be in-corporated
		When	Monthly twice for Type A IRP, Once in three months Type B IRP		When	As and when required both for Type A & Type B IRP
		where	Back washing tank, filter unit		who	Qualified Technical staff Functionaries of VWSC and Operating Staff for Type A IRP. User group and care taker for Type B IRP
		Who	Qualified technical personnel for both Type A & Type BIRP,			

Out-let water	Quality , quantity of water and user satisfaction as well as health data of community	What	Water is safe for drinking and cooking and iron content within permissible limit and the quantity of water as designed, user satisfaction	Water should not contain any harmful contaminants ,which compromise with safety and acceptability of water for drinking cooking , washing and other domestic purposes. Flow rate ,should not be in variance from design requirements	What	For any short comings corrective measures need to be initiated
		How	Lab testing of water quality ,regular interacting with user group, assessing flow of outlet water adopting any standard method		How	Scientifically investigating the reason ,duly consulting the expert wherever necessary, action plan for corrective measures to be developed
		When	Monthly twice for Type A IRP, Once in three months forType B IRP		When	As and when required both for Type A & Type B IRP
		where	At the out-let point of IRP		who	Expert group, LI Agency, user group etc.
		Who	Jalsurakhak/ASHA/ user group			

7. Supporting Programme

Supporting Programmes are those activities that indirectly support water safety, they are also essential for proper operation of the control measures. Supporting Programmes cover a range of activities including communication and capacity development, preventive maintenance and hygiene and sanitation as well as legal aspects such as a programme for understanding the organisation's compliance.

Suggestive format for capture of Supporting Programmes is provided in Table 7

Table 7, Information capture format of Supporting Programmes that could be included in the WSP (not exhaustive)

Programme	Purpose	Examples
Communication & Capacity Development	Success of effective planning and implementation of WSP for IRP to a great extent depend upon the awareness and commitment of the stake-holders of different level which need to be enhanced Skill of the operating staff is most important.	• Developing Information Education Communication (IEC) material to enhance the effective participation of various level stake-holders in WSP • Organising training for upgrading skill for operating staff of IRP
Strengthening Laboratory infrastructure	In-adequate laboratory facilities is one of the major constraints in planning and implementation of WSP in practice. Strengthening laboratory infrastructure need priority	• Manning the existing laboratories with qualified skilled personnel • Setting up of new laboratories at Sub-div level Net-working with PHC Lab
Calibration	To ensure that critical limit of monitoring is reliable and of acceptable accuracy.	Analysing health data co-relating with critical limit
Preventive maintenance	To ensure that malfunctions of important processes of IRP are minimised and assets are in good working order.	• Putting in practice effective preventive maintenance programme • Adequate inventory of spare material /parts to be kept to attend the repair
Hygiene and sanitation	To prevent personnel involved in operation and equipments used in the iron removal system from inducing hazards to the water.	• Hygienic code of conduct of personnel involved in the regular operation must be put into practice • Strict cleanliness of the plant to be maintained
Promoting cost recovery and community involvement	For effective O&M and putting WSP into practice need resources ,tapping resources from users and ensuring their involvement in this regard is most important.	• Evolving effective affordable cost-sharing mechanism • Creating opportunity for the involvement of the community in the process
Attending user complain/suggestion	Enhancing user confidence level regarding reliability of the system Enhancing acceptability of IRP	• Regular dialogue with user group • Action taken on feed-back from user
Research & Development	Action Research on relevant topics of IRP of WSP may help to a great extent in perfecting the system	

8. Verification Schedule

Establishing procedures to verify that the water safety plan is working effectively and will meet the health-based targets is a vital requirement in WSP approach . Such verification broadly may involve two activities that are undertaken together to provide a body of evidence that the WSP is working effectively and will meet the desired objective.

- Water quality monitoring; and
- Auditing of operational activities.

In rolling programmes of verification, for water quality monitoring the main emphasis is likely to be on a single or very limited range of microbial indicators. It is likely that the majority of tests will be for E.coli.

Auditing of operational activities should include checking that consumers are satisfied with the water supplied. It is important that consumers are using the safe, managed water supply rather than less safe alternatives.

In Table-8, Information capture format for verification may be seen

Table-8, Information capture format for verification

Activity	Description	Frequency	Responsible Party	Records
Effectiveness of WSP process in achieving health based target	Analysis of Health Data of community served by the system maintained by NRHM and water analysis reports Water analysis reports	For Type A IRP- Every three months For Type B IRP – Every six months For Type C IRP- checking random	For Type A& Type B IRP WSP team, VWSC and NRHM For Type C IRP , VWSC and NRHM	Health Data of community served maintained by ASHA (NRHM) Water analysis reports
Accuracy of Laboratory Testing	Results of percentage of sample tested may be verified by testing in Referral Lab.	5% of the sample tested as a part of WSP activity	Jalsurakhak, ASHA	Data of Water Quality Analysis carried out both as routine as well as in Referral Lab.
Compatibility of the IRP system	Efficiency of the system in the context of removal of iron, as well as for simplicity and cost-effectiveness of O&M	Every six-months	VWSC ,users committee	

Auditing status of the Water Security of the user HH. Checking satisfaction level of the user of the system Verifying users are not using alternative unsafe source rejecting the system	Situation study, meeting and interacting with community, Visit to HH to ascertain ground realities	On regular basis	Subject Expert/ ASHA /grass root worker of LI Agency, Partner Agency, NGO etc.	Evaluation Report etc.
Effectiveness of the training imparted for skill development to the operating staff of Type A IRP, Type B IRP and user group Of Type C IRP	Observing on the job, performance of the personnel trained before and after training	As and when required	Experts /Communication & Capacity Development Unit functionaries	

9. Validation Schedule to ascertain system capability

Validation involves obtaining evidence that the activities taken up supporting the WSP is correct and that the operation of the water supply in accordance with the WSP will be able to achieve the desired health-based targets. Validation normally includes more exclusive and intensive monitoring than routine operational monitoring.

Validation schedule need to be so prepared, that such exercise in a position to ascertain that the overall system design and operation is capable of consistently delivering water of the specified quality to meet the health-based targets

A suggestive information capture format for validation may be seen in Table-9.

Table-9, Information capture format for validation(Indicative)

Item Validated	Hazardous Events	Validation Schedule	Comments
Preventive measures to control microbial contamination to in let water of IRP	Microbial Contamination getting detected in aerated water, in spite of preventive measures to control microbial contamination to inlet water of IRP	Analyse and co-relate water quality data of inlet water to IRP , re-visiting the preventive measures initiated to maintain inlet water to IRP free from microbial contamination effective	Microbial contamination induced through the inlet water may contaminate the IRP system, consequently during the treatment through IRP, water may got contaminated

Aeration process of Type A and Type B IRP	Aeration process is not adequate to oxidise the desired iron content proposed to be removed from raw water	In-corporate necessary modification in the aeration process availing the expert opinion for enhancing oxidising capabilities of aeration process	The process of iron removal is more complicated than it seems The solution for removal of iron consider involves 50 percent science and 50 percent experience. For any problem solution expert opinion is important.
Specification of quality of filter media and their depth	Filter media not in position to retain the entire precipitated iron	Assess the short-comings in the specification prescribed for the filter media, through reality checking incorporate modification	Filtration is the most vital step of IRP process.
Effectiveness of Type C IRP	Many of the Domestic filters failed to remove iron content from water as claimed by manufacturer.	The issue may be taken up with manufacturer	
Code of Hygienic Practices prescribed for operating staff of Type A & Type B IRP	Hygienic Practice adopted during O&M of IRP proved to be not adequate	Evaluate the relevant instruction issued for compliance, training methodology etc. Incorporate any improvement required through participatory process	Effective hygiene practices in O&M most vital

10. Action Plan for Improvement

When the assessment of the drinking-water system indicate that existing practices and technologies of IRP not adequate to ensure drinking-water safety, as a part of full planning and implementation of WSP plan . an action plan for in-corporating corrective measures for addressing the in-adequacy need to be developed which may include both short-term or long-term programmes.

Realistic assessment of fund requirement for implementation of improvement plans and careful prioritization of issues in accordance with the outcomes of risk assessment also need to be done . Implementation of plans should be monitored to confirm that improvements have been made according to action plan and are effective.

A suggestive format for incorporating information related with Action Plan for Improvement in the WSP plan as discussed presented in Table 10

Table-10, information capture format. for Action Plan for Improvement

Issues identified for requirement of improvement	Approach to be adopted for carrying out improvement	Short term/long term	Time frame for implementation	Approximate fund requirement	Responsible for improvement	Degree of priority
Aeration system is not adequate	Analyse raw water quality testing report, av. hourly flow Existing aeration arrangements identify the gap, develop corrective plan. Incorporate necessary modification	Long term	One month	Rs 10,000/ (Type AIRP)	LI Agency	Priority medium
Water losses due to leakage in sedimentation & filtration unit	Identify the leakages conducting water tightness tests Carry out repair of leakage	Long term	Three days	Rs 1,500/ (Type B IRP)	User Committee	Priority medium
Remodelled the existing filter to up-flow filter to minimise Operation & Maintenance problem Type B IRP	Develop remodelling plan, properly studying existing arrangements	Long term	Fifteen days	Rs 2,500	User committee	Priority low
Providing factual information regarding range of iron-content and other water quality parameter which can be treated in particular type of Type C IRP including limitation	Various types of domestic filters for iron removal presently getting marketed and manufactured with a high claim of various treating capabilities, which in reality found to be not correct. Mechanism at National, State and District level must be in-place to provide user factual information for guidance	Long term	Continuous activity		RGNDWM, CSIR Lab, SWSM, DWSM USER GROUP Etc.	Priority medium
Methodology of training imparted, as a part of technology transfer for both Type B & Type C IRP	Masons Training methodology etc. adopted by Rural Sanitary Mart(RSM) CCDU and other establishment to be evaluated , identify the gap Initiate corrective measures	Long Term	Continuous		CCDU & DWSC functionaries	Priority Medium

End Points

Planning and implementation of WSP is a continuous process , required continually revisiting to ensure that they remain up-to-date and relevant.

Chapter-13

"Pump and tank water supply for single village"

Pump and tank water supply for single village

1.0 Introduction

There are many ways to cover rural population under safe drinking water supply. Though spot sources are the common method to provide water in rural areas, piped water supply schemes are also being implemented. Uncovered habitations are located mainly in isolated pockets where population is not big. For such habitations, it is difficult to justify big or medium-piped water supply schemes. One of the options in those areas could be pump and tank water supply systems. Such schemes are small and can be habitation specific. Local community can also easily implement and maintain such schemes without much external support. In this system, a small drinking water source is to be created first and then water is to be supplied to the villagers by pumping. Considering need of the villagers, either single tank near the water source or multiple tanks at different locations of the habitation could be provided in such water supply systems. In case of providing multiple tanks, distribution lines are to be laid to cover the entire habitation.

2. Water Supply Process Description

For any program, there are certain processes through which the objective of that program is achieved. The main processes involved in case of pump and tank type of water supply schemes, starting from catchment to till it reaches households, are mentioned below:

Source: Precipitation, storage, runoff and evaporation of earth's water follow an unending sequence known as the hydrologic cycle. During this cycle, the total amount of water in the atmosphere and in or on the earth remains the same; however, its form may change. A portion of rainfall flows across the ground surface until it reaches the stream, after which it flows to the ocean. A small portion of the rainfall is also stored in water bodies over the surface of earth as pond, lake etc. The remaining portion infiltrates directly into the ground and seeps downward and becomes part of the groundwater body. Seepage from streams, lakes and other water bodies is also another important source of recharge.

In pump and tank water supply scheme, the source of water can either be groundwater or surface water like pond, lake etc. Rainwater percolates through the soil pores and is deposited as groundwater. Thus, this water is generally free from suspended particles. However, chances of chemical contamination are there if ground strata through which the rainwater percolates contains soluble chemicals. If groundwater contains toxic chemicals like arsenic, fluoride etc beyond permissible limit, it cannot be used for drinking purpose until the chemicals are removed by specific treatment. Otherwise, after lifting groundwater, it can be supplied directly to the consumers. Surface water on the other hand, is not generally very clean and free from suspended solids. Moreover, surface water is also bacteriologically contaminated. Thus, in case of its use as drinking water, it is to be treated first for removal of suspended solids and then disinfected properly.

(a) Treatment: Generally, chemically contaminated groundwater is not considered for drinking purpose as, treatment of chemically contaminated water is troublesome and invites recurring cost, hazards and effort. If any other water source is not available, then only it is used. There are many technologies for removal of chemical contaminants. In some cases, removal plant is attached with the tube well while in other cases; it could be a separate treatment plant. In case of use of surface water, the raw water is to be tested for certain parameters. If turbidity of raw water is within permissible limit, it can be treated by slow sand filtration or any other method. If turbidity is on higher side, it should be lowered for filtration. As surface water is bacteriologically contaminated, the treated water is to be disinfected. Disinfection is accomplished by adding chlorine depending on the demand. Usually bleaching powder is used as the source of chlorine.

(b) Transportation: On lifting of water from the tube well with the help of pump, it can be either pumped directly to the distribution system or, pumped to an overhead storage tank. Water can then be supplied from the overhead tank through the distribution system. Single or multiple tanks can be provided at convenient locations to facilitate collection of water by the villagers.

(c) Water Quality Requirements: The quality of the water must satisfy the quality standard prescribed by the BIS (IS10500) or Manual on Water Supply and Treatment published by the Ministry of Works and Housing. The chemical water quality parameters viz, pH, turbidity, iron, chloride, fluoride, hardness arsenic etc will be tested as prescribed by the Government of India in addition to the bacteriological analysis While testing of all chemical parameters is to be undertaken at least once in a year, bacteriological quality is to be tested on regular basis.

(d) Handling of water at House Holds: Special care has to be taken to see that water do not get contaminated at household level. For this purpose, safe storage and handling of drinking water is to be ensured. A good practice of hand washing before touching the pitchers must be adopted. Besides, the containers shall always be kept covered; water may be collected from the container either tilting the pitcher of with the help of a ladle. The containers shall also be cleaned regularly.

3. Technology description including sanitary map of the water catchment

Generally, in pump and tank type of water supply schemes, the following measures are to be taken:

a) Creation of the water source: This is the most important component of any water supply scheme. For tank and pump type of water supply schemes, either a tube well or any surface water body could be the source. In places where exploration of groundwater by sinking tube well is easy and convenient, the source could easily be a tube well. However, before sinking of tube well, it is to be examined that the source is sustainable. Availability of water round the year is to be ensured. Adequate care should be taken while locating and sinking the tube well. Sanitary survey and mapping of catchment should be done before the source is developed.

During construction of the tube well, the requirement of water of the population to be served is to be kept in mind based on which the length of tube well assembly and aquifer that is to be tapped will depend. The Upper well casing should suit the requirement of the pump that is to be lowered in the tube well. Selection of type of tube well assembly is also important. These days, there are very good options for use of different kinds of plastic pipes.

In areas where there is lot of rainfall, there are small or big rivers or other traditional surface water bodies like lake, pond etc. Many of them have sufficient water even during the lean periods. These types of surface water can easily be used to serve drinking water to small communities. In case of use of surface water for drinking purpose, the water is to be treated suitably. Before selection of the water source, the raw water is to be tested for certain parameters. If turbidity of raw water is within permissible limit, it can be treated by slow sand or any other filtration method. In case, turbidity is beyond permissible limit, turbidity should be lowered either by providing suitable settling tank or by providing any type of roughing filter (horizontal or up flow). It is convenient to locate the treatment plant near the water body. After treatment, the treated water may be stored in the clear water reservoir (built near the treatment plant) wherefrom the water can be supplied by pumping.

b) Lifting of water from the tube well: Water can be lifted from a tube well with the help of pumps. Two different drive arrangements exist for water pumping from tube wells: shaft driven (vertical turbine pump) and close coupled submersible motor (submersible pump).

In case of shaft driven pumps, the crankshaft or motor is placed at the ground surface and powers the pump using a vertical drive shaft or spindle. In such case, a long drive shaft will need support at regular intervals along its length and flexible couplings to eliminate any stresses due to misalignment. The advantage of drive shaft is that the drive mechanism may be set at ground or in a dry pit. Thus, this will be readily accessible for maintenance and repair. Here, accurate alignment of the shaft is necessary. Again, shaft-drive arrangement is not possible in crooked tube wells. In case of close-coupled submersible electric motor driven pump, a centrifugal pump is connected directly to an electric motor in a common housing, with the pump and motor as a single unit. This unit is developed for submerged operation in the water to be pumped. Very often, the pump-motor unit is termed as submersible pump.

In earlier days, mostly, vertical turbine pumps were installed to lift water from tube wells. However, due to inherent problems of vertical turbine pumps as stated above, these days, use of submersible pumps has gained popularity.

c) Distribution system to the community: Once the source is created, the water is to be pumped either from the tube well or from the treatment plant site for distribution to the community. This can be done in two ways. Water can be pumped directly to the distribution system with the help of delivery head of the pump lowered in the tube well or by clear water pump of treatment plant. In such case, no overhead reservoir is to be constructed. This can be best suited for a habitation or hamlet of smaller population where provision of overhead storage tank could be avoided. However, if drinking water is to be served to a comparatively larger community, it may be better if an overhead storage tank is provided. In this case, the water is to be transmitted to the overhead tank by a rising main and then it is to be distributed with the help of distribution system to be laid from the overhead tank.

To facilitate collection of water by the villagers, either stand posts or small water tanks could be provided at convenient locations of the village. In case of stand posts, the villagers would be in a position to collect water during supply period only. However, in case of provision of water tanks, the tanks would be filled up during supply period and, the villagers would be in a position to collect water from the tanks at their convenient time. If the habitation is small, a single tank can be provided near the water source. However, if the habitation is comparatively bigger, several tanks could be provided to ease collection of drinking water by the villagers. At least one water tank is to be provided for 20 families. The size of the water tank can be determined based on the families to be served by a tank. For example, if a tank is meant to serve 20 families and, water is supplied two times a day, the capacity of the tank may be 2,000 litres (considering the norm of supply as 40 lpcd). Two or three self-closing taps can be provided in one tank.

d) Water quality requirements at various steps: If groundwater is used, the quality of water is to be tested just after sinking of the tube well to ensure that the quality of water conforms to the parameters as laid down in BIS 10500 for drinking water. Groundwater in many areas contains arsenic, fluoride, salinity or any other chemical components beyond permissible limit. Such water cannot be served to the community for drinking or cooking purpose.

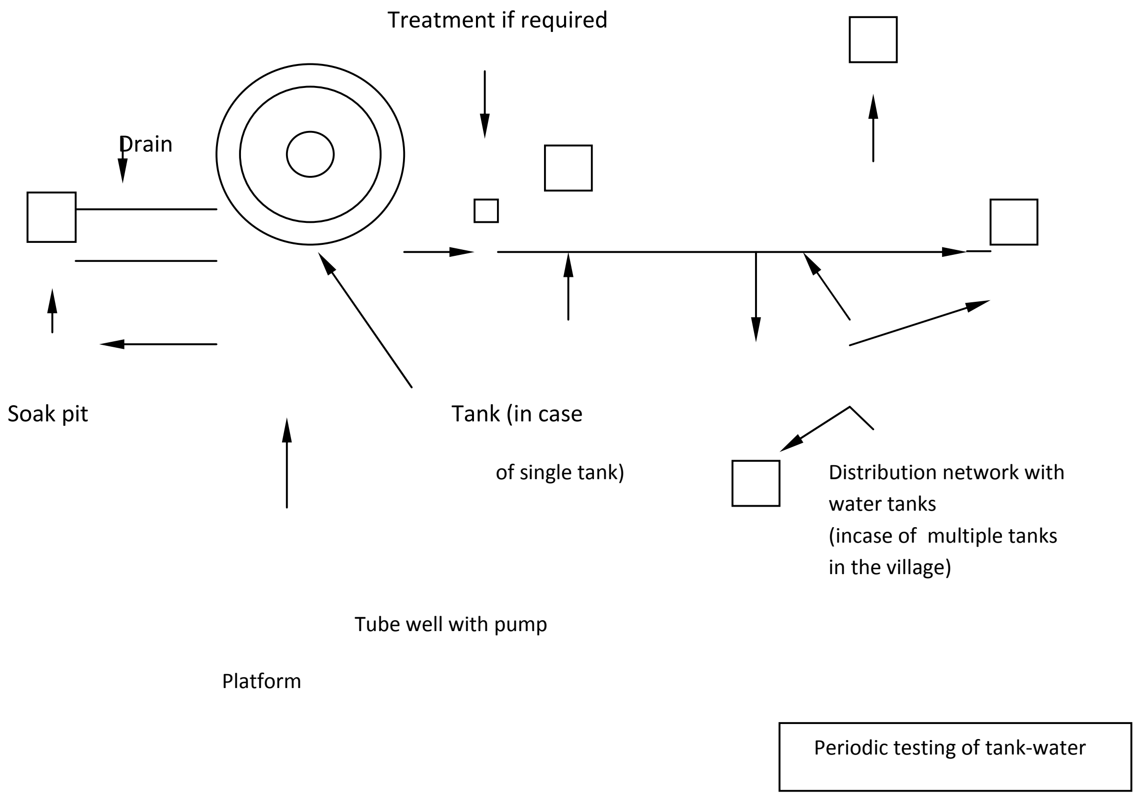
In case of use of surface water for supplying to the community, adequate precautions are to be taken to protect the water body from indiscriminate use by the villagers. Measures should also to be taken to protect the water body from external pollution through surface runoff from the neighboring areas (use of fertilizers, pesticides, insecticides etc). This can be done by constructing embankments surrounding the water body and launching awareness generation campaign amongst the community. The treated surface water should be disinfected properly. This can be done either chlorinating the water in the pipe line itself with the help of chlorinators or, by promoting home chlorination. Home chlorination can easily be done with the help of stock solution of sodium/calcium hypochlorite.

Format for capturing information regarding water supply process and technology, should be in the line as given in Table 1 and 2 of Chapter 3.

4. Flow diagram with labeling

Pump and Tank Water Supply System for single village

Process Flow Diagram



5. Hazards analysis

In case of pump and tank type of water supply systems, there could be potential hazards in areas like; quality of groundwater, defective construction of tube well, resulting availability of required quantity of water, contamination of the tube well water at ground level, contamination during repair of pump, non-availability of electricity, damage of pumps including availability of spares in time, availability of trained pump operator, mechanic, plumber etc in the village, pollution of surface water body, malfunctioning of water plant, contamination during distribution, running and maintenance of the scheme etc.

Nature and types of different kinds of hazards, causes for hazards, risk involved, control measures required to be taken for prevention of the hazards in respect to pump and tank water supply schemes have been indicated in Table 1.

Table 1: Hazard analysis

Process step	Hazardous events	Hazard type	Control measures	Risks	Additional control measures
Construction of tube well	Presence of arsenic, fluoride, iron, salinity or any other toxic materials beyond permissible limit	Chemical contamination of water	Testing of water and discarding water source if necessary	Toxic effect on human	Use of toxic contaminant removal plant
Construction of tube well	Poor yield from tube well	Non-availability of water	Selection and tapping of appropriate aquifer	Insufficient yield of water affecting supply	Geo-hydrological investigation Yield test of tube well
Construction of tube well	Contamination of tube well water at ground level	Bacteriological contamination	Provision of proper platform, drainage and soakage pit	Suffering of people from diseases	Providing cover and sanitary sealing of tube well Adequate distance of tube well from latrines etc
Repair of pump	Contamination of tube well water	Bacteriological contamination	Disinfection of pump and spares before lowering	Supply of bacteriological contaminated water	Disinfection of tube well water
Supply of water	Non-availability of electricity	Disturbance of supply	Provision of tandby generator	Non-availability of water by the villagers	Regular contact with electricity department
Supply of water	Non-functioning of pump	Damage of pump	Keeping ready stock of spares	Non-availability of water by the villagers	Availability of trained local mechanic
Supply of water	Disturbance in distribution system	Leakage or any other problem in pipe lines	Keeping ready stock of spares	Non-availability of water by the villagers	Availability of trained local plumber
Use of raw water for treatment	Contamination of surface water body	Contamination of supplied water	Stop rough use of the water by the villagers	Supply of contaminated water	Construction of embankment to arrest run off IEC campaign
Treatment of surface water	Improper functioning of treatment plant	Insufficient and poor quality of treated water	Routine check and maintenance	Non-availability of water by the villagers	Maintenance of stock of spares
Supply of water	Leakage in distribution system	Bacteriological contamination	Keeping ready stock of spares	Supply of contaminated water	Availability of trained local plumber Disinfection of distribution system
Process step	**Hazardous events**	**Hazard type**	**Control measures**	**Risks**	**Additional control measures**

Supply of water	Stoppage of water supply	Disturbance in supply	Availability of trained pump operator	Non-availability of water by the villagers	Availability of local standby operator
Maintenance of scheme	Availability of fund	Disturbance in supply	Collection of water tariff from villagers	Non-availability of water by the villagers	Availability of fund from panchayat

* In the above table hazardous event and risks have been described subjectively. However, it is preferable that in line with Table-4 of Chapter 3, the WSP team could quantify and prioritize risks.

6. Operational Monitoring Schedules

Operational monitoring schedule includes monitoring of control and other corrective measures that are to be taken to achieve desired objectives of the water supply schemes. For this purpose; various steps in the areas of performance indicator, monitoring process, critical limit, corrective actions, supportive program etc that are to be taken have been shown n the Table 2 below:

Table 2: Operational Monitoring Schedule

Process step	Performance indicators	Monitoring process	Critical limit	Corrective action	Supporting program
Quality of drinking water	**Parameters of drinking water**	**Testing of chemical quality and regular testing of bacteriological qualities**	**Within permissible limit as per BIS10500**	**Creation of alternate source in case of chemical contamination** **Disinfection in case bacteriological contamination**	**Ensure availability of services from the water testing laboratory** **If necessary, capacity of laboratories to be augmented**
Pumping of water	**Operation of pumps** **(hours)**	**Maintenance of log book for pump operator and pump**	**Operation time of pump to be ensured to produce and supply designed quantity of water (hours)**	**Vigilance over duty of the pump operator and action to ensure that the pump is always in running condition**	**Engagement of local people as pump operator and training of pump operators** **Make spares parts available**
Sanitary measures to protect water source	**No bacteriological contamination** **Presence of free residual chlorine**	**Regular testing of chemical and bacteriological quality of supplied water**	**Within permissible limit as per BIS10500**	**Disinfection in case of bacteriological contamination**	**Provide platform, drains, soak pit etc at tube well site** **Protective measures surrounding surface water**

					body Device for measuring residual chlorine Involve community IEC campaign
Process step	**Performance indicators**	**Monitoring process**	**Critical limit**	**Corrective action**	**Supporting program**
Collecti-on of water by villagers	Availability of required quantity of water for every family on time	Feedback from villagers	40 lpcd for each family	Ensure duration of supply Proper maintenance of distribution system	Involvement of users and launching of IEC activities
Stoppage of wastages of water	No leakage in pipe lines and water tanks Taps remain closed when not used	Involvement of users	Availability of water for each of the family	Timely repair of pipe lines, taps etc	Involvement of users and launching of IEC activities

7) Verification Schedules

To ensure proper functioning of the water supply schemes and, also to achieve the objectives of WSP; verification schedules for each of the activities indicating frequency of verification, the responsible agency for verification etc are to be institutionalized. This type of verification helps to understand whether the system is delivering water of specified quality and; what type of appropriate corrective measures are to be taken to avoid failures or lapses. The suggested verification schedule has been shown in the Table 3.

Table 3 Verification Schedules

Activities	Agency responsible for verification	Frequency of verification	Method of verification and how records would be maintained
Functioning of water supply scheme	VWSC/VHC	Once in a month	With the help log book maintained for pumps Feed back from the users based on format Records are to be maintained by VWSC
Availability of desired quantity of water	VWSC/VHC	Once in a month	Feedback from the villagers based on a prescribed format
Quality of water	VWSC/VHC and facilitator (water sample collector)	Once in a month	With the help of nearest water testing laboratory

			and residual chlorine measuring kit **Records are to be maintained by the VWSC**
Availability of fast and slow moving spares	**GP, pump operator, plumber and mechanic**	**Once in a month**	**Verification format to be developed by the SAE of the block**
Collection of water tariff, opening of bank account and maintenance of cash book	**GP Pump operator to collect water tariff** **Two authorized persons to sign cheques**	**Checking by VWSC** **Collection in every month** **Audit once in a year**	**To be verified by the representative of concerned GP** **To be audited every year by external auditors**

8) Validation Schedule

It is desirable to monitor proper functioning of the water supply schemes with the help of a structured validation schedule. This helps in identifying the loopholes and take appropriate corrective measures. The suggested validation schedules that are generally to be taken mainly for hazardous events involved in different processes of pump and tank water supply schemes have been shown in Table 4.

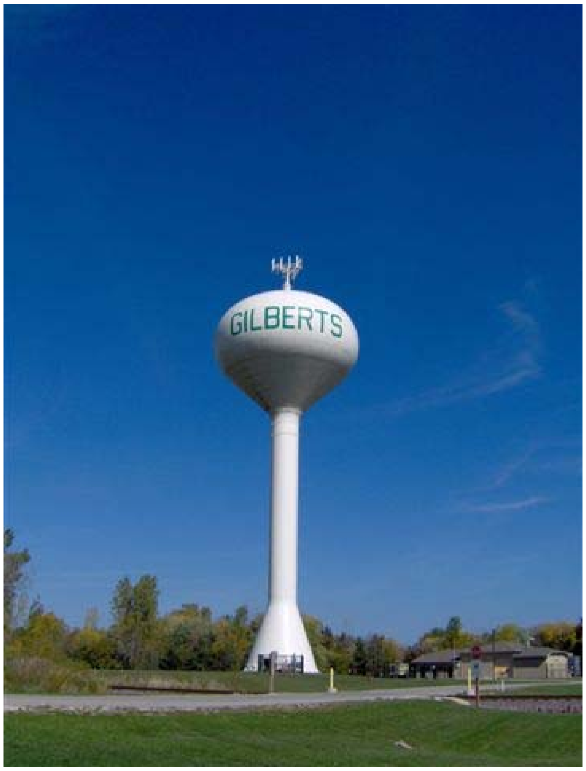
Table 4 Validation Schedule

Process	**Hazardous events**	**Validation**	
		Frequency	**Responsible person/agency**
Pumping and supply of water	Damage of motor and pump due to mechanical failure or short circuiting	Once the event occurs	Local electrician/ mechanic
Functioning of tube well	No yield or insufficient yield of tube well	Once in six months	Pump operator with the help of Sub Assistant Engineer, Rural Water Supply
Supply of water to consumers	Disruption of pipe lines due to flood or any other natural calamities	Once the event occurs	Local plumber
Supply of water to consumers	Bacteriological contamination of water in the pipe lines due to flooding or any other reasons	Once the event is noticed	Facilitator and local water testing laboratory

9) Improvement Action Plan

For any water supply schemes, improvement due to various reasons is necessary. From time to time, based on the consumer needs of water supply, hazards analysis, operation monitoring schedules, verification schedules and validation schedule; the scheme is to be improved and upgraded. The VWSC should examine all the reports, finding and recommendations and discuss all the issues in its meetings. Based on the recommendations, the VWSC should take up improvement plan to address the present problems and to take care of the future needs.

Chapter-14



"Multiple village piped water supply systems with conventional water treatment for surface sources"

Multiple village piped water supply systems with conventional water treatment for surface sources

1. Introduction:

Management of a multiple village rural water supply system including the surface water treatment plant, transmission mains and distribution systems involves a number of organizations at the state, district and village level for the effective operation, maintenance, monitoring and surveillance of the same. Given the existing institutional and regulatory set up and infrastructural facilities in the rural India for community water supply system, effective risk assessment and risk management would largely depend upon well-coordinated actions by the implementing agency at the state level and the agencies responsible for operation and maintenance at the district, block and habitation level. The water safety plan (WSP) for the system needs to address these primary concerns.

2. Water supply system description and analysis:

In developing the WSP, it is essential to ensure that the members of the team have a good understanding of both how the water supply is designed and operated and the needs of the people who are served by the supply. The first stage is therefore to develop a description of t he system, which may be supported by a basic flow diagram for the supply. This is followed by defining the intended use of the water and assessing the level of vulnerability of the varied end-user groups. The description of the water supply should include the following:

Source of water and catchment (for instance capacity of the source in relation to demand protection measures applied, developments in the catchment that may affect quality and known water quality problems);

treatment processes applied (providing information about configurations, numbers of individual units, age of plant, treatment efficiency at various steps)

storage within the distribution systems (how many service reservoirs, their volume, areas that they serve, age, etc)

distribution system (scopeand, extent, population served, known problems), proximity to human excreta and waste disposal systems/leakages and cross connection.

Consideration of re-contamination in household distribution and/or storage.

Describing the catchment and treatment processes should be relatively easy as data is known or can be readily acquired. When undertaking the preliminary system analysis, it is worth reviewing the data available to evaluate the likely source-water contaminant loads. For treatment processes, the literature can be consulted to identify expected reductions through individual treatment processes and this can be used as a guide to whether these will provide sufficient removal in relation to expected source-water loads. At this stage, it is also useful to prepare a diagram showing the flow of water through the treatment works, identifying each unit process and the location of principal inlets, flow control valves and dosing pumps as well as valves, backwashing tanks, etc. The diagram in this way gives a breakdown of the main treatment unit processes and the location of the principal pumps and meters. The location of the isolation and sluice valves may not be included in order to keep this stage of the summary simple. Once a thorough understanding of the source, catchment and treatment of the supply has been established, it is important to summarize the system as a whole, indicating the location of the service reservoirs and the general configuration of the distribution system, before providing a detailed description of the distribution system. This initial description can be summarized in the form of a simple flow chart. Once a detailed system description has been undertaken, an initial assessment can be made to ascertain if the water supply can, at least in principle, supply drinking-water within safe limits. This stage is critical as it determines whether there will be a need for investment in infrastructure in order to deliver safe drinking-water. For instance, if the water source is heavily contaminated surface water with seasonally high turbidity loads and the only treatment applied is rapid sand filtration and terminal disinfection, it is unlikely that safe drinking-water can be assured. By contrast, the same source treated with coagulation, flocculation, settling, rapid sand filtration and chlorination could assure safe drinking water.

2.1 Source

Most large surface water treatment based multi-village water supply systems draws water from large perennial rivers like Ganga, Brahmaputra, Yamuna, Godavari, etc. In India, most of these rivers are highly polluted and having very high faecal coliform count. Sometimes the MPN of faecal coliform count in these rivers exceeds from 50,000-100,000. The problem of chemical contaminations with heavy metal and pesticides is also an emerging critical issue. High suspended colloidal particles in another concern. As such monitoring of the source regularly and seasonally is a must. Depending on the source quality pre-treatment like pre-chlorination or pre-sedimentation might be required.

2.2 Treatment

Treatment would depend on the quality of the surface water sources. In case of low level of turbidity and faecal contamination the water could be treated by plain sedimentation followed by slow sand filtration and disinfections. However, if the turbidity is high and colloidal nature and microbial contamination is also high then full conventional treatment including primary sedimentation, flocculation, coagulation, rapid gravity filtration and disinfection would be required. For very high bacteriological count in raw water pre-chlorination may be necessary. Depending on the land use in the catchment area, the surface water sources might be contaminated with pesticides, and heavy metals and other toxic chemicals. In such an eventuality tertiary treatment like activated carbon and other physico-chemical processes might be required.

2.3 Transportation and Distribution

Generally for large surface water supply system, water from the river is pumped into the intake structure and from there through the various stages of the treatment plant; it is stored in the clear water reservoir after proper disinfection. From the clear water reservoir, the water is pumped through the trunk mains into the regional overhead storage reservoirs. Water is then supplied from the overhead tank through the distribution system to the consumers. In absence of house hold connection in most cases, consumers collect water from road side stand posts.

2.4 Water Quality Requirements

The quality of water for the consumption of the people must satisfy the quality standard prescribed by Bureau of Indian Standards (ISI 0500). All chemical and microbial parameters at the source, during the treatment and at consumption point should be tested as per prescribed guidelines of the GOI manual.

2.5 Handling of water at house hold level

Special care has to be taken to see that water do not get contaminated at household level during storage & handling. For this purpose, safe storage and handling of drinking water is to be ensured. A good practice of hand washing before touching the pitchers must be adopted. Besides, the containers shall always be kept covered; water may be collected from the container either tilting the pitcher or with the help of a ladle. The containers shall also be cleaned regularly.

The underground and overhead reservoirs of individual houses should be disinfected periodically. At the time of disinfecting household reservoirs, the water distribution lines, inside the building should also be disinfected thoroughly.

3. Water supply use details along with consumer needs:

As per erstwhile guidelines issued by the government of India for implementation of National Rural Water Supply Program (NRWSP), at least 40 liters per capita per day (lpcd) should be provided to meet the following requirements:

Table-1

Purpose	Quantity (LPCD)
Drinking	3
Cooking	5
Bathing	15
Washing utensils & house	7
Ablution	10
Total	**40 litres/capita/day**

However the present guideline on water quality safety and security envisage that all rural water supply systems should be based on water quality and quantity dictated by the community requirement at the household level. In addition, provision should also be allowed at 30 LPCD for animals in hot and cold deserts/ecosystem in 227 blocks of 36 DDP districts of the country. In case of surface water supplies, it is mandatory to disinfect the water. If disinfection is found to be inadequate before distribution, house hold disinfection is to be promoted with the help of Sodium/Calcium Hypochlorite.

4. Assessing water supply system and technology including the Catchment:

Useful information in assessing water supply system & technology including catchment

Table-2

Component of drinking water system	Information to consider in assessing component of water system drinking
Catchments	Geology and hydrology

	Meteorology and weather patterns
	General catchment and river health
	Wildlife
	Competing water uses
	Nature and intensity of development and land use
	Other activities in the catchment that potentially release contaminants into source water like open defecation/ waste disposal etc.
	Planned future activities
Surface water source	Description of water body type (e.g., river, reservoir, dam)
	Physical characteristics e.g., size, depth, thermal stratification, altitude)
	Flow and reliability of source water
	Water quality (physical, chemical, microbial)
	Recreational and other human activity
Treatment	Treatment processes (including optional processes)
	Equipment design
	Monitoring equipment and automation
	Water treatment chemicals used
	Treatment efficiencies (Of all unit operation)
	Disinfection /removal of pathogens
	Disinfectant residual / contact time
Service reservoirs and distribution	Reservoir design
	Retention times
	Protection (e.g., covers, enclosures, access)
	Distribution system design
	Hydraulic conditions (e.g., pressures, flows)
	Backflow protection/cross connection with waste water
	Disinfectant residuals
	Leakage/Leak detection
	Proximity to sewer/on-site sanitation
Stand Posts House hold Storage & Handling	Construction and Material
	Platform
	Proximity to on-site sanitation
	Residual disinfectant
	Cross connection with waste water line
	Protection and disinfection of underground and overhead domestic reservoirs
	In house handling and storage

5. Flow Diagram:

- Low turbidity, Low Faecal Contamination of the surface water sources (Fig. 1)
  High colloidal turbidity, High Faecal Contamination of the surface water sources (Fig. 2)
- 2+ Heavy metals and pesticides (Fig. 3)

Figure 1:

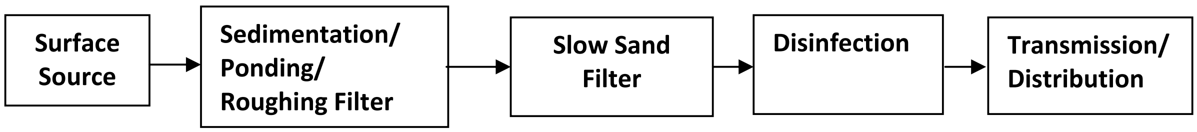


Figure 2:

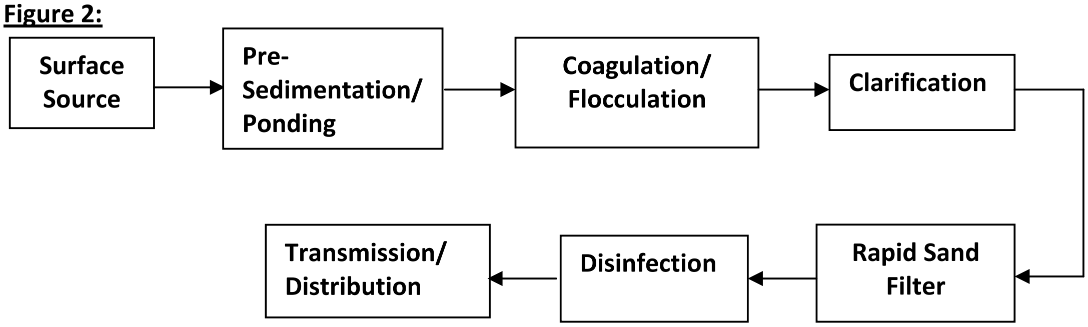
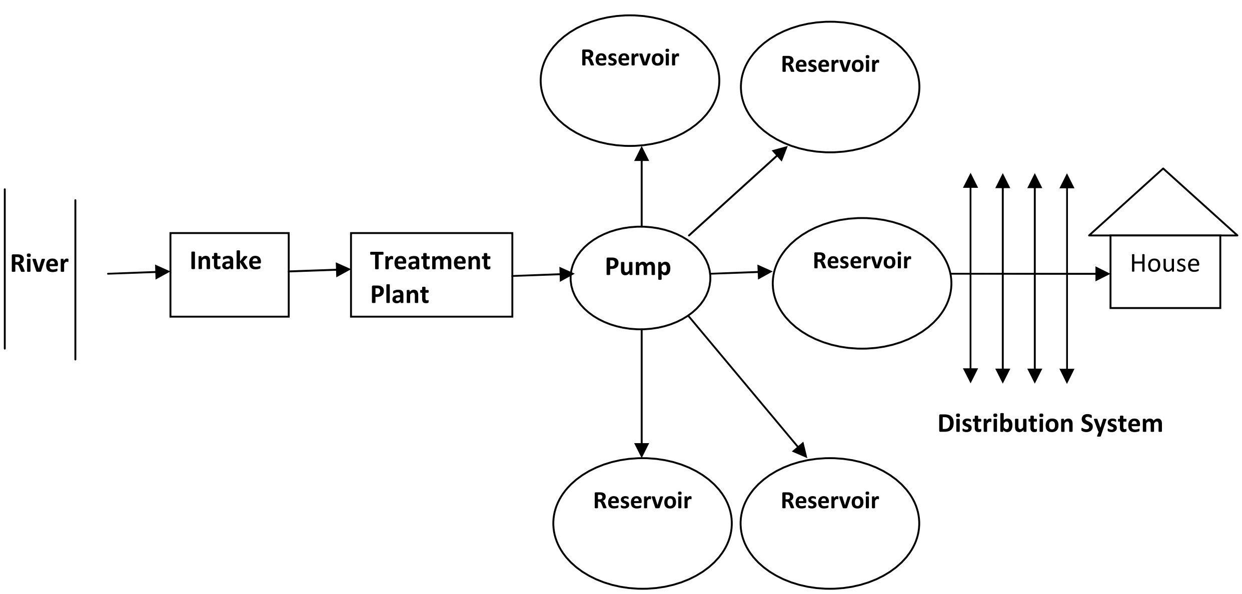


Figure 3:

Same flow diagram as in Fig. 2, with additional tertiary treatment (Activated carbon adsorption) for removal of toxic heavy metals / pesticides.



Typical Layout of a Multiple Village Water Supply System

6. Hazard Analysis:

In case of water supply systems, based on treatment of water drawn from surface sources, there could be potential hazards and risks in areas like quality of the water of the surface sources, operation and maintenance of treatment plants, pumping mains, underground and over head reservoirs, distribution systems and storage and handling of water at the household level. Design and operation of the treatment plant must be tailored to the raw water quality and the quality requirement of treated water. The treatment efficiency of the plant must be monitored continuously and immediate remedial measures taken as and when required. There could be unexpected hazards like disruption of supply of electricity, contamination during repair of pumps or pipelines, non-availability of equipments and spares in time, sudden increase in the pollution of the surface water bodies resulting in malfunctioning of the treatment plant, etc. Nature and types of different kinds of hazards, causes for hazards, risks involved, control measures required to be taken for prevention of the hazards, etc, are shown in the table given below.

Table-3, Information capture format for Hazard Analysis and Risk prioritization

Process Step	Hazardous Event	Cause	Risk Prioritization * (semi quantitative method)			Control Measures
			In category of Likelihood	In Category of Consequence / Impact	Risk Rating / Impact	
Source Water	Microbial/ Chemical Shock load	Industrial/ Municipal/ Non-point pollution	Moderate (3)	Major (4)	12 Process malfunction-ning/poor water quality	Pre-chlorination/ Adjustment of chemical dosing /Modification of treatment design
Treatment Plant	Stoppage of power supply	Electricity failure	Moderate (3)	Moderate (3)	9 - do-	Suspend Operation
Treatment Plant	Supply of poor quality chemicals	Lack of management	Moderate (3)	Moderate (3)	9 - do-	Suspend /Rectify/ Check water Quality/Restart
Treatment Plant	High turbidity seasonal	Meteorology climate	Major (4)	Major (4)	16 -do-	Adjust Chemical Dosing/Check Water Quality
Treatment Plant	Breakdown of mechanical parts	Lack of supervision	Moderate (3)	Moderate (3)	9 - do-	Replace with spares. Redesign Check Water quality
Treatment Plant	Contamination of parts/pipes/ equipments	-Do -	Moderate (3)	Moderate (3)	9 - do-	Suspend operation/Disinfe ct/Restart/ Check Water quality
Treatment Plant	Poor quality of treated water	Faulty Design/Poor chemicals/ Poor operation	Unlikely (2)	Major (4)	8 - do-	Suspend operation/check design & operation/Adjust hydraulic loading/Chemical dosing
Pumping Main	Leakage / Cross connection	Faulty Design/Poor material	Unlikely (2)	Major (4)	8 Loss of water, contaminatio n health risk	Repair/Disinfect

Distribution System	-Do -	Intermittent system/ poor material /low pressure	Major (4)	Major (4)	16 -do-	-Do -
Distribution System	Lack of residual disinfectant	Low dose of disinfection	Major (4)	Major (4)	16 contamination health risk	Increase dosing of Disinfectant
Village Stand post	Cracks/ Leakages/ Broken platform	Poor Construction	Moderate (3)	Moderate (3)	9 - do-	Repair / Reconstruct
Household Reservoir	Lack of residual disinfectants/ Contamination	Lack of maintenance cleaning & Disinfection	Moderate (3)	Major (4)	12 Health risk	Disinfect/ Flushing (Super Chlorination)
Household water distribution system	Leakage & Cross Connection with waste water lines	Lack of maintenance & supervision	Moderate (3)	Moderate (3)	9 - do-	Disinfect/ Flushing (Super Chlorination)

* Risk rating numbers are indicative. The WSP Team would determine the same, depending on the local situations.

7. Operational Monitoring Schedule

Operational monitoring schedule includes monitoring of control and other corrective measures that are to be taken to achieve desired objectives of the water supply schemes. For this purpose; various steps in the areas of performance indicator, monitoring process, critical limit, corrective actions, supportive program etc that are to be taken have been shown in the Table below:

Table-4, Operational Monitoring Schedule

Process step	Performance indicators	Monitoring process	Critical limit	Corrective action	Supporting program
Quality of drinking water	Parameters of drinking water	Testing of chemical quality and regular testing of bacteriological qualities	Within permissible limit as per BIS10500	Creation of alternate source in case of chemical contamination Disinfection in case bacteriological contamination	Ensure availability of services from the water testing laboratory If necessary, capacity of laboratories to be augmented
Pumping of water	Operation of pumps (hours)	Maintenance of log book for pump operator and pump	Operation time of pump to be ensured to produce and supply designed quantity of water (hours)	Vigilance over duty of the pump operator and action to ensure that the pump is always in running condition	Engagement of local people as pump operator and training of pump operators Make spares parts available
Sanitary measures to protect water source	No bacteriological contamination Presence of free residual chlorine	Regular testing of chemical and bacteriological quality of supplied water	Within permissible limit as per BIS10500	Disinfection in case of bacteriological contamination	Provide platform, drains, soak pit etc at tube well site Protective measures surrounding surface water body Device for measuring residual chlorine Involve community

					IEC campaign
Collection of water by villagers	Availability of required quantity of water for every family on time	Feedback from villagers	40 lpcd for each family	Ensure duration of supply Proper maintenance of distribution system	Involvement of users and launching of IEC activities
Stoppage of wastages of water	No leakage in pipe lines and water tanks Taps remain closed when not used	Involvement of users	Availability of water for each of the family	Timely repair of pipe lines, taps etc	Involvement of users and launching of IEC activities

8. Verification and Validation schedules:

As discussed in Chapter 13, to ensure proper functioning of any water supply scheme including treatment plant, transmission and distribution pipes, and to address the objectives of WSP for the same, verification and validation schedule indicating the frequency and agency responsible for the same need to be institutionalized. Properly executed verification and validation processes help us to understand whether the system is delivering water in adequate quantity and of specified quality and what type of corrective measures are to be taken to avoid failures and lapses.

Table-5, Verification schedule

Activities	Agency responsible for verification	Frequency of verification	Method of verification and how records would be maintained
Functioning of water supply scheme	VWSC/VHC	Once in a month	With the help log book maintained for pumps Feedback from the users based on format. Records are to be maintained by VWSC
Availability of desired quantity of water	VWSC/VHC	Once in a month	Feedback from the villagers based on a prescribed format
Quality of water	VWSC/VHC and facilitator (water sample collector)	Once in a month	With the help of nearest water testing laboratory and residual chlorine measuring kit. Records are to be maintained by the VWSC
Availability of fast and slow moving spares	GP, pump operator, plumber and mechanic	Once in a month	Verification format to be developed by the SAE of the block
Collection of water tariff, opening of bank account and maintenance of cash book	GP Pump operator to collect water tariff Two authorized persons to sign cheques	Checking by VWSC Collection in every month Audit once in a year	To be verified by the representative of concerned GP To be audited every year by external auditors

Table-5, Validation schedule

Process	Hazardous events	Validation	
		Frequency	Responsible person/agency
Intake, pumping and supply of water.	Damage of motor and pump due to mechanical failure or short circuiting	Once the event occurs	Pump operator /Local electrician/ mechanic
Functioning of treatment plant	Inadequate or poor quality of treated water.	Once in six months	Executive Engineer/Asst. Engineer/ Water Works Technicians
Supply of water to consumers	Disruption of pipe lines due to flood or any other natural calamities	Once the event occurs	PHED/Panchayet/ Local plumber
Supply of water to consumers	Bacteriological contamination of water in the pipe lines due to flooding or any other reasons	Once the event is noticed	Facilitator and local water testing laboratory

9. Improvement Action Plan

For any water supply schemes, which includes surface sources, intake structure, treatment plants, transmission and distribution pipelines etc, covering large population spread over multiple villages, actions for improvement would be required from time to time depending on the findings of hazard analysis, operational monitoring and verification and validation process. Improvement in the technical and management aspects of the scheme may be also required due to upgradation of water quality standards of the National Govts. or the quantity norms for per capita water supply. The various rural institutions as described in Chapter-2, at the village, block, district and state level, should examine all the reports, findings and recommendations and would then take appropriate action plans for improvement. The improvement action plan would naturally depend on the availability of resources and communities' willingness to pay for improved standard of community water supply in the rural areas.

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