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Guidance Manual for Conducting Sanitary Surveys of Public Water Systems; Surface Water and Ground Water Under the Direct Influence (GWUDI)

DISCLAIMER

This manual provides guidance on how to conduct a sanitary survey of surface water and ground water under the direct influence (GWUDI) of surface water drinking water systems. The U.S. Environmental Protection Agency believes that a comprehensive sanitary survey is an important element in helping water systems protect public health.

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ACRONYMS

ANSI/NSF	American National Standards Institute/National Sanitary Foundation
ASME	American Society of Mechanical Engineers
AWWA	American Water Works Association
CCP	Composite Correction Program
CFR	Code of Federal Regulations
CPE	Comprehensive Performance Evaluation
CT	Concentration of Residual Disinfectant multiplied by Time of Water Contact (Detention Time)
CTA	Comprehensive Technical Assistance
D/DBP	Disinfectants/Disinfection Byproducts
DHS	Department of Health Services
EPA	Environmental Protection Agency
GAC	Granular Activated Carbon
GIS	Geographic Information System
GLUMRB	Great Lakes Upper Mississippi River Board
GREP	Generally Recommended Engineering Practice
GWR	Ground Water Rule
HAA	Haloacetic Acids
IESWTR	Interim Enhanced Surface Water Treatment Rule
MCL	Maximum Contaminant Level
M-DBP	Microbial-Disinfectants/Disinfection Byproducts
NODA	Notice of Data Availability
NSF	National Sanitation Foundation
O&M	Operation and Maintenance
SDWA	Safe Drinking Water Act
SWTR	Surface Water Treatment Rule
TCR	Total Coliform Rule
TDT	Theoretical Detention Time
THM	Trihalomethane
TTHM	Total Trihalomethane
TNRCC	Texas Natural Resource Conservation Commission
UFTREEO	University of Florida Training, Research, and Education for Environmental Occupations
USGS	United States Geological Survey
VOC	Volatile Organic Contaminant
WFI	Water Facilities Inventory
WHPA	Wellhead Protection Area

1. INTRODUCTION

1.1 Objective of this Manual

This manual provides guidance on how to conduct a sanitary survey of surface water and ground water under the direct influence (GWUDI) of surface water drinking water systems. A comprehensive sanitary survey is an important element in helping water systems protect public health. Sanitary surveys are carried out to evaluate: (1) the capability of a drinking water system to consistently and reliably deliver an adequate quality and quantity of safe drinking water to the consumer, and (2) the system's compliance with federal drinking water regulations. Much of the information generated by a sanitary survey helps identify existing and potential sanitary risks. This guidance manual will identify **assessment criteria** to be evaluated for sanitary risks. The manual also describes how to identify **significant deficiencies** that represent an imminent health risk and require immediate correction.

This manual is intended to help state agencies improve their sanitary survey programs where needed and to help ensure consistency in how surveys are conducted and documented across state sanitary survey programs. In addition, owners and operators of public water systems may find the information useful in the operation and management of their drinking water systems and their sources. The U.S. Environmental Protection Agency (EPA) has promulgated specific sanitary survey requirements in the Total Coliform Rule (TCR) and the Interim Enhanced Surface Water Treatment Rule (IESWTR) and is considering expanding those requirements under future regulatory efforts (e.g., the Ground Water Rule).

The overall structure of the guidance manual centers around the four principal stages of a sanitary survey: (1) planning a sanitary survey; (2) conducting the onsite survey; (3) compiling a sanitary survey report; and (4) performing follow-up activities including responding to a sanitary survey. The manual is organized as follows:

- **Chapter 1 – Introduction.** This chapter provides information about the objective and regulatory context of this manual, as well as other sanitary survey background information.
- **Chapter 2 – Planning the Survey.** This chapter discusses the preparatory steps to be taken by inspectors before conducting the onsite portion of the survey.
- **Chapter 3 – Conducting the Survey.** This chapter discusses each of the elements of a sanitary survey as listed in *the 1995 EPA/State Joint Guidance on Sanitary Surveys* and IESWTR requirements. The chapter explains each element's importance to the effectiveness of the sanitary survey and presents general guidelines (assessment criteria) for evaluating important components of each element. Discussions within each element identify the components of high priority that may be considered significant deficiencies.

- **Chapter 4 – Compiling the Survey Report.** This chapter presents guidelines for preparing the sanitary survey report, maintaining adequate documentation, categorizing findings on deficiencies, addressing corrective action, and determining outstanding performance.
- **Chapter 5 – Report Review and Response.** This chapter provides information on follow-up activities for the system operator and the inspector/ inspecting agency (e.g., the state).

1.2 Background

In the preamble to the IESWTR, a sanitary survey is defined as:

> *"an onsite review of the water source (identifying sources of contamination using results of source water assessments where available), facilities, equipment, operation, maintenance and monitoring compliance of a public water system to evaluate the adequacy of the system, its sources and operations and the distribution of safe drinking water."*

Conducting sanitary surveys on a routine basis is an important element in preventing contamination of drinking water supplies. EPA recognizes the importance of sound sanitary surveys in helping water systems protect public health. Sanitary surveys are an opportunity to work and communicate with water systems in a preventative mode.

As stated in the December *1995 EPA/State Joint Guidance on Sanitary Surveys*, the primary purpose of a sanitary survey is: "to evaluate and document the capabilities of the water system's sources, treatment, storage, distribution network, operation and maintenance, and overall management to continually provide safe drinking water and to identify any deficiencies that may adversely impact a public water system's ability to provide a safe, reliable water supply." In addition, the joint guidance notes that sanitary surveys provide an opportunity for state drinking water officials or approved third party inspectors to establish a field presence at the water system and educate the operators about proper monitoring and sampling procedures, provide technical assistance, and inform them of any upcoming changes in regulations. Sanitary surveys also aid in the process of evaluating a public water system's progress in complying with federal and state regulations which require the improvement of the capabilities of the system to provide safe drinking water. Sanitary surveys provide the water system with technical and management information regarding the operation of the system from the water source, through the treatment facilities and the distribution system.

This draft guidance manual provides additional information about planning for, conducting, and reporting the results of a sanitary survey. As stated in the December *1995 EPA/State Joint Guidance on Sanitary Surveys*, EPA recommends that states work with EPA Regions in using sanitary survey guidance to improve their sanitary survey programs while still addressing the problems and issues specific to the state.

1.3 Regulatory Context

Under 40 CFR 142.10(b)(2), as a condition of state primacy, states are required to have "a systematic program for conducting sanitary surveys of public water systems in the State, with priority given to sanitary surveys of public water systems not in compliance with State primary drinking water regulations." Currently, the TCR requires a water system to periodically undergo a sanitary survey for all systems that collect less than five routine total coliform samples per month. Additionally, the Surface Water Treatment Rule (SWTR) requires an annual onsite inspection for surface water systems that do not filter (40 CFR 141.71(b)(3)). The IESWTR further elaborates on the sanitary survey requirements for all surface water and GWUDI of surface water systems.

1.3.1 Total Coliform Rule

The first regulatory requirement for the states to have a periodic onsite sanitary survey appeared in the final TCR (54 FR 27544-27568, 29 June 1989). This rule requires all systems that collect fewer than five routine total coliform samples each month to undergo such surveys. These sanitary surveys must be conducted by the state or an agent approved by the state. Community water systems were to have had the first sanitary survey conducted by June 29, 1994 and an additional survey conducted every five years thereafter. Non-community water systems are to have the first sanitary survey conducted by June 29, 1999, and an additional survey conducted every five years thereafter unless the system is served by a protected and disinfected ground water supply, in which case, a survey may be conducted every 10 years. (40 CFR 141.21(d))

As stated in the preamble to the IESWTR:

> *"EPA notes that it will consider sanitary surveys that meet IESWTR requirements to also meet the requirements for sanitary surveys under the TCR, since the definition of a sanitary survey under the IESWTR is broader than that for the TCR (i.e., a survey as defined under the IESWTR includes all the elements of a sanitary survey as required under the TCR). Moreover, with regard to TCR sanitary survey frequency, the IESWTR requires that surveys be conducted at least as frequently, or, in some cases, possibly more often than required under the TCR."*

1.3.2 Surface Water Treatment Rule

The SWTR does not specifically require water systems to undergo a sanitary survey. Instead, it requires that unfiltered water systems, as one criteria to remain unfiltered, have an annual onsite inspection to assess the system's watershed control program and disinfection treatment processes. The onsite survey must be conducted by the state or a party approved by the state.

This onsite survey is not a substitute for a more comprehensive sanitary survey but the information can be used to supplement a full sanitary survey. The elements of the onsite survey include:

- A review of the effectiveness of the watershed control program;
- A review of the physical condition of the source intake and how well the intake is protected;
- A review of the system's equipment maintenance program to ensure a low probability for failure of disinfection processes;
- An inspection of disinfection equipment for physical deterioration;
- A review of operating procedures;
- A review of data records to ensure that all tests are being properly conducted and recorded and that disinfection is effectively practiced; and
- Identification of any improvements that are needed in equipment, system maintenance and operation, or data collection.

As a supplement to the SWTR, EPA published a guidance document entitled *Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources*, in 1991. Appendix K of the guidance suggests that in addition to the annual onsite inspection, a sanitary survey be conducted every three years for systems serving 4,100 people or less and every five years for systems serving more than 4,100 people for both filtered and unfiltered systems. According to the appendix, this time period is suggested "since the time and effort needed to conduct the comprehensive survey makes it impractical for it to be conducted annually."

1.3.3 Interim Enhanced Surface Water Treatment Rule

The IESWTR requires that a sanitary survey address each of the eight elements listed in the 1995 EPA/State joint guidance. These eight elements are source; treatment; distribution system; finished water storage; pumps, pump facilities, and controls; monitoring and reporting and data verification; system management and operation; and operator compliance with state requirements.

Under the preamble to the IESWTR:

> *"The State must complete sanitary surveys for all surface water systems (including ground water under the direct influence of surface water) no less frequently than every three years for community systems and no less frequently than every five years for non-community systems. The State may "grandfather" sanitary surveys conducted after December 1995 for the first set of required sanitary surveys if the surveys address the eight survey components of the 1995 EPA/State guidance. The rule also provides that for community systems determined by the State to have outstanding performance based on prior sanitary surveys, successive*

sanitary surveys may be conducted no less frequently than every five years. In its primacy application, the State must include: 1) how it will decide whether a system has outstanding performance and is thus eligible for sanitary surveys at a reduced frequency, and 2) how it will decide whether a deficiency identified during a survey is significant.

In the IESWTR, a sanitary survey is defined as an onsite review of the water source (identifying sources of contamination using results of source water assessments where available), facilities, equipment, operation, maintenance, and monitoring compliance of a public water system to evaluate the adequacy of the system, its sources and operations and the distribution of safe drinking water.

Components of a sanitary survey may be completed as part of a staged or phased State review process within the established frequency interval set forth below. A sanitary survey must address each of the eight elements of the December 1995 EPA/State Guidance on Sanitary Surveys including: source; treatment; distribution system; finished water storage; pumps, pump facilities, and controls; monitoring and reporting, and data verification; system management and operation; operator compliance with State requirements. In addition, sanitary surveys include review of disinfection profiles for systems required to comply with disinfection benchmarking requirements....

States must have the appropriate rules or other authority to assure that facilities take the steps necessary to address any significant deficiencies identified in the survey report that are within the control of the public water system and its governing body. A State must also, as part of its primary [primacy] application, include how it will decide: 1) whether a system has outstanding performance and is thus eligible for sanitary surveys at a reduced frequency, and 2) whether a deficiency identified during a survey is significant for the purposes of this rule. In addition, a State must have appropriate rules or other authority to ensure that a public water system responds to significant deficiencies outlined in a sanitary survey report within 45 days of receipt of the report, indicating how and on what schedule the system will address significant deficiencies noted in the survey."

Table 1-1 indicates the required frequency for conducting sanitary surveys under the IESWTR.

Table 1-1. Sanitary Survey Frequency for Public Water Systems under the IESWTR

System Type	Minimum Frequency of Surveys
Noncommunity Water System	Every 5 years
Community Water System	Every 3 years
Community Water System with Outstanding Performance Based on Prior Sanitary Surveys	Every 5 years

1.4 EPA/State Joint Guidance on Sanitary Surveys

EPA and the states (through the Association of State Drinking Water Administrators) have issued a joint guidance on sanitary surveys entitled *EPA/State Joint Guidance on Sanitary Surveys*. The guidance outlines the following elements as integral components of a sanitary survey:

- Source (Protection, Physical Components and Condition)
- Treatment
- Distribution System
- Finished Water Storage
- Pumps/Pump Facilities and Controls
- Monitoring/Reporting/Data Verification
- Water System Management/Operations
- Operator Compliance with State Requirements.

The IESWTR requires that sanitary surveys address all of the eight elements of the EPA/state joint guidance. These elements are described in Chapter 3.

1.5 Rationale for Sanitary Surveys

1.5.1 Goal of a Sanitary Survey

As stated earlier, sanitary surveys are a means by which a comprehensive inspection of the entire water delivery system and its operations and maintenance (O&M) can be performed. These surveys are structured to determine whether a system's source, facilities, equipment, operation, maintenance, and management are effective in producing safe drinking water. Sanitary surveys also evaluate a system's compliance with federal drinking water regulations, as well as state regulations and operational requirements. In addition, a sanitary survey evaluates water quality data and administrative issues and draws conclusions about the system's integrity and its capability for consistently and reliably delivering an adequate supply of safe drinking water to consumers. Conducting sanitary surveys on a regular basis is the best means of identifying potential problems and possible reasons for trends in finished water quality and demand that may need to be addressed by enhanced O&M or a system upgrade. Sanitary surveys play a fundamental role in ensuring that reliable and safe drinking water is provided to the public by public water systems.

1.5.2 Benefits of a Sanitary Survey

EPA believes that periodic sanitary surveys, along with appropriate corrective measures, are indispensable for assuring the long-term quality and safety of drinking water. Properly conducted sanitary surveys help public water systems protect public health. Sanitary surveys have many benefits for the operation and management of public water systems. Sanitary surveys may also provide support to enforcement actions by establishing a record of conditions and operations at a point in time.

The *1995 EPA/State Joint Guidance on Sanitary Surveys* lists the following specific benefits of conducting sanitary surveys:

- Operator education;
- Source protection;
- Risk evaluation;
- Technical assistance and training;
- Independent, third party system review;
- Information for monitoring waiver programs;
- Identification of factors limiting a system's ability to continually provide safe drinking water;
- Reduction of monitoring requirements;
- Reduction of formal enforcement actions in favor of more informal action;
- Reduction of oversight by state monitoring and enforcement personnel;
- Increased communication between state drinking water personnel and public water system operators;
- Provision of contact personnel to notify in case of emergencies or for technical assistance;
- Improvement of system compliance with state drinking water regulations;
- Identification of candidate systems for enforcement action;
- Identification of candidates for Comprehensive Performance Evaluations;
- Verification of data validity;
- Validation of test equipment and procedures;

- Reduced risk of waterborne disease outbreaks;
- Encouragement of disaster response planning; and
- Improved system security.

2. PLANNING THE SURVEY

This chapter describes some basic activities that the inspector should accomplish before conducting the onsite portion of the survey. These activities help the inspector determine what areas to focus on and how to divide up the limited time during the onsite inspection. Once onsite, the inspector may identify other priority areas that need more attention. If so, the inspector should then adjust the onsite schedule accordingly.

Prior to initiating other activities for a survey, an inspector should review the previous sanitary survey report and other relevant records to determine if a system has an outstanding performance designation. Since this designation affects the required frequency for a survey, it may impact whether that system will be inspected at the current time. When a system is being inspected, a review of the water system's file should be conducted to obtain pertinent information about the physical facility and water quality data before the actual site visit. Information that should be collected includes: the treatment process(es) in place, monitoring requirements, the compliance history of the facility, and the condition of the system during the previous sanitary survey. This information is used to compile a list of questions/assessment criteria for the onsite inspection. Familiarity with federal and state requirements (e.g., operational requirements, operator certification, design standards) can assist the inspector in preparing for the sanitary survey.

This chapter also includes a list of equipment which the inspector should take to the onsite inspection. A list of persons to contact before the inspection is provided with some suggestions for the types of topics to be discussed. The chapter concludes with an overview of the onsite inspection process.

2.1 Determination of Outstanding Performance

Community water systems that are classified as having outstanding performance are eligible for having sanitary surveys conducted less frequently than other community systems. Under the IESWTR, community water systems must have a sanitary survey performed by the state at least once every three years, unless the system has outstanding performance. If the state determines that a community system has outstanding performance, it must be surveyed at least once every five years.

Each state, as part of its application for primacy, is required to develop a means for determining whether a system has outstanding performance. A state should have defined outstanding performance and established certain specifications for determining outstanding performance. To determine if a system has outstanding performance, the inspector should review the report from the system's previous sanitary survey to see if the system was considered to have outstanding performance then. If the state includes information on outstanding performance designations in a tracking database, the inspector should check the system's listing in the database. The inspector should also examine the state's records on the facility collected since the last sanitary survey. The records of interest will depend upon the state's criteria for outstanding performance but may include: monitoring data, violation records, and notifications of changes to the physical facility or the operator personnel. This information will help the inspector to determine if there are any changes in performance since the previous survey that indicate the system no longer satisfies the state's definition of outstanding performance.

2.2 Review of Pertinent Files on Physical Facilities

Office files and files provided by the water system owner and operator will provide insight into the design, construction, operation, maintenance, management, and compliance status of the facility. The sanitary survey inspector should thoroughly review all pertinent documents before the onsite inspection in order to fully understand the site-specific issues. The following subsections describe important types of documentation which the inspector should review if possible. While not all-inclusive, the following subsections discuss significant types of information often available. Information to review includes:

- Previous sanitary survey reports;
- Water system plans;
- Water system schematic/layout maps;
- Project reports;
- Construction documents;
- Water source information; and
- Source protection information.

If available, cross connection control plans should also be reviewed.

2.2.1 Previous Sanitary Survey Reports

Previous sanitary survey reports provide valuable information on the system's history and compliance status. The sanitary survey report includes a record of system treatment processes, operations, and personnel and their compliance with SDWA requirements. Significant deficiencies identified in the previous sanitary survey indicate some of the areas the sanitary survey inspector should focus on during the inspection to determine if they have been corrected and have not become problem areas again. Review of several previous sanitary survey reports may reveal a pattern of noncompliance in certain aspects of the system. If so, the inspector should pay particular attention to these areas during the onsite inspection and ask appropriate personnel about these problems and how they are being addressed.

2.2.2 Water System Plans

Some states may require water systems to develop and maintain comprehensive plans describing the operations, financing, and planned improvements for the system. The level of detail in the plans depends on the size, complexity, past performance, and use of the water system.

The water system plans may include a description of the following items:

- A description of the water system;
- Basic planning data including population served, service connections, and land use and development;
- System analysis including design standards, water quality data, and a system inventory description;
- Water source analysis including water use data, water demand forecasts, a conservation program, source of supply analysis, water shortage response plan, water rights analysis, and water supply reliability analysis;
- A description of source protection measures;
- Monitoring plans;
- A description of the facility operation and maintenance program;
- An emergency response/preparedness plan;
- A description of capital improvements planned for the system; and
- Financial information, including demonstration of financial viability.

The water system plans should be reviewed by the inspector in advance of the sanitary survey. Review of these plans will assist the inspector planning for the survey to identify those portions of the system which require special attention during the survey. The state may require reports from water systems identifying the progress made in developing their water system plans. Water systems may also have to transmit their water system plans to adjacent utilities, and local governments having jurisdiction to assess consistency with ongoing and adopted planning efforts. These plans may require periodic update, depending upon the state regulations.

2.2.3 Water System Schematic/Layout Maps

A schematic or layout map of the public water system will enable the inspector to obtain a quick understanding of the complete drinking water system. If possible, prior to the site visit, the inspector should obtain a schematic or layout drawings of the portions of the facility that will be evaluated during the survey. The schematic or layout map should start at the source and continue through the treatment facilities and storage facilities to the distribution system.

The primary purpose of the schematic or layout map is to help the inspector quickly understand the basic operation of the system. Therefore, it should be drawn in enough detail to facilitate the inspector’s understanding. A schematic typically provides general information on the basic system components and the direction of water flow in the system. Water system schematics should include an identification of source water supply facilities (e.g., source water body and intake, or well; pumping station; transmission line), the treatment plant, any booster plants, finished water storage (e.g., clearwells, elevated and ground storage tanks, pressure zones), the entrance to the distribution system, any associated facilities (e.g., pumping stations), and any interconnections with other public water systems. A schematic of a typical public water system is provided in Figure 2-1.

Layout maps are more detailed than schematics and contain more specific information on the location and orientation of physical facilities. In collecting the layout data, an inspector may easily obtain the latitude and longitude data of a public water system by using portable Geographic Positioning System (GPS) equipment. A water system may have separate layout maps for its treatment plant and distribution system.

For identification purposes, the name and identification number of the public water system, as well as the date of the sketch, should be included on each schematic and layout map. The dated schematics and layout maps will help future inspectors identify water system changes. The schematic and/or map should be current and reflect any changes that have been made since initial construction of the system and since the last sanitary survey.

Suggested criteria for assessing treatment plant schematic or layout map(s):

1. **Does the drawing(s) show the name of the facility and date of the last modification made to the drawing(s)?**

   This will help future inspectors know between which two sanitary surveys modifications took place. Taken together, a chronological set of schematics will help document a system's history.

2. **Does the schematic or map(s) contain a legend that explains key symbols used in the drawing(s)? Is there a numerical or a graph scale on the layout map?**

   With the aid of a legend, the inspector will get a better idea about the location of principal treatment units and appurtenant equipment. The drawing with its legend will provide the inspector with information useful for determining where to start and end the inspection, as well as areas that the inspector should focus on and inspect in particular detail.

3. **Does the schematic or map(s) identify source water type(s)?**

   Many treatment plants draw raw water from different sources (ponds, rivers, lakes, springs, and ground water). Some treatment plants use ground water to supplement scarce surface water during the summer season or occasionally during a dry year. Highly variable raw water quality greatly impacts treatment requirements and processes.

4. **Are influent, effluent, and residual disposal points clearly shown on the drawing(s)?**

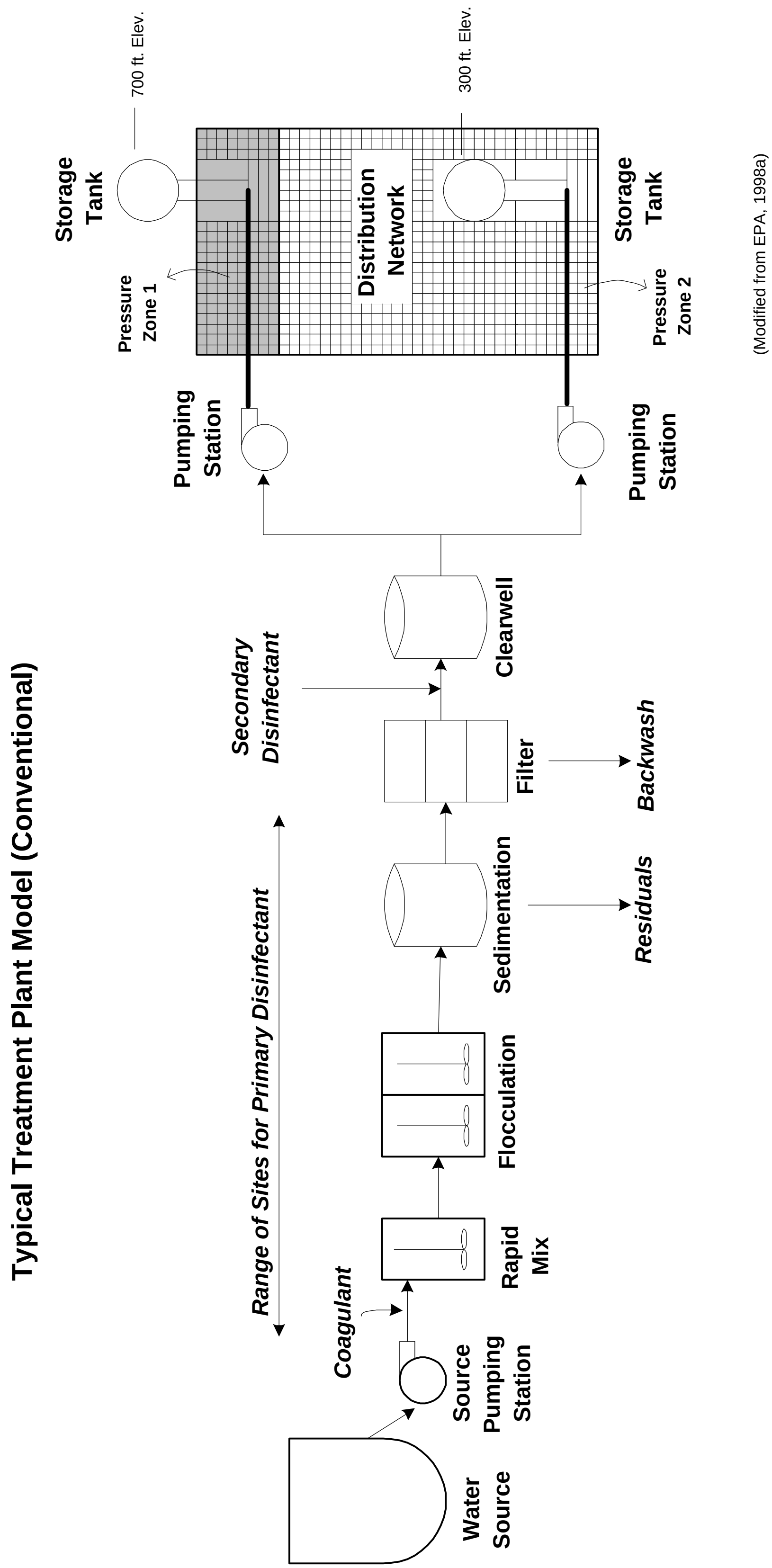


Figure 2-1. Schematic of a Typical Public Water System

If these points are not shown on the schematic or the layout map during the onsite inspection, the inspector should add sketches for these points to the drawing(s) or use a separate sheet and have inspection comments adjacent to the sketches.

5. **Does the schematic or map(s) show all the elements of the water system, from source facilities to the distribution system? Does the schematic or map(s) reflect the actual water system?**

   The inspector should review the schematic or map(s) to verify that all elements of the treatment system are shown and the drawings are complete. During the onsite inspection, the inspector should compare the drawings to the actual system layout to assess the accuracy of the drawings. Some systems do not update their maps to reflect system modification or have incomplete drawings, limiting their usefulness.

2.2.4 Project Reports

The water system may need to submit project reports to the state for approval before any change in equipment, chemical treatment, or operation, or installation or construction of any new water system, water system extension, or improvement, or when requested.

A project report should demonstrate consistency with the state design requirements for water systems and should include:

- A **project description—**Why the project is being proposed, how problems are to be addressed, the relationship of the project to other system components, and the impact of the project on system capacity and ability to serve customers. In some states a project description should contain "a statement of determination" related to the state environmental policy act, and include source development information and type of treatment;
- **Planning data—**General project background with population and water demand forecasts, how the project will impact neighboring water systems, construction schedule, estimated capital and annual operating costs;
- An **analysis of alternatives—**Description of options and the rationale for selecting the proposed option;
- A **review of water quality—**How water quality relates to the purpose of the proposed project, including analytical results of raw water and finished water quality;
- A **review of water quantity—**Applicable water rights as they relate to the project;
- **Engineering calculations—**Sizing justification, hydraulic analyses, physical capacity analyses, and other relevant technical considerations necessary to support the project; and

- **Design and construction standards—**Performance standards, construction materials and methods, and sizing criteria.

The inspector should review any available project reports for proposed, ongoing, and recently completed projects at the water system. These reports may describe upcoming activities that are already planned and may address some of the problems the inspector finds during the sanitary survey.

2.2.5 Construction Documents

Water systems typically are required to submit the construction documents to the state for approval prior to installation of any new water system, or any significant modification to an existing water system (e.g., change in treatment or water system extension or improvement). At the completion of construction, the water system may be required to submit an as-built or record set of the construction drawings and a certificate of completion.

Construction documents should be consistent with state required design standards and may include:

- Drawings, such as detailed drawings for each project component;
- Material specifications;
- Construction specifications, including a list of detailed construction specifications and assembly techniques for the project;
- As-built construction drawings with the latest updates on all significant modifications;
- Testing criteria and procedures;
- Disinfection procedures; and
- Inspection provisions.

The inspector should obtain and review construction documents, including for all significant modifications to the water system. These documents will provide the inspector with a description of how the system should exist, and will assist the inspector in locating components of the system.

2.2.6 Water Source Information

A water system seeking source approval may need to provide the state with sufficient documentation, in a project report or in supplemental documents, for demonstrating the feasibility of using the water source. These materials may show that:

- The source is reasonable and feasible, when compared with alternatives, based upon preliminary cost estimates of construction, conservation, vulnerability to contamination, and operation and maintenance costs;

- The system has adequate water rights sufficient to meet maximum daily demand without exceeding the maximum instantaneous or annual withdrawal limits specified by the water right;
- The source is physically and reliably available in the necessary quantities;
- Whether ground water is under the direct influence of surface water; and
- The source meets water quality criteria as required by the state.

The documentation may include: construction documents for the water intake or well (e.g., the driller's log); a copy of the water right or other written evidence of the existence of the right; a map showing the intake or well location and the vicinity; a map depicting topography around the source, and distances to the intake or well from property boundaries, buildings, potential sources of contamination, ditches, drainage patterns, and any other natural or man-made features affecting the quality or quantity of water. The system's water source information will provide the inspector with a preliminary assessment of the potential for contamination of the source. This information can be verified by the inspector during the onsite inspection, discussions with the operator(s), and document review.

2.2.7 Source Protection Information

The system may have prepared a plan to control sources of pollutants before they reach the source water under Source Water Assessment and Protection Programs (SWAP and SWPP), the Wellhead Protection Program (WHPP), and the Watershed Control Program.

The 1996 Amendments to the Safe Drinking Water Act (SDWA) expanded information gathered on source water to include systems using surface water sources. Under Section 1453 of the SDWA, states are required to develop and implement Source Water Assessment Programs (SWAPs). The SWAP must:

- Delineate the source water areas for all public water systems in the state,
- Identify the potential sources of contaminants within the areas, and
- Determine the susceptibility of the water systems to the contaminants.

In creating SWAPs, states should use information and analyses from previous related efforts such as developing Wellhead Protection Programs.

State SWAPs are intended to serve as a basis for developing, implementing, and improving source water protection efforts in source water protection areas and to encourage the development and implementation of local Source Water Protection Programs (SWPPs). Water systems may develop and implement SWPPs to protect the drinking water in a protection area. A local SWPP often incorporates the SWAP elements and adds the steps of developing a local team, monitoring source water quality, implementing management measures for sources of contamination, and planning for contingencies (EPA, 1997c).

State Drinking Water programs are required to develop Wellhead Protection Programs (WHPPs) under Section 1428 of the 1986 Amendments to the SDWA. Implementation of WHPPs is voluntary in many states. The WHPPs are to:

- Identify the members of a team to develop and implement the WHPP,
- Delineate a wellhead protection area surrounding the well based on "all reasonably available hydrogeologic information,"
- Identify all potential sources of contaminants,
- Describe a program to protect the water supply within the wellhead protection area (WHPA),
- Include contingency plans for providing drinking water in the event of contamination of the water supply, and
- Consider potential pollutant sources for all new wells.

State WHPPs provide guidelines and a framework for the development of local, system-based WHPPs. Many systems have used these guidelines to develop their own WHPP to address local water protection concerns.

Unfiltered systems are required by the SWTR (40 CFR 141.71) to satisfy a number of filtration avoidance criteria which include the preparation of a watershed control plan. The watershed control plan must minimize the potential for contamination of the source water by *Giardia lamblia* and viruses. The IESTWR also requires that the plan minimize the potential for contamination by *Cryptosporidium*.

The watershed control plan should include:

- A comprehensive review of the watershed,
- A description of activities to monitor and control detrimental activities in the watershed, and
- A description of the ownership or other land use controls within the watershed.

To the extent that they are available, an inspector should review the source water assessment and any source water protection plans, WHPP, and watershed control plan for a system in advance of the sanitary survey. This information will provide the inspector with a list of potential contamination sources which may require investigation. The information may also identify source control measures which may require inspection to determine if they are being implemented. In addition, the source water assessments will provide valuable information on well or intake integrity and hydrogeologic or hydrologic sensitivity.

2.3 Review of Pertinent Files on Water Quality

A review of pertinent files addressing water quality is a useful tool in identifying potential problems with a public water system. Monitoring plans and compliance reporting are the two primary sources of water quality information.

2.3.1 Monitoring Plans

EPA drinking water regulations and state equivalents establish minimum requirements for the contaminants to monitor and acceptable concentrations for each in the finished water stream. The monitoring frequency, requirements for re-testing, and sample location are also typically included in the monitoring plans.

Separate monitoring plans are typically prepared for:

- Total coliforms;
- Inorganic chemicals;
- Organic chemicals;
- "Unregulated" chemicals; and
- Radionuclides.

2.3.2 Compliance Reporting

The water system should submit reports to the state on a regular basis (typically monthly) detailing the system operations and identifying any problems encountered during the month. This monthly operating report (MOR) includes information about system flows, samples collected, sample analytical results, and any changes. Ideally, an inspector would review all of the MORs submitted since the last sanitary survey to ascertain any trends (e.g., changes in water quality, chemical usage, flow rates, or chlorine residuals) which may help to focus the inspection. Often there is not enough time available to review all of the reports. Therefore, the inspector should focus on violations or system problems which either the water system reported to the state or were identified during the previous sanitary survey, as well as water quality problems typical for the geographical area.

Federal regulations require the water system to issue notices to the public when the system:

- Violates an MCL or treatment technique requirement; or
- Fails to comply with monitoring requirements or analytical method requirements.

All public notices should include:

- A clear, concise, and simple explanation of the violation;
- A discussion of potential adverse health effects;
- A discussion of any segments of the population that may be at higher risk;
- A list of steps the water system has taken or plans to take to remedy the situation;
- A list of any preventive steps consumers should take;
- Any need for seeking an alternative water supply; and
- The water system's name and telephone number.

In some cases, depending on the severity of the violation, additional specific requirements (e.g., including mandatory health effects language in the notice) apply. The public notices are to be distributed by mail or hand delivered to all consumers served by the water system, or placed in newspapers widely-circulated in the area. Certain violations may also require announcements on radio and television stations serving the area. (40 CFR 141.32)

State regulations may also require the water system to submit a report to the state or issue a public notice under certain conditions [e.g., a system is identified as the source of a waterborne disease outbreak (surface water systems), experiences an unscheduled loss in pressure, or fails to comply with a state order].

2.4 Assessment Criteria

As part of planning for a sanitary survey, the inspector should prepare a set of criteria to evaluate during the onsite inspection. Inspectors should generally start with a standard set of criteria that are used for all sanitary surveys done by the state primacy agency. This standard set should then be tailored as appropriate based on water system-specific information obtained from the pre-survey file review and onsite observations. These criteria assist the inspector with evaluating key processes where potential significant deficiencies may exist.

The 1995 *EPA/State Joint Guidance on Sanitary Surveys* recommended that states develop assessment criteria for each of the eight minimum elements reviewed during a sanitary survey. The IESWTR reiterates the need to address these eight elements in conducting sanitary surveys. Assessment criteria are needed to ensure that deficiencies are evaluated consistently by sanitary survey inspectors. As part of this effort, states should identify the types of deficiencies that are considered to be significant and should provide appropriate follow-up actions for both significant and lesser deficiencies.

As outlined in the joint guidance, the eight essential elements of a sanitary survey are:

- Source (Protection, Physical Components and Condition)
- Treatment

- Distribution System
- Finished Water Storage
- Pumps/Pump Facilities and Controls
- Monitoring/Reporting/Data Verification
- Water System Management/Operations
- Operator Compliance with State Requirements.

Chapter 3 of this guidance manual provides assessment criteria that inspectors may use to evaluate each of the eight elements. The criteria include descriptions of what inspectors should look for and how the criteria are related to sanitary risk. Since states may have their own set of assessment criteria for sanitary surveys, inspectors should check with the primacy agency before preparing a list of criteria for a sanitary survey.

2.5 Inspection Tools

Prior to the onsite inspection, sanitary survey inspectors should ensure that their field equipment is in good working order. Preventive maintenance is essential for all types of equipment. Equipment which is broken, dirty, in disrepair, out of calibration, or otherwise improperly maintained will not provide dependable, reproducible, or accurate data. For best results, the inspector should follow the manufacturer's specifications for preventive maintenance. The inspector also should check expiration dates and keep up with and use current standard testing procedures and calibration methods. Recommended types of field equipment include but are not limited to:

- Portable pH meter with digital readout;
- Hand held colorimeter, portable spectrophotometer, or other mechanical residual chlorine test kit;
- Accurate pressure gauge;
- Portable Geographic Positioning System (GPS) equipment;
- Camera with automatic time/date stamp;
- Binoculars;
- Small mirror (to inspect areas that are not accessible or are not in the direct line of sight); and
- Flashlight.

The sanitary survey preplanning effort needs to address safety considerations, both for the field inspector and the system's operating staff. Safety hazards can include head injuries from low clearance piping, snake and spider bits, insect stings, electrical shock, chemical exposure, drowning, confined space entry, noise, lifting injuries, and slipping, tripping, and falling. Prior to the onsite inspection, the inspector should ensure that personal protective equipment is available. The most frequently used equipment includes safety hats, goggles, gloves, ear plugs, and steel-toed safety shoes. Respirators and a self-contained breathing apparatus may also be used in some cases.

2.6 Communication Activities

Coordination and communication between the inspector and the primacy agency, local health department, and water system management personnel are essential in preparing for a sanitary survey. The inspector needs to work with each of these entities to be properly prepared for the sanitary survey. Some of the information the inspector should exchange with each of these entities is listed in Table 2-1.

Based on the information collected and reviewed during survey planning and preparation, the inspector should make an assessment of which areas need particular attention during the onsite visit. The inspector can then establish a preliminary schedule for the onsite visit, allocating more time to the areas that seem to warrant greater focus. Once onsite, the

Table 2-1. Communication Activities

Entity	Activities
Primacy agency	The primacy agency should provide the inspector with information on which water systems to consider for sanitary surveys (based on when the previous survey was done), past sanitary survey reports, and other information in the agency files for the relevant water systems. The primacy agency should also provide the inspector with agency inspection requirements and guidelines, such as assessment criteria, a list of significant deficiencies, and any sanitary survey forms used by the agency.
Local health department	The inspector should contact the local health department to find out if the water system is in compliance with OSHA (Occupational Safety and Health Administration) requirements and has been issued a rodent/pest control permit. The inspector should also ask the health department if there have been any reported illnesses attributed to drinking water.
Water system management personnel	The inspector should contact the water system and first determine the appropriate personnel for further sanitary survey discussions. With the appropriate personnel, the inspector should describe the purpose of the sanitary survey and the steps of the survey, particularly the onsite inspection (described in the next section). Preliminary discussions should also include: – a review of previous sanitary survey reports and the system's historical records (including chemical and bacteriological data), – correspondence, – engineering studies, – past violations, and – any records that are needed for review but are not available from the primacy agency's files. The inspector should also schedule the onsite inspection with the water system.

inspector may observe problems in other areas that need detailed inspection and thus require changes to the preliminary schedule. Through these preparations, the inspector will be able to assemble and evaluate the proper information during the survey and make sound recommendations in the sanitary survey report.

2.7 Parts of the Onsite Inspection

The onsite inspection includes the following parts:

(1) Opening interview
- Introductions
- Review of the purpose of the sanitary survey
- Review of the parts of the onsite inspection and the schedule for the inspection
- Review of the facility layout and location of the intake(s) and treatment processes
- General discussion of basic system information; the condition of the system and its operation, staffing, and management; whether relevant plans and procedures have been developed and are adequate
- Discussion of deficiencies identified in previous sanitary survey reports and any violations/compliance problems since the last survey, and corrective actions taken and their effectiveness in addressing the deficiencies and problems.

(2) Walk through
- Physical inspection of all eight elements of a sanitary survey
- Asking questions of appropriate personnel for clarification, to determine the knowledge of system personnel, and to check information obtained during records review and other aspects of survey planning and preparation
- Note taking for documentation and writing up the findings in the sanitary survey report.

(3) Organization of findings and documentation
- Filling in any gaps in inspection notes and add detail where needed
- Completing sanitary survey checklists/forms (if used)
- Clarification of any remaining issues with water system personnel
- Obtaining any documentation still needed
- Preparation for closing interview.

(4) Closing interview/debriefing the system on inspection findings
- Presentation of findings, particularly any significant deficiencies, to the water system
- Informing water system management of next steps (i.e., writing and submitting the report, corrective action).

3. CONDUCTING THE SURVEY

Previous chapters of this manual have provided a definition of a sanitary survey, the regulatory framework for conducting a survey, and the critical steps for planning a sanitary survey. This chapter presents the essential elements for completing the walkthrough inspection of an onsite sanitary survey. The onsite sanitary survey includes visiting the water supply source and source facilities, pump stations, the treatment plant, storage facilities, the distribution system, and sampling locations. One of the most important functions of the onsite portion of the survey is to determine whether the existing facilities are adequate to meet the needs of the water system's customers at all times. Therefore, this visit should include review and verification of the capability and capacity, construction and operation, and physical condition of the water system's facilities.

There are eight elements that are considered essential for review in the proper conduct of a thorough sanitary survey. These eight elements are listed below:

- Source (Protection, Physical Components, and Condition)
- Treatment
- Distribution System
- Finished Water Storage
- Pumps/Pump Facilities and Controls
- Monitoring/Reporting/Data Verification
- Water System Management/Operations
- Operator Compliance with State Requirements.

This chapter presents a general description of each element and its importance as part of the sanitary survey, general guidelines for evaluating important components of each element, and a discussion of priority components under each element. The order of the eight elements is not intended to dictate the sequence of survey activities, but to provide a logical division of the essential elements for a sanitary survey. Each element is divided into components and includes a discussion of the issues that an inspector should consider when evaluating a particular component. Guidelines for evaluating the components are provided in the form of a list of assessment criteria. The assessment criteria identify areas that need to be reviewed during a sanitary survey. The criteria are intended to help the inspector identify sanitary risks that may arise due to deficiencies in a particular component.

At the end of the discussion for each element, a set of priority criteria are provided. Priority criteria are those criteria that generally have the greatest impact on health risks related to a given element and thus should be considered significant. Since states should develop their own lists of significant deficiencies, this guidance manual does not contain a standard list of what deficiencies all states should consider significant. However, Section 4.3 discusses the process of categorizing the findings of the sanitary survey and provides examples of potential significant deficiencies. In conducting the sanitary survey, the inspector should pay particular attention to those areas where deficiencies would be considered significant and thus warrant prompt corrective action. This format allows states flexibility in evaluating the components based on system type, size, and complexity. Appendix A includes examples of sanitary survey checklists used by several states and EPA regions. These checklists are from the *1995 EPA/State Joint Guidance on Sanitary Surveys*.

3.1 Source (Protection, Physical Components, and Condition)

The water supply source is the beginning of the drinking water system. As such, the source can provide the opportunity for the reduction of contaminants, pathogens, and macroparticles. Preventing source water contamination is the most effective means of preventing contaminants from reaching consumers. Source water protection also helps ensure that additional, potentially more costly treatment is not necessary to remove further contaminants. As the first opportunity for controlling contaminants, the reliability, quality, quantity, and vulnerability of the source should be evaluated during the sanitary survey.

The objectives of surveying the raw water source are to:

- review the major components of the source to determine reliability, quality, quantity, and vulnerability; and
- determine and evaluate data that define the potential for degradation of the source water quality.

To accomplish these objectives, the inspector needs to review available information on source water facilities, including watershed control plans, source water assessment reports and protection plans, and/or wellhead protection plans where they exist for a system. In the field, the inspector should discuss the water supply source with the operator(s) and verify the information received from the plans with field observations.

The following areas should be reviewed as part of the sanitary survey.

3.1.1 Watershed Management Program

The primary goal of watershed management programs are to maintain the highest quality feasible for a surface water source. For an unfiltered water supply, it is particularly critical to achieve the highest level of raw water quality practicable. A watershed management program is designed to protect the quality of a water system’s surface water source by monitoring activities in the source watershed and minimizing their impact. An effective watershed management program will reduce the levels of pathogens, turbidity, organic compounds, and coliforms.

Development and implementation of a watershed management program is generally done by a team that may include water system staff, private consultants, planning agencies, cooperating agencies, and advisory committees. The water system often takes the lead, and can gain valuable contributions (e.g., expertise, resources) from the other agencies with jurisdiction over the watershed. Cooperative efforts are particularly valuable when the water system does not have the staff or expertise to fully develop and implement a program, and when difficult issues are involved. (EPA, 1999c)

A watershed management program should include a description of the watershed, identification and monitoring of activities in the watershed that may impact water quality, a program to control land use activities in the watershed, and annual reporting (EPA, 1991). Source water assessments should provide valuable information on the vulnerability of the source water(s) of a surface water-supplied public water system. Each component of the program is described in the following sections.

3.1.1.1 Watershed Description

A description of the watershed provides valuable information to both the inspector and the system personnel to evaluate the vulnerability of the source. The watershed description should include the geographical, geological, and physical features of the watershed; pertinent hydrology (e.g., annual precipitation patterns, stream flow characteristics, etc.); land use/ownership in the watershed; location of the surface water intake or well; as well as any open-air conveyances that carry water from the intake to the treatment plant.

It is important that the intake(s) or well(s) for a public water system be located as accurately as possible. The intake(s) or well(s) may have been located previously and the inspector need only verify that the location(s) is correct. The inspector may find that a new intake or well has been constructed since the last inspection, either authorized or unauthorized, and a previous one has been abandoned and/or plugged. The inspector should make note of this new condition and advise the system if they should report the new intake or well to the state. A U.S. Geological Survey (USGS) 7.5-minute topographic quadrangle or similar map can be used to plot the location of the water sources. The Global Positioning System (GPS) is a recently developed tool that can be used to determine the precise location of a surface water intake or a well.

3.1.1.2 Watershed Characteristics and Activities

The characteristics and activities that may affect the source water quality should be identified by the system. The naturally-occurring attributes that can affect the source water quality include terrain, soil types, land cover, precipitation and runoff, and animals. In particular, the animal populations that can be found in the watershed should be identified, so that potential contamination sources of *Giardia, Cryptosporidium*, and any other pathogens can be evaluated.

The man-made attributes that can affect water quality include point and nonpoint sources. Point sources of particular interest are discharges from wastewater treatment and industrial plants and runoff from barnyards, and feedlots. The nonpoint sources that can significantly impact source water quality are septic systems, construction activities, impervious cover runoff (i.e., runoff from a highway or parking lot); farming and ranching activities (e.g., the use of pesticides, animal husbandry); logging; recreational activities; and unauthorized or accidental discharges of contaminants.

Various techniques or plans can be developed to minimize the effect of watershed activities on source water quality. Some of the more common techniques used to control watershed activities include ownership of the land by the water systems, obtaining zoning restrictions from local governments, as well as entering into agreements with the present landowner(s). With zoning, the local government can control the degree of land development and require erosion control. Land ownership by the water system and agreements with landowners are discussed in the next section.

3.1.1.3 Land Ownership/Agreements with Owners

For a water system to have the best opportunity to realize the goals of a watershed management program, the water system should have complete ownership of the watershed. However, complete ownership is not practical for most water systems. Therefore, the water system should try to gain ownership of the critical elements in the watershed, such as reservoir or stream shoreline, highly erodable land, and areas providing access to the water supply source.

The water system should enter into agreements with landowners in the watershed that will allow the water system to have control of the land use so that activities having an adverse effect on water quality can be minimized. The agreement should also include a provision stating that the water system has the legal right to ensure that the land use complies with the agreement. As an example, the water system enters into an agreement with a logging company (man-made attribute) located in the watershed. The agreement states that the logging company will develop and implement procedures or practices, such as installing silt fences around all disturbed areas to control erosion, that will minimize the impact of logging on source water quality. With the logging company controlling erosion in disturbed areas, the elevated turbidity levels (caused by the erosion) in the source water will be reduced. The inspector should review the water system’s plans to minimize the water quality impact of the various activities in the watershed.

3.1.1.4 Annual Reports

A watershed management report should be prepared annually that outlines the steps taken to acquire all or critical elements of the land within the watershed, efforts made to monitor the watershed activities, a list of activities that cause special concern, efforts to mitigate the detrimental affects to water quality, and known future activities that may impact water quality and a plan to reduce the potential impacts. This report should be submitted to the state primacy agency for review and approval.

Assessment Criteria

The following are suggested assessment criteria for the watershed management program:

1. **Is the entire watershed for the source protected? Is the water system trying to purchase all land within the watershed? If not, are the critical elements of the watershed protected or purchased by the water system?**

   The origin of most contaminants, either chemical or biological, found in drinking water can be traced to the watershed of the source. If the watershed, all or critical parts, for the source is protected, then potential sources of contamination can be reduced significantly. By reducing the level of contaminants in the water source, the water treatment process has to remove or inactivate less contaminants.

2. **If the water system cannot purchase portions of the watershed, does the water system have an agreement with the landowner concerning land use? If the water system does not have an agreement, what is the plan to acquire control of the land use within the watershed?**

   The water system should gain the highest degree of control possible of the watershed utilizing the means available. The typical means to secure watershed control is to either purchase the land or obtain an agreement with the landowner on the allowable use of the land. Purchasing the land is the most costly means for a water system to achieve control of the watershed. Depending on the resources of the water system, it may take a long time to obtain complete control of the watershed. Therefore, the water system should have a plan and schedule for acquiring the highest control of the watershed possible (if not the entire watershed, at least the critical parts).

3. **Are all activities within the watershed identified and located? If so, have there been any changes since the last sanitary survey?**

   The source(s) of contaminants in drinking water will be either naturally occurring or man-made. The water system needs to identify and locate the activities within the source watershed that are potential contaminant source(s). Based on the type and location of the activities in the watershed, the water system can develop a plan to mitigate the sources of contamination of the drinking water supply.

4. **What are the practices used to mitigate critical activities within the watershed that may degrade water quality? How are these practices monitored? Should there be any changes to the existing practices?**

   With the activities in the watershed known, the water system can develop a plan to mitigate the occurrence of contaminants. As with any plan, a means must be developed to measure the effectiveness of the plan through routine monitoring and evaluation.

3.1.2 Wellhead Protection Program

A Wellhead Protection Program (WHPP) is designed to protect the quality of a water system's ground water source by monitoring and minimizing the impact of the activities in the source recharge area as well as the portion of the aquifer that supplies the system. This program applies to ground water and the associated recharge area. The main components of a WHPP are delineating the wellhead protection area (WHPA), identifying and locating all potential sources of contaminants that could impact the well, and developing and implementing a strategy to manage the WHPA and protect the source from contamination. Since the WHPP has elements and requirements similar to the watershed management program, discussion of these elements and requirements will not be repeated here.

Due to the similarity of the wellhead protection program and the watershed management program, the suggested assessment criteria would be the same. However, the methods used to delineate the wellhead protection area for the wellhead protection program and the watershed management program may be different and should be evaluated. For example, recorded sanitary control easements can be used to help prevent contamination in a WHPA. The easements specify that sanitary hazards cannot be located within a specified distance (e.g., 150 feet) of a well.

3.1.3 Source Vulnerability Assessment

A vulnerability assessment is used to determine the likelihood that potential contaminant sources in the watershed or drinking water protection area will degrade the public water system's source water quality. The 1996 Amendments to the SDWA require that states determine susceptibility of all their public water systems to contamination. A susceptibility determination will include consideration of several factors: hydrogeologic or hydrologic sensitivity, contaminant source characteristics (e.g., persistence and mobility, toxicity, volume of discharge), contaminant source management, and well or intake integrity. A completed Source Water Assessment Program (SWAP) susceptibility determination may suffice as the source vulnerability assessment for a sanitary survey, and may be integrated with vulnerability assessments performed under monitoring waiver programs, pesticide management plans, or other programs.

Suggested assessment criteria for assessment of source vulnerability include:

1. **What is the sensitivity of the source water protection area (SWPA)? Has it's hydrogeologic/hydrologic sensitivity been adequately assessed?**

This refers to the transport of contamination from any point within an SWPA to a well or intake. Higher sensitivity ratings apply to geologic settings through which contamination can move more quickly and lower sensitivity ratings apply to settings through which contamination should move more slowly (i.e., sensitivity, like susceptibility, is local and relative). Sensitivity does not address the question of whether contamination or potential sources of contamination are present in the SWPA. Specific factors that should be included in a sensitivity assessment are:

Surface water:

Intake environment: Intakes in turbid water or near shore are more sensitive than intakes away from shore in clear water.

Slopes: Water fed from steep slopes is more sensitive than water fed from shallow slopes.

Plant coverage: Water fed from land with no vegetation is more sensitive than water fed from land with thick vegetation.

Soil permeability: Water fed from paved surfaces is more sensitive than water fed from highly permeable top soils.

Ground water under the direct influence of surface water:

Saturated zone: Aquifers close to the surface are likely to be more sensitive than aquifers further beneath the surface.

Well screen: Shallow well screens are more sensitive than deep well screens.

Unsaturated zone: Aquifers overlain by thin unsaturated zones are more sensitive than those overlain by thick zones.

Confining layer: Aquifers overlain by no confining layers are more sensitive than aquifers overlain by thick layers.

Conduits: Aquifers with many conduits to or near the saturated zone are more sensitive than those with no conduits.

2. What is the integrity of wells, intakes, and conveyances?

Source water structures, such as the well casing, joints, screened sequences, padding at the wellhead, conveyance structures, and equipment to move water from the well or intake to the distribution system should be assessed for integrity. Integrity means the quality of design, construction, maintenance, and the state of repair of the infrastructure. Factors that should be included in an integrity assessment are:

Design: Does the infrastructure design meet current state code? Is the infrastructure design appropriate for the hydrogeologic setting and pumping rate?

Construction: Is there a well log and does it adequately document how the well was built? Are the materials and equipment that were used appropriate for the hydrogeologic setting and pumping rate?

Maintenance: Has there been an operative maintenance schedule in place since construction? Is the maintenance schedule appropriate for the design and construction of the specific infrastructure?

State of repair: Has the infrastructure been operating reliably? If not, why not?

3. Are potential sources of contamination identified and managed?

Potential sources of contamination (PSCs) may be point source or nonpoint source and federally regulated, state regulated, locally regulated, or unregulated. A PSC may be a facility or activity, including or excluding human involvement. PSCs may or may not use infrastructure or management practices to prevent, reduce, or mitigate the likelihood of contaminant release into the SWPA and those efforts may or may not be effective. Factors that should be included in a PSC assessment are:

Acute health effects: Sources of acute contamination may present greater public health risk than sources of chronic contamination.

Distance to well or intake: PSCs located closed to drinking water wells or intakes usually present greater risk than PSCs further away.

Point/Nonpoint source: Point sources usually have greater disaster potential than nonpoint sources, but are also more easily managed.

Federal/State regulation: PSCs under federal or state regulatory programs are likely to be better managed than unregulated PSCs.

Containment infrastructure: Are there physical barriers to contaminant release?

Containment practices: Are the standard operating practices designed to prevent contaminant release?

Contingency plans: Are there contingency plans for accidental release and are operations personnel familiar with them?

3.1.4 Source Water Quality

Impurities can be found in any natural water source. Surface water can pick up impurities, including chemical and biological contaminants, as it comes in contact with soil, rock, and vegetation. The dissolution of minerals from the soil and rock is very common for ground waters.

EPA has established maximum contaminant levels (MCLs) for impurities that must be removed from or inactivated in raw water before the water can be classified as potable. The contaminants can be removed or inactivated naturally or by treatment. For ground water, many of the particles and microorganisms originally found in surface water are removed as it seeps into the ground and through the aquifer, due to the natural filtration effect as water passes through soils, and the potentially long travel times in the aquifer.

Surface waters are very different from ground water. Surface waters require a high degree of treatment to remove impurities and contaminants from natural and man-made sources. Some impurities in the water, such as large suspended solids, are easily removed. Smaller particles, including many pathogens, are more difficult to remove. Some pathogens, such as *Giardia* and *Cryptosporidium*, also resist inactivation by chlorine. A discussion of water treatment systems is found later in this chapter (see Section 3.2).

The type of surface water source (i.e., lake, stream, etc.) is an important factor that can affect raw water quality. A stream with a large watershed in which a land use is predominantly farming, may experience large swings in raw water turbidity, particularly after a rainfall event. If the source is a lake or reservoir with the same general watershed characteristics, the potential for large raw water turbidity swings is greatly reduced, due to the dilution and settling that occur in a reservoir.

There are many potential raw water quality problems for a surface water source, including:

- Zebra mussels and Asiatic clams – can clog intakes reducing capacity;
- Algae – can cause taste and odor problems;
- Pathogens – can cause intestinal illnesses and other diseases;
- Turbidity –can be difficult to remove depending on the size and concentration of particles;
- Natural organic matter – difficult to remove and can form carcinogenic compounds in combination with certain disinfectants;
- SOCs (synthetic organic compounds) and IOCs (inorganic compounds) of anthropogenic origin – can cause adverse health effects and affect treatment decisions; and
- Iron and manganese – can cause discoloration and staining problems.

These are just a few physical, chemical, and biological elements found in a surface water that make treatment (filtration and disinfection) necessary to ensure a safe supply of potable water.

Historical information should be gathered from the operators. The inspector also needs records concerning the fluctuations of raw water quality for use prior to the survey and during the onsite inspection. The steps taken by the water system to mitigate significant changes should be evaluated to determine their effectiveness. Additional steps may be needed to further reduce water quality fluctuations if the mitigating measures do not sufficiently protect water quality.

The following assessment criteria are applicable to the inspection of source water quality:

1. **What is the quality of the source? Is the source water quality monitored by the system? What are the ranges of the required water quality parameters?**

   The quality of the water at its source will prescribe the treatment needed to produce safe, potable water. In particular, the historical range of constituents in the source water will dictate the level of treatment required. For example, the pH of a particular source water is typically 7.2, but it ranges from 6.5 to 8.0. If the pH of the potable water leaving the plant is less than 7.0, it is acidic and can be corrosive, which may result in increased levels of lead and copper in the consumer's water. Therefore, treatment should be provided to raise the pH of the water leaving the plant to an acceptable level and to assure that the water is noncorrosive. The water system should regularly monitor the quality of the source to identify any changes that may necessitate changes in the level of treatment required. The inspector should review the system's source water monitoring records to assess whether the source water quality is sufficient and does not pose significant sanitary risks.

   Another example is the source water microbial quality, as represented by measurement of the indicator total coliform bacteria. The persistent presence of total coliform in source water requires removal and/or disinfection to the levels specified by regulations. In general, all regulated contaminants should be monitored, as specified, to determine treatment levels.

2. **Is there an emergency spill response plan for events that are man-made which may affect water quality?**

   The source watershed may have crossing roadways and pipelines that carry hazardous chemicals. If a truck on the roadway had an accident or the pipeline develops a leak, a hazardous chemical could spill into the source water. If the plant operator is unaware of the accident, the hazardous chemical could pass through the water treatment plant and out into the distribution system. Therefore, a plan should be developed to respond to these types of situations. At the least, the plan should include notification of all water systems in the watershed of the chemical spilled as well as a listing of the options and alternatives for either treating the chemical at the water plant or using a temporary source until the threat is over.

3. **Is the area around the intake restricted in accordance with primacy agency rules?**

   Typically, the intake for a water treatment plant is unmanned and may be visited once a shift or once per day. Therefore, there is no continuous means to observe all the activities around the intake. Restricting access to the area around the intake with fencing, signs, and buoys will limit the possibility of sabotage or accidental contamination.

4. **Are there any sources of pollution at or near the intake? If so, what is the water system doing to mitigate the sources of pollution?**

   There are many sources of contaminants that can affect the raw water quality. Man-made sources would include publicly owned treatment works, industrial treatment works, private onsite septic systems, pesticide runoff from farming, fecal contamination from confined animal feeding operations, marinas, etc. Natural sources of contamination may include birds and hoofed mammals. Each source could release contaminants that end up in the source water and affect the potable water delivered to the consumer. If the contaminant source is near the intake, there is little or no time for the water system to respond to the accidental release of a contaminant. Therefore, the water system should know what pollution sources are close to their intake and what contaminant(s) could be released. If possible, the water system should try to either eliminate or significantly reduce the chance(s) of a contaminant release from each source.

5. **Have there been any significant fluctuations in water quality? If so, what was the cause and how is the water system preventing future fluctuations? If improvements are in place to mitigate the fluctuations, how well are they performing? Are any further improvements needed?**

   Rapid, significant changes to any water quality parameter will impact the ability of a water treatment plant to produce a safe, potable water. For example, if the raw water turbidity, which normally is 50 NTU, were to increase to over 500 NTU in a few hours, the efficiency of all treatment processes could be significantly impacted to the point that the quality of water produced is seriously compromised. In particular, the disinfection process could be compromised due to the interference caused by the high solids loading. Therefore, water systems need to review the historical raw water quality data to learn whether there have been instances of rapid, significant water quality fluctuations and investigate the cause of significant fluctuations. When the cause is identified, the water system should identify a means to mitigate future fluctuations. Once mitigation measures are in place, the water system should regularly evaluate the performance of the improvements to determine whether or not the raw water quality fluctuations are under control.

   A system's monitoring program can help the water system recognize any deterioration of water quality over time that may eventually make it necessary for the system to explore new sources. The inspector should review the system's source water monitoring records to assess whether there are any trends of deteriorating quality and if the water system has adequately addressed the problems. Inspectors can also compare raw water turbidities to finished water turbidities to assess whether changes in raw water quality are affecting finished water quality. If raw water quality changes are measurably affecting finished water quality, the inspector should ask the operator(s) about process control decisions being made and evaluate whether the operator(s) are making adequate process changes to address raw water quality changes.

3.1.5 Source Water Quantity

One of the most important requirements for any water system is the ability to meet the water quantity demands of customers at all times. This requirement means that an adequate quantity of source water should be available to meet the customers' needs. It is important to determine whether the water system has an adequate source of supply, because prolonged interruptions or reductions in the source water supply may cause low pressures or water outages in the distribution system that pose a public health hazard. When service pressure is insufficient, other liquids are much more likely to enter the system through cross-connections and contaminate the water supply.

In many places, particularly in arid and heavily populated areas, water conservation is necessary. Water systems should have a water conservation plan that includes short- and long-term goals, education plans, water rationing procedures in case of drought, and water conservation information available to the public. An aggressive water conservation plan can be a cost-effective alternative to the expansion of water production facilities.

Suggested assessment criteria for evaluating the adequacy of the source water supply are:

1. **What is the water quantity required to meet the needs of the water system?**

   The water system must be able to supply an adequate quantity of potable water to meet the highest anticipated demand of the customers. If not, then areas of the distribution system may experience little or no pressure due to the lack of water. With the loss of pressure, the contamination potential of the system is heightened significantly.

2. **What is the available water quantity of the source?**

   The quantity of source water available must be sufficient to meet the highest anticipated demand of the water system. In addition, the water system needs to plan for the continued growth of its service area and look ahead to obtaining an adequate quantity of water to meet those future needs. If operating records show decreasing water quantity over time, the system should be investigating additional supply.

3. **Is the source adequate to meet the current and future expected needs of the water system, even during times of drought? If not, what other sources are being investigated to meet the needs? Has the water system developed and implemented a water conservation plan?**

   Knowing the maximum water demand of the system and the quantity available from the source, a quick determination can be made of the system's ability to meet the present and future needs of its customers. The inspector can verify that an adequate supply is available by checking to see if the supply source has ever gone dry or if water ever had to be rationed because of a shortage of source water. A water system may have developed a water conservation plan as part of its overall water system master plan and may already be implementing the water conservation plan regardless of the adequacy of source water quantity. Implementation of a good water conservation plan can be a cost-effective alternative to the expansion of water production facilities as a result of increased demand. If the source water supply appears to be inadequate, the water system should be in the process of implementing further water conservation measures and/or obtaining an additional supply.

4. **Does the system have a meter to monitor production? Does the system measure usage by consumers?**

   The system needs to have meters in place to monitor overall production and water usage in the system to determine if supply is adequately meeting customer demand. Data from meters can be used to identify and track trends in both water supply and usage so that any potential future shortages can be noticed earlier and additional supplies obtained.

3.1.6 Location of Source Facilities

The location of source water supply facilities is an important factor in determining the ability of the water system to meet the customer needs at all times. For instance, the facilities should not be located in the flood plain, because the operation of the water system could be seriously impaired by flooding of the structure(s) and equipment necessary to supply source water. Source water quality also can be significantly impacted by location. If the intake is located on a river instead of a reservoir, it is reasonable to expect significant quality fluctuations over time. When locating the facilities on a reservoir, the prevailing wind direction may cause surface debris to be blown against the intake, which could cause mechanical failures if not accounted for in the design.

The following assessment criteria are suggested for the location of source water facilities:

1. **What is the flood level in the area of the source facility? What is the level of the floor for the source facility? Can the source facility be flooded?**

   The source water supply facilities should be able to operate at all times to produce safe, potable water to meet the customers' needs, regardless of the surrounding conditions, either man-made or natural. The source facility should be able to supply water to maintain an adequate pressure in the distribution system for safety purposes, which would provide water for fire fighting, pressure to keep contaminants out, and meet the basic consumer necessities. If the source facility is flooded, the ability to supply water to satisfy these demands may be compromised. Therefore, the flood level and floor elevations should be checked to determine whether or not the facility can be flooded.

2. **Has the source facility ever been flooded? If so, was the operation of the source facility impaired? If the source facility has been flooded and**

operation not impaired, what is the access to the source facility during a flood?

Depending on the design of the facility, portions of the plant could have been flooded, yet it was still able to produce potable water. In this situation, access to the source facility needs to be maintained to allow for the ingress/egress of personnel and equipment as needed.

3. **What measures have been taken to prevent contamination of the raw water at the source facility during a flood event?**

   Flooding is a natural source of contaminants in the water supply source. Surface runoff, which is a major contributor to flooding, will transport dirt, oil, pesticides, fertilizers, and other contaminants that might be found in the watershed. Since flooding will introduce contaminants into the water supply source, the water system needs a means to mitigate the contamination of the raw water. For instance, some water systems in areas that have raw water sources subject to flooding have constructed raw water storage facilities onsite, so that no water needs to be taken from the water source during a flood event.

3.1.7 Capacity of Source Facilities

The initial step of the onsite visit should be determining the required capacity of the source facilities. The required capacity should be at least equal to the maximum daily demand of the water system over the previous several years or as determined by the rules and regulations of the state primacy agency. Reviewing the operating records of the plant should provide the maximum daily demand. The maximum daily demand typically occurs during the summer time, often due primarily to extensive lawn watering activities. However, there have been situations where the maximum daily demand occurred during hard freezes in the winter, when customers left faucets running to prevent their water pipes from freezing. Operating records for the last few years should be checked to determine the historical maximum daily demand.

The state primacy agency may have rules and regulations that specify the capacity requirements for the source facilities. The rules may require that capacity be based on design factors and the numbers of customers or connections served by the water system. The inspector should determine the required capacity for the source facilities before beginning the onsite portion of the survey.

The pumps and associated facilities at the source are critical components of the water supply system. The capacity of the source facilities (i.e., pumps, piping, metering, etc.) that deliver the source water to the treatment facilities or distribution system needs to be sufficient to deliver the quantity of water required to meet the treatment demands or those of the customers.

The existing capacity of the various units in the source facility can be checked to verify the adequacy of the units to meet the required capacity of the water system. The capacity of raw water supply pumps and transfer pumps are usually evaluated with the largest unit out of service since it is reasonable to assume that one of the pumps may be inoperable due to repair or maintenance when peak demand conditions occur. This is sometimes referred to as “firm” pumping capacity. For example, the “firm” capacity of a booster pump station with two 20-gpm pumps and one 30-gpm pump is 40 gpm. (Pump capacity is discussed further in Section 3.5.2.)

The following are suggested assessment criteria to determine the adequacy of the source facility capacity:

1. **What is the design capacity of the source water facilities? What is the historical maximum daily demand of the water system? What is the storage capacity of the system? Given service connections or population, are they reasonable?**

   The historic maximum daily demand of the water system can be found in the operating records of the facility. The source water supply capacity, the treatment plant capacity, and the treated water storage capacity of the water system can be determined from design and construction documents. Using this capacity information, the historic maximum daily demand, and information on population increase and decrease trends, the inspector can draw conclusions as to whether the source water supply facilities are capable of meeting the maximum daily demand of the water system, or whether the facilities need to be upgraded or expanded.

2. **If the state primacy agency has specific unit capacity requirements, does the system meet the requirements?**

   Some state primacy agencies have set minimum requirements for the capacities of source water supply pumps, based on historical water use data for the area, industry standards, and generally recommended engineering practices (GREPs). The state primacy agency criteria is usually established at levels adequate to ensure that capacity is available to meet any and all demands of the system’s customers for normal as well as emergency use. Typically, the capacity requirement is based on the number of connections served and fire fighting demand (e.g., raw water pumping capacity of 0.6 gpm per connection served). With the number of connections served by the system, the state required capacity of the facility can be determined.

3. **Is the system structure silting up? Is the sump of the source water supply pumps silting up? Are there any dead fish or wildlife animals floating? Is there plant or manmade debris floating?**

   Silting and the accumulation of floating debris at the intake may negatively affect the source water supply by reducing pumping capacities, degrading raw water quality, or preventing variable level capability.

4. **Are the source water supply facilities capable of meeting the required capacity with the largest unit (e.g., raw water pump) out of service?**

   Since the equipment used in a treatment plant is mechanical, it will be necessary to take individual units out of service periodically for maintenance, repair, or replacement. During this time period, the facility should be able to satisfy the maximum daily demand of the system. To ensure that adequate capacity is available at all times, the capacity of the source water supply facilities should be determined with the largest unit out of service.

5. **Can the operating characteristics of the existing units be checked? If so, does the system check them periodically? How does the existing operational point compare to the original operational characteristics of the unit? Should the capacity of the unit be derated? If so, what is the new capacity?**

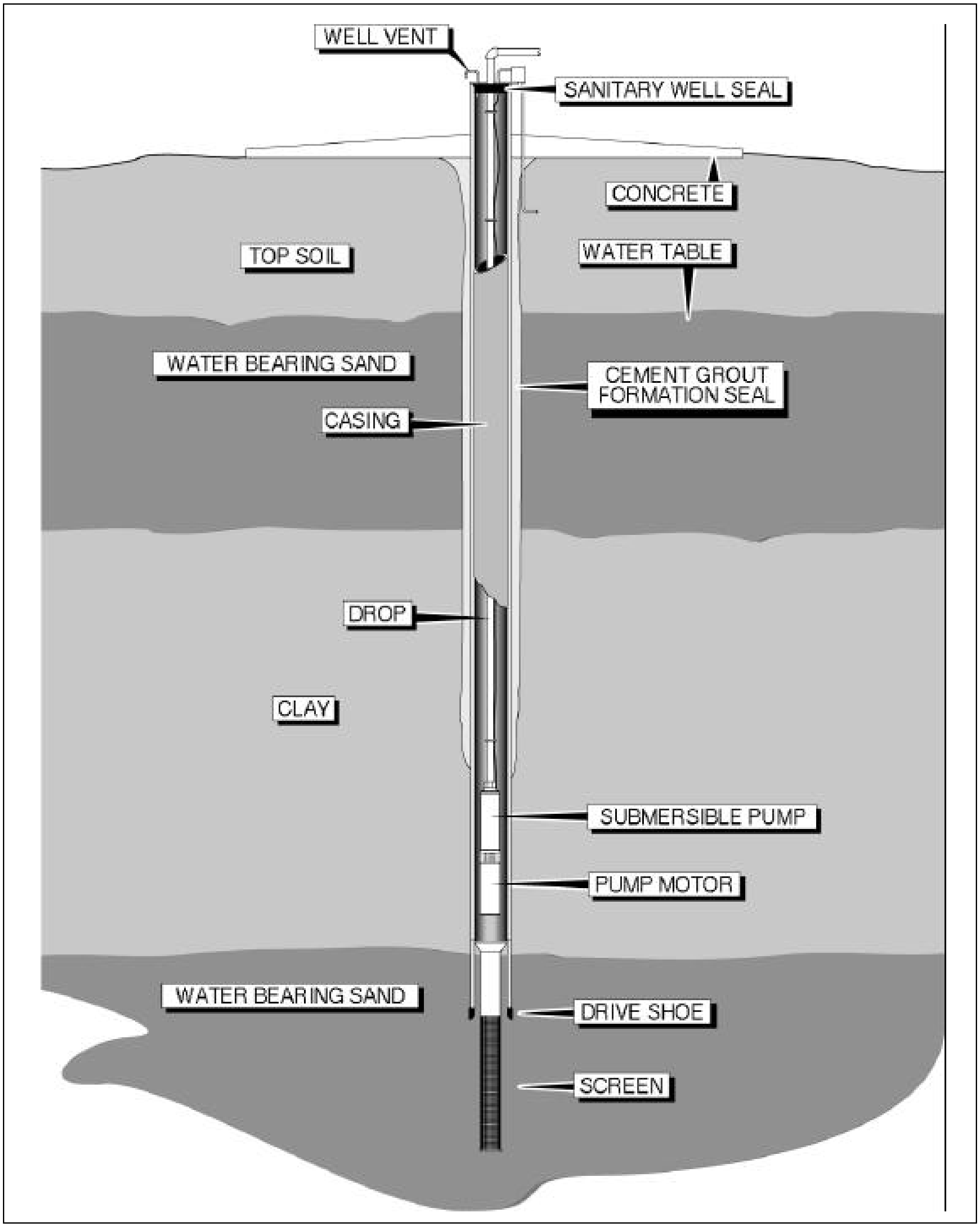
   As with most mechanical equipment, the equipment in a facility will degrade over time due to usage. For instance, the capacity of a raw water pump may decrease over time from the original nameplate capacity, due to wear of the impellers. Periodically, the equipment should be checked to compare the present to original capacity. A meter at the source facility provides a means to check the capacity of individual units and the capacity of all units operating at one time. The system should read the meter regularly under normal operating conditions, to determine volumes, rates, and current capacity. The results for a unit should then be compared to the original operating characteristics to determine the current operating performance. This check provides a means of determining the degree of wear of a unit. The capacity of a unit may have to be derated if the present operating capacity is significantly less than the original. If a unit's capacity is derated, the overall capacity of the facility may be reduced and the new capacity may be less than required. If the present capacity is less than the original, the equipment can either be repaired to obtain the original capacity or the actual capacity can be used in all further capacity determinations.

3.1.8 Design of Source Facilities

This section is divided into five subsections addressing different raw water sources, because each source has unique design characteristics. These different sources are grouped as ground water facilities; surface water facilities; infiltration galleries; springs; and catchments and cisterns.

Ground Water Supply Facilities

Ground water is water withdrawn from underground aquifers. To get the ground water to the distribution system, a well is drilled and a pump installed below the water level. A major concern in the design of a well is preventing contaminants from entering the aquifer. The major components of a typical ground water well are shown in Figure 3-1.



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(Source: UFTREEO Center, 1998; Used with permission)

Figure 3-1. Major Components of a Typical Ground Water Well

Because only the casing is above ground, it is not possible to visually inspect a ground water supply well to verify that the proper design and construction methods were followed for components below ground. The original well construction records (e.g., driller's log, material settling data) and records of after-construction modifications to the well, if available, should be used to verify that the well was properly constructed. The results of inspections and repair work performed by qualified technicians may provide additional information on the construction of the well. The inspector should verify that design and construction methods meet applicable state requirements for wells.

A well is started by drilling a hole in the ground into a water-bearing aquifer. The drilled hole is supported by solid casing installed to just below the water table. Screen material is installed below the casing to allow water into the casing while preventing the migration of sand and silt into the bottom of the well. The screen should be constructed of corrosion resistant material that is both strong and hydraulically efficient. A pump (usually submersible) and discharge line are lowered down the casing into the water.

The annular space between the drilled hole and the casing is filled with bentonite to prevent surface water and undesirable ground water from getting into the well and contaminating the aquifer. Grout or bentonite clay are used to fill the annular space. The well also needs to be sealed at the surface to prevent surface contamination from entering the well. This seal is usually a concrete pad poured around the casing and sloping away from the well, and a wellhead cover or a cap with a sanitary seal.

The following are suggested assessment criteria for a groundwater supply well:

1. **What is the depth of the well? Is the well encased the full length? If not, how long is the casing? Is the annular space around the well casing filled with grout or bentonite clay?**

   A well provides a direct conduit from the ground surface to the aquifer from which water is taken. If the well is not constructed properly, surface runoff and shallower aquifers can contaminate the aquifer chosen as the water source. Well casing is a very important part of proper well construction. The encasement of a well acts as a barrier to surface water and contamination from other aquifers. The encasement should be constructed of either steel or plastic, depending on the depth of the well and local regulations, and adhere to AWWA and NSF standards. The encasement should extend up a minimum of 18 inches above the natural ground level or finished floor elevation. The encasement should pass through all undesirable water bearing strata and extend down at least to the depth of the shallowest water bearing strata to be developed. However, the encasement will not completely fill the hole drilled for the well. The annular space around the casing needs to be filled with a material, such as bentonite or grout, that will prevent the leakage of water from the surface and intervening water-bearing layers down the outside of the casing into the aquifer. The bentonite or grout should be pumped to ensure that the annular space is completely filled.

2. What is the screen constructed of? What is the depth of the screen?

The water-bearing aquifer will typically consist of sand and gravel. A screen allows the maximum amount of water to flow into the well and prevents abrasive sand and gravel from reaching the pump. The screen should be constructed of a material that is strong and will not degrade over time due to exposure to water and surrounding environmental conditions. The material generally chosen for the screen is stainless steel. The screen should be checked periodically for corrosion and deterioration, especially if there is a reduction in pumping volumes.

3. Is the well properly sealed at the surface? Does the casing extend at least 18 inches above the well slab, floor, or ground surface? Does the well vent terminate above the maximum flood level with a turned down gooseneck and corrosion resistant bug screen?

As noted above, surface runoff can migrate down the annular space along the outside of the well casing and contaminate the aquifer. Therefore, all sources of leakage should be plugged to prevent contamination. The most visible point of leakage is the encasement at the surface. The construction of the well above the surface should prevent leakage down the outside of the well casing as well as through the casing cap, which is located on top of the casing. A concrete slab extending 2 to 4 feet around and sloping away from the well casing provides an effective seal of the casing. By extending the casing at least 18 inches above the well slab, surface runoff should not be able to enter the casing. The well casing cap has to be a watertight sanitary seal to prevent water from entering through it. In addition, the casing vent through the cap should extend above flood level to preclude surface runoff from entering the well directly and the end of the vent should be terminated with a down turned gooseneck and screen to prevent rain and bugs from entering.

4. Is there an acceptable tap for raw water sampling?

The discharge from the well should have a sample tap with a smooth nozzle to allow for sampling before the addition of any chemicals or disinfectants. A sample of the raw water will allow the water system to test for any contaminants that might be present or any changes in water quality.

5. Is the wellhead protected from vandalism and accidents?

There are numerous ways that the water supply for a system can be contaminated, including vandalism. Due to the location of the well, the wellhead may be vandalized, introducing contaminants down the well casing. If the wellhead is located near a street or highway, the wellhead could be damaged by a traffic accident. The location of the wellhead will dictate the measures required to protect it from vandalism or physical damage. For instance, a security fence and structurally sound buildings with locked doors would protect the wellhead from intentional vandalism or bollards would protect it from traffic accidents.

6. **What is the general condition of the piping and valving, the site, and the electrical system? Do they appear to be well maintained? Does the electrical system have lightning protection? Can the pump be maintained easily and the water for the system continually supplied?**

   As the source for the water system, the well should be in good operational condition to ensure that a dependable supply of high quality source water will be available at all times. Good operational condition means that the piping is not leaking or corroded, the valves and controls are operable, the electrical system is protected from the elements and is not corroded, the well site is graded to prevent ponding of surface water and to direct drainage away from the wellhead, and the housing and fencing is properly maintained. Valves and meters need to be fully functional and well-maintained to keep out contamination. Personnel should have sufficient access to these valves for cleaning. The electrical system should be protected from lightning since the sudden electrical surge caused by lightning striking the wellhead or nearby may cause the electrical components to burn out. If the electrical components of the well are not functional, then the well will not operate. The inspector should check for lightning protection and backup power supplies

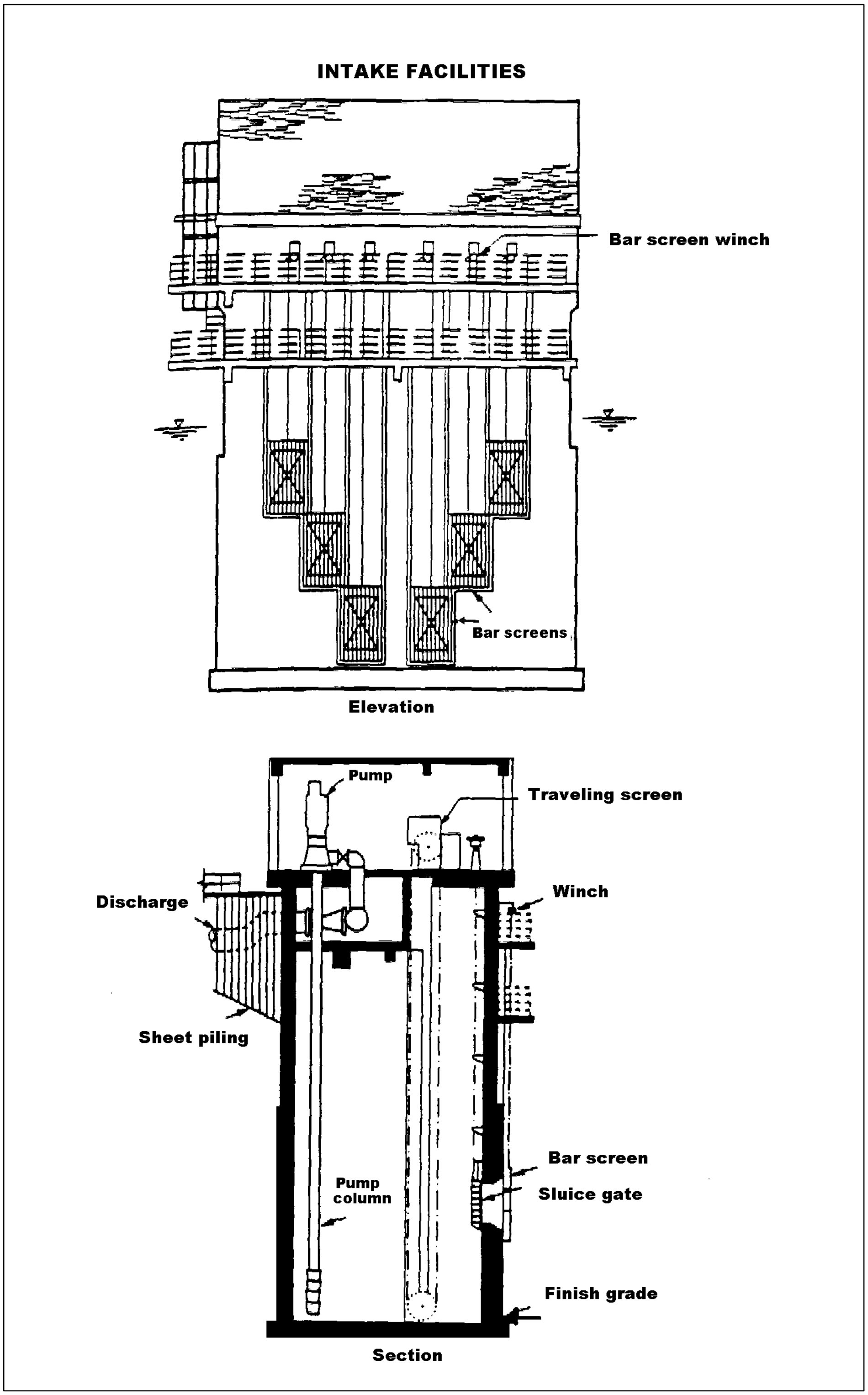
7. **Has the source been evaluated for GWUDI? If the well is under the direct influence of surface water, is proper treatment provided (filtration, disinfection)?**

   A ground water well may be under the direct influence of surface water. GWUDI of surface water has increased sanitary risks because of the additional opportunities for contamination to enter the water supply. A water system should evaluate its ground water supply to determine if it is GWUDI of surface water and, if so, apply appropriate treatment at the plant. The inspector needs to determine if a ground water supply is GWUDI in order to evaluate if appropriate treatment is provided.

Surface Water Supply Facilities

The design of a surface water source facility should provide some flexibility to accommodate fluctuating water quality. The location and position of the intake point in a river or reservoir can greatly affect the quality of water coming into the intake. Intake points should be located a sufficient distance (preferably upstream) from potential sources of contaminants. Water quality can vary with depth, and the elevation of a water surface changes over time. Intakes should be located at more than one depth so that the operator can draw water from the intake offering the best water quality (based on monitoring of water quality at different depths) and can withdraw water during times when the water level is very low. Figure 3-2 depicts the design of a surface water intake which can accommodate water quality variations with multiple level withdrawals.

There are several design methods that provide some flexibility to accommodate fluctuating water quality. The most common method for a surface source is to provide multiple levels of withdrawal. For instance, at a surface source, if the turbidity at a water depth of 20 feet



(Source: AWWA and ASCE, 1998; Used with permission)

Figure 3-2. Surface Water Intake with Multiple Level Withdrawals

is higher than at a depth of 5 feet, the design of the intake should provide the flexibility to withdraw at the 5 foot depth, which is the better quality level. The design of the source facility should be checked to determine whether water can be withdrawn at the lowest recorded or projected water level, and an appropriate range of levels. Water systems may also use bar screens and grates at their surface water intakes to prevent large debris from entering. Large debris, if allowed to enter, can damage supply pumps.

All mechanical equipment has to be maintained, either on a preventative basis or in an emergency. The design of the source facility should allow for the removal from service of a unit for maintenance. Typically, valves are provided on the discharge of pumps to take the unit out of service for maintenance and allow the facility to remain operational. Lockable breakers on the electrical service to the unit should also be provided to prevent the starting of the unit while it is out of service. Because all mechanical equipment has to be periodically maintained, it is very important that a means be provided to allow for maintenance while the facility remains operational at all times to meet the needs of customers. The onsite inspection of the source facility should check the design or features of the source facility to verify that it meets the needs of the water system and satisfies the regulatory requirements, if necessary.

The following assessment criteria are appropriate for a surface water supply facility:

1. **Is the source water quality the best possible? Can the best quality of water be withdrawn? If so, how? Is there an area around the source facility that is restricted? How is the area marked? Is the existing marking adequate? Are there any nearby sources of contamination evident? If so, what is being done to protect the source water?**

   The system should have the ability to withdraw water from several different depths within the reservoir, so that the operators can adjust the intake depth to obtain the best raw water quality. A single, fixed level intake point may be acceptable if historical records on the quality and use of source water indicate that there is no need for variable level capability. There should be no evidence of potential sources of contaminants such as septic systems, pit latrines, or fuel storage tanks in the area around the intake structure. Where contaminants are present, there should be spill containment or other measures in place to prevent the contamination from reaching the intake. There should be no debris or refuse accumulated around the intake structure. The area surrounding the intake should be clearly marked with signs, and if appropriate, buoys. Fencing may also be necessary to prevent unauthorized access to the surface water intake and supply facilities.

2. **What conditions cause fluctuations in the raw water quality?**

   Raw water quality may vary for surface water systems as a result of a number of factors, such as rainfall, snow melt, temperature, and changes in the watershed. The inspector should ask the system operators what factors cause changes in raw water quality for their system and if there are any steps that the system takes to minimize the impact.

3. **Can a unit be taken out of service for maintenance and the facility remain operational? If so, how? Can the unit be locked out at the electrical service? If not, what is the method for preventing the starting of the unit during maintenance?**

   The ability to maintain the intake structure and raw water pumps is important to the water system's ability to provide a safe and reliable water supply. The system should have the ability to maintain an intake or raw water pump without having to take the entire water system off line.

4. **Can water be withdrawn during a prolonged drought? What is the minimum projected water level? What is the level of the lowest withdrawal point?**

   The system operators should be able to show how they can adjust the intake depth during periods when the level of the surface water source is low.

Infiltration Galleries

An infiltration gallery is one means of using the natural filtration benefits of the ground to reduce water quality variances. The infiltration gallery, shown in Figure 3-3, consists of a perforated pipe in a gravel or sand bedding constructed along or beneath the source. Typically, sand backfill is placed over the bedding to improve the filtration of the natural soils in which the gallery is constructed. It is important that the embedment and backfill of the infiltration pipe be protected so that it is not washed out. The perforated pipe is connected to a well or caisson along the shore of the source. Raw water pumps lift the water from the well to the treatment facility. The wellhouse should be located at an elevation above the highest flood level of the source.

Infiltration galleries are often under the direct influence of surface water and therefor are frequently classified as GWUDI. The water system needs to determine if an infiltration gallery is classified as GWUDI and is considered to be a surface water source under the definition used by its state. If so, it should be treated as a surface water source.

The design and construction of an infiltration gallery is similar to a ground water well, therefore the assessment criteria for wells applies to an infiltration gallery; however, there are a few differences. The following additional assessment criteria are appropriate for an infiltration gallery:

1. **Is the water system experiencing any significant fluctuations in water quality? If so, when and why?**

   Fluctuations in water quality from an infiltration gallery may indicate the overlying sand or other bedding material has washed out, and the water is not being filtered as it flows from the surface to the collector well. The system may need to excavate the infiltration gallery and replace the washed bedding.

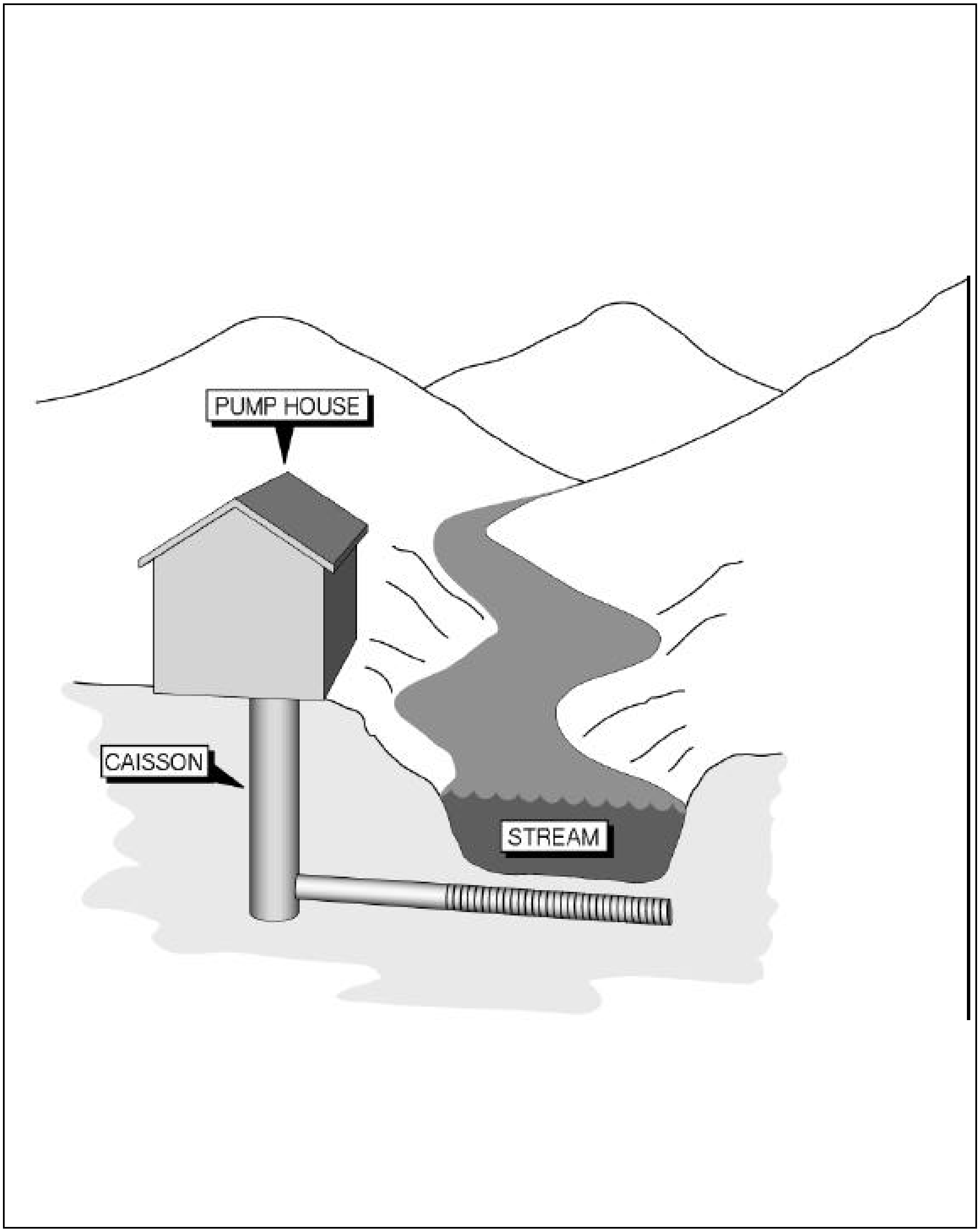


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Figure 3-3. Infiltration Gallery

2. **Is the infiltration gallery still providing an adequate supply of water? If not, when and why was the supply inadequate? When was the infiltration gallery last inspected? Was there any damage to the gallery—pipe, bedding, and backfill? Does it appear that the backfill and bedding, if visible, were clogged with silt? If so, how was it changed or cleaned?**

   The sand overlaying the infiltration collector pipes may become clogged with silt or other fine sediments, reducing the rate at which water can flow into the collector pipes. The system may need to excavate and replace the bedding.

3. **Has the source been evaluated for GWUDI? If the source is under the direct influence of surface water, is proper treatment provided (filtration, disinfection)?**

   Many infiltration galleries in certain geographic areas are under the direct influence of surface water. GWUDI of surface water has increased sanitary risks because of the additional opportunities for contamination to enter the water supply.

Springs

Springs occur where the natural flow of ground water rises to the surface. There are two types of springs, gravity and artesian. Gravity springs discharge from unconfined aquifers, which are water-bearing aquifers that rest on an impervious stratum and outcrop to the surface. Artesian springs discharge from artesian (confined) aquifers, which are aquifers that have both an upper and lower layer of impermeable material that forms a natural barrier of protection against contaminants. Artesian springs are under pressure because of the confining strata between which the water-bearing aquifer lies. Because of the upper confining layers, the water in the aquifer is at a pressure greater than the atmospheric pressure. An artesian spring occurs where the artesian aquifer either is cracked by a fault allowing the pressured water to escape or outcrops at a low elevation. The general geologic formations for each type of aquifer and spring are shown in Figure 3-4. (UFTREEO Center, 1998)

Springs may be considered either surface water or ground water sources, depending on their characteristics and on the way a state classifies springs. The water system needs to determine if the spring is under the direct influence of surface water and if it would be classified as a surface water source under the definition used by its state. If so, it should be treated as a surface water source.

When a spring is chosen for a water supply, the water system should determine that the water quality is acceptable, the quantity of water available is adequate to meet the needs of the water system, and the spring is protected from contamination. The quantity of water available from a spring can vary significantly due to changes in ground water storage. Depending on the type of spring, changes in ground water storage can come from seasonal variations such as dry periods and withdrawals of nearby wells. Special steps should be taken to prevent contamination of the spring during construction of the improvements necessary to supply the source water.

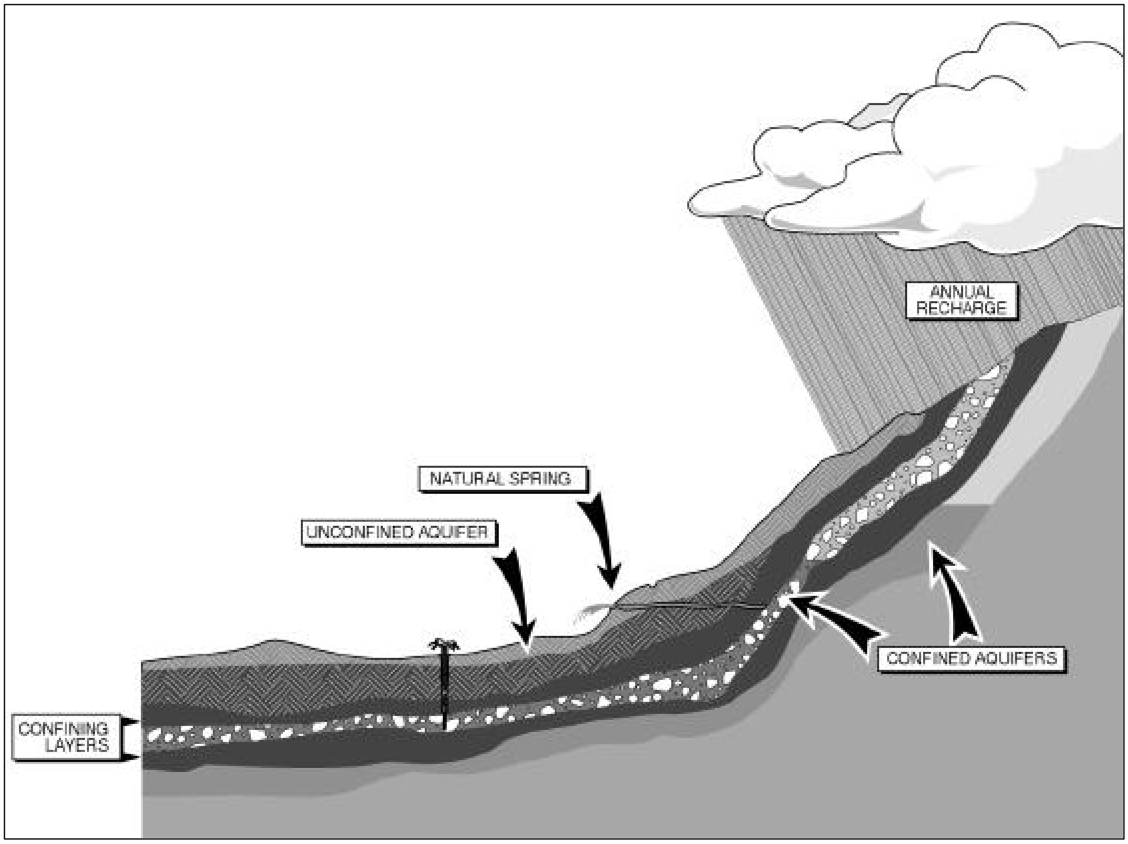

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Figure 3-4. Geological Formation for Springs

Many of the collection system improvements for a spring are similar to that for a well or an infiltration gallery (see above subsections), depending on the type of spring. If the spring is artesian, a vertical well is drilled into the aquifer (either directly at the spring or near the spring) and constructed in the same manner as a ground water well. Water rises in the well due to the pressure of the artesian spring, so unlike ground water wells, a pump may not be needed to raise the water in the well. However, pumps may be used to deliver the water to the treatment plant. If the spring is gravity driven, then a horizontal well (similar to an infiltration gallery) is constructed to collect the spring water before it exits at the surface.

Since water from a gravity spring outcrops to the surface by gravity, pumps may only be needed to feed the water to the treatment plant, instead of the pumps used to lift water from the infiltration gallery well.

Due to the similarity of the spring water collection system to a ground water well or an infiltration gallery, the assessment criteria for those facilities apply to the collection systems for springs; however, there are some differences. The following additional assessment criteria are appropriate for springs:

1. **Is the spring area protected from contact with animals and vandalism?**

   Protective devices, such as good fences and warning signs, deter human and animal activities that might disturb the spring area.

2. **Is the spring box or storage tank watertight, with a lockable, watertight, overlapping lid or cover? Does the springbox have a screened overflow? Is there a drain with a screen and shutoff valve? Is the supply intake properly located and screened?**

   The springbox or storage tank and cover need to be watertight to prevent undesirable water from entering. The cover should also be lockable to prevent the access of unauthorized parties. Since most springs never stop producing water, an overflow is needed to ensure that water pressure does not build up and damage the springbox. Springboxes need a drain to turn out the water in case the source water quality degrades. The end of the drain should have a screen to prevent the entrance of animals. The intake to the water system from the tank or springbox should be located about 6 inches above the bottom and screened to minimize the amount of sludge that is drawn into the intake from the chamber (UFTREEO Center, 1998).

3. **Is there a diversion ditch around the upper end of the spring area? Is there an impervious barrier over the spring area to keep out rainwater and surface contamination?**

   A diversion ditch keeps rainwater from flowing over the spring area and infiltrating the ground, and should be located at the uphill end of the site. A good impervious barrier, such as clay or a plastic liner, can help ensure high quality water by preventing potential contaminants from entering the collection facilities.

4. **Does the spring meet requirements for setbacks from sanitary hazards?**

   Springs should meet appropriate state requirements for setback distances from sanitary hazards.

Catchments and Cisterns

In some areas, catchments and cisterns are used to collect rain water from the roofs of structures. Sometimes, the quantity and quality of the collected rain water may be doubtful, but it may be the best (or only) source available for individuals or small communities (UFTREEO, 1998). The biggest factor affecting the quality of the water collected is the type of material used on the roofs, and the condition of the gutter system.

The important factors for quantity are the collection and storage areas, annual rainfall, and per capita use.

Particular attention should be paid to the material and condition of the roof and gutters when reviewing the design of the catchment system (see Figure 3-5 for the major components). The roof and gutter system should be constructed of weather resistant material, such as metal or plastic. Debris from trees and brush should not be allowed to collect on the roof or accumulate in the gutter system.

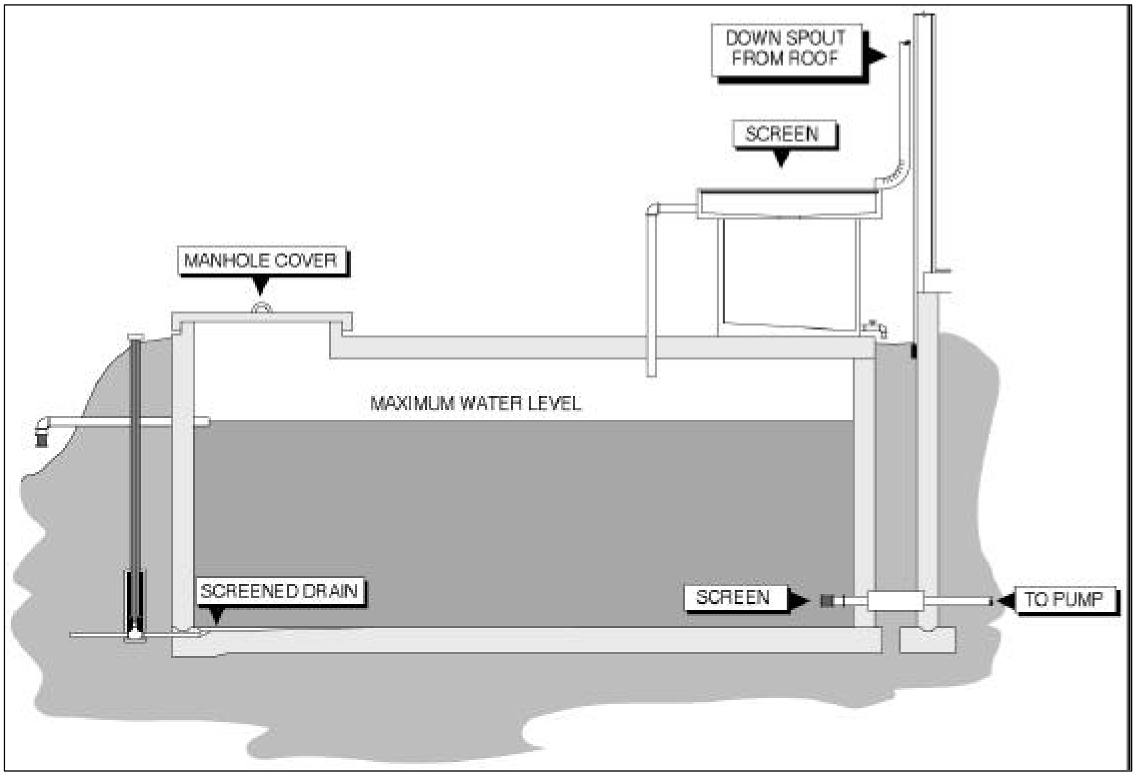

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Figure 3-5. Catchment and Cistern System Components

Rain water flows off the roof into the gutters and then to a central collection point, a tank that is commonly known as a cistern. A diversion box should be provided at this central point to divert the first water that runs off the roof. This first flush typically contains the debris and bird droppings found on the roof and in the gutters at the time of the rain and should not be allowed to flow into the cistern. After the diversion of the first water, the diversion box is switched to allow the rain water to flow through a screen into the cistern. The screen is needed to collect the remaining debris.

Roof structures are often accessible to rats, raccoons, opossums, birds, and other animals and therefore are vulnerable to contamination from animal populations that carry protozoan cysts pathogenic to humans. As a result, there may be significant potential sanitary risks associated with the use of catchments and cisterns as public water supply sources without proper treatment (e.g., at least disinfection to treat for potential bacterial and viral contamination).

The cistern should be constructed of non-toxic materials that make it watertight. The access cover to the cistern should be at least 2 inches above the surface, heavy enough to prevent removal by children, and lockable. The piping for the cistern should include a drain for cleaning, an overflow to allow water to escape the tank, and an intake to the system pump. The drain and overflow should be screened on the end to prevent insects and animals from getting into the cistern. A free-flowing drain line with an isolation valve should be located at the bottom of the cistern. The intake to the system should be installed at least six inches above the floor of the cistern with a screen on it to prevent any debris that may have settled from entering the system.

To assess catchment and cistern designs, the following criteria are appropriate:

1. **Is the water supply adequate to meet the needs of the community? If not, what other sources are available?**

   The cistern should be capable of meeting the system's demand for water even during periods of drought or alternate sources should be provided. Inadequate capacity could lead to customers utilizing unsafe sources of water.

2. **What is the condition of the roof and the gutters? If signs of deterioration are evident, when will the system be renovated?**

   The condition of the roof and gutters can have an impact upon the quality of the water collected in the cistern. The roof and gutter should be constructed of weather proofed materials and should not have the potential to leach contaminants into the water supply. There should be no accumulated debris on the roof or in the gutter, which could be washed into the cistern.

3. **Is there a diversion box? Is the diversion operable?**

   The first flush of runoff typically contains the highest level of debris and other potential source of pollutants. A diversion box prevents the first flush from entering the catchment. The first flush tank should be emptied before the next rain.

4. **Is the cistern properly constructed? Does the water quality appear acceptable in the cistern (no floating debris, etc.)?**

   The cistern should be watertight. There should be an adequate cover for the cistern, which is secure. There should no way for contaminants on the surface to enter the cistern.

5. **Are there screens at the entrance to the cistern, at the drain overflow and intake to the system? Are the screens in good condition?**

   There should be a drain pipe to allow for cleaning of the cistern and an overflow pipe. Both the drain and overflow pipes should be screened to prevent animals or insects from entering the cistern.

3.1.9 Condition of Source Facilities

The physical condition of the source facility can be a good indicator to the inspector of how often the facility is visited and how well it is maintained. Regardless of the location, all critical facilities should be visited at least once a day to determine that all equipment is operating correctly. If the grass around the facility is knee high, with no apparent trails through the grass, a reasonable assumption can be made that the facility is not visited daily (or maybe even monthly). Another indication of the general visitation schedule by operation personnel is the amount of spider webs in the corners or dirt on the floor.

The overall condition of the equipment will provide some insight into the water system's philosophy towards preventative maintenance. If the equipment appears to be in good condition with little rusting, then the system places value on preventative maintenance. However, if the equipment does not appear to be in good condition (e.g., zinc fittings painted over), then the system either places little value on preventative maintenance, may have little money allocated for maintenance, or has an inadequate staffing level to perform maintenance.

Suggested assessment criteria for the physical condition of the source facility include:

1. **How often is the facility visited?**

   Source facilities should be checked by system personnel at least once a day.

2. **Does the facility appear to be well maintained – grass mowed, equipment painted, facilities kept clean, etc.?**

   The appearance of the facility does not directly impact the quality of the water, but it does provide an indication of the overall amount of maintenance which the facility receives.

3. **Is the facility required by the state or local government to have a rodent and pest control permit? Does the facility have one? Are there any visible places where wildlife can enter the facility and take shelter (including rodents, birds, and snakes)?**

   The inspector should evaluate the appropriateness of any rodent/pest control measures. The inspector should observe whether there are any signs of the existence of wildlife inside the facility. While at the facility, the inspector should look for any signs of earlier flooding in the facility or water marks on the walls that may be signs of equipment malfunctioning.

3.1.10 Transmission of Source Water

Untreated water travels from the source to the treatment plant through a transmission system of pipes. Some source water facilities are at a considerable distance from treatment facilities. The transmission lines present a potential opportunity for liquids and materials to both enter and leave the system. If the raw water is used before it receives treatment, it presents a sanitary risk and may be unsafe. If the transmission lines are not in good condition, they may allow contaminants to enter the raw water supply or may cause the supply to be interrupted. Transmission lines need to be assessed for sanitary risks during the sanitary survey. The inspector should travel along the raw water transmission lines and speak with the operators to verify information already obtained from maps and other records about the location of transmission lines, air release valves, pressure release valves, drain valves, and other pertinent information.

Suggested assessment criteria for the raw water transmission lines include:

1. **Do the transmission lines deliver all the raw water directly to the treatment plant?**

   The transmission lines should not contain connections directly to any customers or to the distribution system. All raw water should be delivered to the treatment plant and should not be able to bypass the plant. The transmission pipes should not contain any valves that could be activated to permit bypassing. The inspector should check for any connections that may deliver untreated water to customers. If there are any connections to customers directly from the transmission lines, the inspector should check if adequate treatment is being provided. If not, the inspector should inform the system that the connections present a serious sanitary risk and need to be removed.

2. **Are the transmission lines reliable for providing a continuous supply of raw water to the treatment plant?**

   If the system relies on a single transmission line, a failure of this line could leave the system and consumers without water. If transmission pipes are in poor condition due to age, deterioration, or natural events (e.g., weather conditions, earthquakes), the inspector should assess the potential for failure and subsequent interruptions to the water supply.

3.1.11 Priority Criteria

The following criteria related to the source water element of the sanitary survey are considered high priority based on their potential for impacting public health:

- **Source Water Quality –** The quality of the raw water source can have a significant impact on treatability, due to rapid fluctuations in the physical, chemical, and biological characteristics of the source water (Section 3.1.4).

- **Source Water Quantity –** The quantity of water available should be checked to determine that there is a long-term supply available (Section 3.1.5).
- **Location of Source Facilities –** The location of the raw water facilities can impact the operation of the water system and can affect how much water quality varies over time, particularly due to nearby sources of contamination and natural causes such as flooding (Section 3.1.6).
- **Capacity of Source Facilities –** The capacity of the source facilities should exceed the potential demands even when equipment is down for maintenance (Section 3.1.7).
- **Condition of Source Facilities –** If the physical condition of the facility is poor, this can be an indication of inadequate preventative maintenance by the system and can have a negative impact on system reliability (Section 3.1.9).
- **Transmission of Source Water –** All raw water needs to be properly treated before use. If the transmissions lines can bypass the treatment plant or there are connections directly to consumers from the transmission line, a serious sanitary risk exists (Section 3.1.10).

3.2 Treatment

The type of treatment processes and facilities used to achieve safe drinking water are dictated primarily by the quality of the source water and the regulatory requirements that must be met. In general, most surface water sources require complete conventional treatment which includes coagulation/flocculation, sedimentation/clarification, and filtration processes to physically remove pathogens and other particulates, and disinfection to inactivate any pathogens that are not physically removed. The physical facilities at a conventional surface water treatment plant typically include chemical feed equipment, rapid mixing basins, flocculation basins, sedimentation/clarification basins, filters, and treated water storage facilities. The chemical feed facilities usually include storage and feed equipment for coagulants, disinfectants, and stabilizers.

In some cases, specific source water conditions may require supplemental treatment processes and facilities. For example, aeration is used to remove undesirable gases such as radon and VOCs from source water. Carbon adsorption (GAC) is used to control taste and odor problems and to remove organic contaminants including VOCs, pesticides, color- and turbidity-causing compounds and some inorganic contaminants such as radon and some heavy metals. Chemical oxidation is used to facilitate precipitation and improve the filtration process. Softening is used to reduce scale forming tendencies. In the case of high quality source water, complete surface water treatment may not be necessary. For example, the treatment facilities for a GWUDI may consist only of direct filtration and disinfection.

The sanitary survey inspector should evaluate all water treatment processes in use at the water system. This evaluation should consider the design, operation, maintenance, and management of the water treatment plant to identify existing or potential sanitary risks.

Water treatment facilities are the primary means of preventing unacceptable drinking water quality for public consumption. The treatment facilities and processes should be capable of removing or inactivating physical, chemical, and biological impurities in the source water. The new regulatory requirements related to the IESWTR and disinfection byproduct control place additional demands on the treatment facilities. The treatment facilities and processes should be evaluated to determine their ability to meet these regulatory requirements and to provide an adequate supply of safe drinking water at all times, including periods of high water demand and poor source water quality.
A sanitary survey of a treatment facility should:

- Analyze all the distinct parts of the treatment process, including but not limited to coagulation/flocculation, sedimentation, filtration, disinfection, chemical feed systems, hydraulics, controls, and wastewater management;
- Review source water quality data that may impact the treatment process, such as turbidity, pH, alkalinity, and water temperature;
- Identify features that may pose a sanitary risk, such as cross connections in the plant; and
- Review the criteria, procedures, and documentation used to comply with regulatory requirements – adequate disinfection based on CT study, individual filter turbidities, finished turbidities, post backwash turbidity profiles, etc.

The inspector will need to review the design criteria, plant records, and compliance strategies in addition to performing the actual inspection of the facility. The following sections discuss specific portions of the treatment facility to be evaluated during an inspection.

3.2.1 Location of Treatment Facilities

Theoretically and preferably, all water treatment plants should be located above 100-year flood levels. However, in some locations this is not the case, particularly for some old treatment facilities. Also all treatment plants and their raw water sources should be located at a safe distance from potential sources of contamination. The sanitary survey inspector should evaluate the location of the treatment facilities with respect to any state regulations regarding potential flooding and required distances from potential sanitary hazards. Onsite, the sanitary survey inspector should confirm the location and elevation of the treatment facilities using a topographic map. The inspector should ask about the activities carried out in nearby facilities and buildings. The inspector should also ask the plant operator(s) about any old water marks evident on the outside walls of any building within the facility and about underground storage and farm tanks in the area and how long they have been there.

Suggested criteria for assessing the location of treatment facilities:

1. **Is the treatment plant located at a level below the 100-year flood line?**

A treatment plant located in a flood plain should have measures in place to avoid a shutdown during flood events.

2. **Are there any sources of contamination in the vicinity of the treatment plant?**

   Treatment plants located near farm industries, chemical and petroleum industries, open mine pits, downstream from a wastewater discharge point, or near or in an unsewered area may have a higher risk of having a contaminant end up in the water than treatment plants located far away from contamination sources.

3.2.2 Treatment Plant Schematic/Layout Map

A schematic or layout map of the public water supply treatment plant will enable the inspector to obtain a quick understanding of the treatment type(s), what water quality problems the plant was designed to treat, and how the plant is laid out. If possible, before the site visit, the inspector should obtain a schematic or layout drawings of the treatment plant. An example of a layout map of a water treatment plant is shown in Figure 3-6. The layout map should show the major treatment processes and should be drawn in enough detail to facilitate the inspector's understanding.

For identification purposes, the name and identification number of the public water system, as well as the date of the sketch, should be included on the schematic. The dated schematics will help future inspectors identify water system changes. The schematic should be current and reflect any changes that have been made since initial construction of the system and since the last sanitary survey.

Suggested criteria for assessing treatment plant schematic or layout drawing(s) are:

1. **Does the drawing(s) shows the name of the facility and date of the last modification made to the drawing(s)? Are the drawings up-to-date?**

   This will help future inspectors know between which two sanitary surveys modifications took place. Taken together, a chronological set of schematics will help document a system's history.

2. **Does the schematic or layout map(s) contain the proper information (e.g., a legend that explains key symbols used in the drawing(s), a numerical or a graph scale on the layout map)?**

   With the aid of a legend, the inspector will get a better idea about the location of principal treatment units and appurtenant equipment. The drawing with its legend will provide the inspector with information useful for determining where to start and end the inspection, as well as areas that the inspector should focus on and inspect in particular detail.

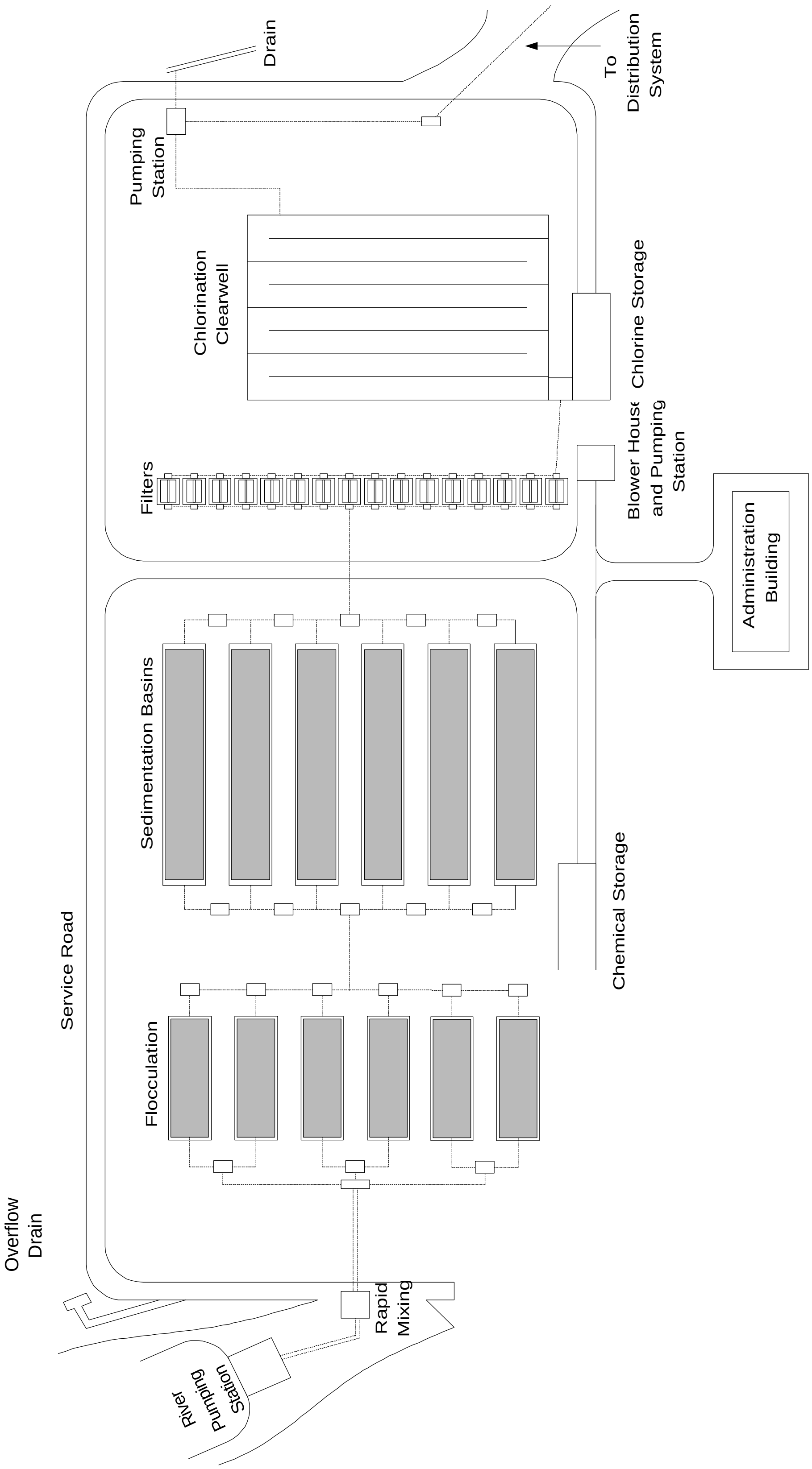

Figure 3-6. Water Treatment Plant Layout Map (not to scale)

3. **Does the schematic or layout map(s) identify treatment type(s)?**

   The identification of treatment type(s) will give the inspector an indication about what the treatment plant was designed for and whether bypassing or bringing certain treatment units on-line in response to raw water quality changes is appropriate. A list of the types of treatment plants and information specific treatment processes and facilities are included in Section 3.2.4 Treatment Processes and Facilities.

4. **Are all treatment units shown on the schematic or layout map(s)? Is there a treatment unit (including chemical injection points) that appears to be out of place?**

   Examples of out-of-place treatment are alum added at a clearwell and disinfectant only added ahead of a GAC filter. Treatment plant schematics and layout maps may not reflect the actual treatment plant configuration. Some design errors are corrected during construction and are not reflected in the layout drawings. In addition, construction errors or drafting errors can should verify whether any treatment that appears to be out-of-place on the drawings is out-of-place in the actual plant.

3.2.3 Capacity of Treatment Facilities

One of the initial steps of the onsite visit should be determining the required capacity of the treatment facilities. The required capacity should be at least equal to the maximum daily demand of the water system over the previous several years or as determined by the rules and regulations of the state primacy agency. Reviewing the operating records of the plant should provide the maximum daily demand. Generally, the maximum daily demand occurs during the summer time. However, there have been situations where the maximum daily demand occurred during hard freezes in the winter, when customers left faucets running to prevent their water pipes from freezing. Operating records for the last few years should be checked to determine the historic maximum daily demand.

The state primacy agency may have rules and regulations that specify the capacity requirements for source water supply facilities and individual treatment units. The existing treatment facilities should be evaluated to determine if the capacity requirements are met. The capacity of sedimentation basins is usually evaluated based on surface overflow rate and hydraulic detention time. The capacity of filter units is usually evaluated based on the hydraulic loading rate. The inspector should identify the component of the treatment process that most limits the production capacity of the plant (i.e., the unit that reaches maximum capacity first and thus prevents production of treated water at a higher rate).

The following are suggested assessment criteria to determine the adequacy of the treatment facility capacity:

1. **What is the design capacity of the treatment facilities? What is the historical maximum daily demand of the water system? What is the**

storage capacity of the system? Given service connections or population, are treatment facilities reasonable?

The historical maximum daily demand of the system can be found in the operating records of the facility. From design and construction documents, the system capacity can be determined. From the design capacity and maximum daily demand and population increase or decrease trends, the inspector can determine whether the source water supply facilities are close to meeting its design capacity and whether expansion plans or upgrades need to be established.

Based on storage capacity and the hourly consumption rate record over 24 hours during the day when maximum daily demand occurs, the inspector can draw conclusions on whether the source water capacity can meet the maximum daily demand.

2. **If the state primacy agency has specific treatment unit capacity requirements, does the system meet the requirements?**

Some state primacy agencies have set minimum requirements for the capacities of major treatment units, based on historical data for the area, industry standards, and GREPs. The state primacy agency criteria is usually established at levels adequate to ensure that capacity is available to meet any and all demands of the system's customers for normal as well as emergency use. Typically, the capacity requirement is based on the number of connections served and fire fighting demand (e.g., raw water pumping capacity of 0.6 gpm per connection served). With the number of connections served by the system, the state required capacity of the facility can be determined.

3. **Are treatment facilities capable of meeting the required capacity with the largest unit out of service?**

Since the equipment used in a treatment plant is mechanical, it will be necessary to take individual units out of service periodically for maintenance, repair, or replacement. During this time period, the facility should be able to satisfy the maximum daily demand of the system. To ensure that adequate capacity is available at all times, the capacity of any major treatment process should be determined with the largest unit out of service.

4. **Can the treatment process be interrupted by power outages, etc.? What backup or standby provisions are available? If a generator is provided for emergency power, how often is the generator used? Can the operator demonstrate that the backup systems are operational?**

Backup power generators should be checked on a weekly basis. They need to be exercised under load, rather than simply having the power turned on and off. Backup power generators should have sufficient power to run all essential treatment processes.

5. Can the operating characteristics of the existing units be checked? If so, does the system check them periodically? How does the existing operational point compare to the original operational characteristics of the unit? Should the capacity of the unit be derated? If so, what is the new capacity?

As with most mechanical equipment, the equipment in a facility will degrade over time due to usage. For instance, the capacity of a raw water pump may decrease over time from the original nameplate capacity, due to wear of the impellers. Periodically, the equipment should be checked to compare the present to original capacity. A meter at the treatment unit provides a means to check the capacity of individual units and the capacity of all units operating at one time. The system should read the meter regularly under normal operating conditions, to determine volumes, rates, and current capacity. The results for a unit should then be compared to the original operating characteristics to determine the current operating performance. This check provides a means of determining the degree of wear of a unit. The capacity of a unit may have to be derated (lowered) if the present operating capacity is significantly less than the original. If a unit's capacity is derated, the overall capacity of the facility may be reduced and the new capacity may be less than required. If the present capacity is less than the original, the equipment can either be repaired to obtain the original capacity or the actual capacity can be used in all further capacity determinations.

3.2.4 Treatment Processes and Facilities

The specific treatment processes and facilities at a surface water treatment plant and a GWUDI of surface water treatment plant depend on the quality of the source water and the regulatory requirements that must be met. The various combinations of these processes and facilities are sometimes classified based on the overall treatment objective of the plant as follows:

- *Conventional Filtration* – consists of facilities for rapid mixing, flocculation, sedimentation, filtration, and clearwell. Typically has chemical addition points to provide for coagulation, oxidation, pH adjustment, fluoridation, and disinfection. Also should include facilities for residuals (e.g., wastewater and sludge) management (e.g. treatment, disposal).

- *Direct Filtration* **–** consists of facilities for rapid mixing, flocculation, filtration, and clearwell storage. Typically has chemical addition points to provide for coagulation, oxidation, pH adjustment, fluoridation, and disinfection. Also, should include facilities for residuals management.
- *In-Line Filtration* **–** consists of facilities for rapid mixing, filtration, and clearwell storage. Typically has chemical addition points provide for

oxidation, pH adjustment, fluoridation, and disinfection. Also, should include facilities for residuals management.

- *Slow Sand Filtration* – consists of a slow sand filter and clearwell storage . Typically has chemical addition points to provide for oxidation, pH adjustment, fluoridation, and disinfection.
- *Single Stage Softening* – consists of facilities for rapid mixing, flocculation, sedimentation, filtration, and clearwell storage. Typically has chemical addition points to provide for coagulation (including the addition of chemicals such as lime and soda ash), oxidation, pH adjustment (including the addition of chemicals such as sodium hydroxide to increase pH and carbon dioxide for recarbonation), fluoridation, and disinfection. Also should include facilities for residuals management.
- *Two Stage Softening* – consists of facilities for lime rapid mixing, flocculation, sedimentation, lime rapid mixing, flocculation, sedimentation, filtration, and clearwell storage. Typically has chemical addition points to provide for coagulation (including the addition of chemicals such as lime and soda ash), oxidation, pH adjustment (including the addition of chemicals such as sodium hydroxide to increase pH and carbon dioxide for recarbonation), fluoridation, and disinfection. Also should include facilities for residuals management.
- *Conventional Filtration/Softening* – consists of facilities for rapid mixing, flocculation, sedimentation, lime rapid mixing, flocculation, sedimentation, filtration, and clearwell storage. Typically has chemical addition points to provide for coagulation, oxidation, pH adjustment (including carbon dioxide addition), lime addition, fluoridation, and disinfection. Also, should include facilities for residuals management.
- *Split and Complex Treatment Trains* – treatment plants with parallel treatment trains that may consist of identical or different treatment units. Typical examples would be where the influent is split directly or through an equalization basin into two parallel trains, with one treatment train consisting of one process (such as conventional coagulation, sedimentation, and dual media media filtration), and the other treatment train consisting of a different process (such as a upflow clarification and deep bed GAC filtration). Other complex treatment trains may contain aeration units and/ or membrane filtration units. In addition, the treatment plant should include facilities for residuals managment.
- *Membrane Filtration* – typically consists of pressure-driven membranes. These technologies are employed in drinking water treatment facilities to remove various contaminants. Micro-filtration membranes are used to filter out particulates including pathogenic cysts. Ultrafiltration membranes are used to remove specific dissolved organics such as disinfection byproduct precursors and to remove particulates. Nano-filtration is used to remove calcium and magnesium ions (hardness) and disinfection byproducts

precursors. It is also used to remove microbial contamination including viruses. Reverse osmosis (RO) membranes are typically used to remove organic and inorganic contamination.

- *Greensand Filtration* – consists of a pumping station, a continuous or intermittent potassium permanganate chemical feed system, the greensand filter itself, and a disinfection unit following the filtration process. Typically employed in ground water systems with iron problems.
- *Simple Aeration Plant* – consists of facilities for aeration, followed by disinfection treatment units. These units are found in ground water systems, including some ground water under the direct influence of (GWUDI) surface water systems.
- *Disinfection Treatment* – consists of a disinfection unit. Surface water, GWUDI of surface water, and ground water systems employ this type of treatment.

The treatment processes and facilities being used at a treatment plant should be evaluated with respect to the regulatory requirements of the state primacy agency. If the required treatment processes are not in place, then the files and information gathered before beginning the survey should be checked for waivers and/or exceptions granted by the state primacy agency, to determine if the existing treatment facilities are acceptable. A more detailed discussion of specific treatment processes and facilities found at surface water treatment plants is included below. The inspector should make certain that individual unit treatment processes are being operated within their design specifications.

3.2.4.1 Presedimentation

Presedimentation basins are typically used at treatment plants with raw water sources that are highly turbid. In such cases, the presedimentation process allows the removal of larger suspended matter and provides a more uniform quality of raw water. Presedimentation basins also provide an important buffer in the event that the primary source of supply is temporarily impacted by a chemical spill or other source of contamination. The presedimentation process is sometimes supplemented with aeration equipment to help control taste and odor problems.

Presedimentation basins are typically designed with large storage volumes that can meet the design capacity of the treatment plant for several days or weeks. In cold regions, these basins are usually designed with depths of greater than 15 feet and have additional capacity to account for surface freezing. In very hot climates, the basins are designed to account for excessive evaporation and some evapotranspiration.

Suggested criteria for assessing presedimentation facilities include:

1. **Is the total capacity of the presedimentation basins large enough to accomplish the purpose of reducing turbidity?**

The main function of the presedimentation basin is to reduce turbidity by causing elements such as silt, clay, and other collodial material to settle out of the water to the bottom of the basin. The inspector should review and compare the turbidity levels of water drawn from the inlet and the outlet of the presettlement basin(s) to conclude if it is functioning adequately.

2. **How often are the presedimentation basins cleaned?**

   The inspector should look at the records and ask the treatment plants operator(s) about the frequency of cleaning the presedimentation basins and how it is done.

3. **Do waterfowl cause a problem during certain periods and how does the plant operator(s) deal with this problem?**

   Waterfowl take refuge in ponds and settled water basins like presedimentation basins. In some areas they rest in large numbers on the water surface where they feed and excrete, posing a serious source of microbial and organic contamination.

3.2.4.2 Flow Control and Metering Systems

Two types of flow measurement are encountered in a water treatment plant: open channel flow measurement and closed pipe flow measurements. There are various types of flow control and metering devices. Open channel flow measurement includes Parsall flume and weir flow measurement. Flow measurement devices for full flow closed pipes are diverse. These include turbine meters, positive displacement meters, metering pumps, electromagnetic flow meters, ultrasonic flow meters, drag-force flow meters, and variable pressure-drop flowmeter such as the Venturi type tube flow meter (Doebelin, 1983).

Suggested criteria for assessing flow control and metering systems are:

1. **Are flow measurement devices installed at source water inlet and finished water outlet? Are they functioning? Are they calibrated to assure accuracy?**

   The sanitary survey inspector should take note of any out of service on-line flow measurement meter. The inspector should also note any missing flow measurement devices. This is important because flow rate is an important factor in determining required chemical additions. Having inaccurate flow measurement will result in under or over dosing of chemicals that might cause serious sanitary risks to water consumers.

2. **Are there adequate flow measurement devices thoughout the treatment process?**

   Flow meters should be installed at least at points where filter backwash is recycled, where a split in the treatment train occurs, and before and after major treatment units such as a clearwell.

3.2.4.3 Rapid Mix

In a typical water treatment plant, the coagulant chemicals are introduced into the raw water ahead of or directly in the rapid or flash mix unit. The purpose of the rapid mix unit is to provide a thorough and complete mixing of the raw water and coagulant chemicals. Mixing can be achieved by the use of mechanical mixers, diffusers or baffles in a basin(s), or a static mixer in the raw water line. Figure 3-7 shows three different configurations for rapid mix units.

Diligent operation and process control are important for good performance of rapid mix units. One of the biggest problems with rapid mix units is providing enough energy to completely mix the coagulant chemicals with the particulates in raw water.

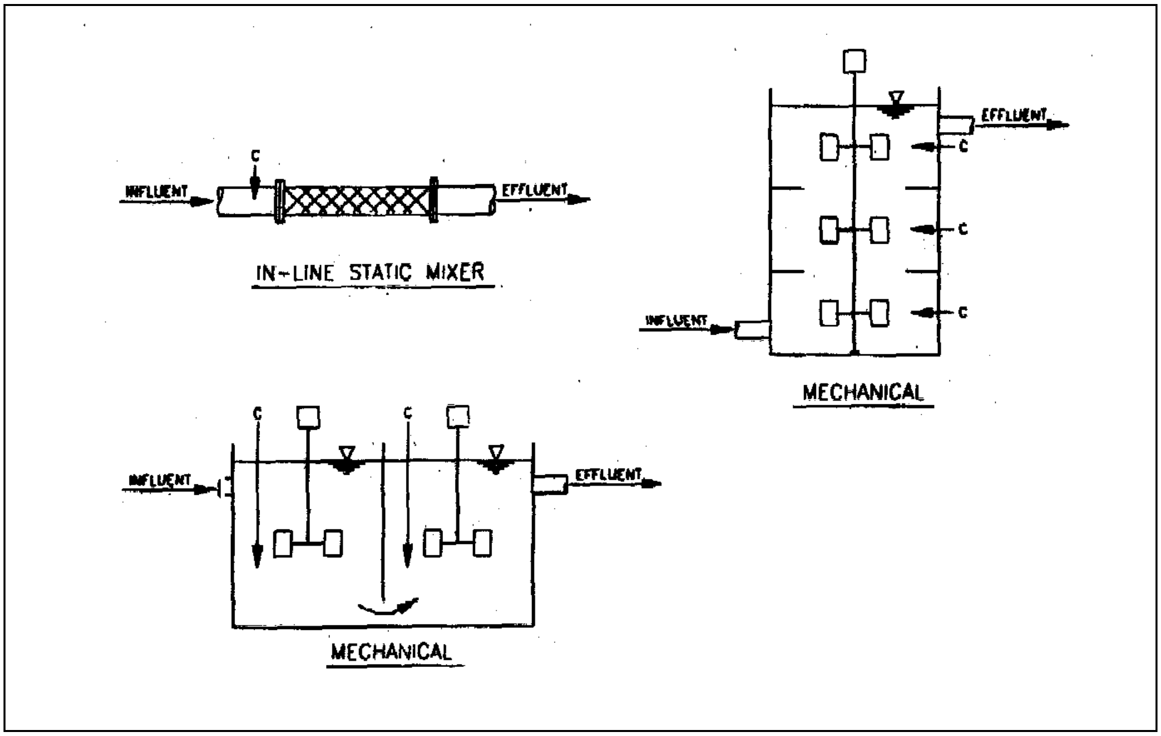

Figure 3-7. Schematic Drawings of Types of Rapid Mix Unit Configurations

One means of estimating the mixing energy used for the rapid mix is calculating the velocity gradient, *G*. The velocity gradient is a function of the energy used (water horsepower) and the volume of the basin.

The formula for velocity gradient is as follows:

$$G=\sqrt{\frac{P}{Vm}}$$

in which

G = Velocity gradient, in feet per second per foot (fps/ft) or sec^{-1}
P = Power to the water, ft-lb/sec
V = Volume of basin, in cubic feet
μ = Viscosity (0.273×10^{-4} lb-sec/ft^2 at 50 °F)

The *G* for the rapid mix process should range from 700 to 1,000 fps/ft, depending on the detention time of the basin (Reynolds, 1982).

The design detention time in a typical mechanical rapid mix unit ranges from 15 to 60 seconds. Recent developments in treatment technology are focused on providing more mixing energy with less detention time. For instance, the static in-line mixer has a very short detention time, but imparts tremendous mixing energy into the water.

Plants should have more than one rapid mix unit at the treatment plant. With two or more units, depending on the design flow, one unit can be removed from service for maintenance and the plant can remain in operation. If the plant has to be shutdown to perform maintenance (e.g., if there is only one rapid mix unit), maintenance may be performed less often and the condition of the unit may suffer. Based on generally recommended engineering practices and the Ten State Standards of 1997 (GLUMRB, 1997), there should be at least two rapid mix units if the design flow of the plant is greater than three mgd.

Suggested assessment criteria for the rapid mix process include:

1. **Does the rapid mix unit visually appear adequate?**

   The inspector should look for signs of equipment deterioration that might negatively affect the treatment process and the sanitary condition. Examples of inadequate equipment conditions include rusting on the inside and/or the outside of the mixer. Rust areas are signs of potential or imminent equipment break down and a source of concern, because they are potential breeding grounds to many microorganisms that might end up in the drinking water distribution network.

   The inspector should also look for signs of corrosion if oxidants are injected into the raw water just before the rapid mixing process. The inspector should note any signs of leaks around chemical injection points and should note if early signs of leaks exist. The inspector should also look for signs of calcium buildup where water softening is practiced. Excessive calcium buildup can adversely impact both the effectiveness and efficiency of the mixing unit.

   The inspector should look for signs of cracks or breaks in the hopper of dry feed rapid mixers. If liquid coagulants, coagulant aids or oxidants are used, the inspector should inspect liquid lines for signs of clogging. The inspector also should ask about the preventive maintenance program and the schedule. The inspector needs to examine the last entries in the repair log as to when the last preventative maintenance of the rapid mixer occurred and when unscheduled repairs had to be made and under what circumstances. This will give the inspector an idea about whether more frequent inspection and preventive maintenance ought to occur.

The inspector should look at the general sanitary condition of the housing of the rapid mix unit. Moldy, dusty, and dirty walls and floors are signs of unsanitary conditions. The inspector should note the existence of wildlife taking shelter inside and even outside the housing unit and should note if there is a possibility that a wild animal or its feathers, hair, or droppings may end up inside the rapid mixing unit.

2. Are coagulant chemicals being fed continuously during treatment plant operations?

Intermittent chemical feed can lead to uneven treatment of the whole volume of water entering the treatment plant. The inspector should look for signs of intermittent chemical feed and should note any discussions with the plant operator about the causes of intermittent chemical feed and potential solutions to this problem. The inspector should determine if the water system has a mechanism for monitoring coagulant feed and providing an alarm if any interruptions in coagulant feed occur.

3. Does the plant have multiple mix units? How often is maintenance done?

Rapid mixing units should be kept clean, well maintained, and ready for use. They should be rotated in service with the other mixing units. The inspector should note whether these idle units are put in service routinely following a rotation schedule or only when the operational unit is out of service.

4. Is the mechanical equipment working? Are there any hydraulic inadequacies?

Hydraulic inadequacies such as overflowing of the rapid mixing unit or rise of water level in the unit to the point where it splatters are signs of improper operation, clogging of water inlet and/or outlet, or improper design.

The sanitary surveyor should ask that idle units be run during his visit even for a short time to ensure that the mechanical equipment is working. The inspector should note if all the mixing units are well lubricated (e.g., operation is smooth and vibration is minimal) and appear to be well maintained. The surveyor should note whether moving parts of mixing units are causing unusual noises. The surveyor should conduct visual inspection of the mixing blades and note signs of chipped, broken, or missing blades. He should also note if clumps of coagulants are attached to the mixer shaft or blade surfaces. Coagulant clumps on the mixer blades or shaft will reduce the efficiency of the mixer and hence will result in a lower velocity gradient and impair the desired uniform mixing of coagulants with influent water. The inspector should look for any visual signs of inadequate mixing, such as dead zones and low mixing velocity.

5. **Is the rate of mixing adjustable, so that the correct mixing can be provided at all flows? If so, can the operator adjust the rate of mixing?**

   Mixing units with adjustable mixing rates can be used with different types of coagulants and chemicals. Flow-paced adjustable mixing rates ensure that adequate energy is being delivered during different flow conditions, particularly at the design flow rate.

6. **What is the design *G*? Is it within the generally accepted range? What is the detention time? Is it within the generally accepted range?**

   Knowing the design G value and the detention time at which the unit was designed, the inspector should make sure that the velocity gradient G and the minimum detention time are met if the system operates at design flow. During low flow periods, the inspector needs to make sure that all the mixer blades are fully immersed in water (otherwise inadequate mixing may occur).

   The inspector should look further for signs of inadequate rapid mixing at the influent entry point to the flocculator. Signs such as clumps of dry coagulants and immediate precipitation may imply that rapid mixing is not occurring at the desired level and/or the coagulant being used is not of the grade it is supposed to be, or the coagulant being used is incompatible with the quality of the water being treated.

7. **Have rapid mix units been evaluated for cross-connections?**

   Cross-connections, particularly from submerged inlets for chemical feeds, are common. The inspector should check for cross-connections to help ensure the integrity of the water supply.

3.2.4.4 Chemicals and Chemical Feed Systems

The type of chemicals that are used at a surface water treatment plant and a GWUDI of surface water treatment plant depend on the specific treatment facilities and objectives. The two most common chemicals that are used in surface water treatment process are coagulants and disinfectants. GWUDI of surface water treatment processes are likely to use disinfectants and coagulants, and many also use lime or soda ash for softening. Coagulants are used to condition the water for effective particle removal through sedimentation and filtration. To accomplish this a primary coagulant, such as aluminum sulphate or ferric sulphate, is added at the rapid mixing basin. Coagulant aids, such as polymers, are sometimes used to supplement primary coagulants at different points between the rapid mixing basin and filters. Disinfectants are used to inactivate pathogens that may not be physically removed during sedimentation and filtration. Chlorine, chloramines, and chlorine dioxide are the most common disinfectants, although there is growing interest in ozone and ultraviolet (UV) light. Both the coagulation/flocculation process and the disinfection process are described in more detail in subsequent sections.

Chemicals are also used at a surface water treatment plant for oxidation, corrosion control, pH adjustment, softening, taste and odor control, iron and manganese removal, organics and inorganics removal, and fluoridation.

Oxidation is used for taste, color, and odor control, iron and manganese removal, sulfur removal, and removal of synthetic organics like herbicides and pesticides. For water treatment, the oxidants used include chlorine, chlorine dioxide, permanganate, oxygen, and ozone. The oxidant used in a particular situation is determined by the contaminants present, the raw water quality, and local issues (e.g., costs). (AWWA and ASCE, 1998)

Water stabilization is used at many surface water treatment plants to prevent water conditions that are either corrosive or scale forming. Corrosive water can deteriorate water system piping and degrade the quality of drinking water delivered to the customer. In most cases, the corrosive conditions can be corrected by adjusting the pH and alkalinity of the water with the addition of lime or caustic soda. Corrosive conditions can also be controlled by adding a corrosion inhibitor to the water. Hard water can cause scale forming problems due to relatively high levels of dissolved minerals, mainly calcium and magnesium. In these cases, a softening process involving the addition of lime is used to reduce the scale forming tendency of the water.

In addition to oxidation, carbon adsorption is also used to remove organics. Organics can cause taste and odor problems and can contribute to the formation of THMs. Activated carbon, either in powder or granular form, is used to adsorb the organic substances. Fluoridation is the addition of fluoride—either sodium fluoride or sodium silicofluoride (both dry powders) or hydrofluosilicic acid (liquid)—to the water supply in order to achieve the desired level of fluoride in drinking water. Fluoride is generally added to drinking water to help reduce dental problems in consumers. (UFTREEO Center, 1998)

The systems used for handling, storing, and applying treatment chemicals are dependent on the chemical characteristics, the quantity used, and control system needed. A typical liquid chemical feed system would include: (a) a storage tank; (b) a metering pump with a suction line into the storage tank; (c) a discharge line with a check valve and injector at the application point; and (d) a flow switch to control the metering pump operation. If the flow switch is automatic, it must be tied to a flow meter or another control sensor. This type of liquid chemical feed system is shown in Figure 3-8.

The feed system for a dry chemical is very different from that for a liquid chemical, due to the difference in physical characteristics of the chemical being fed. A dry feed system would include: (a) a gravimetric or volumetric feeder to meter the dry chemical; (b) a mixing tank or solution chamber with a mixer; and (c) a gravity discharge line to the application point. Typically an open line or channel is used to carry the mixed "liquid" chemical to the application point for ease of cleaning and maintenance. The general equipment arrangement for a dry chemical feed system is shown in Figure 3-9. The sanitary survey inspector should be aware that some states do not consider the vacuum breaker shown in Figure 3-9 to be adequate protection. Therefore, the sanitary survey inspector should consult relevant state regulations on what constitutes acceptable equipment for water treatment.

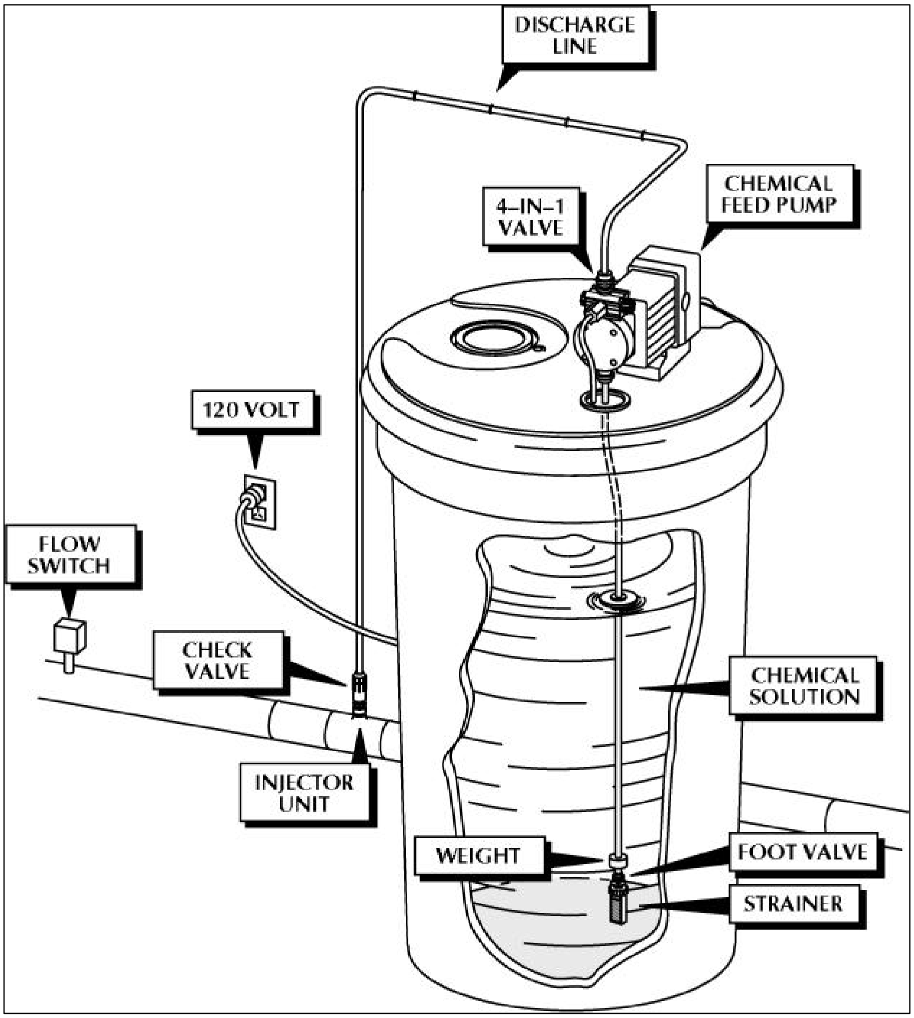

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Figure 3-8. Liquid Chemical Feed System

These chemical feed systems also may include bulk storage facilities that need to be inspected. Day tanks should be used for liquid chemicals that are bought in large quantities and stored in bulk tanks. The use of day tanks helps to limit the amount of chemicals that can enter a water system if pump failure occurs and chemicals siphon into the water supply. Chemical feed systems should be carefully inspected for potential cross-connections with potable water. All potable water make-up or delivery lines connected with chemical feed systems should be equipped with non-return flow valves.

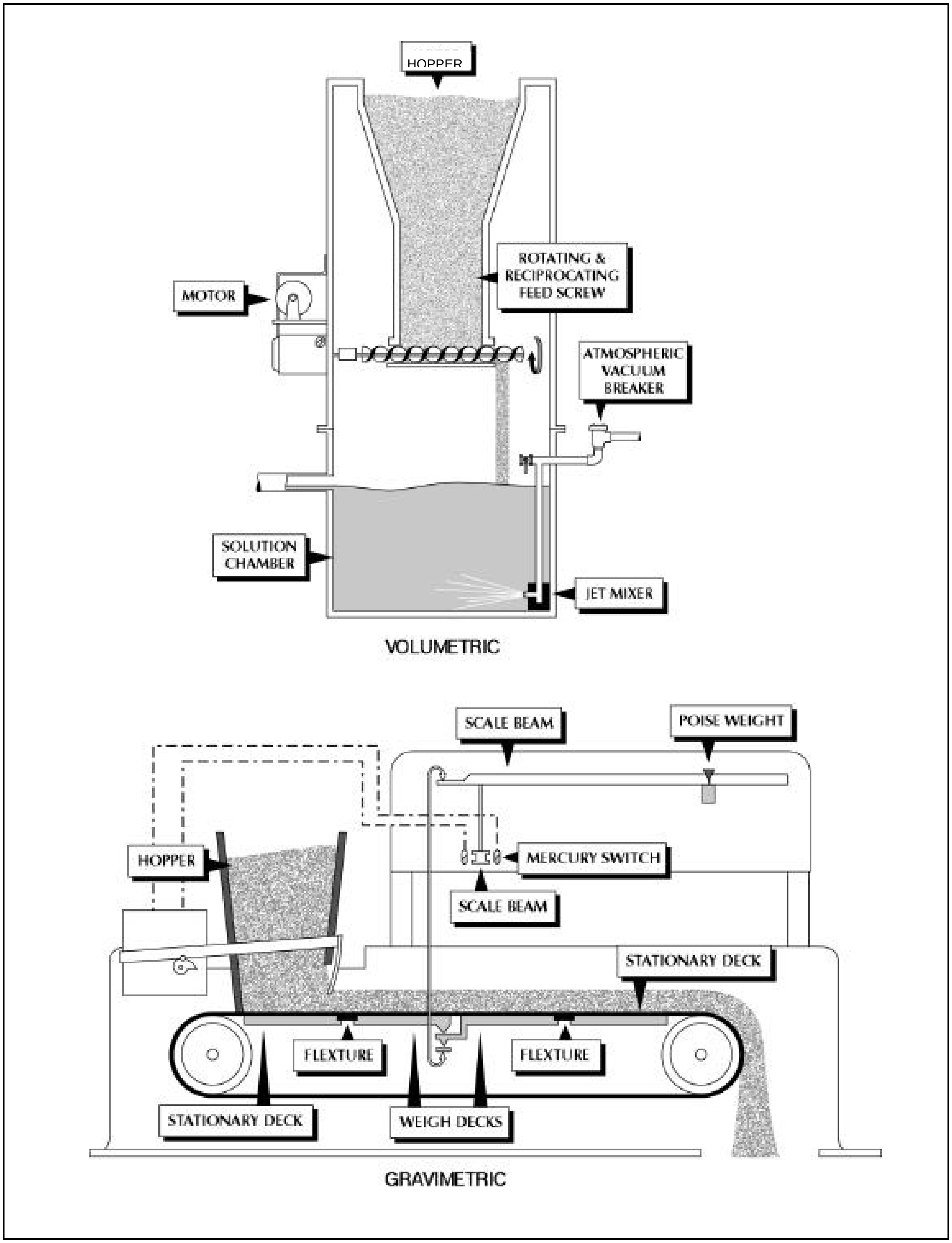

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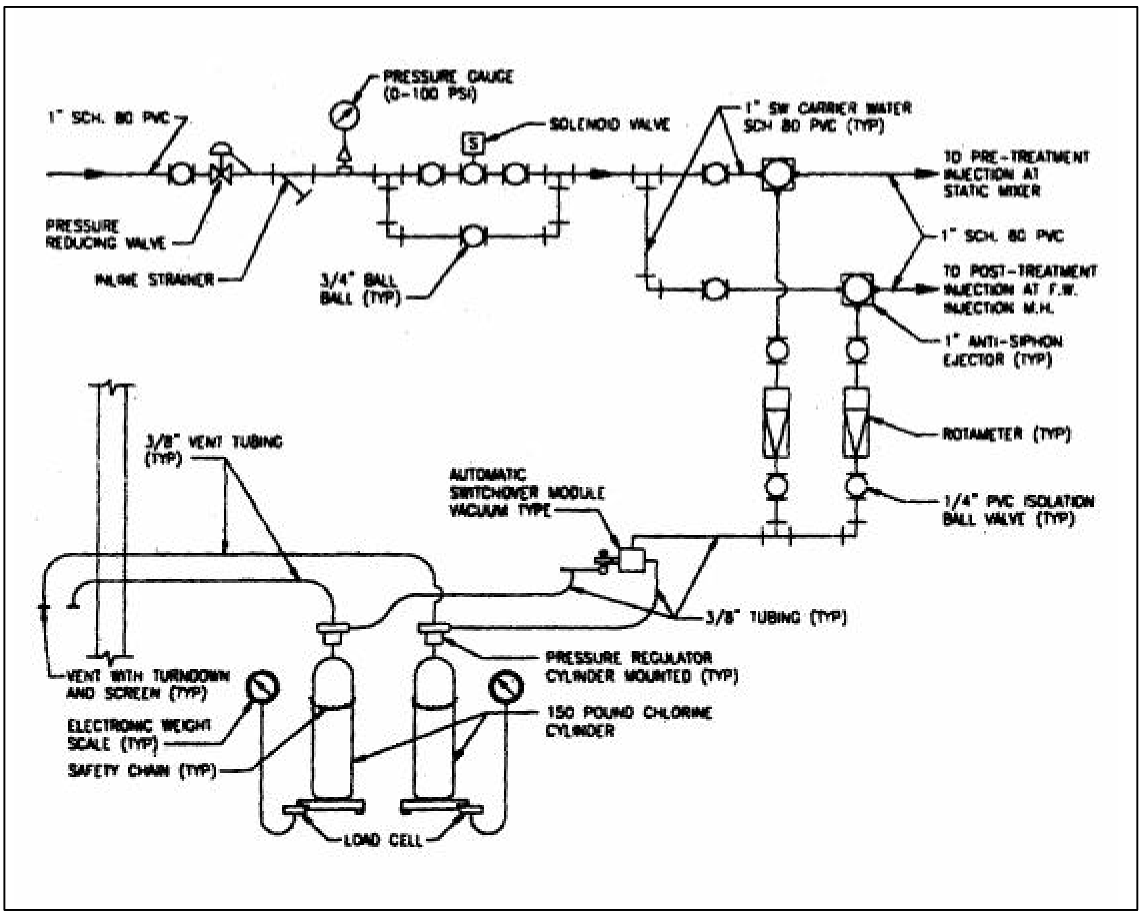
Figure 3-9. Dry Chemical Feed System

The feed system for a gaseous chemical can be either a vacuum or pressure feed system, depending on the hazardous nature of the gas. For example, a vacuum feed system is used for chlorine, which is very hazardous, while a pressure feed system is used for ozone and carbon dioxide. For both systems, there is: (a) a gas storage tank; (b) a line to a feeder with a pressure regulator; (c) a feeder with a rotameter to measure and control the amount of gas fed; and (d) a discharge line from the feeder to either an injector for a vacuum system or the application point for a pressure system. For a vacuum system, water flows through the injector creating a vacuum on the gas feed line that causes the gas to flow. The vacuum system is considered less hazardous than the pressure system, because of the reduced potential for high volume gas leaks. High capacity feed systems may also use vaporizers. The general equipment arrangement for a gaseous chemical feed system is shown in Figure 3-10. All the valves for a system like the one in Figure 3-10 should be non-return valves to provide protection against backsiphonage and back pressure backflow.



**All valves are non-return valves.*

Figure 3-10. Gaseous Chemical Feed System

Suggested assessment criteria for chemical feed systems include:

1. **What chemicals are used? Are the chemicals approved for use in drinking water?**

   Check for a National Sanitation Foundation (NSF) or Underwriters Laboratories (UL) determination that chemicals used conform to all applicable requirements of NSF Standard 60: Drinking Water Chemicals – Health Effects. Treatment plant operators may be using compounds or chemicals that are not NSF approved. These plants may have used these chemicals before the EPA established the Drinking Water Additives program and continued using them after EPA established that program. Starch is an example of a compound that was formerly applied as a coagulant in drinking water treatment and is no longer approved for use in water treatment.

2. **Are the chemicals that are used for treating water appropriate for meeting the water quality goals of the system?**

   Water systems may purchase and use chemicals that are not appropriate for the plant or its treatment objectives (e.g., an operator may be convinced by a chemical company sales person that a particular product is the best and should be used at the plant, even though it is not appropriate for the specific application). The inspector should assess whether the chemicals used in treating the water are appropriate.

3. **What chemical amounts are used – average and maximum? Are the various systems sized to feed more than the maximum amount required?**

   It is important that the treatment plant have a capacity to apply chemicals above the current maximum daily use. One hundred and fifty percent of maximum use is recommended. The treatment plant should always have excess capacity to deal with unexpected deterioration in raw water quality resulting from natural and man-made causes, and should maintain excess chemical feed capacity to respond to a period of unusually high water demand.

4. **Where are various chemicals applied?**

   The inspector should inspect chemical feed points and note where and how the chemicals are added, whether the feed points are active or standby, whether the application points are appropriate, and the compatibility of the feed points with other chemicals used at the plant. The inspector should note whether the point of application can be used to supply other chemicals with different chemical and physical characteristics, and make the determination if the feed points can be used inappropriately. Any signs of previous or current leaks at the chemical feed points and its equipment should be noted. The inspector should ask and note down answers as to when any leaks occurred, why they occurred, and how they were contained.

5. **What type of chemical feed equipment is used? Are the materials used for each chemical feed system compatible with the chemical? What is the general condition of the chemical feed equipment?**

   The inspector should note the type of chemical feed equipment and its ability to feed chemicals on a continuous basis. The chemical feed equipment should be clean and free from dust, oil, dirt, and vapor. Pipes should be free from signs of cracks and leaks. The equipment should be rust free, and the inspector should record and inquire about any unusual noise emanating from any moving parts. The inspector should review the preventive maintenance program for the chemical feed equipment and check the repair log.

6. **How often is the feed rate checked for each chemical? How does the operator determine the amount of chemicals used on a daily – weekly – monthly basis? Is a measurement device provided – flow meter or calibration cylinder for liquid chemicals and scale for dry chemicals? Are there provisions to calibrate the chemical feed equipment?**

   The chlorine feed rate is usually measured by a rotameter, while the feeding rate of liquid chlorine is measured using a valve meter. All chemical feed equipment is calibrated at the time of installation, however as equipment ages and as flow regimes change, the equipment requires re-calibration. In addition, when replacement parts are installed, and other treatment equipment is attached to the treatment train, feeding equipment should be re-calibrated. Therefore, the inspector needs to note if the treatment plant periodically tests and recalibrates chemical feed equipment and whether re-calibration took place following changes to the treatment process or maintenance to the chemical feeding equipment itself. The inspector should inquire about calibration checks and how they are done, and review any calibration records for the feed equipment.

7. **Is the chemical feed equipment adjustable? Is the control of the chemical feed equipment manual or automatic? What is the control parameter (e.g., raw water flow rate) for each chemical feed system? Does the system use day tanks for liquid chemicals bought in large quantities?**

   The majority of chemical feed equipment is adjustable. Chemical feed equipment adjustment can be manual and/or automatic. If the adjustment is automatic, the inspector should note whether the operator can override the automatic adjustment in cases of malfunctioning. The method for controlling chemical feed quantity is important. The inspector should note the conditions that cause accidental overfeeding of chemicals and the steps that are necessary to protect against it. The use of day tanks is one method for limiting accidental overfeeding.

8. **Is a standby feeder and/or metering pump provided for each chemical? Is it operable? Is it large enough to replace the largest unit that might fail?**

According to generally recommended engineering practices and the Ten State Standards (GLUMRB, 1997), essential equipment, such as chemical feed equipment and feed pumps, should be redundant. Redundant equipment should be of a capacity equivalent to the largest unit.

9. Is backflow prevention provided on the water lines used for chemical feed makeup?

All lines supplying water for chemical feed makeup should be equipped with backflow prevention devices to prevent cross-connections and contamination of potable water.

10. What type of storage facilities are provided? Is the storage area for each chemical adequate and safe? Is containment provided for a potential spill? What provisions are provided for cleanup of a spill? If a drain is provided, where does it discharge? Are incompatible chemicals stored together? Are facilities properly labeled?

Chemical storage area capacity should be adequate to allow space for free access for loading and unloading of chemicals. The bulk storage facility should have indicators for chemicals storage levels. The storage containers should have a convenient method for determining the amount of chemical in each container. The storage facility should have safeguards against accidental spills, and like every other treatment space, should have a clean water source under high pressure and a drain for effective cleaning and decontamination. In the case of some gaseous chemicals, like chlorine, special ventilation equipment and the availability of OSHA approved breathing apparatus may be required. Breathing equipment and other personnel safety equipment and gear should be stored outside the storage area where the equipment can be safely accessed. Incompatible chemicals should be stored separately. For example, strong acids should not be stored near chlorites. The chemicals storage and the storage facility itself should be located so as to not allow a chemical spill to reach the raw water source, the treated water, or water being treated. In addition, every container in the storage area should be labeled and every storage area should be labeled to identify what chemicals supposed to be stored in it.

11. How much storage is provided at average/maximum usage? What is required by the state primacy agency? If storage provided is less than required, what is the local resupply availability?

The inspector should be able to assess, from the information provided on chemical use rates and water demand, whether the chemical storage capacity is adequate and in compliance with state regulations or with the Ten State Standards (30 days supply at the average chemical consumption rate) (GLUMRB, 1997). If the state requires more storage or allows less storage, the inspector should note the basis for the required storage capacity. Some water systems are reluctant to store as much as the recommended 30-day supply of chlorine gas or other highly dangerous chemicals onsite since they pose a safety risk to operators and the community. If the system keeps less than the required supply onsite, the inspector should document why and ask the operator about resupply options. The inspector should ask about reliable sources of chemicals resupply and whether local alternative suppliers are available.

12. What is the general condition of the building/room housing the chemical feed equipment? Are dusty and dry chemicals, and feed equipment housed separately? Is proper and adequate ventilation provided?

The general condition of the building housing the chemicals is an indicator of the standard of maintenance the operator upholds. Adequate ventilation, heating, and air conditioning are important in maintaining the sanitary conditions within the storage facility and the treatment plant as a whole. The equipment for controlling and removing dust and vapors in the chemical building/room should be functional and effective.

3.2.4.5 Coagulation/Flocculation

The coagulation/flocculation process at a surface water treatment plant is essential to properly condition raw water for effective particle removal through sedimentation and filtration. Although coagulation/flocculation is sometimes referred to as a two step process, coagulation is generally understood to begin at the point of coagulant addition and continue during the flocculation process. Coagulation is initiated by rapidly dispersing a coagulant, such as aluminum sulphate, in the raw water under high energy mixing conditions to cause the destabilization and initial contact of small particles suspended in the raw water. The particles attach to each other, the coagulant, or coagulant aid to form settleable particles (floc). This is followed by gentle mixing, or flocculation, to improve the contact of the particles and encourage the destabilized particles to form into larger, denser solids that are more easily removed during sedimentation and filtration. The size and quality of the larger floc particles formed in the final stage of flocculation are indicators of the overall effectiveness of the coagulation/flocculation process.

The coagulant dose that is required to treat raw water is determined based on various chemical, physical, and biological tests conducted both onsite and offsite of the treatment plant. Of particular importance are the onsite jar tests. These tests are conducted to determine the type and dose of coagulant to be used in response to a change in key raw water quality parameters such as turbidity, temperature, and alkalinity. The sanitary survey inspector should ask the operators how often they conduct jar tests and how the current coagulant dose was determined. If time allows, the inspector should have the operators perform a jar test during the inspection.

The physical facilities required for coagulation/flocculation include chemical feed equipment, rapid mixing facilities, and flocculation facilities. Chemical feed equipment and rapid mixing facilities were covered in previous sections.

There are two basic types of flocculation units - baffled and mechanical. Baffled flocculation units usually include a system of serpentine channels, ported walls, or diversion plates that allow gentle hydraulic mixing as the water flows through. Mechanical flocculation units usually include chambers or basins equipped with mechanically driven mixing devices. Figure 3-11 shows examples of two mechanical flocculators - a horizontal paddle flocculator and a vertical paddle flocculator. For the vertical flocculator, water enters through the ports on the left and then goes into the compartment on the right side; the exit compartment is not shown.

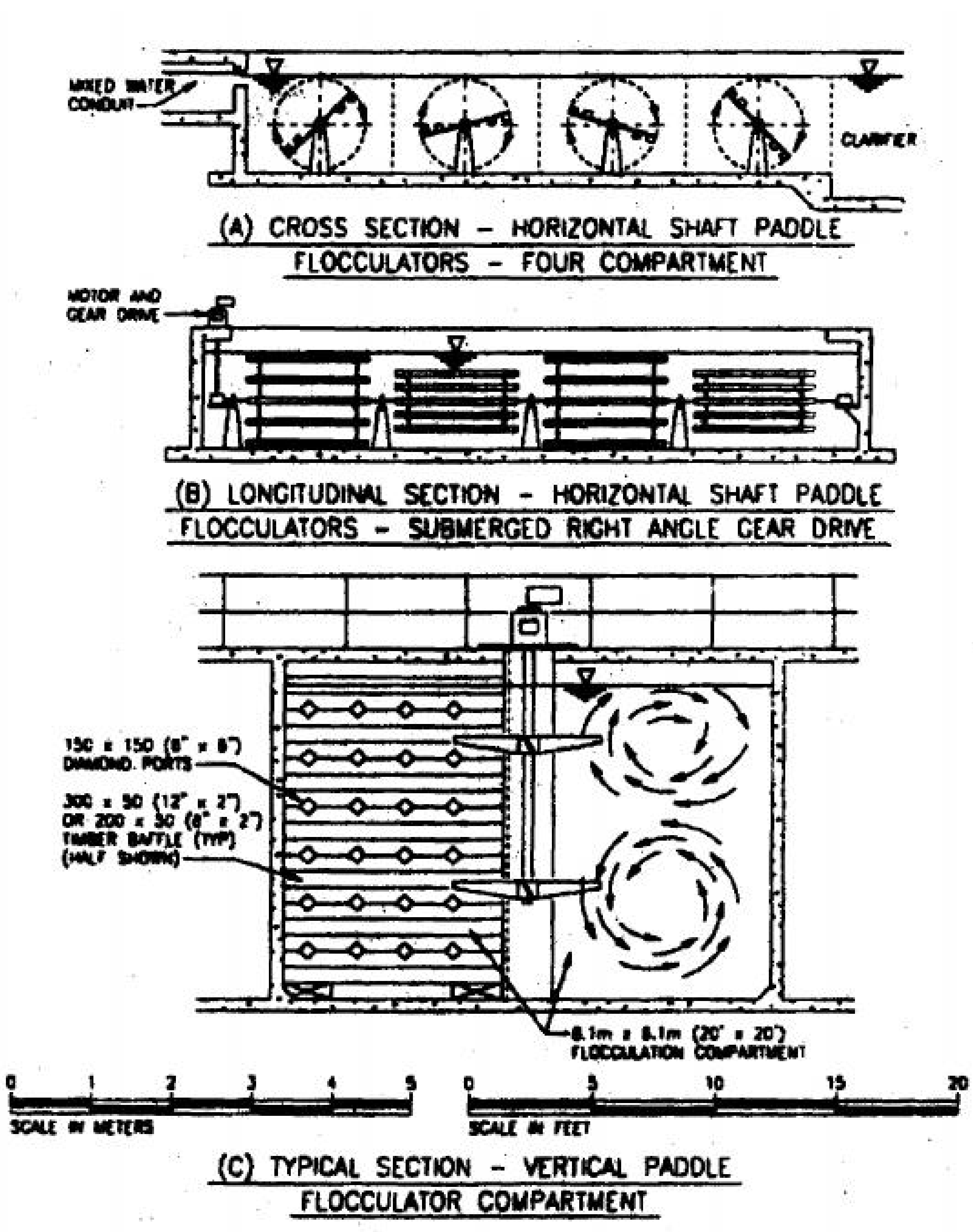
Diligent operation and process control are important for good performance of the flocculation process. Adequate mixing energy is needed to promote the collision of destabilized particles to form floc that will precipitate in the sedimentation basins. Tapered mixing energy is frequently used to keep large particles in suspension, promote particle collisions and growth, and prevent shearing of floc. The optimum configuration for tapered mixing depends upon the type of mixing equipment number of stages, water temperature and turbidity, and plant flow rate. The velocity gradient, G, provides a means to calculate the mixing energy used for the flocculation process. For most water treatment plants, the G for the flocculation process should start at 50 to 100 fps/ft in the first stage of flocculation, depending on the detention time of the basin, and decrease to 20 to 50 fps/ft in the second or third stage (JMM, 1985).

Controlling the tip speed on mechanical mixers is another method for minimizing the shearing of floc during the flocculation process. If the tip speed of the mixer is too high, then floc particles will be sheared. For most water treatment plants, the peripheral tip speed of the mixers should be between 0.5 to 2.0 fps (Sanks, 1978). The inspector can roughly estimate the tip speed by means of a stop watch and observing the distance cut by the tip of the paddle. This might not be attainable in the first stage because of the poor visibility of the mixing paddles moving in the very turbid waters.

For most water treatment plants, the design detention time in the flocculation basin ranges from 20 to 60 minutes (JMM, 1985). The sanitary survey inspector should be aware that waters with low turbidity require longer detention times than waters with higher turbidity levels. To reduce attenuation time in the flocculation and sedimentation basins, coagulant aids and polymers are used.

Another design parameter for flocculators is *GT* (*G* times detention *T*ime), which is used as an indicator of the capability of the flocculation process to cause particle collisions. For most water treatment plants, the *GT* for the flocculation process should range from 30,000 to 120,000, depending on the characteristics of the water (JMM, 1985).

Most plants today have more than one coagulation/flocculation unit at the treatment plant. With two or more units, one unit can be removed from service for maintenance and the plant can remain in operation. In general, there should be at least two coagulation/ flocculation units.



(Modified from AWWA and ASCE, 1998; Used with permission)

Figure 3-11. Mechanical Flocculator Types

Suggested assessment criteria for the coagulation/flocculation process include:

1. **What type of flocculation facilities are being used? Does the coagulation/flocculation process visually appear adequate?**

   The inpector should note the type of flocculation facilities (baffled units or mechanical mixers). If the water system is using baffled units, the inspector should identify whether the units have serpentine channels, ported walls, or diversion plates. The inspector should be able to visually determine good floc formation prior to sedimentation. Best floc size ranges from 0.1 to 3 mm in diameter.

2. **Is there any evidence of clumps of coagulants in the first compartment of the flocculator?**

   The inspector should watch for any clumps being discharged into the flocculator. Also, if possible, the inspector should look for signs of sediments in the first compartment of the flocculator.

3. **Is the mechanical equipment working? Are there any hydraulic inadequacies?**

   All mechanical equipment should be functional. Standby equipment should always be in a ready-to-operate state. Instrumentation to monitor motor speeds, flow rates, pH, and temperature also should be functional and calibrated. Hydraulic inadequacies may be visually detected in the flocculation, sedimentation, and filtration stages. Indications of hydraulic inadequacies include visible surges of water through the flocculation basins, short circuiting of floc particles through the basins, stationary flocs in dead zones, and unusual and buildup of sludge in the basins.

4. **Does a preventive maintenance program exist?**

   Manufacturers and equipment suppliers provide preventive maintenance schedules. The treatment plant operators should adhere to these schedules.

5. **Is the rate of mixing adjustable, so that the correct mixing can be provided at all flows? If so, can the operator adjust the rate of mixing?**

   Adjusting flocculator mixing rates can be done either automatically or manually. Mixing rates can be changed by removing and adding planks onto the arms of the rotating shaft. The inspector should ask the operator about the frequency of adjusting mixing rates and how it is done.

6. **What is the *G, GT*, and tip speed? Is it within the generally accepted range? What is the detention time? Is it within the generally accepted range?**

   If available, values for G, detention time, GT, and tip speed need to be collected for both design values and operation values at the time of the sanitary survey. Acceptable G values should range between 100/sec to 20/sec (JMM, 1985); GT values should range between 20,000 to 120,000 (JMM, 1985); detention time may range between 20 to 60 minutes (JMM, 1985); and tip speed between 0.5 ft/sec to 2 ft/sec (Sanks, 1978).

3.2.4.6 Sedimentation/Clarification

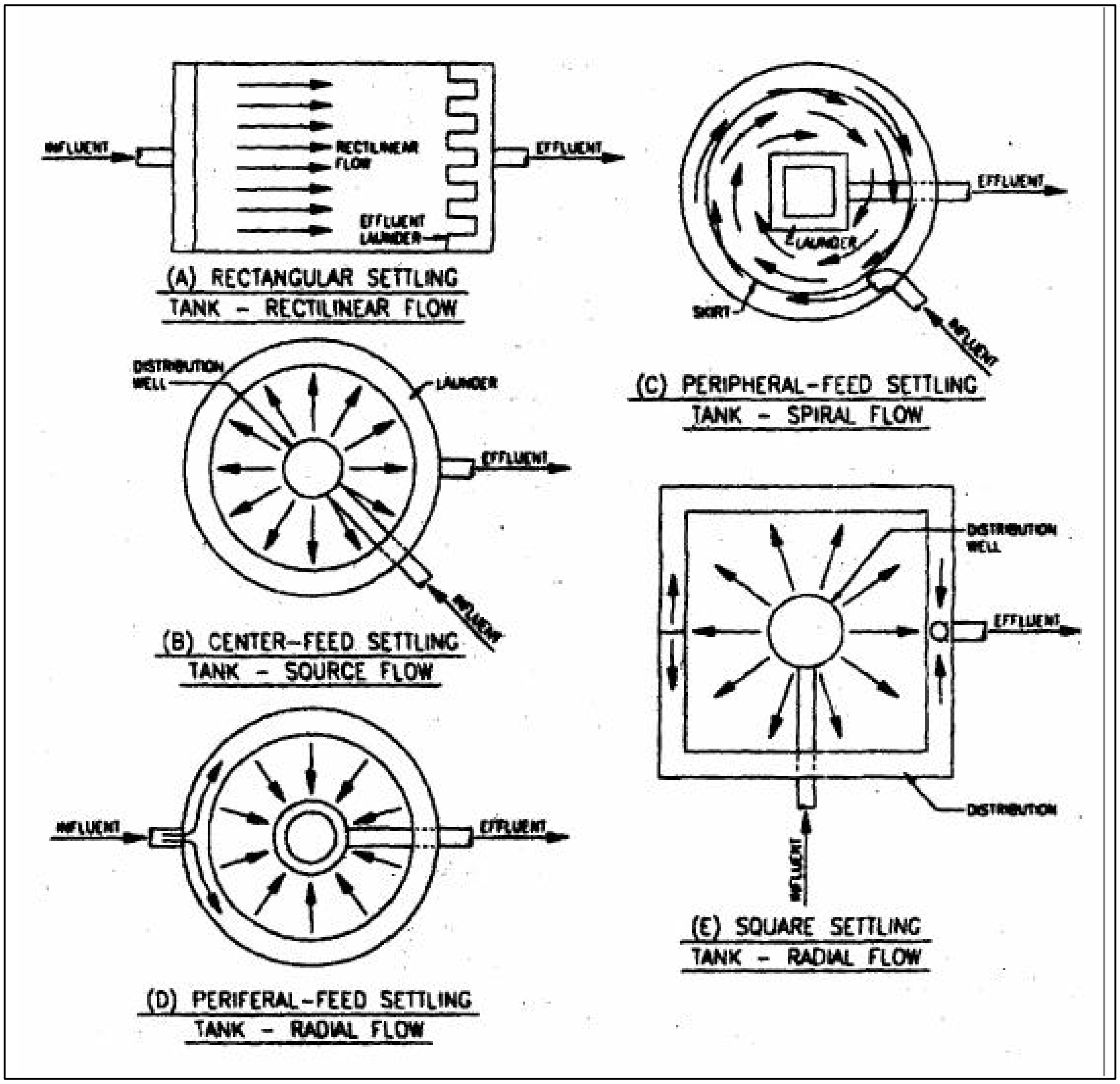
One of the most important processes in a water treatment facility is the settling of flocculated particles following coagulation/flocculation, called sedimentation or clarification. Floc removal occurs during a protracted quiescence period of a continuous flow in a sedimentation basin or clarifier. Today, essentially all continuous flow sedimentation basins include continuous sludge removal with mechanical equipment and the old fill and draw basins are obsolete. Efficient operation of the clarification process allows the filtration process, which follows, to operate longer between backwashing and with fewer problems.

Typically, a clarifier will have four zones, each with a characteristic function. The four zones and their associated functions are:

- Inlet zone – A transition zone that converts the influent flow to the uniform, steady flow desired in the settling zone;
- Settling zone – The section of the clarifier in which settling occurs. This zone should be free of interference from the other zones;
- Outlet zone – A transition zone that converts the steady flow from the settling zone to the effluent flow; and
- Sludge zone – The section of the clarifier that the floc particles settle into. The sludge accumulates in this zone to prevent interference with the removal of particles in the settling zone.

Clarifiers can be classified based on their configuration and type of flow. Types of clarifiers include horizontal flow units, inclined flow units, and upflow clarifiers. Horizontal flow units are generally rectangular or circular in shape, although square tanks are also used. Water flows through the unit in a horizontal manner, but can follow various types of flow patterns. These units are considered conventional clarifiers and are the most commonly used type for drinking water treatment. The various shapes and flows of conventional clarifiers are shown in Figure 3-12. (AWWA and ASCE, 1998; AWWA, 1990)

Inclined flow units include tube or plate settlers, which are generally mounted in rectangular or circular basins. These units are high-rate modifications of conventional clarifiers. They are considered high-rate clarifiers because they can generally be loaded at higher rates than the conventional clarifiers decscribed above. Tube settlers are designed with several shallow parallel tubes at an incline and adjacent to one another. Plate settlers consist of vertically inclined plates onto which solids first settle and then slide down into a basin below. The designs for both tube and plate settlers increase the surface area and decrease the distance for particle settling, and also reduce flow through velocity to reduce scouring. All of these factors enhance solids removal. (AWWA and ASCE, 1998; AWWA, 1990)



(Source: AWWA and ASCE, 1998; Used with permission)

Figure 3-12. Different Clarifier Shapes

Upflow clarifiers are units that generally have chemical mixing, flocculation, and sedimentation in a single tank. Some units may have a separate rapid mixer, rather than feeding chemicals directly to the clarifier inlet pipe for mixing within the unit. Upflow clarifiers include solids-contact units such as sludge-blanket clarifiers and slurry recirculation clarifiers, which are often used for water softening processes. These units are designed to provide more efficient flocculation, greater particle contact, more uniform flow, and less short-circuiting. Because of these factors solids-contact units can often handle three or four times the hydraulic loading of conventional clarifiers. (AWWA and ASCE, 1998; AWWA, 1990)

Clarifier characteristics which significantly impact floc settling efficiency include the tank surface area (dependent on overflow rate), depth (dependent on detention time), and the velocity of the flow through the clarifier, which is dependent on the cross-sectional area and configuration of the basin. The weir loading rate at the effluent launderers is also important to prevent the breakup of any floc particles that may reach the launderers.

The surface overflow rate should be equal to the settling velocity of the floc particles entering the basin. The detention time should be adequate for the removal of all solids. The velocity through the basin should be uniform over the cross-section of the basin. The effluent launderer overflow rate should be small. The values for the various design factors should be conservative to allow for site specific circumstances. General design value ranges are shown in Table 3-1.

Special consideration should be given to the inlet and outlet flow conditions in evaluating the performance of clarifiers. The inlet flow should be distributed uniformly between sedimentation basins and the flow to each basin should be distributed uniformly over the full cross section of the individual basin. In general, the performance of the basin is controlled more by the inlet condition than the outlet condition.

Table 3-1. Clarifier Design Factors

Surface Overflow Rate (gpm/ft^2)	
Alum floc	0.4 – 0.7
Lime softening	0.4 – 1.4
Tube settlers (overall basin rate)	1.0 – 3.0
Plate settlers (overall basin rate)	2.0 – 6.0
Upflow units	0.7 – 1.8
Lime softening/Upflow units	0.7 – 2.2
Detention Time (hour)	1.5 – 4
Velocity (fpm)	1.0 – 3.0

(Modified from AWWA and ASCE, 1998)

To evaluate the performance of the clarification process, the best criteria is the turbidity of the settled water leaving the clarifiers. In general, the turbidity of the water leaving a clarifier should be no greater than 10 times the acceptable turbidity level of the finished (i.e., filtered) water. Filters are assumed to remove at least 90% of the remaining particles in the water. Some states require that settled water turbidity be less than 5 NTU. For optimized turbidity removal goals, settled water with a turbidity of less than 2 NTU is expected when the average raw water turbidity is greater than 10 NTU, and 1 NTU when average raw water turbidity is less than 10 NTU. Under the Comprehensive Performance

Evaluation (CPE) process EPA has established an optimization goal of 2 NTU for water leaving the sedimentation basin.

Sludge accumulation in the clarifier has to be removed to maintain the clarification process at peak efficiency. Sludge should be removed on a continuous or time-controlled basis. In plants with a low solids loading, sludge is typically removed from the basin intermittently for 5 to 15 minutes every hour, which is called a time-controlled basis. For those plants with a high solids loading, sludge is typically removed continuously.

Similar to the previous treatment processes, many plants have more than one clarifier/ sedimentation basin at the treatment plant. With two or more units, depending on the projected water demands, one unit can be removed from service for maintenance and the plant can remain in operation. There should be at least two clarification units. If a plant has only one unit, then maintenance of that unit may suffer, because the plant has to be shutdown to perform maintenance.

Suggested assessment criteria for the clarification process include:

1. **What type of sedimentation/clarification process and facilities are being used? Does the sedimentation/clarification process visually appear adequate?**

   The inspector should determine what type of process and facilities (e.g., cross flow sedimentation basin, radial flow sedimentation basin, upflow solids contact clarifier) are used and whether they appear adequate. Near the outlet of the sedimentation basin, water should be visibly clear.

2. **Is the flow distributed evenly to all basins? Is the inlet flow distributed uniformly over the full cross section?**

   The inspector should look for signs of bridging or short circuiting and should look for signs of flocs breaking up at the sedimentation basin inlet. The inspector should inspect the mechanism through which the flow is evenly distributed among the multiple basins. Uneven flow distribution may result in the basins receiving disproportionately high flows and this may cause less than optimum sedimentation.

3. **Does the plant have multiple units with some that are not in use? Are the idle basins in a condition to be used if needed?**

   Not all sedimentation units are used during low demand. Standby sedimentation basins should be inspected for their readiness to be used. The inspector should check the condition of any empty basin for cracks, cleanliness, and paint condition, and should note whether plants, moss, or other botanical forms are growing inside the basin. The inspector should also note whether the in-service sedimentation basins contain any larvae, toads, or fish.

4. **Is the mechanical equipment working? Are there any hydraulic inadequacies?**

   Sludge removal equipment should be functional. Manual controls for overriding automatic controls should be inspected and tested. A turbulent flow regime is an obvious sign of hydraulic inadequacies. Turbid water at the basin outlet during high flow conditions may indicate hydraulic overloading.

5. **What is the surface overflow rate, detention time, and the velocity flow? Is it within the generally accepted range?**

   The inspector should record the plant flow rate and confirm the basin dimensions during the inspection. From this information, the inspector may calculate the surface overflow rate, detention time, and velocity flow. If the values of these parameters are outside the generally acceptable range, the inspector should try with the help of the operator to determine if there is a specific reason or reasons for operating at the calculated parameters. Poorly maintained weirs may cause short circuiting that might affect both the overflow rate and the sedimentation process.

6. **Does there appear to be too much sludge in the basin(s)? Is it impacting settled water performance? How is sludge removed from the clarifier(s)? How often is sludge removed?**

   Too much sludge in the sedimentation basin is an indication of inadequate sludge removal rate. An indication of inadequate sludge removal is when the settled material appears to be in a colloidal suspension with upward movement occurring. Excessive sludge accumulations in a clarifier may interfere with the solids removal process and lead to anaerobic conditions in the basin. The inspector should record the frequency of sludge removal during the period of inspection and should ask about seasonal fluctuations and extreme operational conditions.

7. **What is the settled water turbidity? Does it meet the general criteria?**

   Settled water turbidity should not exceed a level of 5 NTU. This is assuming that filtration will drop this turbidity level to less than 0.5 NTU. If the settled water NTU levels are higher than 5 NTU, the inspector should pay closer attention to the subsequent treatment barriers. For optimized turbidity removal goals, settled water with a turbidity of less than 2 NTU is expected when the average raw water turbidity is greater than 10 NTU, and 1 NTU when average raw water turbidity is less than 10 NTU. The CPE process uses 2 NTU as an optimization goal for water leaving the sedimentation process. For further information on turbidity levels, see EPA's *Handbook: Optimizing Water Treatment Plant Performance Using the Composite Correction Program* (EPA, 1998b).

3.2.4.7 Filtration

The filtration process is the final barrier for physical removal of particles at a surface water treatment plant. Without it, the suspended particles that remain in the water following the sedimentation/clarification process would be delivered to the customers. Depending on the quality of the source water, these particles may include pathogens that are resistant to disinfection and significantly increase the risk of waterborne disease. To minimize this risk, water from the sedimentation/clarification process should to be passed through a properly designed and operated filtration system. Filtration in a water treatment plant is an adaption of the natural process that occurs as water moves through granular soils. Over time, filtration enhancements for solids removal have been developed to include the use of coagulants, and various types of filter media, underdrain design, and backwashing techniques.

Filtration systems are divided into two general categories - gravity and pressure. Pressure filters are typically used at small water treatment plants. These filters usually consist of a pressure vessel or tank that contains a porous filter media, an underdrain system, and piping for inlet and outlet flow and backwash. Pumping facilities are used to force settled water through the media in the pressure filter and into a clearwell. A major disadvantage of pressure filters is that the media cannot be visually observed during backwash or easily inspected for the formation of mudballs.

Gravity filters are the most common filtration system found at surface water treatment plants. These units differ significantly from pressure filters in that the media and underdrain system are contained in a filter box that is open to the atmosphere, and water flows through the media by gravity. There are two types of flow control systems for gravity filters - constant rate and declining rate. Constant rate filters are generally equipped with an effluent rate-of-flow controller that includes a flow measuring device and an automatically adjusting valve. A constant filtration rate can also be accomplished by splitting the influent flow to each filter. Constant rate filters can be further divided into those that operate under a relatively fixed water level common to all the filters, and those that operate under rising water levels that vary in each filter depending on the filter headloss.

A declining rate filter, on the other hand, usually includes submerged inlets that allow diversion of influent flow from a dirty filter to a clean filter. There are no effluent rate-of-flow controllers, although an orifice plate is sometimes used to establish a maximum filtration rate for a clean filter. Declining rate filters start with a high filtration rate that declines as the filter begins to plug with filtered solids. Although the initial filtration rate of the declining rate filter is usually higher than that of a constant rate filter, the overall production rate of a constant rate filter will usually be greater assuming the filter run of the two filters is the same.

Filter media systems are usually identified according to the number of media layers (e.g. single, dual, or multiple media) and the type of media (e.g. sand, anthracite). Single or mono media filters usually consist of sand, although anthracite and GAC beds are also used. When single media sand filters were first developed, they were referred to as rapid sand filters to distinguish them from the older slow sand filtration systems that were common at the time. Filtration rates have increased even more with the development of dual and multiple media filtration systems. Dual media is the most common and consists of a layer of anthracite over a layer of sand. Multiple media usually includes anthracite and sand layers over a third layer of denser material such as garnet.

Media depths vary with the type of filter and media. Total media depths of 30 to 36 inches are typical with a minimum depth of 24 inches. Single media filters that utilize anthracite or GAC may have deeper beds of 48 inches. Typical maximum filtration rates for the more common filters and media types are shown in Table 3-2.

Table 3-2. Typical Maximum Filtration Rates

Filter/Media Type	Filtration Rate (gpm/ft^2)
Pressure – All media types	2
Gravity – Rapid Sand/Constant Rate	2
Gravity – Rapid Sand/ Declining Rate	3
Gravity – Dual or Multiple Media/Constant Rate	5
Gravity – Dual or Multiple Media/Declining Rate	6.5

(Source: TNRCC, 1997)

A variety of underdrain systems are used to support the filter media, allow collection of the filtered water, and distribute backwash supply water. The most common underdrain systems include perforated laterals, perforated support blocks, and false floors with nozzles. In cases where the underdrain openings are larger than the media to be supported, a layer of graded gravel is installed between the underdrain system and the media. Some underdrain systems include features that allow for air scour as well as the distribution of washwater during backwash.

The filtration units should include the features and controls necessary to assure proper monitoring and operation of the filter. The specific features and controls will depend on the type of filter and how the filtration rate is controlled. Loss-of-head gauges are used to provide the difference between influent and effluent pressure or head, so that the condition of the filter media can be monitored. Rate-of-flow controllers or flow limiting devices are used to control the filtration rate and prevent surges through the media that may cause particle breakthough. On-line turbidimeters on the filter effluent lines are used along with loss-of-head data to monitor the condition of the media and determine when the filter should be backwashed.

Filtration units should also be equipped with facilities to clean the filter media when it becomes dirty. The typical approach to cleaning or backwashing a dirty filter is to force potable water back up through the media at a high rate causing the media to expand 20 to 30 percent. As the media expands, the particles adhering to the media grains are flushed out of the filter to waste. The facilities and equipment that are used to clean filters include backwash supply pumps or elevated washwater tanks, surface wash or air scour equipment, associated piping and controls, and wastewater management/disposal facilities.

The operational procedures that are used to backwash a filter depend on the design of the filter, the condition of the filter media, and the temperature of the backwash supply water. If a plant has a dual or multiple media filter, the media should be restratified before the completion of the backwash. In order to restratify these types of media correctly, backwash practices using surface wash or simultaneous air-water application should be followed by a backwash. A multiple media filter, for example, may restrict the use of surface wash or air scour to the beginning of the backwash cycle in order to assure proper restratification of the media layers. If the filter media is a mono media type, then no restratification is needed and the backwash method is not restricted (AWWA and ASCE, 1998). In addition, higher washwater temperatures result in lower water viscosities, so higher washwater supply rates may be required in the summer than in the winter to achieve the same bed expansion.

An effective backwash procedure usually includes the following steps: adjusting the raw water flow rate (to prevent hydraulic surges in the remaining filters), gradually increasing the washwater supply rate, restricting surface wash or air scour to the beginning of the backwash cycle (to allow proper media restratification and minimize media loss), maintaining the maximum washwater flow rate until the water on the top of the filter is visibly clear, gradually decreasing the washwater flow rate, observing idle time before reactivating the filter, and gradually increasing the filtration rate when the clean filter is reactivated. Table 3-3 includes more specific information on filter backwash procedures. Operators should be following the backwashing method described in the written operational procedures for the specific filter. In all cases, the filter backwash procedure that is used should provide effective cleaning of the media, protect the structural integrity of the media and underdrain system, and minimize post backwash turbidity spikes in the filtered water. The backwash water should be evenly distributed throughout the filter during a backwash. The turbidity of the backwash waste should be measured during the inspection to determine if the length of the backwash is adequate.

The criteria that are used to initiate a filter backwash impact the effectiveness of the backwash, the condition of the media, and the filtered water quality. In the past, filter run time and headloss have been used as the primary criteria for backwashing a filter. Filter run times range from 12 to 72 hours with 24 hours being typical. A filter headloss of 8 to 10 feet has also been used as a trigger for filter backwash. More recently, and with the increasing use of individual filter turbidimeters, the turbidity of the water leaving the filter has become the overriding criteria for initiating backwash. Some plants use an individual filter turbidity goal of 0.1 NTU as a trigger for backwash before target levels for loss-of-head or filter run time have been reached (AWWA and ASCE, 1998).

An increasing number of facilities are adding filter aids and using filter-to-waste piping to improve the effectiveness of the filtration process. The filter aids usually consist of a polymer or coagulant that is added in small dosages to the settled water prior to the filters. Filter aids can also be added to the backwash supply water at the end of the backwash process to help minimize particle breakthrough when the filter is restarted. Filter-to-waste is used at many facilities to eliminate problems with post-backwash turbidity spikes, but requires the installation of special piping that is not possible at all plants.

Table 3-3. Recommended Backwash Rates

Backwash Method	Water Wash Rate (gpm/ft^2)	Water Wash Duration (minutes)	Air Scour Rate (scfm/ft^2)	Air Scour Duration (minutes)
Upflow Water Wash (1step)	15–23	3–15	–	–
Upflow Low Rate Water Wash with Initial Air Scour (2 steps)				
(1) Air Scour	–	–	1–2	3–5
(2) Low Rate Water Wash	5–7.5	3–5	–	–
Upflow High Rate Water Wash with Initial Air Scour (2 steps)				
(1) Air Scour	–	–	2–5	3–5
(2) High Rate Water Wash	15–23	3–5	–	–
Concurrent Upflow Water Wash and Air Scour (2 steps)				
(1) Concurrent Air and Water First	6.3–7.5	5–10	6–8	5–10
(2) Water Wash only	6.3–15	5–10	–	–
Upflow Water Wash with Surface Wash (3 steps)				
(1) Surface Wash only	0.5–2.0	1–3	–	–
(2) Low Rate Water Wash*	5–7.5	5–10	–	–
(3) High Rate Water Wash*	15–23	1–5	–	–
*with concurrent surface wash				

(Source: AWWA and ASCE, 1998)

In addition to the conventional filtration systems described above, several other filtration technologies are used in the water treatment industry. Some are older systems, such as slow sand filtration and diatomaceous earth filtration. One of the more recent technologies that is receiving increased attention is membrane filtration. These filtration units use pressure driven membranes to achieve levels of particulate and contaminant removal that are not possible with conventional filtration systems. Micro-filtration membranes are used to filter out particulates including pathogenic cysts. Ultrafiltration membranes are used to remove specific dissolved organics such as disinfection byproduct precursors and to remove particulates. Nano-filtration is used to remove calcium and magnesium ions (hardness) and disinfection byproducts precursors. It is also used to remove microbial contamination including viruses. Reverse osmosis (RO) membranes are typical used to remove organic and inorganic contamination. Typically RO membranes are used to purify raw waters containing high levels of total dissolved solids such as brackish water and sea water. All membrane technologies require some kind of pretreatment. Prescreens are commonly used with micro- and ultra-filtration. Cartridge filters are commonly used with nano-filtration and RO membranes. Typically ultra- and micro-filtration units consist of a number of modules mounted on skids. Nano-filtration and RO units consist of a number of elements housed in pressure vessels which in turn are mounted in trains.

Suggested assessment criteria for filtration include:

1. **What type of filtration system is being used (gravity or pressure; constant or declining rate) and what kind of media has been installed (mono media, dual media, or multi media)?**

   - *What is the maximum filtration rate at design capacity with one filter out of service? Is it at or less than the maximum water demand?*

     Overflowing filters are a sign of inadequate hydraulic conditions. If the maximum water demand is at or higher than design capacity, then the system should have expansion or water conservation plans prepared.

   If a ***pressure filtration system*** is installed, then the following should be checked:

   - *When was the last internal inspection of the filters performed? Is the inspection frequency in accordance with local/state requirements? Were the media and depth, internal piping, and interior surface of the pressure vessel checked? Can the operator provide copy of the inspection report? Were there any deficiencies noted in the inspection report? If so, have the deficiencies been corrected?*

     Manufacturers, equipment suppliers, and many states require periodic inspection of pressure filters. Many operators will not be able to inspect the intervals of the pressure filter, but should be monitoring whether the filter is functioning properly or not. The litmus test for any filter during the sanitary survey visit is to observe whether the turbidity of the finished water is acceptable and that the drop in turbidity level between the influent to the filter and the effluent is at least 90 percent. This can be easily determined using an accurate turbidimeter. If operationally possible at the time of inspection, the inspector should ask that the filter be operated at peak hourly rate and design flow rate. Otherwise, the inspector should ask the operator how the filters performed the last time the peak hourly flow rate and design flow rate occurred at the plant.

   - *Ask the operator to backwash a filter. What are the means and method for backwashing a filter? Is the correct backwash procedure followed based on the filter media type and appurtenances? What is the high rate backwash flow? Is it adequate?*

     It is useful to observe the backwash operation to determine if proper backwash procedures are followed. The inspector should note how the wastewater from backwash operations is managed or disposed of.

- *What is the turbidity of the backwash waste?*

  The turbidity of the backwash waste should be measured by the inspector during the inspection to determine if the backwash length is adequate. The turbidity of backwash waste at the end of the backwash process should be very close to the turbidity of the water used in the backwash.

- *What is the turbidity level of the effluent water following the backwash?*

  The inspector should measure the turbidity of the filter effluent water to determine if the filter is functioning as it is supposed to after backwashing. In addition to turbidity, underdrain flow rate should be measured. A post-backwash turbidity profile using on-line turbidity meter is important in indicating filter performance. In addition to turbidity measurements, the filter effluent flow rate should also be recorded from the filter control panel of from a flow meter, if available.

If a ***gravity filtration system*** is installed, then the following should be checked:

An inspection of the filters should be completed. Note that it may not be possible to check on all filters in a plant; therefore, the inspector should determine which filter or two should be checked based on the available on-line instrumentation and discussions with the operator(s).

After completely draining the filter(s) that will be checked and backwashed, the inspector should visually check the filter.

- *Is there any visible indication of problems on the surface of the filter?*

  Visible evidence of problems would be particulate matter remaining on the surface; mudballs, mounding, cracks, holes, depressions in the media surface; and an uneven media surface.

- *Are there any pressure relief vents from the underdrain through the filter media? What are the construction means and method of the vent system? What is the condition of the piping? Is protection from insects and animals entering the vent provided? Can the vent be flooded by water – filtered, unfiltered, or other?*

  The inspector should look for signs of poor sanitation in the underdrain area (filter piping gallery). These include the presence of mold, smut on the walls and floors, and insect and animal droppings.

- *Obtain information on the subsurface condition of the filter media and underdrain system based on depth measurements and limited excavations. What are the type, depth, and condition of the filter media? Is the support gravel level?*

  Depth measurements using a steel rod provide information on the depth of the filter media and the levelness of the underdrain support system. Limited excavations provide information on the subsurface condition of the media, and in the case of dual or multiple media, provide information on the stratification of the media layers. The inspector should note problems such as mudballs or support gravel within the media, improper stratification of media layers, inadequate media depth, and significant variations in the elevation of the support gravel. A core sample of the filter media can also be used to evaluate subsurface media conditions, but usually does not provide as much information as depth measurements and limited excavation. Additional information on the collection and interpretation of core samples of filter media can be found in EPA's manual addressing CPEs (comprehensive performance evaluations) (EPA, 1998b).

Written inspection procedures and training should be provided to inspectors who are expected to perform subsurface media evaluations to assure the personal safety of the inspector and to minimize the potential for damage to the filter media and underdrain system. The media in some filters (such as constant rate, rising level filter banks) are deep enough to be designated as confined spaces and pose special safety hazards. There are other safety issues such as the slippery surfaces down in the filter unit. In some cases, there are also structural concerns related to walking on the media surface or in the backwash troughs. The results of a recent inspection conducted by a qualified filter contractor may provide the necessary information without the inspector having to perform a subsurface media evaluation.

- *After completing the inspection of the filter, the inspector should ask the operator to prepare the filter for backwashing. What are the means and method for backwashing? Is the correct backwash procedure followed based on the filter media type and appurtenances? What is the high rate backwash flow? Is it adequate?*

  Note the means and method used. Filtered water (not settled water) should be used to flood the media before backwashing. All air should be expunged from the underdrain and media by this flooding before backwashing the filter.

  The inspector should also note if the correct backwash procedure is followed based on the filter media type and appurtenances, and the high rate backwash flow. The inspector should note if the high rate backwash flow is adequate, and if there is even distribution of water/air across the filter. Any boiling of the media and any explosions of the media due to trapped air should be noted. When refilling the drained filter, the media should be slowly flooded with backwash supply water to protect against damage that can be caused by entrapped air in the media and underdrain system.

Backwash troughs should be inspected for levelness. In addition, surface wash arms and nozzles should be operational and functioning appropriately.

- *What is the turbidity of the backwash waste?*

  The turbidity of the backwash waste should be measured by the inspector during the inspection to determine if the backwash length is adequate. The turbidity of backwash waste at the end of the backwash process should be very close to the turbidity of the water used in the backwash.

- *What is the turbidity level of the effluent water following the backwash?*

  The inspector should measure the turbidity of the filter effluent water to determine if the filter is functioning as it is supposed to after backwashing. In addition to turbidity, underdrain flow rate should be measured. A post-backwash turbidity profile using on-line turbidity meter is important in indicating filter performance. In addition to turbidity measurements, the filter effluent flow rate should also be recorded from the filter control panel of from a flow meter, if available.

2. **Is the monitoring instrumentation (loss-of-head, effluent flow rate, and filtered water turbidity) working for all filters? What condition is the instrumentation in?**

   The monitoring instruments should be present and functional. The inspector should ask the plant operator about the frequency of monitoring equipment calibration and should note if the calibration frequency and procedures are in accordance with manufacturers' recommendations and state regulatory requirements.

3. **What criteria are used by operators to determine when a filter requires backwashing? Do all operators of the treatment plant use the same criteria? Are filters ever stopped, then started-up again without backwashing them first? Are filters ever "bumped" to extend filter runs?**

   The inspector should note how the operators determine the need to backwash the filter. It is important to note whether the backwash is triggered by measuring head loss or rise of water levels in the filters, by an increase in turbidity levels in the finished water, or other reasons that might be as simple as an automated preset-backwash timing based on manufacturer or salesman recommendation. The inspector also should note if all operators at the plant adhere to the same criteria. Some operators "bump" their filters to extend the length of the filter run. Bumping is done by opening the backwash valve during the filter run to dislodge trapped solids. This is a bad practice that results in an immediate increase in filtered water turbidity.

4. **What equipment is included in the backwash system? What is the capacity of this system? Is there a backup backwash system? What is its**

capacity? Is it operable? Is there a means of measuring the backwash flow rate? Is it working? What is its condition? When was the flowmeter calibrated last? Can the backwash flow be varied to allow for varying conditions? If so, can the operator adjust the rate of flow?

Backwash pumping system and piping capacity should be recorded. The inspector should make sure that the pipes and valves of the backwash system are properly color coded, the backwash flow meter is functional, and the last calibration date is available. The inspector should note if the backwash flow rate has been adjusted and for what reason.

5. **Are newly backwashed filters brought back into service at low rates that are gradually increased (ramped-up) in order to minimize post-backwash turbidity spikes? Are operating filter flow rates reduced when another filter is backwashed?**

   Newly backwashed filters should be brought back online at a low loading rate and then the loading rate gradually increased to the pre-wash loading rate levels. This practice will prevent compaction of the filter media and will allow the filterable material to attach to the filter media. The practice of gradual increase in filter loading rate reduces the levels of post-backwash filter effluent turbidity spikes.

6. **What is the condition of the piping in the filter gallery? Is it color coded for the use or service in accordance with local/state requirements? Are there any cross-connections?**

   All pipes in the filter gallery should be color coded and marked in accordance with local and state regulations.

7. **Is there a floor drain to remove all leaking water from the filter gallery floor?**

   The inspector should note any leaks from valves and pipes and check the floor drain to determine if it is partially or totally clogged. The inspector should also determine the point of discharge for the floor drain and any other drains in the filter gallery. Some plants are designed with the clearwell located underneath the filter gallery. Drains should not discharge to the clearwell and drain piping should not pass through the clearwell.

3.2.4.8 Disinfection

The practice of disinfection has proven to be one of the most important advances in reducing the incidence of waterborne disease. In this regard, disinfection is an essential component of the surface water and GWUDI of surface water treatment process to assure the destruction or inactivation of disease causing organisms that may not be physically removed during sedimentation and filtration. Two sets of regulations affect the type of disinfectants that are used and where they are applied in the treatment process. First, the disinfection process should assure specific reductions of *Giardia* and viruses required by the Surface Water Treatment Rule (SWTR). Second, the disinfection process is restricted by regulations limiting the formation of certain disinfection byproducts (DBPs). With the enacment of the Stage 1 DBP Rule in December 1998, any public water system that treats its water with a chemical disinfectant must meet MCLs or treatment techniques for several disinfectant residuals (chloramines, chlorine dioxide, chlorine) and their byproducts [TTHMs (total trihalomethanes), haloacetic acids (HAA5), chlorite, bromate]. It is important that the inspector evaluate whether the disinfection system is adequate to ensure compliance with current drinking water standards.

Although the primary purpose of disinfection is to inactivate disease-causing organisms that may not be physically removed during sedimentation and filtration, the disinfection process often provides other benefits related to improved coagulation, oxidation and precipitation and/or filtration of iron and manganese and hydrogen sulfide compounds, taste and odor control, algae control, and a measurable disinfectant residual in the distribution system. These benefits depend on the type of disinfectant being used and the point at which it is being applied in the treatment process. Types of disinfectants include chlorine, chloramines, chlorine dioxide, ozone, and ultraviolet (UV) light.

Chlorine is the most widely used disinfectant for drinking water because of its proven effectiveness, low capital and operating costs, and established history in the water industry. Free chlorine provides a high level of disinfection at the treatment plant and a measurable residual in the distribution system. Unfortunately, free chlorine also combines with organic precursors that may be present in the source water to form DBPs, such as trihalomethanes (THMs). As a result, many treatment plants use chlorine in combination with ammonia to establish a chloramine residual and minimize THM formation. A chloramine residual is a weaker disinfectant than free chlorine, but is more durable and easier to maintain in the distribution system. At plants where THMs are not currently regulated, chlorine is often added at the raw water pump station or the rapid mixing basin to establish a free chlorine residual through the entire treatment process. This approach provides a high level of disinfection, improves the coagulation process, and minimizes algae growth in the treatment units. However, it may also result in high THM levels.

Chlorine dioxide is being used as an alternative to chlorine at a growing number of treatment plants. Even at low concentrations, chlorine dioxide provides both a high level of disinfection at the treatment plant and a measurable disinfectant residual in the distribution system. Chlorine dioxide residuals rapidly dissipate in sunlight and often cannot be maintained through the sedimentation process. Chlorine dioxide does not form the same DBPs associated with the use of chlorine, but does form chlorite which is regulated under new disinfection byproduct regulations.

Ozone is another disinfectant that is used as an alternative to chlorine. Ozone provides a high level of disinfection, does not form chlorinated byproducts, and improves the coagulation process. It is also very effective in controlling taste and odor problems. Ozone is usually added at the beginning of the treatment process. It dissipates rapidly and does not provide a suitable disinfectant residual in the distribution system. The expense and complexity of ozonation facilities have prevented serious consideration of the process at many small and medium size treatment plants.

Ultraviolet (UV) light treatment, at sufficient intensity and appropriate wavelength and exposure time, is an effective disinfection agent for drinking water. The process involves the direct exposure of the water stream to UV light. UV systems come in two types, closed and open, with closed systems more commonly used in potable and sterile water applications. The effectiveness of UV disinfection depends on the intensity of the radiation, proper wavelength, exposure time, water quality, flow rate, type and source of the microorganisms (natural or culture), and the distance from the light source to the targeted microorganisms (EPA, 1996). UV disinfection is more suitable and effective for clean water sources with little suspended matter. Therefore, water often should be pretreated (e.g., for iron and manganese removal) before reaching the UV light disinfection unit. UV disinfection does not provide a disinfectant residual in the distribution system.

Disinfectants are added at a particular point in the process for specific reasons. When a disinfectant such as chlorine or chloramine is used, the disinfectant usually is added at two general areas in the treatment process. The first area is at the rapid mix and prior to filtration, which is called pre-disinfection. The second area is after filtration and before the distribution system, and is called post-disinfection. A disinfectant may be added to either location, or both. However, pre-disinfection may cause DBPs at levels that might cause adverse health effects. It is important to establish the need and the expected results when evaluating the disinfectant addition location. For example, pre-chlorination assists in iron and manganese removal by facilitating precipitation prior to filtration. If the only disinfectant addition point is at the post-disinfection zone, then the iron and manganese particulates would enter the distribution system, leading to customer complaints and concerns about water quality. Since pH must sometimes be increased to effectively precipitate manganese, disinfection credit may be impacted.

The effectiveness of the disinfection process in inactivating disease causing organisms is measured by compliance with the disinfection requirements in the SWTR. With the enactment of the SWTR, surface water treatment plants were required to demonstrate the removal and/or inactivation of 3-log *Giardia* and 4-log viruses. If the quality of the water leaving the plant meets the minimum requirements of the SWTR, then the facility with conventional filtration is credited with removing 2-log *Giardia* and 2-log viruses. A well-operated and maintained treatment plant with a conventional filtration process can receive a 2.5-log removal for *Giardia* and 3-log removal for viruses. The remainder should be inactivated (killed) by the disinfection process. To provide a reasonable means for demonstrating that the required level of inactivation is obtained, the *CT* concept was developed. *CT* is residual disinfectant concentration (in mg/L) times the water contact (detention) time (in minutes). The detention time used is T_{10}, which is the detention time at which 90 percent of the design flow passing through a basin is retained.

The *CT* values for different disinfectants at various water quality conditions are provided in the SWTR guidance manual (EPA, 1991). There are two different approaches in the

SWTR for demonstrating compliance with the disinfection requirements. The first method is to demonstrate that the facility has maintained a minimum disinfectant residual through the disinfection zone (i.e., between the disinfectant injection point and the residual measurement point), based on the projected worse case water quality conditions at the facility. The second approach is to compare the actual *CT* to the required *CT* using actual conditions (flow, temperature, water quality, etc.) for that day. To determine the actual *CT* required to inactivate *Giardia* and/or viruses for a given day, the disinfectant residual concentration and the detention time of the water T_{10} must be known.

The concentration of the residual disinfectant is determined by measuring the concentration of the treated sample. The detention time is measured either using a tracer study or by estimating using baffling conditions. The SWTR Guidance Manual provides full details on how to conduct both measurements, how to calculate the actual *CT* for various disinfectants, and how to look up the required *CT* for different levels of *Giardia* and virus inactivation. Inspectors should evaluate whether the plant is operating within the operating parameters for its *CT* requirements.

The SWTR also requires that the disinfectant residual entering the distribution system be at least 0.2 mg/L and that there be a detectable residual in all parts of the distribution system (specific requirements are given in 40 CFR 141.72 and the assessment criteria below). Therefore, a higher residual may be necessary at the entrance to the distribution system to assure that an acceptable residual is maintained throughout the distribution system. A state may have a more stringent requirement. Some states have minimum requirements for disinfection residuals at the far end of distribution systems, in addition to the minimum residuals at the entrance to the distribution system.

The general assessment criteria for the disinfection process equipment were presented earlier in this section and will not be repeated here. The assessment criteria listed here will be strictly related to the disinfection process. Suggested assessment criteria for the disinfection process include:

1. **What type of disinfection process and facilites are used at the treatment plant? Does the operator understand the disinfection process?**

   The operators should be knowledgable about the disinfection process and facilities used at the treatment plant so that the disinfection process can be properly managed and adequate disinfection treatment provided. The capabilities of the operators concerning the disinfection process should be explored with questions. When the operator is not knowledgeable about the process and equipment, equipment failures and problems in the effectiveness of the process may <u>not</u> be resolved in a timely manner. Operator training in the use and maintenance of disinfection equipment is important. Since an operator's lack of knowledge in this area can pose a serious sanitary risk, it may be considered a significant deficiency.

2. **How was T_{10} determined – calculated or field tracer study? How was *CT* determined at this facility? How many inactivation logs are required?**

What are the disinfection zones in the plant? How is compliance with this requirement demonstrated – minimum disinfectant residual level or calculated? Is continuous disinfectant monitoring being done? Are adequate records kept showing compliance with the *CT* requirement?

Plant operators should be able to calculate the sum of the actual *CT* for each disinfection segment under actual operating conditions (i.e., $\Sigma C \times T_{10}$). The operator should be able to tell the inspector if the T_{10} values are based on tracer studies or on the use of the baffling conditions as directed by the state or SWTR guidance manual. Generally, T_{10} is calculated using (peak hourly rate/volume) $\times$ baffling factor. The state provides credit removal to plants with filtration processes. Determining residual free chlorine should be done in the lab using one of the EPA-approved methods for analysis. However, the inspector should use an accurate field kit for on-the-spot measurement of free chlorine and total chlorine residuals. The sanitary survey inspector should refer to EPA's guidance manuals on alternative disinfectants and oxidants (EPA, 1999a), and disinfection benchmarking (EPA, 1999b) for evaluating *CT* credit for disinfectants other than chlorine. The inspector should make sure that water quality parameter measuring equipment (including temperature and pH meters) are operational, well-maintained, and properly calibrated.

3. **What is the chlorine residual leaving the treatment plant? Does it meet SWTR requirements? What is the chlorine residual at the first customer and throughout the distribution system? Does the residual provide adequate protection out in the distribution system? Do disinfectant residuals meet state requirements?**

   The SWTR requires that finished water leaving the treatment plant have a chlorine residual that is not less than 0.2 mg/L for more than four hours. The SWTR also requires the presence of detectable residual in the distribution system, specifically that the chlorine residual cannot be undetectable for more than 5% of the samples each month for any two consecutive months (40 CFR 141.72). The residual leaving the plant may need to be higher than 0.2 mg/L to ensure that an adequate minimum residual is maintained out in the distribution system. The state may have more stringent requirements.

3.2.4.9 Waste Streams

Waste streams (primarily backwash water) from a water treatment plant have been historically discharged either to a receiving stream or the nearest sanitary sewer. More facilities are recycling all waste streams to conserve water as much as possible. In such cases, the recycled waste streams are returned to the head of the plant. The method of returning this flow can have a significant impact on the treatment plant performance. One of the major concerns with recycled waste streams is the concentration of microbials, particularly protozoa such as *Cryptosporidium* and *Giardia*. The inspector should check if the water system's practices for recycling backwash water are in accordance with applicable federal and state requirements.

Wastewater from the filter backwash process is usually pumped from a holding pond(s) back to the raw water line coming into the plant. It is important that the recycled stream enter far enough upstream of the treatment process to allow for proper monitoring of raw water quality prior to chemical addition. In some cases, the pumping rate to return the waste streams as quickly as possible is fairly high ($\geq$ 25 percent of treatment rate). In others, the pumping rate is low ($\leq$ 10 percent of treatment rate). A variable pumping rate (approximately 5 percent of treatment rate) that provides a continuous flow based on the treatment rate of the plant is preferable. If the recycle return rate is high (compared to the treatment rate), hydraulic surges within the facility may result causing a significant disruption of the treatment process and ultimately leading to a degradation of the finished water quality. The recycle return rate should be low compared to actual treatment rate to minimize hydraulic surges.

Another concern of recycling the waste streams is the additional solids added to the existing raw water. In some plants, the additional solids are needed to enhance the coagulation and sedimentation process. In others, the additional solids would upset the treatment process, because the feed rates for the coagulant chemicals may not be set right to accommodate the higher loading. Solids may not settle in the clarifiers if the coagulant chemical dosages are not set properly. Therefore, the coagulant chemical dosages should be adjusted to consider the solids from the recycle stream. Finished water used in backwashing tends to have a lower pH (0.5–1 unit), a higher temperature (0.5–1°C), and a lower alkalinity than raw water. The coagulation/flocculation dosages need to be adjusted to account for these changes in pH, temperature, and alkalinity.

Suggested assessment criteria for recycling of waste streams include:

1. **How are wastewater from the backwash process and sludge from the sedimentation process managed? Is filter backwash water wasted or recycled? Are all discharge and disposal activities in accordance with applicable requirements?**

   It is important to note the conditions under which wastewater and sludge are discharged or disposed of. The inspector should also note if the waste stream is disposed of into a sewer line, french drain, or pond. It is also important to note whether the backwash water is wasted or recycled. The inspector should determine if the plant has an NPDES (National Pollutant Discharge Elimination System) permit to dispose of backwash waters into surface water. Additional information on addressing wastestreams can be found in *Technology Transfer Handbook-Management of Water Treatment Plant Residuals* (EPA, ASCE, and AWWA, 1996).

2. **If recycled, does backwash water receive any treatment to decrease pathogen densities?**

   Many water plants use settling ponds in series and add oxidants and disinfectants to recycled waste streams to reduce pathogen population and to improve coagulation.

3. **Do the recycle pumps operate manually or automatically? What is the recycling rate of the waste streams? How does this compare to the normal treatment rate (percentage basis)? Is it constant or variable flow?**

   To avoid disrupting the hydraulic regime of the treatment plant, waste stream holding tanks are used. The inspector should note the volume of the holding tank and the volume of the waste stream being recycled and the portion that is being wasted.

4. **How much solids are in the recycled waste streams? How does this compare to the solids in the raw water?**

   The solids content of the recycled waste stream is important in determining the coagulant dose needed. The plant should use jar tests to determine the necessary coagulant dose.

5. **Are the coagulant dosages adjusted to accommodate the recycle flows? If so, how? Are any jar tests performed to determine the impact of the recycle stream and what changes to the coagulant dosages are needed?**

   When a plant recycles its waste stream, very often coagulant dose is reduced. However, in some cases different coagulant is used or a coagulant aid should be added to the process. Jar tests are crucial in determining coagulation needs (both quantity and quality).

3.2.4.10 In-Plant Cross-Connection Control

Cross-connections are links between a potable and a non-potable water supply and/or waste water or chemical supply line, through which contaminating materials may enter a potable water supply. Cross-connections present a serious sanitary risk to a drinking water supply since they can be the source of contamination of drinking water, leading to illness and disease. At a cross-connection, contaminants can enter the potable water when the pressure of the contaminated, non-potable stream is greater than the pressure of the potable water. This situation causes backflow to occur. There are two types of backflow: back pressure backflow and backsiphonage backflow:

- **Back pressure backflow** is the flow of non-potable, contaminated water toward a potable water supply because the contaminated water has a greater pressure.
- **Backsiphonage backflow** occurs when there is a vacuum in the distribution pipes of a water system, causing untreated, non-potable water to be sucked out toward the potable water. (EPA, 1989)

The potential for cross-connections is very high within water treatment facilities. Typical examples of cross-connections at a water treatment plant are described below and are shown in Figure 3-13. For example, the check valve near the boiler in Figure 3-13 does not provide adequate protection since the potable water is not protected against backflow from the chemical feed line. Back pressure backflow is a potential problem in buildings where there are two or more piping systems that are not fully separated. A common situation for a back pressure cross-connection is when the potable water supply for the plant is tied into the water supply for the chemical feed system. Water containing chemicals under a higher pressure may backflow into the high water demands that result in a backflow of untreated water into the distribution system. This is one reason that it is important for a system to maintain adequate pressure in its distribution system.

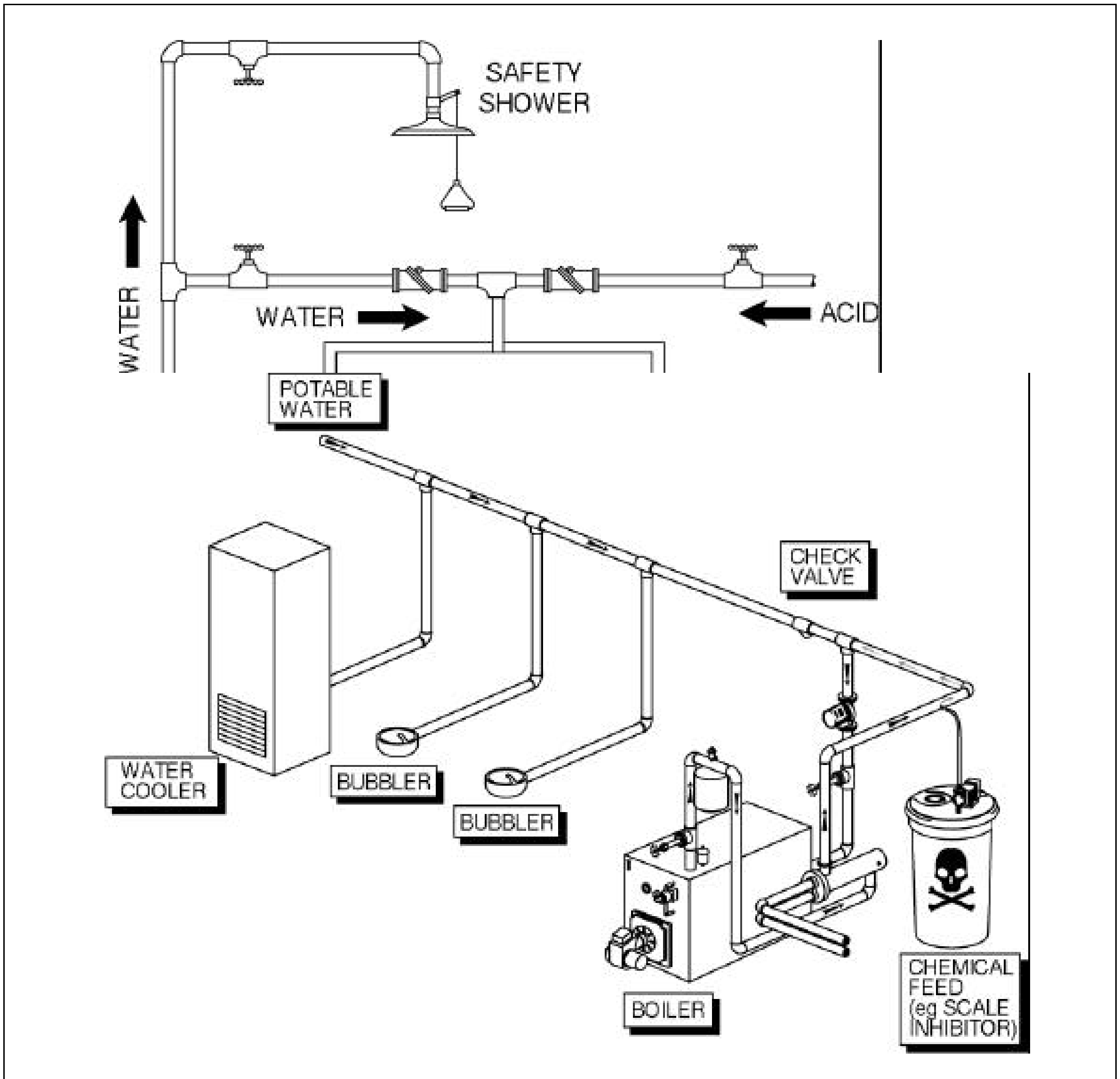


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Figure 3-13. Examples of In-Plant Cross-Connections

A backsiphoning scenario that is found throughout many water treatment plants is the carrier water supply for a coagulant chemical that may be connected to the plant water system. A high service pump discharging into the distribution system may cause a negative pressure and result in backsiphoning of some of the chemicals into the potable supply. Common cross-connections occur within the plant from high pressure hose bibs without vacuum breakers. Since negative pressures can also occur within the plant as a result of using high-pressure hoses supplied by the plumbing system, all hose bibs at the plant (particularly those that might hang down into chemical tanks or treatment basins) should be equipped with vacuum breakers. An example of a back pressure cross-connection is a hot water boiler connected to the plant water system. If the boiler creates a pressure that is greater than the system pressure, backflow can occur. Other examples of in-plant cross-connections include unprotected connections between filtered and nonpotable water in the filter piping gallery and the potable water lines that are used to provide makeup water and carrier water for chemical feed equipment. A very common cross-connection at surface water systems is backflow from the raw water source into the clearwell through a split feed (pre- and post-chlorination) chlorination system.

When surveying the plant, it is important to determine the source of water for all areas (chemical, water flush for pump bearings, etc.) that could potentially contaminate the potable water supply. The water system should eliminate potential cross-connections with an air gap or the appropriate backflow prevention device (see Figure 3-15). If the plant has a single plant water supply connection, installing a backflow prevention device on this line at the connection to the potable water supply will solve the problem. If the piping is such that a single device will not solve the problem, then a control device will have to be installed at all uses that pose a potential cross-connection.

Suggested assessment criteria for cross-connection control in-plant include:

1. **Does the water system have a cross connection control plan for the plant? Is the program active and effective in controlling cross connections?**

   Treatment plants should have a cross connection control plan for the plant. The plan should include testing various cross connection prevention devices for proper functioning. All pipes in the treatment plant should be color coded. Hookups to various types of pipes should be different. For example, a hose that is used to clean the grounds using clear water should not fit on the outlets of a coagulant or waste pipeline. All pipes should be labeled as coagulant line, clear waterline, waste line, gas line, etc. Also, flow direction should be marked on these pipes.

2. **What are the water uses in the plant? Where does the supply for these uses come from? Are proper backflow prevention devices installed to protect potable water at the plant?**

   All water uses in the plant should be verified. All potable water lines should be equipped with the necessary air gaps or proper backflow prevention devices to assure protection against the backflow or backsiphonage of contaminants. All hose bibs should have a vacuum breaker installed that cannot be easily removed.

3. **Are the appropriate backflow preventers used for all existing cross connections?**

   The inspector should have a copy of EPA's *Cross-Connection Control Manual* (EPA, 1989) or any equivalent state manual for verification of which devices ought to be used to prevent backflow.

3.2.5 Priority Criteria

The following criteria related to the water treatment element of the sanitary survey are considered high priority based on their potential for impacting public health:

- **Capacity of Treatment Facilities –** The capacity of major treatment processes needs to be sufficient to produce enough finished water to meet customer demands (Section 3.2.3).
- **Rapid Mix, Chemicals and Chemical Feed Systems, and Coagulation/Flocculation –** The proper use of coagulant chemicals can aid the sedimentation/clarification and filtration processes (Sections 3.2.4.3–3.2.4.5).
- **Sedimentation/Clarification –** The clarification process allows the particulates to precipitate and be removed by sedimentation (Section 3.2.4.6).
- **Filtration –** Filtration is the last physical barrier for the removal of particulates, organic and inorganic contaminants, and pathogens in the water (Section 3.2.4.7).
- **Disinfection –** Disinfection has proven to be the one treatment process that has had the most significant impact on public health due to the inactivation of pathogens (Section 3.2.4.8).
- **Waste Streams–** Recycled waste streams may have a high concentration of microbials and solids and may have a lower pH, higher temperature, and lower alkalinity than raw water. High recycle return rates can cause hydraulic surges that disrupt treatment processes. Treatment processes need to adequately account for these factors if waste streams are recycled (Section 3.2.4.9).
- **In-Plant Cross-Connection Control –** Connections between contaminated and potable water sources at the treatment plant can lead to contaminated water supplies, if not controlled. Cross-connections can be present in water treatment plants and are usually made unintentionally or are made because their hazards are not recognized or are underestimated (Section 3.2.4.10).
- **Treatment Plant Schematic/Layout Map –** Modifications to treatment processes can have a major impact on water quality and should be clearly identified on treatment plant schematics and layout maps (Section 3.2.2).

3.3 Distribution Systems

The water distribution system is the final link between the water source and the consumer. The distribution system is the primary means of delivering drinking water produced at the water treatment facility to the water system's customers. A typical water distribution system comprises miles of water pipes constructed in a network which includes numerous valves, fire hydrants, pumps, storage tanks, meters, and other appurtenances.

Water distribution systems are generally considered to be a composite of three basic elements: treated water storage facilities (ground storage tanks, elevated storage tanks, standpipes, hydropneumatic tanks), pumping facilities (booster pumps, piping, control, pump building, etc.), and the distribution lines (piping, valves, fire hydrants, meters, etc.). These components should be integrated in order to function as a comprehensive system that can meet various schedules of demand. A thorough inspection of the water distribution system is needed to determine whether the distribution system can provide a safe, reliable, and adequate supply of drinking water to the customers.

The objectives of surveying the water distribution system are to:

- Determine the potential for degradation of the water quality in the distribution system;
- Determine the reliability, quality, quantity, and vulnerability of the distribution system; and
- Ensure that the sampling and monitoring plan(s) for the system conform with requirements and adequately assess the quality of water in the distribution system.

To meet these objectives, the inspector will need to review system mapping, design and construction criteria, system operation and maintenance records, and sampling and monitoring plan(s) in addition to the actual inspection of the system. The following sections discuss the specific portions of the water distribution system that need to be evaluated during an inspection. Finished water storage and pumps/pump facilities are discussed further in Sections 3.4 and 3.5, respectively.

3.3.1 Distribution Maps and Records

The inspector will need to review the mapping and other records for a distribution system to assess the components and size of the system to be evaluated. Maintaining accurate mapping and records of the distribution system is essential for a water utility to repair and maintain the existing system, as well as to plan for future improvements or expansion. The mapping should show the location, size, and material of all pipes, valves, and fire hydrants in the distribution system. The mapping should also show any pressure zone boundaries, pumping facilities, storage tanks, and interconnections with other public water systems. A distribution system map for a small system could just be one map showing all the pertinent details. For a large system, the mapping could include an overall system map at a large scale with many smaller-scale, detailed maps showing the location of all utilities (including water and other utilities also) and valves at street intersections, on roadways, and other important areas. The maps should be updated regularly to record any changes or additions to the distribution system.

In addition to the distribution system mapping, an inspector should also review the historical records for a system. A good record system provides a history of the distribution system, including normal and emergency operation, maintenance, and repair. The records should include the standards used for construction, repair, and disinfection of new and repaired components of the system. Documentation of the inspection, operation, and maintenance of all valves and fire hydrants as well as leak detection and repairs completed should be in the record system. Customer complaints and investigation reports with the findings and actions should also be included in the record system.

Suggested assessment criteria for mapping and records include:

1. **Are there maps of the distribution system? Are all major features shown – line and valve location, size, and material; fire hydrant location; dead end mains; pressure zone(s) boundary, (if any); ground and elevated storage tank(s); and booster pump station(s)?**

   An accurate distribution system map enables systems to locate water mains and appurtenances for repairs and for maintenance. A distribution system map also permits the systems to accurately plan for improvements or expansions. Lack of an accurate map may be an indication that a system does not perform maintenance on its distribution system. Particularly for large systems, the inspector should check if system problem areas are identified on a system map.

2. **When were the maps last updated? How are changes or additions reported and the map(s) updated?**

   The distribution map should be updated to reflect the most recent modifications to the distribution system. Typically the date of the last revision to a map is noted in the title block or map key.

3. **Is there a record system? Does it include documentation of operation and maintenance repairs, leak detection, and construction standards?**

   Maintenance and repair records for a water distribution system can provide an indication of the portions of the distribution system which need to be rehabilitated or modified. The records should include reports upon repairs made to the distribution system as well as maintenance activities such as water main flushing. The other reports which should be maintained are the results of any leak detection and repair activities. A record of distribution system standards should also be maintained so that they are readily available to system personnel and contractors. These distribution system standards should include standard operating procedures (SOPs) for the repair of broken mains, as well as the standard details and specifications for pipelines and materials used in the construction of new water mains. The lack of standard operating procedures or construction specifications may indicate that repairs or extensions to the distribution system are not being properly completed.

4. **Are customer complaints and investigation reports kept? Is there an apparent/common problem indicated by the customer complaints?**

   Customer complaints can provide an indication of where water quality may be suffering. For example, a high number of stagnant water complaints on a dead end main may indicate the need for increased flushing or looping the main back into another part of the distribution system. Systems which maintain records on complaints an analyze them by mapping or other means, are proactively addressing potential sources of contamination in their distribution systems.

3.3.2 Field Sampling/Measurements

Some of the most important data collected by the inspector to evaluate the distribution system for sanitary risks are found in the field. The inspector should take measurements and samples for analysis at representative locations throughout the system to determine that an adequate disinfectant residual and pressure are being maintained.

The disinfectant residual should be measured at the points of lowest potential residual (e.g., areas of stagnant water) because these areas represent the greatest challenge for maintaining a residual. When taking the sample, proper procedures should be followed to prevent contamination which may influence the final results. If the disinfectant residual is less than that required, then the cause for the low residual should be investigated and solved quickly. The low residual could be caused by the disinfectant feed equipment not being properly adjusted and set. Excessive chlorine demands in the system could also cause low residual levels, which may indicate a more serious condition. Line breaks or leaks, backflow or back-siphonage due to low pressures, and biofilm growth may be responsible for the excess chlorine demands.

Of the conditions identified that could cause an excessive chlorine demand, biofilm growth is the least serious from a public health standpoint, but biofilm growth is usually the most difficult to treat. Besides compromising the disinfectant residual, the growth could also jeopardize routine microbiological samples. Systems that use chloramines as the secondary disinfectant to maintain the residual in the distribution system are susceptible to biofilm growth under certain conditions, such as high temperature and high total organic carbon (TOC) levels. The disinfectant may be consumed by the biofilm growth, leaving the water unprotected.

When taking the disinfectant residual test, the pressure available at that point in the distribution system should also be checked. The pressure in a distribution system varies due to the changes in water demand, changes in pressure head (e.g., as a result of transmitting water to consumers living on high hills or in deep valleys), and friction losses in the pipe. As such, there are several pressure zones in a distribution system commonly referred to as pressure planes. A pressure plane is the portion of a water distribution system served by the same elevated storage tank or booster station. Additional pressure checks should be performed at the highest and lowest points of a pressure plane or the distribution system. The pressure at all points should be at least as high as the normal operating pressure required by state rules (typically 35 psi). When the pressure is lower than 20 psi, that area of the distribution system is vulnerable to backflow or back-siphonage of contaminated water into the system. Excessive pressures (greater than 100 psi) may damage consumer facilities and plumbing fixtures.

Suggested assessment criteria for data collection include:

1. **What are the maximum and minimum residuals at the extremities of the distribution system or pressure plane? What is the normal residual range in the distribution system or pressure plane?**

   The lack of a disinfectant residual in distribution systems which are required to maintain a residual can be an indication of excessive chlorine demand or improperly set disinfectant feed rates. Excessive chlorine demand may be caused by cross connections, backflow into the system, biofilms or line breaks. Systems with surface water and ground water under the influence of surface water are required by the SWTR to maintain a minimum disinfectant residual concentration at the point of entry to the distribution system of 0.2 mg/L (EPA, 1991).

2. **What are the maximum and minimum pressures at the high and low points in the distribution system or pressure plane? What is the normal operating pressure in the distribution system or pressure plane?**

   A system must maintain positive pressure at all times to prevent contaminants from being drawn into the water mains from outside sources. The lowest pressure in the system should be approximately 35 psi (this depends upon State Standards) and should almost never be lower than 20 psi. Excessively high pressures can cause damage to the system and may result in high water use. The inspector should check to see that the system operators check and record the operating pressure at representative locations throughout the system (CDOHS and EPA, 1996).

3. **How often are pressure readings taken in the distribution system? Are they representative of the system?**

   The frequency of pressure readings depends on the size and complexity of the system. At a minimum, pressure should be checked in the distribution system when chlorine residual concentrations are checked, and in response to customer complaints about water pressure. In addition to checking the pressure in the area near where the customer complaints were received, the pressure at the highest point in the distribution system or pressure plane should also be checked. This high point is where you would expect to find the lowest water pressure.

3.3.3 Distribution System Design and Maintenance

The integrity of the distribution system should be maintained at the highest level possible to protect public health. Since almost all of the distribution system components are located underground, they cannot be easily checked to verify that the system integrity is being maintained. Therefore, standards and procedures for design, material selection, plumbing code, operation, and maintenance should help maintain the integrity of the system.

3.3.3.1 Design/Material Standards

The major component of the distribution system is the underground pipe. As the largest element, a design standard should be established that specifies the minimum requirements for all water lines. To protect the integrity of the distribution system, these standards should apply regardless of who pays for or installs the line(s). The design standard should specify the following items:

- Minimum pipe size (typically there should be no lines less than 2 inch);
- Minimum line size criteria (either maximum water velocity or number of connections served for a given line size);
- Minimum line size where fire hydrants are to be provided (6 inch is the minimum);
- Minimum line size for a specific requirement of the distribution system (e.g., transmission line should be at least 12 inches);
- Design flow for each type of connection (residential, commercial, industrial, etc.);
- Design fire flow for specific areas of development (residential, commercial, industrial, etc.);
- Location of line relative to other utilities (sanitary sewer, in particular) and right-of-way limits;
- Location or spacing of valves;
- Direction of valves (right or left opening);
- Type of valves to be used (vacuum/air release, butterfly, or gate valve);
- Location or spacing of fire hydrants;
- Type of fire hydrants to be used (dry or wet barrel);
- Pipe material, including requirements for internal as well as external corrosion;
- Appurtenances required for flushing of dead-end lines;
- Minimum cover or depth of bury requirements;
- Pressure testing to determine that there are no leaks in the line;

- Construction or installation requirements; and
- Location and construction of appurtenances in the floodplain.

Suggested assessment criteria for design/material standard include:

1. **What kind of piping materials are in the distribution system?**

   The kind of pipe used may provide an indication of the condition of the pipe, and the amount of corrosion which may be occurring in the pipe. Certain types of pipes such as ductile iron, cast iron, steel, concrete and asbestos cement are more susceptible to corrosion when exposed to aggressive soils or water (CDOHS and EPA, 1996). Often times these types of pipes are lined internally with mortar or bituminous materials and are sometimes protected externally. Corrosion of pipes may lead to contamination of the drinking water by leaks or by the corroded pipe material.

2. **Does the water system have a construction standard for water mains? If not, what are the criteria for sizing water line, selecting pipe materials, installing the lines, etc.?**

   The use of a construction standard by water systems in the construction of water mains ensures that the pipes and appurtenances in the distribution system meet minimum acceptable specifications.

3. **Is the standard or method adequate to protect the integrity of the distribution system initially, as well as over time?**

   The construction standards will be protective of the water quality if they are appropriate for the conditions (e.g., aggressiveness of the soil and water) for the specific system. They should also ensure that the pipe and other appurtenances are manufactured in accordance with accepted practices.

4. **Are standards actually followed?**

   Construction standards are only effective if they are followed and enforced. An inspector should ask how the system ensures compliance with the standards. Pipes and appurtenances should be inspected by the system prior to installation. The system should periodically inspect its installation contractors or crews to ensure that they comply with the standards.

3.3.3.2 Maintenance Procedures

Even if the installation of a new waterline and its appurtenances are completed in accordance with the design standards, the integrity of the distribution system could be compromised if it is not properly maintained. Procedures and schedules should be created for the maintenance of all parts of the distribution system. The maintenance procedures for piping systems would include line flushing at a regular interval. For valves, verifying location and regularly exercising the valve between the open and closed positions will help maintain the valve, and keep it ready for an emergency.

Suggested assessment criteria for maintenance procedures include:

1. **Does the water system have a maintenance procedure for all components of the distribution system? If not, is anything being done to maintain the system components? What?**

   A system should have a set of distribution system maintenance procedures to ensure reliable service, to minimize emergency repairs, and to minimize the potential introduction of contaminants. The distribution maintenance procedures should address water main flushing, valve operation and fire hydrant flushing as described below.

2. **Does the system regularly flush the water mains within the distribution system?**

   Flushing of water mains removes sediments or other contaminants which can accumulate in pipes over time, and can lead to taste and odor problems. The system should develop a schedule for flushing mains before taste and odor problems develop. Dead end sections of the system may require more frequent flushing than other portions of the system.

3. **Does the system have a program for inspecting and exercising valves?**

   The system should have a program for inspecting and maintaining all valves. Generally, the valves in the system should be operated at least once a year. The system should have a program under which all valves are opened and closed (or closed and opened). The system should maintain a record of each opening and closing which includes the number of turns of the valve and the date it was exercised. The valve should also be examined to note the condition of the valve packing stem, stem, stem nut, and gearing (CDOHS and EPA, 1996). Because large valves that have been in service for many years may be more prone to breakage, it may be appropriate to exclude them from the valve exercise program (AWWA, 1999). A system's valve exercising program should follow AWWA-recommended practices.

4. **Does the system regularly inspect and operate its fire hydrants?**

   The system's maintenance procedures should include a program to inspect and operate fire hydrants at least two times each year. The hydrants should be inspected for leaks, and dry barrel hydrants should be checked to ensure the barrel drains after use. Nozzles and caps should be cleaned and lubricated. The hydrant should be opened fully and flushed to waste (CDOHS and EPA, 1996).

3.3.3.3 Disinfection of New Water Lines

The distribution system integrity could be compromised if procedures are not followed to protect it from contamination when installing new lines or repairing existing lines. The primary barrier to contamination in the distribution system is the initial disinfection of new or repaired water lines. Following an adopted procedure or standard ensures that the barrier is created to protect the system. AWWA Standard C-651, which is a recognized, national standard, specifies the means and methods for using the various forms of chlorine to disinfect water lines.

Reducing the sources of contamination in the new or repaired pipe will enhance the effectiveness of the disinfection and flushing process. The first step of the installation procedure to reduce contamination sources is to keep the pipe as clean as possible before it is installed and placed into service. Special care should be taken to prevent or minimize the amount of deleterious material entering the new pipe.

Once the installation is complete, the new water line is filled with water and pressure tested for leaks. The pressure should be at least one and a half times the maximum operating pressure of the system. The time period for the test is dependent on the test pressure used. The higher the test pressure the shorter the time period can be. Typically, the test pressure is 150 to 200 psi, and the time period is at least 6 hours.

Flushing the line, once it is completely installed and tested, will help remove the dirt and debris that was not cleaned out during installation. As a general rule, the velocity of the water during this flushing period should be at least 5 feet per second to scour out the remaining dirt. In addition, the flushing period should last long enough to turn the water in the pipe over two or three times.

A sufficient amount of the chosen disinfectant is added to the water line that results in a disinfectant residual 50 to 100 times the normal operating residual. The high level of the disinfectant inactivates any microbiological contamination that may have occurred in the pipe. To ensure that the pipe is thoroughly disinfected, the high disinfectant residual water should remain in the pipe for a designated holding period in accordance with the standards.

After the required holding period, the pipeline should be flushed to remove the water with the high disinfectant residual, and any debris or harmful matter that might be left in the pipe. A sample of the water is collected for a bacteriological test after the high disinfectant level water is purged. One bacteriological sample should be collected for every 1,000 feet of new pipe laid. The bacteriological test will show if any contamination sources remain in the pipe. If the tests are negative, then the new water line can be placed into service. If the test proves positive, then the waterline should be disinfected and flushed until the test is negative. The procedures for the disinfection of a new water line should include a contingency if the bacteriological tests are found to be positive for more than two or three times.

Suggested assessment criteria for disinfection and flushing procedures for new water lines include:

1. **Does the water system have a procedure for disinfecting and flushing new water lines? If not, what steps does the system follow when installing new lines?**

Disinfection of newly constructed water mains prior to placing it into service prevents the introduction of microbial contaminants that may have accumulated inside the pipe during the construction process. A system should require disinfection and flushing of its newly constructed mains in accordance with AWWA Standard 651 or its own equivalent standard.

2. **Are there reports or test results which document the flushing and disinfection of new water mains and the subsequent testing?**

   A system should maintain records of the disinfection and flushing of new water mains. The records should include at a minimum the results of the bacteriological testing done to ensure the new main was disinfected.

3.3.3.4 Disinfection of Repaired Water Lines

The disinfection and flushing procedures for new lines typically cannot be used when repairing existing water lines, because of the need to minimize the disruption of service to customers. Repairs can range from the easy, such as installing a repair clamp, to the very difficult, such as replacing a joint of pipe in a very deep hole where there is a lot of erosion due to the leaking water. Procedures should cover the extreme as well as all the various situations in between.

Leaks or breaks that can be fixed with a repair clamp while the main is in use under normal operating pressure pose little danger of contamination and require no disinfection of the line. The repair clamp should be sprayed or swabbed with a chlorinated solution to clean it before installation. Following these procedures should allow the line to be returned to service as soon as the leak is repaired.

When there is a leak on an existing water line, the ground in the area will likely be wet. If there is a sanitary sewer line in the area, the open area could be contaminated by the nearby sewer. Workers should sprinkle liberal quantities of sodium or calcium hypochlorite around the open area to reduce the danger of pollution from the sewer line. All fittings, pipe, or clamps required for the repair should be sprayed or swabbed with a concentrated solution of chlorine to thoroughly clean them. The distribution system should be thoroughly flushed to remove any sediments that may have been disturbed.

Wherever possible, the section of the water line where the break or leak is located should be isolated by closing distribution valves and turning off all service connections. After repairing the line, the section should be flushed and disinfected in accordance with acceptable procedures or standards, such as AWWA Standard C-651 or the Ten State Standards (GLUMRB, 1997). The line should then be flushed until all discolored or chlorinated water is eliminated. If possible, a bacteriological test should be taken to determine that there is no contamination. For disinfection of main repairs, the use of sodium or calcium hypochlorite may not always be appropriate. Since granular or tablet forms of chlorine can be slow to dissolve and main repairs are done as quickly as possible, careful use is necessary to avoid sending highly chlorinated water out to customers.

Suggested assessment criteria for disinfection and flushing procedures for repairing water lines include:

1. **Does the public water system have a procedure for disinfecting and flushing repaired water lines? If not, what steps does the system follow when repairing existing lines?**

   Disinfection and flushing of repaired water lines is more difficult than for newly constructed mains but equally important. The system should have in place standard procedures to minimize the contamination of line during the repair. The procedures should include sprinkling calcium hypochlorite in the area surrounding the main break, swabbing the fittings, pipe and clamps with chlorine and flushing the section of the line to remove sediments.

2. **Are there adequate repair materials on hand?**

   In addition to reviewing the procedures for disinfecting repaired mains, the inspector should ensure the system has sufficient quantities of disinfectant powder, repair sleeves, and other materials necessary to implement the disinfection and repair procedures.

3. **Are there reports or test results which document disinfection of repaired water mains and any subsequent bacteriological testing?**

   A system should maintain records of the disinfection and flushing of repaired water mains. If any bacterialogical testing was done, the system should have a record of the results. Repairs are often done on an emergency basis and as quickly as possible, so in some cases there may not be sufficient time for water quality sampling.

3.3.3.5 Flushing Procedures

Flushing is normally used to clear up colored water or to remove sediment and biofilm in an existing main and improve the disinfectant residual in dead-end lines. For most distribution systems, it is only necessary to flush out sediment that may have been deposited in areas where the water velocity is insufficient to keep it in suspension. Customer complaints about water quality will provide an indication of the area(s) that need(s) flushing. A good maintenance procedure would include flushing different areas of the distribution system on a regular basis to reduce the potential for water quality degradation.

Suggested assessment criteria for flushing procedures include:

1. **Does the public water system have a procedure for flushing a portion of the distribution system on a regular basis?**

   The system should have procedures to flush water mains in the distribution system regularly. Flushing of water mains removes sediments or other contaminants which can accumulate in pipes over time, and can lead to taste and odor problems. The system should develop a schedule for flushing mains before taste and odor problems develop. Dead end sections of the system may require more frequent flushing than other portions of the system. Flushing procedures should ensure that a minimum flushing velocity of 2.5 feet per second (CDOHS and EPA, 1996).

2. **Are there reports or records which document the portions of the system which have been flushed and the date of the flushing?**

   A system should maintain records of the flushing of water mains. The records should include at a minimum the portion of the system flushed and the date of the flushing event.

3.3.3.6 Cross-Connection Control

A piping cross-connection is defined as an actual or potential physical connection between a water system and another water source of unknown or questionable quality. The physical connection could allow water of a questionable quality to backflow into the water system either as a result of backpressure or backsiphonage backflow. Backflow is the unwanted reversal of water. Backpressure backflow refers to the flow of water toward a potable supply when the contaminated water's pressure is greater than the potable water's pressure. Backsiphonage backflow is a result of a vacuum in the distribution pipes of a potable water supply. If a negative pressure develops in the distribution system, water can back-siphon. Therefore, if there is a cross-connection with a questionable source, a potential for contamination of a water system exists. An example of a cross-connection in the distribution system is shown in Figure 3-14. (UFTREEO Center, 1998)

In the past, the best means of eliminating cross-connections was constant surveillance and inspection of new and existing buildings. Presently, most cities have adopted a plumbing code that requires the builder of a new or remodeled facility or building to eliminate all cross-connections. In addition, the code usually allows local building officials to inspect the facility or building to look for cross-connections during construction, and annually thereafter.

The preferred method for cross-connection control is an air-gap. An air-gap is a separation between the pipe or fixture supplying the water and the receiving fixture (i.e., at the water outlet). An air-gap should be twice the diameter of the water outlet pipe (UFTREEO Center, 1998). Air gaps cannot be installed in pressurized systems. Other backflow prevention devices are necessary when an air gap cannot be made, or to provide additional protection.

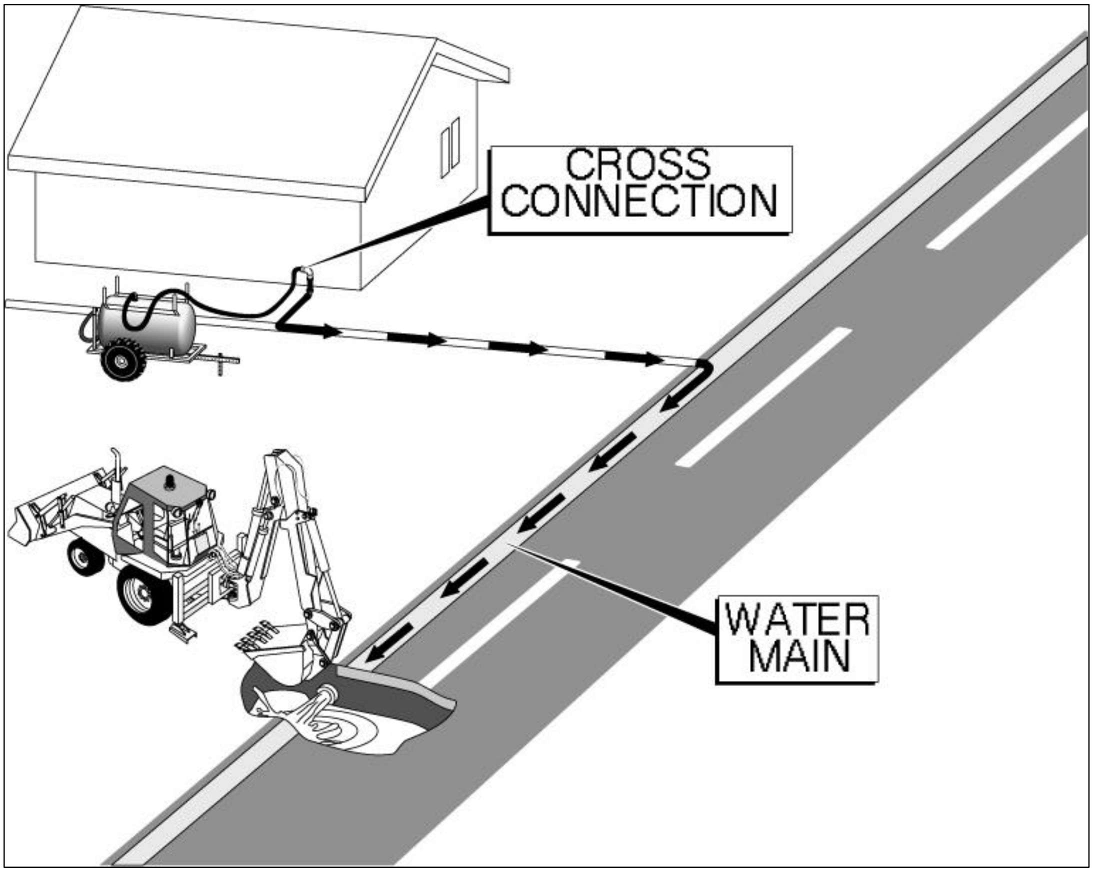

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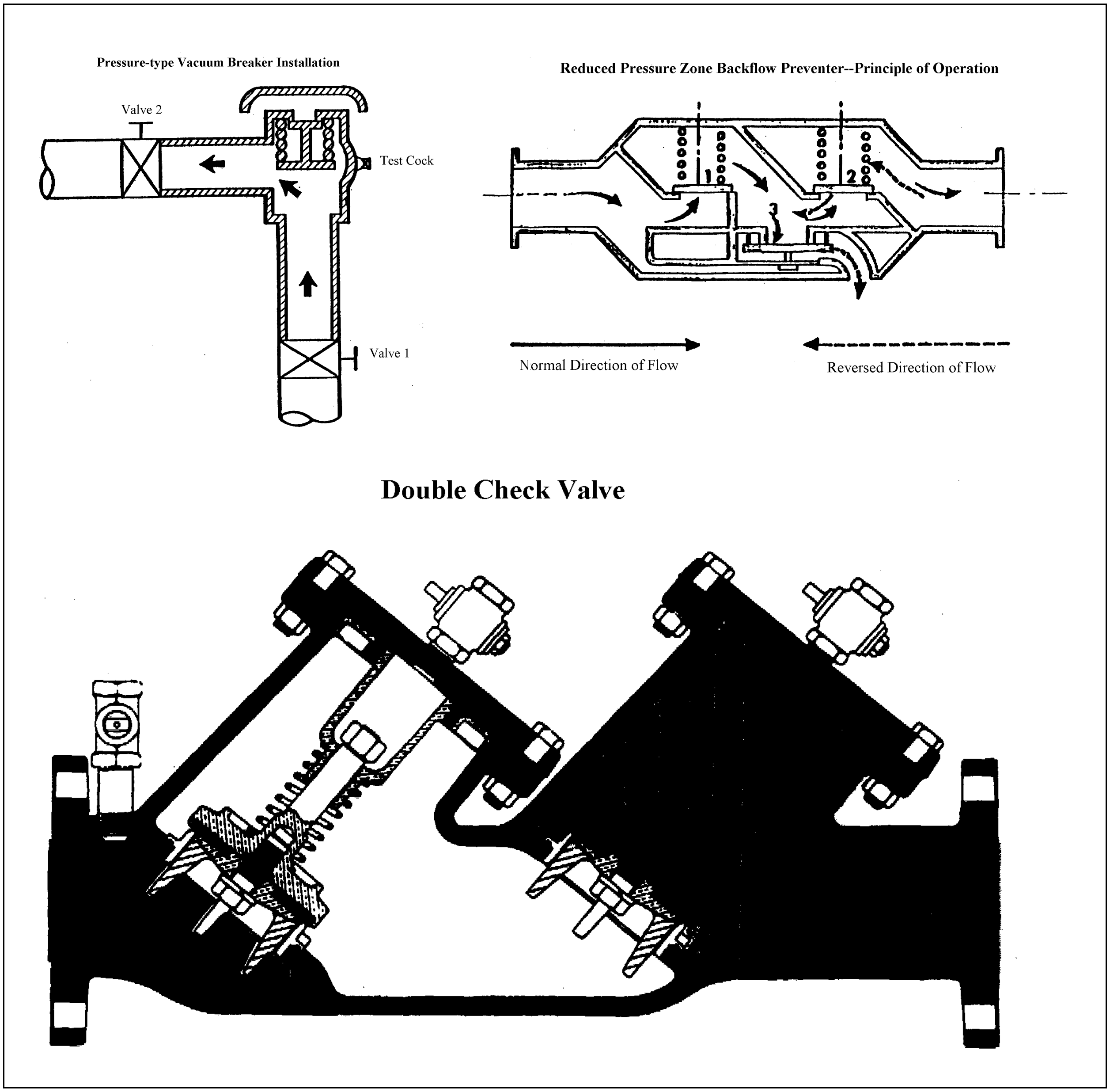
Figure 3-14. Example of a Distribution System Cross-Connection

The most common backflow prevention devices for the control of cross-connections are vacuum breakers, double check valve assemblies, and reduced pressure principle (reduced pressure zone) devices as shown in Figure 3-15. For outside fixtures, such as a hose bib (an outdoor faucet to which a hose may be connected), the plumbing code may require that vacuum breakers be installed. Each device has a specific application and protects against a different type of contamination hazard.

A plumbing ordinance requiring the control of cross-connections is the first step of the process to eliminate the potential contamination of the distribution system. The system should have a program to inspect or locate actual or potential cross-connections. Backflow prevention devices should be tested after installation and repair. Testing should be required and performed by certified testers.



(Source: EPA, 1989a; EPA, 1989)

Figure 3-15. Common Devices for Cross-Connection Control

Additional information can be found in the *Cross-Connection Control Manual* (EPA, 1989) and from other industry sources such as *The Manual of Cross-Connection Control* , ninth edition from the University of Southern California (USC) Foundation and the AWWA M-14 Manual, *Recommended Practice for Backflow*.

Suggested assessment criteria for cross-connection control include:

1. **Does the water system have a formal program to address cross-connections? If not, what steps does the system take to eliminate cross-connections?**

   A system should have enforceable provisions in the plumbing or building ordinance which require the builder of a new or remodeled facility to install backflow prevention devices on all cross connections. The system should set minimum standards for backflow prevention devices and should actively work to inform plumbers and mechanical contractors of its cross connection control policies.

2. **Is there an inspection of new construction as well as follow-up inspections? How often do follow-up inspections occur? Is there a log or documentation of these inspections?**

   There system should ensure that inspections are conducted of all new construction or remodeling projects within its service area to ensure that all potential cross connections are eliminated by the installation of a backflow prevention device.

3. **Is there a requirement for the annual testing of the installed backflow prevention devices? What documentation is available? What qualifications must a tester have? How many certified testers of cross-connection devices are available?**

   The inspector should check to see if the system inspects backflow prevention devices or requires its customers to inspect and maintain backflow prevention devices.

3.3.3.7 Elimination of Water Loss

Water systems are currently able to, or should be able to, meter all sources and uses of treated water. The metering of all sources and end users allows the system to account for the water from production to the end user. This accounting of water provides valuable information, such as per capita water use, and determination of unaccounted water or water losses.

When a system compares the water pumped into the distribution system from its source(s) to the water billed to customers, typically the amount billed is less than that pumped. The difference is the water loss. There are numerous reasons for loss of water in the distribution system. The two biggest causes of water loss are meter inaccuracy and leaks in the distribution system. Other sources of losses normally not accounted for by metering is the water used for fire protection and construction.

Generally, if the water loss for a system is 10 percent or less, then that system is considered a “tight system,” meaning that there are very few sources of water loss that the system can identify. If the water loss for a system is greater than 10 percent, then a program should be instituted to eliminate the “excessive loss” of water. A systematic program should be followed to eliminate the source(s) that are easiest to identify and the least costly to correct.

Evaluation of Service Meters

Normally, the first step of a program to reduce water losses should start by checking the accuracy of the meters at the source(s) and end user or customer. Checking these meters will require the use of another calibrated meter with known accuracy, so a comparison can be made between the two meters.

The main meter at the source(s) should be checked and recalibrated at least annually. The size of the meter and the amount of water used by a specific customer annually dictates how often these meters should be checked. Large meters (the definition of large is system specific) should be checked at least annually, while individual residential meters should be checked every five to seven years. Typically, a system will establish a program to replace all residential meters over the five to seven year period suggested, because it is easier to rebuild these meters in a shop than to recalibrate them in the field.

As the process of recalibrating meters proceeds, the new data obtained about meter accuracy should be compared to the original water loss data. If recalibrating the meters reduces water losses sufficiently to designate the distribution system as tight, then the public water system does not need to continue with its program to reduce water losses. However, all systems should adopt a goal to continually reduce unaccounted for water.

Detection of Leaks

If the main meter(s) have been checked and recalibrated, but water losses are still too high, then the system should begin looking for leaks in the distribution system. The first step of a leak detection procedure should be comparing the water usage for designated areas of the distribution system. These areas should be defined to allow for the easy determination of per capita or per connection water usage. If one area has a higher usage than normal and there is no reasonable explanation for the difference, then this area would be one that should be checked for leaks.

All customers in the area should be checked to determine that there are no unmetered water users that may cause the higher than expected water usage. If all customers are metered, then the distribution system should be checked for leaks. It is expected that the water from a leaking pipe will rise to the surface providing an easy means of locating the leak. Because this type of leak is easily located and corrected, it is not counted in the leaks that cause a significant water loss.

The leaks that account for most of the water loss in a distribution system are the ones that are not easily located by rising to the surface. Different means or methods are needed to locate these types of leaks. With the technology available, there are numerous methods to detect leaking pipes in the ground. The most commonly used technology to locate these leaks is a hydrophone. With this instrument, leaks can be located by the sound of water rushing out of the pipe. Once located, the leaks can be fixed as they are found.

Suggested assessment criteria for the elimination of water losses in the distribution system include:

1. **Is all source water metered at the point of entry into the distribution system? Are all customers metered? How often are the meters checked and recalibrated, if necessary?**

   The system should have meters at all points at which water is supposed to enter and exit the distribution system. This includes all water supplies and all customers. These meters should be read by the system on a regular basis. The system should also check and calibrate meters to ensure the data collected is accurate.

2. **Is the water loss for the system calculated?**

   The system should take the water meter readings and calculate the average volume of water pumped into the distribution system by the water sources and the average volume of water withdrawn from the distribution system. The difference between these two average values is the water loss within the distribution system.

3. **Is the water loss for the system greater or less than 10 percent? If greater than 10 percent, what is the system doing to reduce its water losses?**

   There will always be a certain amount of water loss within a system due to the un-metered withdrawal of water from the system for activities such as water main flushing, fire hydrant testing and fire fighting activities. However, experience with well operated systems indicates that these losses should not exceed 10 percent of the total amount of water supplied to the system. Systems with greater than 10 percent loss should undertake a leak detection and repair program.

3.3.4 Priority Criteria

The following criteria related to the distribution systems element are considered high priority based on their potential for impacting public health:

- **Field Sampling/Measurements –** Adequate disinfection residuals and water pressures in the distribution system are essential for preventing contamination of finished water as it is delivered to consumers (Section 3.3.2).
- **Disinfection of Repaired Water Lines –** If the water distribution system is not properly cleaned and disinfected, system personnel cannot prevent the contamination from spreading to the consumer (Section 3.3.3.4).
- **Disinfection of New Water Lines –** If the water distribution system is not properly cleaned and disinfected, system personnel cannot prevent the contamination from spreading to the consumer (Section 3.3.3.3).

- **Cross-Connection Control –** Connections between contaminated and potable water sources, if not controlled, can lead to contamination of entire water system (Section 3.3.3.6).
- **Elimination of Water Loss –** Excessive leakage can lower water pressure in the distribution system and increase the opportunity for contamination (Section 3.3.3.7).
- **Distribution Maps and Records –** Modifications to the distribution system can impact water quality and should be identified clearly on distribution system maps (Section 3.3.1).

3.4 Finished Water Storage

Prior to the field inspection, the inspector should obtain the information available on the storage facilities for the subject water system from the state's files or the last sanitary survey. The information on storage facilities should include the type of storage (ground, elevated, or hydropneumatic) included in the system, and the volume and location of each storage tank.

Finished or treated water storage facilities provide the following benefits to the operation of a distribution system:

- Allow treatment facilities to operate at or near uniform rates, even though the demands of the system may greatly fluctuate;
- Supply the peak and emergency needs of the system;
- Maintain an adequate pressure in the system, when designed for that purpose;
- Provide extended contact or detention time for disinfection;
- Allow for the sedimentation of settleable particles that may have passed through the treatment facility; and
- Serve as reservoirs for the blending and mixing of water from different sources that may have varying water qualities.

The objectives of surveying the finished water storage facilities are to:

- Review the design and major components of storage to determine reliability, adequacy, quantity, and vulnerability;
- Evaluate the operation and maintenance and safety practices to determine that storage facilities are reliable; and
- Recognize any sanitary risks attributable to storage facilities (UFTREEO Center, 1998).

To accomplish these objectives, the inspector needs to review the information available from state files for the system's finished water storage facilities. In the field, the inspector should perform an inspection to verify the information and to determine that the finished water storage facilities are adequate and in acceptable condition. To verify some of the storage tank information and adequately assess facility conditions, the inspector may need to climb storage tanks as part of the inspection (particularly if the water system uses elevated tanks and standpipes). Since this can pose safety hazards (e.g., slipping, wasps), inspectors who are expected to climb storage tanks as part of the tank inspection should receive written inspection procedures and training in appropriate safety procedures (e.g., use of safety belts and cables). In some cases, the results of a recent inspection done by a qualified tank contractor may provide the inspector with any necessary information without climbing the tank. Some states do not allow their staff to climb water towers, so inspectors may need to rely on information from tank contractor inspections, ground level observations, and conversation with water system operators to verify file information and assess the adequacy and condition of storage facilities.

3.4.1 Type of Storage

The inspector should determine the types of storage facilities in the system. Storage facilities are designed to provide for the (1) storage of treated water (ground storage) that can be pumped into the distribution system or (2) maintenance of an adequate service pressure (elevated, hydropneumatic, or ground storage that is built at a location to act as elevated storage). Storage facilities may be closed tanks or reservoirs.

The first treated water storage tank in a water system is typically the clearwell, located at the treatment plant. The clearwell provides both a treated water reserve for delivery to the distribution system and additional detention time for more effective disinfection. These tanks are sometimes located partially or completely below grade to allow gravity flow from the filters to the clearwell. While this approach reduces operational costs by avoiding additional pumping facilities, those portions of the tank that are below grade cannot be easily inspected and the tank may be vulnerable to seepage from shallow ground water.

Depending on the complexity and size of the distribution system, the next storage tank will probably be designed to provide pressure maintenance for the distribution system. If the system serves a small number of customers, a pressurized tank called a hydropneumatic tank (controlled by both water and air pressures) will most likely be used to maintain the system pressure, because it is cheaper to build than an elevated tank. For larger systems, an elevated tank, which is a tank constructed on structural supports, would be used to maintain an adequate pressure as long as the height is adequate. Different sections of the distribution system are maintained at different pressures (commonly referred to as pressure planes), depending on the water demand and pressure head requirements. For the largest systems, or a system with significant topographical variation such that pressure planes are required, a ground storage tank could be used to provide the system pressure maintenance for a lower area or pressure plane and act as storage for an upper plane. Figures 3-16 and 3-17 depict the various types of storage facilities and pressure maintenance facilities, commonly used in a water system.

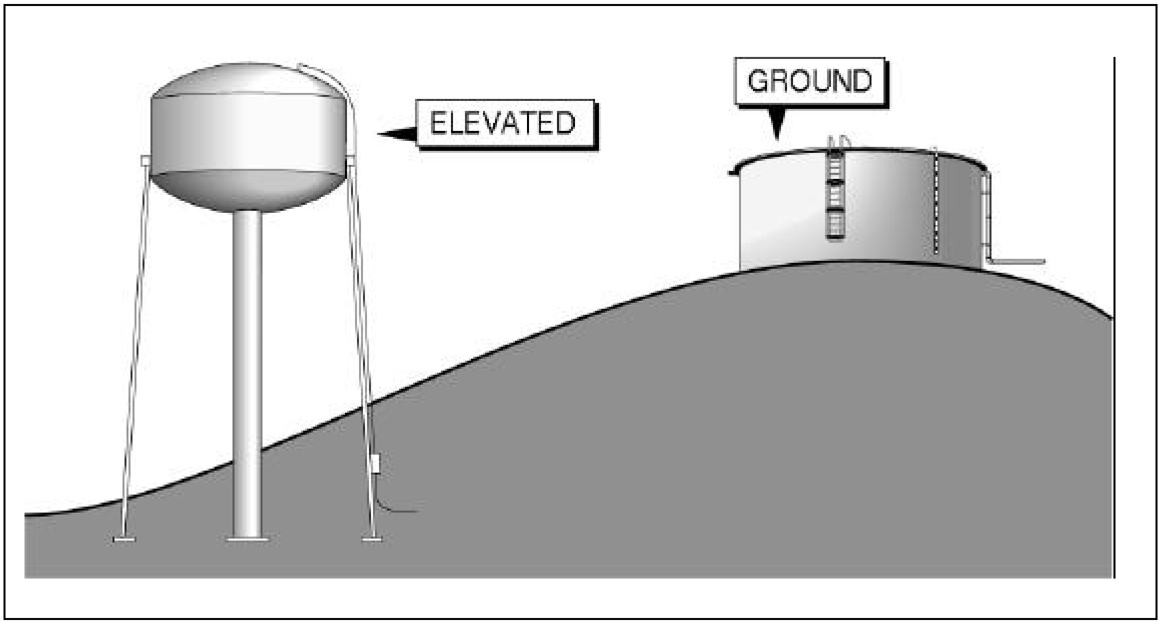


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Figure 3-16. Types of Storage Facilities

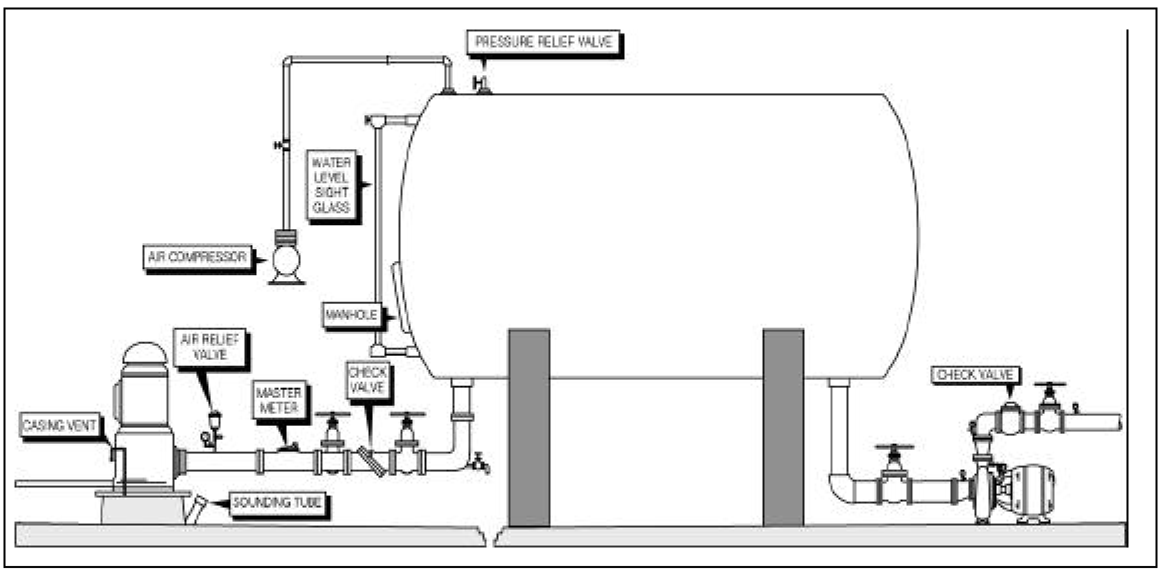

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Figure 3-17. Typical Hydropneumatic Tank Installation

Suggested assessment criteria for the type of storage facilities include:

1. **Are the storage facilities covered or otherwise protected?**

   The IESWTR prohibits the development of new uncovered finished water reservoirs, so any storage facilities constructed after IESWTR promulgation must be covered. EPA recommends that any uncovered finished water storage facilities in existence at the time of IESWTR promulgation either be covered or eliminated from use. Covers prevent airborne contamination from insects, birds, and mammals, and also prevent algal contamination. Covers must be watertight to prevent contamination from entering. Where covering or eliminating uncovered reservoirs is not possible, there are measures that a water system should take to prevent contamination. Development and implementation of these measures is covered in EPA's *Uncovered Finished Water Reservoirs Guidance Manual* (EPA, 1999d).

2. **Where do the overflow pipes end? Do they discharge to a splash pad? Are they equipped with hinged and weighted flaps?**

   Overflows should not be discharged to the ground or to any storm or sewer line. The overflow line should drain 12 to 24 inches above the ground to an open basin or splash pad. A splash pad prevents erosion of the area below the line and around the tank supports or foundation. Overflow pipes should be equipped with a hinged and weighted flap to prevent the entrance of small mammals, birds, insects, and contaminants.

3. **Do the air and roof vents have a screen? Are they protected from rain?**

   A fine mesh screen prevents the entrance of birds, insects, and small debris into the tank. However, a fine screen must be designed to fail in the event of clogging, to prevent the tank from imploding in the event the clogged screen causes a vacuum effect. Vents should be covered or face downward to protect the tank from rain.

3.4.2 Location of Storage

The inspector should determine the location of storage facilities to assess their potential to compromise the integrity of the delivery system. The surrounding area needs to be inspected for sources of potential contamination and sources that may cause physical damage to the tanks. The location and size of the storage tanks can be obtained from the distribution system maps discussed previously. In addition, the tank location should be shown on a United States Geological Survey (USGS) topographical quadrangle map so that coordinates can be determined and placed in the state's Geographic Information System (GIS) to be used for identifying potential sanitary hazards that might be located nearby.

If the state does not have a GIS, the inspector should use the topographical map during the site visit to assess the potential impacts of nearby sanitary hazards. The inspector should discuss the characteristics of the surrounding area with the operator to find out if there have been any changes since the last survey that may pose a sanitary hazard or if there are any questions or concerns about the site itself. The location of the tank on the site should be assessed relative to trees and buildings that could fall on the tank and cause damage. In addition, it is important to assess the general maintenance of the site (e.g., grass mowed and free of trash and debris).

Suggested assessment criteria for the location of storage facilities include:

1. **Are there any potential sanitary hazards in the area? If so, what and where are the hazards? Are the hazards close enough to be of concern to the storage facilities?**

   These hazards include sewage treatment facilities, septic tanks, and absorption systems, sanitary landfills, fuel tanks, industrial pollutant discharges, livestock, surface runoff and poor drainage. Identification of the hazards in relation to the location of the storage tanks or reservoir is important in determining the potential threat to public health. These hazards could contribute to pollutant seepage into the storage tank. Surface runoff and underground drainage should be away from the structure.

2. **Are there any physical features on or around the site that could damage the tank?**

   Trees or other natural features around the tank should not be situated near enough to damage the tank if they fall or are moved by forces of nature.

3. **Is the site well maintained?**

   A well-maintained site, with proper grading to facilitate drainage and free of debris and other potential contaminants, prevents damage to the tank.

3.4.3 Capacity of Storage Tanks

Storage tank capacities should be adequate to meet the water demands of the system, should meet applicable state requirements and industry standards, and be consistent with accepted engineering practice. For example, the total capacity of both ground and elevated storage tanks could be based on a recommended level of 200 gallons per connection. For elevated storage tanks alone, a recommended capacity of 100 gallons per connection is often used. For systems using hydropneumatic tanks instead of elevated tanks, recommended capacities are 20 gallons per connection with ground storage and 50 gallons per connection without ground storage. Capacities for pumps and pumping equipment associated with storage tanks are discussed in Section 3.5.

Suggested assessment criteria for the capacity of storage tanks include:

1. **Is the storage capacity adequate?**

It is important to determine whether the type of storage facilities provided are sufficient for the distribution system. If a large system uses a hydropneumatic tank, for example, the storage may not be sufficient for the pressure head requirements of the distribution system. Water facilities should have at least one day of reserve capacity to allow for power outages and fire control. Facilities without backup storage may lose system pressure in the event of a power surge.

2. **In case of elevated storage tanks, are tanks properly sized and elevated to assure adequate pressures throughout the distribution system?**

   The water tank should be properly sized and elevated to produce pressures of at least 35 psi at the lowest operating level of the tank. Operating pressures in the distribution system should not be allowed to exceed 100 psi.

3.4.4 Design of Storage Tanks

The inspector should examine the design criteria of the storage tanks to assess their potential to meet the water demands of the distribution system and retain structural integrity. Design and construction standards need to be appropriate for the intended use of a storage tank.

3.4.4.1 Storage Tank Components

The series of standards used to design tanks with all the necessary components identified is the AWWA D-100 series. The construction material for the tank should also be examined for structural integrity as well as for any sanitary hazards. For example, opportunistic pathogens, such as Klebsiella can grow to high levels in wooden storage tanks. Figure 3-18 provides a schematic of the various components of a storage tank. The following is a listing of the minimum criteria for a treated water storage tank, whether it is a ground or elevated storage tank:

- Roof sloped to prevent standing water;
- No leakage through the roof;
- A lockable access hatch on the roof, with a raised curb;
- Vent on the roof with openings that face downward, with a fine corrosion resistant screen;
- Water level measurement device;
- Overflow that terminates above ground with a hinged and weighted flap on the end;
- Inlet and outlet piping located to ensure proper circulation of water;
- Drain to remove accumulated silt from the bottom of the tank;
- Access openings on the side (at least 2);

- Access ladder with proper safety equipment;
- Valves on inlet and outlet for isolation;
- Bypass around the tank for maintenance;
- Control system to maintain water level in tank; and
- Alarm system for high/low water levels.

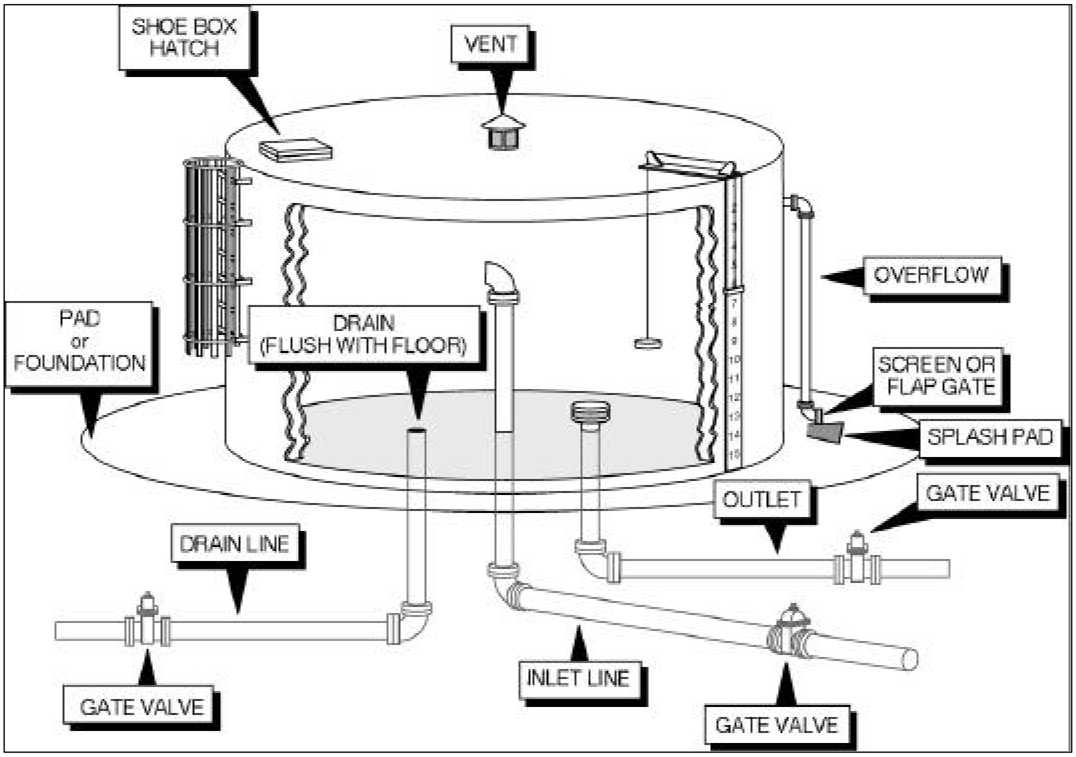

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Figure 3-18. Components of a Storage Tank

Suggested assessment criteria for the minimum design components for storage tanks include:

1. **Does the tank have all the minimum components listed above? Are these components in good condition?**

   The inspection items listed above are important for maintaining the structural integrity of the tank, thereby minimizing contamination of the water.

3.4.4.2 Hydropneumatic Tank Components

Hydropneumatic tanks are specially designed storage tanks which provide pressure maintenance for the system. Hydropneumatic tanks are not storage tanks, technically speaking, but are pressure maintenance facilities. It is important that an auxiliary power source such as a backup generator or separate power supply be provided to ensure that the hydropneumatic tank and associated service pumps continue to operate in the event that the primary power source fails. The minimum design components for this type of tank are significantly different than a ground or elevated storage tank. Figure 3-17 provides a typical hydropneumatic tank installation. Hydropneumatic tank systems can use any of several types of pressure storage tanks. Figure 3-19 depicts the various types of pressure tanks available. While hydropneumatic tanks can be either horizontal or vertical, most that are used in public water systems are horizontal.

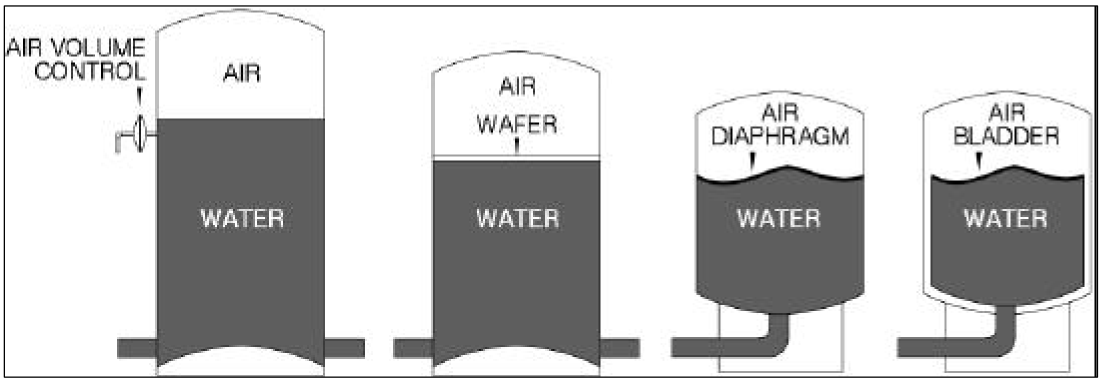


Figure 3-19. Types of Pressure Tanks

For a hydropneumatic or pressure tank, the design criteria should include the following:

- Tank is located completely above ground
- Tank meets ASME standards with a ASME name plate attached
- Access port for periodic inspections
- Pressure relief device with a pressure gauge
- Control system to maintain proper air/water ratio
- Air injection lines equipped with filters to remove contaminants from the air line
- Sight glass to determine water level for proper air/water ratio
- Slow closing valves and time delay pump controls to prevent water hammer.

Suggested assessment criteria for the minimum design components for hydropneumatic tanks include:

1. **Does the tank have all the minimum components as required? Are these components in good condition? Is the tank capacity adequate?**

The inspection items listed above are important for maintaining the structural integrity of the tank, thereby minimizing contamination of the water.

3.4.5 Painting of Storage Tanks

The inspector should assess the painting of storage tanks to determine the potential for lead to enter the water. Historically, the best type of coating for a tank included lead, because it adhered very well to the metal substrate forming a bond that was hard to break. In addition, coal tar coatings were applied to the inside of many older elevated storage tanks. Currently, lead may not be used in any paint system that comes in contact with potable water. The paint used on storage tanks must be approved for potable water use and must be certified to conform with ANSI/NSF Standard 61 and applied by an accredited organization. Paint coating systems are important for assuring that the interior and exterior surfaces of the tank, as well as the tank appurtenances, are adequately protected from corrosion and structural damage.

Suggested assessment criteria for the painting of storage tanks include:

1. **When was the last time the tank was repainted? What type of paint was used? Was it a lead-based paint? Was the paint in conformance with ANSI/NSF Standard 61 for potable water use?**

   Paint used for surfaces in contact with potable water should be approved under ANSI/NSF standards. Lead-based paints are prohibited for use with potable water and other unauthorized paints or coatings can create water quality problems and cause organic or inorganic contamination of the stored water that might cause adverse health effects (EPA, 1989a).

2. **Is the paint in good condition?**

   Chipping, cracking, or fading of the paint coating on the tank surfaces and appurtenances indicates the potential for contamination, corrosion, and structural damage.

3.4.6 Cleaning and Maintenance of Tanks

The inspector should assess the frequency of general cleaning and inspection of the tanks. On a daily basis, the operator should be checking the general condition and operating level of the tank. On a weekly basis, the sanitary and structural condition of the basic tank components should be checked in more detail. (In the case of elevated storage tanks, some inspection activities may have to be done as part of the annual inspection.) On an annual basis, the entire tank and all appurtenances should be thoroughly inspected by qualified personnel and the results documented in a written report.

Suggested assessment criteria for the cleaning and maintenance of tanks include:

1. **Does the tank appear structurally sound?**

   The inspector should look for signs of cracks, leaks, rust, corrosion, failure in steel supports, and other indicators that the tank has not been properly maintained and may not be structurally sound.

2. **How often are inspection and cleaning performed? How often does the water system have its storage tanks inspected by a qualified contractor?**

   The operator should inspect tanks on a daily basis. As noted above, basic tank components should be checked in more detail each week, and the entire tank and appurtenances checked annually. In addition to general inspections, a thorough structural and coating inspection should be done by qualified personnel at least every five years (UFTREEO Center, 1998).

3. **How is the water supply continued when the storage tank is out of service for maintenance?**

   The inspector should ensure that the system has a plan for maintaining the distribution system pressure when the tank needs to be removed for maintenance.

4. **When interior maintenance has been performed, are storage tanks disinfected before being used?**

   Storage tanks should be disinfected to ensure water quality before being returned to service.

3.4.7 Site Security

The inspector should assess the site security of the water system to determine the potential for intruder access. Any potable water storage tank should be enclosed by an intruder-resistant fence with lockable access gates. In addition, all access hatches should be locked. To be intruder-resistant, the Texas Natural Resource Conservation Commission recommends that the fence around the storage tank be at least six feet tall with three strands of barbed wire extending outward at a 45° angle, and be constructed of wood, masonry, concrete, or metal.

Suggested assessment criteria for site security include:

1. **Is the fence surrounding the tank site intruder-resistant?**

   Site security should be part of the operational monitoring program of the plant. The inspector should determine if the tank or plant fence is in good condition, specifically that the fence is structurally sound and not sagging. There should not be any gaps between the ground and the bottom of the fence and the fence gates should be securely locked when the plant is not attended. The inspector should note any evidence of unauthorized access and vandalism, which tend to be a more common problem at elevated storage tank sites.

2. **Are access hatches locked?**

   Hatches should have a watertight cover and be locked with a sturdy device that cannot be easily clipped or opened.

3.4.8 Priority Criteria

The following criteria of the finished water storage element are considered high priority based on their potential for impacting public health:

- **Capacity of Storage Tanks –** The storage facilities should be adequately sized to meet minimum acceptable capacity requirements and the maximum daily demand of the system (Section 3.4.3).
- **Design of Storage Tanks –** The proper components should be provided for storage facilities to allow for proper operation (Section 3.4.4).
- **Cleaning and Maintenance of Storage Tanks –** Storage tanks should be maintained for storage facilities to allow for proper operation (Section 3.4.6).
- **Site Security –** The facilities should be protected from vandalism to protect public health (Section 3.4.7).

3.5 Pumps/Pump Facilities and Controls

In a water system, there are many applications that require a pump(s) to move a fluid (water, chemical, etc.) from one point to another. In addition to transporting water through the system, pump applications include chemical feed systems, sludge removal, air compression and sampling (UFTREEO Center, 1998). Normally, there are several types of pumps that could be used for an application. However, there are usually only one or two types of pumps that will be the best fit for the intended use. In this section, the prime movers of water will be discussed. There are numerous applications for other types of pumps in other sections of this document.

The objectives of surveying the pumps/pump facilities and controls are to:

- Review the design, uses, and major components of water supply pumps;
- Evaluate the operation and maintenance as well as safety practices to determine that water supply pumping facilities are reliable; and

- Recognize any sanitary risks attributable to water supply pumping facilities (UFTREEO Center, 1998).

3.5.1 Types of Pumps

Before going into the field, the inspector should obtain the information available on all the pumping facilities for the water system from the state's files, including the last sanitary survey. The information on pumping facilities should include the type, location, age and installation date, and design conditions of the system's pump(s), pumping facilities, and controls.

In addition, the inspector should review the regulatory requirements for pumps, if any, to assist in the evaluation of the pumping facilities. The regulatory requirements could include, but not necessarily be limited to, state rules and regulations, ANSI/NSF Standards 60 and 61, as well as appropriate guidance manuals.

Upon arriving at the facility, the inspector should review the available data on pumps with system personnel to determine if the information is current. If there have been any changes, the inspector should obtain an updated listing of the pumps used within the system, so that they may be all inspected during the survey. For most systems, the inspector will either have a list of pumps or pump data from a previous sanitary survey or have a list supplied by the system operator. If a system does not have a pump listing, the inspector should work with the system operator to develop a new listing so that all pumps may be inspected during the survey.

There are three types of pumps used in a water treatment plant facility. They are: positive displacement, centrifugal, and ejector.

Positive displacement pumps deliver water at a constant rate regardless of the pressure it must overcome (USEPA 1991a). Typical positive displacement pumps that can be found in a treatment plant are:

- **Helical or Spiral Rotor Pump –** This pump consists of a shaft with a spiral surface which rotates in a rubber sleeve. Water is trapped between the shaft and the sleeve and is forced to the upper end of the sleeve as the shaft turns.
- **Regenerative Turbine Pump –** This pump contains an impeller or a rotating wheel with fins or little buckets on its outer edge. The rotating wheel is inside a stationary enclosure (cast). As the wheel rotates at a high speed, it forces water through the pump cast (also called raceway) at a pressure that is several times that which can be generated by centrifugal mechanisms (USEPA, 1991a).
- **Reciprocating Pump –** This pump consists of a piston moving back and forth in a cylinder. As the cylinder is driven back and water is driven into the cylinder, the intake valve closes and forces the water through the check valve. As the cylinder is driven forward, the water is discharged through a discharge pipe while the check valve is closed (USEPA,1991a).

- **Positive Displacement Pump –** This pump is typically used for online chemical application (i.e., application of chemicals into pressurized water line).

Centrifugal pumps are used when an even flow rate is needed to meet the demands placed on it. The operating curve for a centrifugal pump shows that the pumping rate varies with the discharge pressure of the water at discharge from the pump (i.e., as the discharge pressure increases, the rate of pumping decreases).

With a rotating impeller (i.e., rotor blade) driven by a power source, such as a motor, a centrifugal pump increases the velocity of the water and discharges it into the pump casing. In the pump casing, the velocity of the water is converted to pressure. Typically, a centrifugal pump has only one impeller, and it is called a single-stage pump. If more pressure is needed, multiple impellers or multi-stages are used to generate the necessary discharge pressure at the pump. Multiple impellers only increase the discharge pressure, not the pumping rate (UFTREEO Center, 1998).

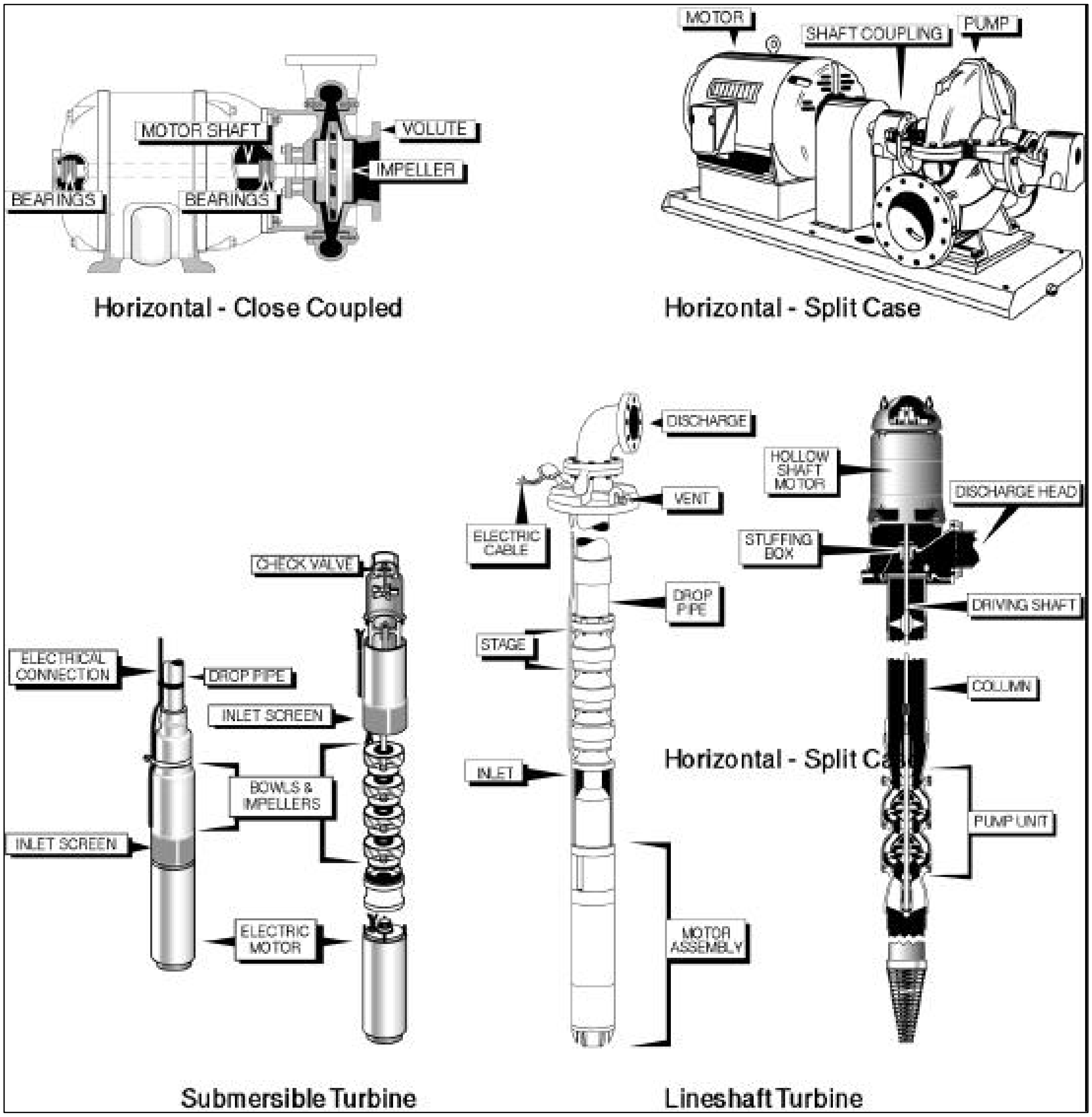
A centrifugal pump cannot create a negative pressure at the suction inlet to pull water into the pump, like a self-priming pump. Therefore, the pressure at the impeller must be positive (i.e., water level is higher than the impeller) in order for the pump to operate.

There are four types of centrifugal pumps that are normally used in a water system for the many pumping applications: submersible, vertical (lineshaft) turbine, split case, and end suction (close coupled). Figure 3-20 shows some of the types as well as the basic components of a centrifugal pump. The most common application of each pump is provided in Table 3-4.

The four types of centrifugal pumps are described below:

- **Vertical Turbine Pump –** This is a multistage centrifugal pump. The pumping unit must be located below the drawdown level of the water source. A vertical shaft connects the pumping assembly to a drive mechanism located above the pumping assembly. The discharge casing, pump housing, and inlet screen are suspended from the pump base at ground surface.
- **Submersible Pump –** This is a centrifugal pump driven by a closely coupled electric motor constructed for underwater operation as a single unit.
- **End Suction and Split Case Pumps –** These are single-stage pumps. The end suction pump is a vertically split case pump, while the split case pump is horizontally split. The advantage of the split case pump over the end suction pump is that it is easier to open and repair. The advantage of the end suction pump is its lower cost.
- **Ejector Pump –** This is a type of vacuum pump. In this pump, gas is removed from a container (e.g., chlorine cylinder) by passing water at a high velocity through a connecting chamber. The high-velocity water creates a vacuum that draws the chlorine into the water stream. This type of a pump is similar to a jet pump; however, in a jet pump, gas (air in water applications) forces water

through a venturi into an area of reduced pressure where a centrifugal pump sucks the water and jets it into the distribution system (USEPA, 1991a).



(Source: UFTREEO, 1998; Used with permission)

Figure 3-20. Common Centrifugal Pump Types and Components

Table 3-4. Applications for Centrifugal Pumps

Application	Type of Pump
Well Pump	Submersible or vertical turbine
Raw Water Pump	Submersible or vertical turbine
Backwash Pump	Vertical turbine or split case
Transfer Pump	Vertical turbine, end suction, or split case
Finished Water Pump	Vertical turbine, end suction, or split case
Booster Pump	Split case or end suction
Sludge Pump	End suction
Backwash Recycle Pump	End suction

Suggested assessment criteria for the types of pumps include:

1. **What type of pumps are provided for the system?**

   The inspector should check the types of pumps used by the water system to ensure they are appropriate for the intended use. Typically, the pump selection is reviewed by the primacy agency at the time of installation; however, the inspector should confirm that the pump has not been replaced with another type of pump without approval from the primacy agency.

2. **Does the information in the files reflect the actual type, number, and capacity of pumps in the system? If not, is there a potential problem?**

   If the inspector finds that the actual type, number or capacity of the pumps is different from the design which was approved by the primacy agency, then the inspector should note the actual configuration for the sanitary survey report. The operators should be questioned as to why and when the modification to the pumps took place, and advised to submit the revised plan to the primacy agency for their review, if necessary.

3.5.2 Capacity of Pumps

The pump capacity or size required is typically dependent on the application or purpose, as well as vulnerability of the pump(s). Typically, state rules will specify the sizing criteria for each critical application. For example, Table 3-5 provides the sizing criteria for different pump applications used by the Texas Natural Resource Conservation Commission (TNRCC) for many water systems. These criteria are in general agreement with standard engineering practice.

Table 3-5. Pump Sizing Criteria

Application	Sizing Criteria
Raw Water Pump	0.6 gpm per connection with the largest pump out of service
Backwash Pump	Dependent on filter size
Transfer Pump	0.6 gpm per connection with the largest pump out of service
Finished Water Pump	Two or more pumps that have a capacity of 2.0 gpm per connection, or that have a total capacity of at least 1,000 gpm and the ability to meet peak hourly demands with the largest pump out of service, whichever is less
Booster Pump	Two or more pumps that have a capacity of 2.0 gpm per connection, or that have a total capacity of at least 1,000 gpm and the ability to meet peak hourly demands with the largest pump out of service, whichever is less

(Source: TNRCC, 1997)

When designing or checking a pumping facility, the maintenance (preventative or emergency) of the pumps should be anticipated. For instance, a system has two raw water pumps, and each is sized to pump one-half the capacity of the water treatment facility. If one pump has to be taken out of service for repairs, then the supply for this system is reduced substantially. During the summer, when the peak demand typically occurs, this system may not be able to meet that demand for a time, because of the repairs to the pump. During this time, the system may experience pressure problems in the distribution system due to an inadequate supply, which could lead to greater problems, such as backsiphonage. The number of pumps for any application is an important consideration that cannot be overlooked. In general, there should be at least two pumps (usually more) for any critical pumping application to allow for maintenance.

With two or more pumps, how should the capacity of a pump or pumping facility be determined? The firm capacity of any pumping facility should be determined with the largest pump out of service to ensure that adequate capacity is available to meet all expected demand/supply conditions. The firm capacity of a pumping facility is the capacity that is available at any time assuming any one pump is out of service for maintenance or repairs. The total capacity of a pumping facility, then is the sum of the capacities of all associated pumps and is larger than firm capacity.

Suggested assessment criteria for the capacity of pumps include:

1. **What are the capacities of the pumps? How many pumps are located at each facility?**

   The capacity of a pump is sometimes listed on the motor plate along with the horsepower, motor speed and other pertinent information. The inspector should note the capacity or other information provided on each pump and compare this information to the approved design for the pump station. The actual capacity of the pump may be less than the rated capacity as a result of wear or an increase in the operating head. Actual pump capacity can be measured if an accurate flow metering device is installed on the pump discharge line.

2. **What is the firm capacity and the total capacity of each pumping facility?**

   The inspector should confirm that the firm capacity of the pumping facility, or the capacity of the facility with its largest pump out of service is consistent with the minimum capacity approved by the primacy agency.

3. **Are the pumps compliant with state rules?**

   If the inspector finds that the actual type, number or capacity of the pumps is different from the design which was approved by the primacy agency, then the inspector should note the actual configuration for the sanitary survey report. The operators should be questioned as to why and when the modification to the pumps took place, and advised to submit the revised plan to the primacy agency for their review, if necessary.

3.5.3 Condition of Pumps

In addition to confirming that the pump facility complies with the approved design, the inspector should also evaluate the condition of each of the pumps in the facility to ensure that it is operating as designed. It is extremely important that all pumps in a system be operational to ensure the continued supply of drinking water to the customers. The pumps should not be vibrating excessively, making loud noise, be overheating or creating odors. Any of these may be a sign that the pump requires repairs or maintenance.

The inspector should review available maintenance records for the pumps. The pumps should be regularly lubricated and maintained in accordance with the manufacturers recommendations. Any lubricants which may contact the water should be ANSI/NSF approved.

The inspector should confirm that each pump has working check valves, and pressure gauges on the discharge side of the pump. There should also be working isolation valves on the intake and discharge sides of the pump to permit taking the pump out of service for repairs or maintenance (UFTREEO Center, 1998).

Suggested assessment criteria for the condition of pumps include:

1. **Are all the pumps operational? If not then when does the system intend to repair or replace the pump?**

   A system should maintain the capacity to provide drinking water to its customers and should have the reserve capacity available for pump malfunctions. Systems should take steps necessary to repair or replace pumps which are not operational as quickly as possible.

2. **Are the pumps vibrating excessively, overheated, making excessive noise, or producing an odor?**

Inspectors should briefly examine each pump to see if there are obvious signs of the need for maintenance or repair. Appropriate safety precautions should be taken around open, spinning shafts.

3. **Are pumps regularly maintained and lubricated in accordance with the manufacturers recommendations?**

   The inspector should ask to see records which show the dates the pumps were lubricated and maintained. The inspector should also ensure that all lubricants which come into contact with the potable water are NSF/ANSI approved.

3.5.4 Pumping Station

Most pumping applications rely on a pumping station that includes a pump(s), a structure to house or support the pump, piping – suction and discharge, lighting, ventilation, an electrical center and control panel for the pump(s) and lighting, and appurtenances. The inspector should determine if there are any sanitary risks by thorough inspection of all pumping facilities. Appurtenances of a typical pumping station are shown in Figure 3-21.

3.5.4.1 Location of Pumping Facilities

The structure for a pumping station can be as simple as a slab that supports the pump(s) to a building that houses the pump(s) and all appurtenances. However simple the structure, the location of the pump station is probably one of the most important factors to evaluate for sanitary risks. If the pump station is located in an area that is subject to flooding or electrical outage, then the pump station will be out of service for a time. If the pump station is down for a time, the system may experience problems with providing an adequate supply of treated water or pressure in the distribution system.

One of the first things an inspector should do upon entering the station is to look for evidence of past flooding. If there is no evidence, the inspector should ask system personnel if there has been any flooding in the past. The pump station should be located so that the finished floor elevation is at least one foot higher than the known 100-year flood elevation for the area. If the floor elevation is lower than the flood elevation, then berms or dikes should be constructed around the station to prevent flooding.

Since most pumping facilities require electricity for power, the electrical service reliability should be verified. If the station is located in a remote area with only one incoming service, a documented plan should be available for keeping the pump station in operation during electrical outages. The plan could include the use of an emergency generator or oversizing of storage to accommodate the power outage at the station.

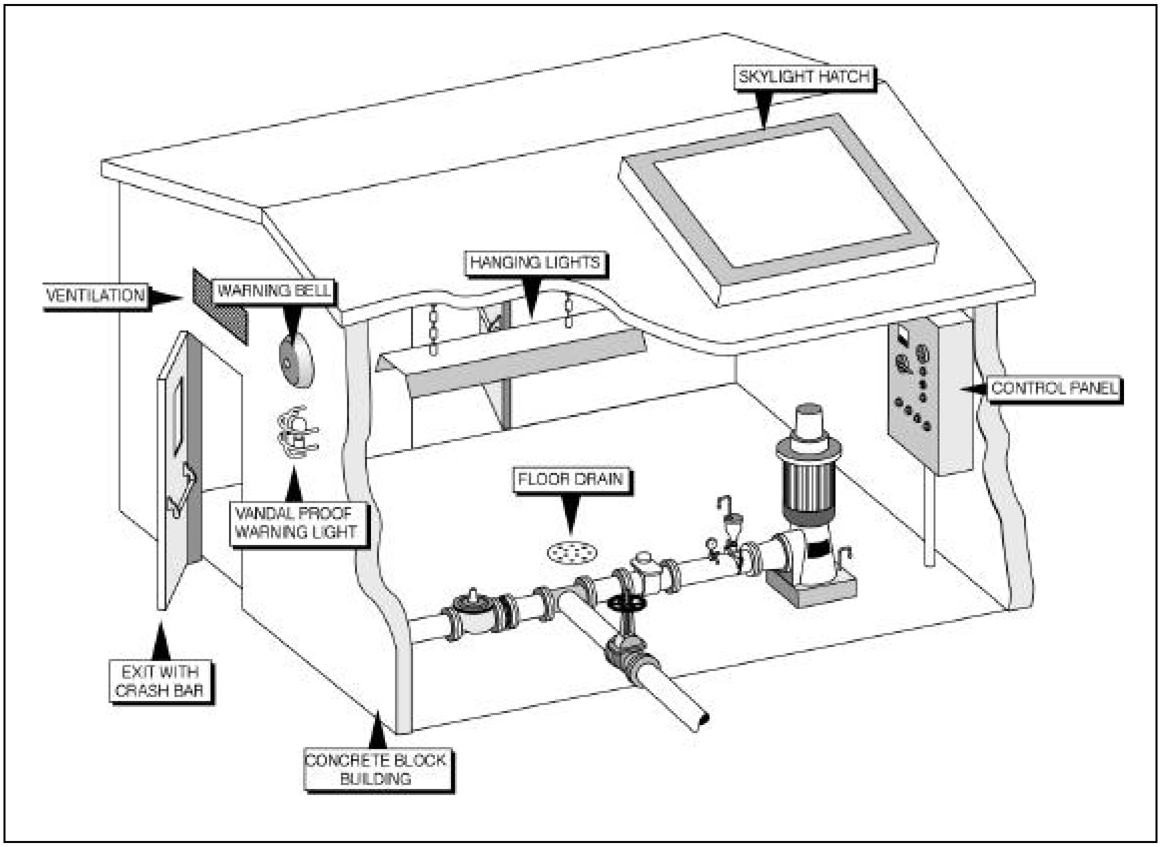


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Figure 3-21. Typical Pumping Station

The purpose and vulnerability of the pumping facility location should be evaluated to determine the measures needed to maintain its reliability.

Suggested assessment criteria for pumping station/location include:

1. **Is the location subject to flooding? If so, what provisions are provided to accommodate the flooding?**

   If the pump station is adjacent to a stream, river or other water body, the inspector should check for evidence of flooding such as stains on the floors or walls. Typically, a pump station is located above the 100-year flood plain, however, if the station is susceptible to flooding, the inspector should make certain that electrical controls and motors are high enough to avoid flood waters.

2. **Is the location subject to electrical outages? If so, what provisions are provided to accommodate the electrical outage?**

The inspector should ask the operators how often there is a power outage in the area serving the pump station. If the operators indicate there are frequent outages, or if there is little or no elevated storage within the system the inspector should ask if the system has emergency standby power.

3.5.4.2 Pumping Station Structure

The type of structure provided for a pumping station is somewhat dependent on the site-specific requirements, but there are general similarities for all facilities. When visiting the site, the inspector should assess the security and maintenance of the structure as well as the pumps and piping.

The station should be protected from unauthorized entry and vandalism by having the doors and windows locked when unattended. The electrical service to the structure should be checked to see that unauthorized persons cannot either cut off power to the station or access outside panels, switches, or valves. All drain and vent openings should be screened to prevent the entry of animals and insects.

The structure should be sized to provide adequate room to maintain the equipment within the structure. Certain building codes will specify some maintenance area requirements; for example, the electrical code may require at least a 3-foot clearance in front of all electrical panels. However, most of the area needed for maintenance is not restricted by building codes and will therefore vary within a particular structure. In general, the size of the structure should be such that at least 3 to 4 feet (or more) of area is provided around all major pieces of equipment and piping to allow for ease of maintenance.

Suggested assessment criteria for pumping station/structure include:

1. **Is the structure secure from unauthorized entry and vandalism? Are all drains and vents screened to prevent the entry of animals?**

   A system should take steps to prevent unauthorized entry of humans and animals to the pump station. The pump station should be located within a secure area such as a locked building or fenced area.

3.5.4.3 Pumping Station Appurtenances

The pump station appurtenances that should be evaluated include lighting, heating, ventilation, interior drainage, signs/labeling, and controls. The following is a listing of the appurtenances and reason to be included in this evaluation:

- Lighting – should be adequate (both inside and outside) for ease of maintenance and security;
- Heating – systems should be adequate to prevent pipes from freezing;
- Ventilation – should be adequate to maintain acceptable temperatures and air flow for personnel safety and proper operation of equipment;
- Interior drainage – floor drains should be provided to eliminate standing water on the floor from leaks that may pose a safety hazard;

- Signs/labeling – proper signs and tagging of equipment improve the ability of system personnel to maintain the equipment; and
- Controls – should be simple and easy to maintain. In addition, all instruments and wiring should be labeled and tagged.

Suggested assessment criteria for pumping station/appurtenances include:

1. **Is the lighting adequate for security and maintenance?**

   The inspector should check the lighting inside the pump station to ensure that the operators have sufficient light to operate the pumps and outside the facility to deter vandalism.

2. **Is the area subject to freezing? Can the piping in the station freeze? If so, is heating provided?**

   The inspector should ensure that the pump stations located in frost prone areas have heaters or other means to prevent freezing of the water in the pipes or pumps.

3. **Is the station equipped with ventilation? If so, does it work and is it adequate to maintain a reasonable temperature?**

   The inspector should ensure that the pump station has adequate ventilation (louvers, fans, etc.) to maintain acceptable temperature and air flow for personnel safety and proper operation of equipment.

4. **Is there a floor drain to collect all leaks? Is the floor drain operable?**

   There should be no standing water in the pump station. The floor should be sloped to an operating drain.

5. **Are the pumps, valving, and other major equipment items tagged? If not, how does the system number the equipment for maintenance purposes?**

   The system should have a system to identify the equipment for maintenance purposes. The inspector should see if the pumps and valves in the station are tagged to identify them, and if the tags correspond to the maintenance records.

3.5.5 Priority Criteria

The following criteria related to the pumps/pump facilities and controls element of the sanitary survey are considered high priority based on their potential for impacting public health:

- **Capacity of Pumps –** The capability of the facilities must exceed the potential demands so that even when one pump is out of service, adequate capacity is still available to meet all expected demand/supply conditions. Otherwise, the system may experience pressure problems in the distribution system that could lead to greater problems like back-siphonage (Section 3.5.3).

- **Pump Station Location –** The location of the facilities can impact the operation of the water system. For instance, if the facilities are located in a flood plain, then the facilities will be flooded on a regular basis and be out of service for a period (Section 3.5.4.1).

3.6 Monitoring/Reporting/Data Verification

An important part of any industry that produces a product for the consumer is quality control. Quality control is a defined method of checking the product to ensure the consumer that it meets or exceeds regulatory requirements as well as their minimum expectations. For the water industry, quality control consists of monitoring the product, drinking water, from the source to the tap, with in-house as well as outside laboratory testing for confirmation. A monitoring plan provides the operator with data to assist in identifying potential problems and adjusting treatment processes accordingly. It is important that all water systems create a water quality monitoring plan and document monitoring results. For most water systems, regulatory requirements, either state or federal, dictate the minimum scope of a water quality monitoring plan.

The objectives of surveying the water quality monitoring/reporting/data verification are to:

- Review the water quality monitoring plan of the public water system for conformance with regulatory requirements;
- Verify that the water quality monitoring plan is being followed by checking test results;
- Verify that all in-house testing as well as equipment and reagents being used conform to accepted test procedures;
- Verify the data submitted to the regulatory agency; and
- Evaluate the procedures an operator follows to identify any problems with the process, determine the changes needed to correct the problem, and how adjustments to the process are approved and performed as needed.

3.6.1 Regulatory Records Review

Before the inspector goes into the field, the data available in the regulatory agency's files concerning the subject water system should be reviewed carefully. Reviewing the files of the subject system will indicate to the inspector how well the system is meeting its responsibilities. The inspector should look for the following information:

- Violations of MCLs, treatment techniques, monitoring, or reporting, as well as a compliance plan to correct any violations;
- Regulatory agency orders and compliance plans that apply to the system;

- Regulatory agency approval of mandated sampling plans, such as for TCR and disinfection by-products (e.g., THMs);
- Regulatory approval of any changes to the system since the last sanitary survey; and
- Reported water quality monitoring data where required (UFTREEO Center, 1998).

If there are no violations or orders, and the required monitoring data are available, it is an indication that the water system has accepted its assigned responsibilities and is trying to complete its duties accordingly. In general, the inspector will only have to verify that all sampling and monitoring plans are up-to-date based on the latest regulatory changes, if any. In addition, the inspector will verify that the data reported to the agency are accurate based on the records kept by the system. Self-monitoring data, monthly operating reports, and daily logs should be reviewed to determine if data are of questionable quality and to evaluate the potential for data falsification.

If there are no violations or orders, but the required monitoring data are not available, it may be difficult to determine if the water system is in compliance with all requirements. Laboratory results for bacteriological, chemical, and radiological monitoring must be kept for specific time periods. The inspector should review the records to determine if they are kept for the required time period in accordance with each regulation.

If there are violations or orders, and all the required monitoring data are not available, it is a general indication of possible troubles at the public water system. The inspector should carefully review the compliance plans required by the violations or orders, and verify that the plan is being followed by the system. If all the required monitoring data are not available, the inspector should determine the reason. Sometimes the cause may be simple, such as the report was being mailed to a wrong address. However, if the problem is persistent, then the inspector should develop a plan with the system to remedy the problem.

Suggested assessment criteria for data collection include:

1. **Are there any violations or orders for the subject system? If so, is there a compliance plan? If so, what documentation is there to verify compliance?**

   If the treatment plant has submitted a compliance plan, the inspector should take copies of the plan to verify that the compliance plan is being properly implemented.

2. **Have the required sampling plans been submitted and approved? If no, what action is being taken to prepare and submit the plans?**

   Every water system has to submit a sampling plan to be approved by the state. Such a plan should include the number of samples for each parameter, where samples are taken, at what time and frequency, who is the person in charge of taking the samples, how they are going to be handled, and who is going to analyze them.

3. **Are all the required monitoring data submitted? If so, do the data appear reasonable? Do the data reported match field log books?**

   If a plant has complete, up-to-date, reasonable monitoring data, this is an indication that it is well managed. However, it is still necessary to verify field log books with submitted reports to rule out any human error in copying the data.

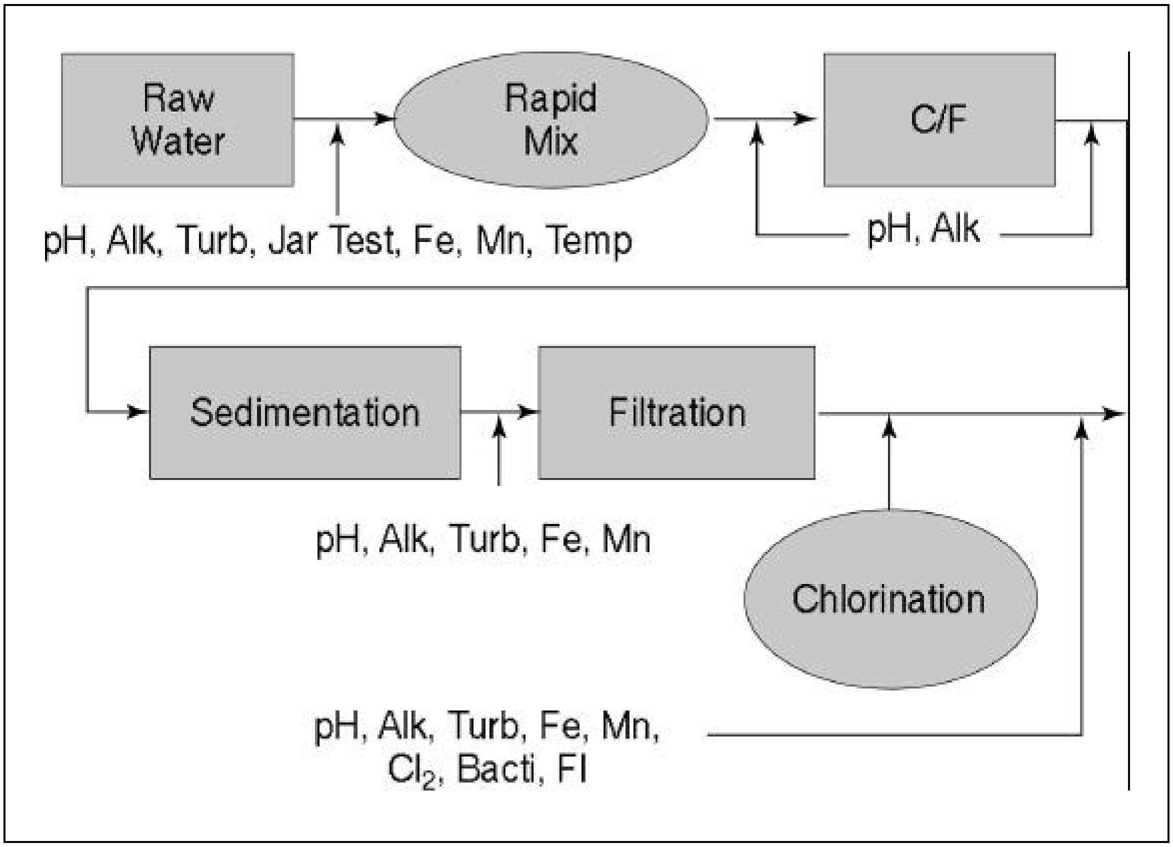
3.6.2 Water Quality Monitoring Plans

For all water systems, there are two levels of water quality monitoring plans: (1) the water quality monitoring plan(s) that the system institutes for quality control purposes (non-regulatory monitoring); and (2) the water quality monitoring plans required by regulation (e.g., disinfectant residual and turbidity). Typically, the water quality monitoring plan for quality control is carried out in-house by the system operator. For the monitoring plans required by regulation, samples are collected by system personnel in accordance with the approved plan and are then often sent to a certified laboratory for analysis. However, for some regulatory monitoring such as turbidity tests, samples are analyzed at the treatment plant rather than an off-site laboratory. The water system needs to have a properly equipped laboratory to perform these tests, as well as non-regulatory quality control tests, at the treatment plant.

3.6.2.1 Non-Regulatory Monitoring Plans

The in-house plan provides the operator with a means of monitoring and evaluating the operation of the system, normally the treatment facilities. This plan allows the operator to control processes on a continuous basis and make adjustments in treatment (e.g., chemical feed rates) as needed. Since this plan will be system-specific, the inspector will have to check each plan individually. The plan should include the location, number, and frequency of various tests that are needed to verify the process. A typical water quality monitoring plan layout for a surface water treatment facility is shown in Figure 3-22. When reviewing the plan, the inspector should assess whether the location and frequency are adequate to identify problems that may occur. Monitoring needs to provide data that can help the operator(s) quickly identify problems so that adjustments can be made in a timely manner. In addition, the timing and methods for monitoring used should be in accordance with accepted test methods. The inspector should ask the operator(s) if monitoring results are used to make adjustments in the treatment process. So, the inspector should ask the operator(s) to describe how the data are used.

All test methods require that the equipment used is calibrated on a regular basis. This regular calibration ensures that the results obtained are reasonable and accurate. Laboratory test equipment manufacturers will provide the calibration procedures as well as calibration standards that should be followed for each piece of equipment. As part of checking the methods and procedures used for in-house monitoring, the inspector should check the procedure for and the frequency of calibration. In addition, the calibration standards should be checked to determine whether or not the standard is usable based on the date of preparation. In some cases, calibration procedures and frequencies may be dictated by the state primary agency.



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(Source: UFTREEO, 1998; Used with permission)

Figure 3-22. Typical Water Quality Monitoring Plan Layout for a Surface Water Treatment Facility

Suggested assessment criteria for in-house water quality control monitoring plan include:

1. **Does the plan appear to be adequate for this system? If not, what changes should be made and why?**

   The inspector should compare the plant's water quality monitoring plan with the treatment processes being used. Plants with poor raw water quality tend to have extensive water quality parameter testing between the intake and the clear well. As the number of chemicals and processes increase, the inspector should expect an increase in the number of testing sites and in the number of parameters tested.

2. **Are proper testing procedures being followed?**

   The inspector should compare the testing methods being used in the treatment plant with those approved by EPA.

3. **Are the equipment and facilities for monitoring adequate? Are the reagents out of date? How are test results logged? Where are past logs stored?**

   Old testing equipment might be suitable for measuring contaminants and water quality parameters. However, the inspector should verify when the laboratory was certified and whether old equipment was used to run the tests. Laboratory certification may not be required to perform specific monitoring tests. In these cases, the equipment that is being used must be evaluated to ensure that it is in good condition, is properly calibrated, and provides the necessary degree of accuracy.

4. **Does the operator use test results to identify treatment adjustments?**

   The inspector should verify from the operator how treatment is adjusted based on water quality tests. Adjustment may include the addition of an oxidant, increase or decrease in chemical dose, backwashing filters, and increasing or decreasing underdrain flow.

5. **Is there a procedure, and what is the frequency, for calibrating monitoring equipment, both laboratory and on-line? Is it in compliance with manufacturer's recommendations, and is the procedure adequate? Are the calibration standards acceptable?**

   Cleaning and calibrating monitoring equipment is vital to good water quality control. The inspector should verify that the calibration is done in accordance with the manufacturer's recommendation. The inspector should look for variances between his field test kit (for example pH) and those recorded by on-line probes. To obtain meaningful results from this comparison, the inspector should ensure that the field testing equipment that is used is properly maintained and calibrated.

3.6.2.2 Regulatory Monitoring Plans

With the enactment of the recent amendments to the SDWA, various monitoring plans have been required of a public water system to verify that the consumer is receiving safe drinking water. The monitoring plans that are required and the associated rules are as follows:

- Volatile Organic Contaminant monitoring (Phase I Rule);
- Synthetic Organic Contaminant (regulated and unregulated)/Inorganic Contaminant monitoring (Phase II/V Rule);
- Coliform monitoring plan (TCR);

- Lead and copper monitoring plan (Lead and Copper Rule);
- Turbidity and disinfection monitoring plan (SWTR); and
- Disinfection and filter profiles, if necessary (Proposed IESWTR).

The inspector should verify that each system has an approved plan, and that the plan is being followed. Note that for all the analyses required by these plans except the disinfectant residual and turbidity analyses, the analyses must be performed by a certified laboratory.

Suggested assessment criteria for regulatory monitoring plans include:

1. **Are all required monitoring plans approved by the state or other primacy agency and are these monitoring plans being followed? If not, why?**

   All water quality monitoring plans have to be approved by the state. Systems without an approved plan should work closely with the state on developing such a plan.

2. **Is a certified laboratory being used for all testing?**

   All regulatory water quality tests except disinfectant residual and turbidity have to be conducted by a laboratory certified for testing specific contaminants. Multiple laboratories may be used to conduct all necessary tests. The inspector should verify the certification of the laboratory(ies) being used by the treatment plant.

3.6.3 Priority Criteria

The following criteria related to the monitoring/reporting/data verification element of the sanitary survey are considered high priority based on their potential for impacting public health:

- **Non-Regulatory Monitoring Plans –** This plan is the quality control of the final product, which is the drinking water. If no quality control is completed, then the quality of the water is not known (Section 3.6.2.1).
- **Regulatory Monitoring Plans –** The regulations require this monitoring plan because it addresses parameters that are critical to public health (Section 3.6.2.2).

3.7 Water System Management/Operation

Management and/or administration is a major factor that affects the performance of a water system. Management provides the direction, funding, and support that is needed for a public water system to continually supply safe drinking water. For instance, if management does not understand the requirements to produce and provide the quality of drinking water demanded by the consumer, policies may be implemented that hinder the performance of the system and its ability to provide what the consumer wants. Therefore, management and staff need to work together to create an environment that facilitates meeting the goal of providing the best possible quality of drinking water to the consumer.

The objectives of surveying the water system management/operation are to:

- Review the water quality goals and evaluate any plan(s) the system has to either accomplish or maintain the stated goals;
- Identify and evaluate the basic information on the system, management, staffing, operations, and maintenance;
- Review and evaluate the plan(s) for safety, emergency situations, maintenance, and security to maintain system reliability; and
- Evaluate the system's revenue and budget for drinking water to establish the long-term viability of meeting water quality goals (UFTREEO Center, 1998).

3.7.1 Administrative Records Review

While much data have been collected concerning the physical features of the system, in this section, the data needed concern the management (people) area of a public water system. If the data are not already on file with the regulatory agency, then the inspector needs to obtain the information during the survey. The information needed is as follows:

- Past sanitary survey reports (the latest one typically, but others can be helpful to see what changes have been made over time);
- Pertinent correspondence concerning compliance monitoring, plans of the system that show changes made since the last survey, sampling plans, compliance plans, and other management related issues;
- Management structure as well as people in these positions for the system;
- Budgetary information to include bond indebtedness, rate structure, and specific budgetary information pertinent to the water system; and
- Capital improvements program for the water system.

Suggested assessment criteria for data collection include:

1. **What changes have been made since the last sanitary survey in the system management, personnel, budget, etc.?**

   The inspector should note any changes that have been made in the system's management, personnel, and budget, and ask the appropriate staff about any changes that could have a detrimental affect on system performance. Changes in personnel since the last sanitary survey may mean that the inspector needs to work with different members of the system staff for this sanitary survey. The inspector needs to be sure to work with the most appropriate personnel both on the operations and management staffs so that the most complete and accurate information possible is obtained during the survey.

2. **Are the system's files up-to-date with the latest correspondence on compliance monitoring, plans of the system showing changes made since the last survey, sampling plans, compliance plans, and other management related issues?**

   The general organization, timeliness and completeness of a system's files provide the inspector with an indication of the system's approach to data management and how much its data are available for use in decision-making. The water system should have procedures and tools (e.g., paper filing system, computer databases) for managing information such as maintenance and repair records and plans, compliance monitoring plans, system maps, budgets, financial data, and operating reports. The information management system should provide for updating the information at regular intervals.

3.7.2 Water Quality Goals

Water quality goals provide a target that the public water system should strive to attain to produce the best quality product possible. The water quality goals for a system should include all parameters that have a regulatory level established, as well as other quality parameters that are deemed appropriate. For parameters with established regulatory levels, the system should set goals to achieve a higher (or at least equal to) quality of drinking water than what is required by regulations. By striving to reach a goal that is higher than required, the system will be more assured of meeting the regulatory requirements at all times. For instance, if the turbidity regulatory requirement is 0.3 NTU for finished water, setting a goal of 0.2 NTU or lower and operating the system to meet that goal will provide greater assurance that the regulatory requirement is consistently met. Some surface water treatment plants have adopted optimized performance goals associated with the highest level of protection against waterborne disease. These goals include a filtered water turbidity of less than 0.1 NTU from each individual filter.

The system should set other, non-regulatory water quality parameters, as appropriate, to help it achieve its overall goal of producing a reliable, high-quality water supply. Examples of some of these other water quality goals include the number of customer complaints for a month, threshold odor number, or flavor profile analysis.

Suggested assessment criteria for water quality goals include:

1. **Has the system established any water quality goals? If not, why?**

   Water quality goals can provide overall direction to water system management staff and operations staff. The inspector should assess whether a system's goals seem reasonable (e.g., achievable, measurable) and appropriate for the system.

2. **Should there be any other parameters included in the goals? If so, which parameters, and what level?**

   There are important considerations other than specific regulatory requirements in providing customers with a reliable, high-quality water supply. For instance, customer complaints can provide a means of determining whether a water supply not only meets regulatory requirements, but also satisfies consumers' needs (e.g., taste, color, odor).

3. **Do the operators know what the plant goals are, and why the levels were established? Do operators monitor to assess whether goals are being met and then make any appropriate process control adjustments and measure the results of the adjustments?**

   Water quality goals are of little value if they do not impact both day-to-day plant operations and long-term planning. Operators need to be aware of the system's water quality goals and understand the goals in order to make decisions about plant operations that lead to achieving the goals.

3.7.3 Water System Management

The direction of the system is controlled by the system's management through the implementation of the budget and policies. During the inspection, the knowledge and experience of these individuals concerning drinking water should be verified. As an example, if the individual at the top of the management structure has little or no experience with a water system, then the implemented budget and policies may reflect that lack of knowledge in determining how the system is operated and maintained. If the individual has the knowledge, then the water system will probably be operated and maintained differently. Therefore, the knowledge and experience that management has with water systems plays an important role in how a system is operated and maintained.

Another impact that management can have is on the morale of the personnel. A positive atmosphere is generated if the management encourages an open dialogue between all levels. This open communication allows the workers to express their opinion without fear of reprisal. Encouraging the training and advancement of personnel will also foster a positive morale. Although, there will be some expenses incurred on the part of the utility, this effort shows that management wants their employees to gain the knowledge necessary to further their careers. With the positive attitudes of personnel, the operation and maintenance of the system will probably be at a higher level. Mistrust between management and the O&M personnel will have an adverse effect, so if personnel have a negative attitude, system operation and maintenance will likely be affected.

Suggested assessment criteria for system management include:

1. **What is the management structure, and who are the individuals at the various levels? What is their experience level with water systems?**

If the water system has an organizational chart, the inspector should review the chart to gain an understanding of the system's management structure and which individuals are responsible for the different elements of system operation and management. The system needs to have a means of clearly indicating to its own staff who has the responsibility for various functions and who has the authority to make decisions and approve changes to policies, procedures, system operations, and other areas pertinent to treatment plant performance and water supply quality. Personnel in positions of responsibility and management should be experienced with and knowledgeable about drinking water systems and their operation, and have detailed knowledge about their own system and its performance and needs, as well as the regulatory requirements that apply to their system.

2. Does the water system have a planning process? Does the planning process appear to be implemented?

Water system management should be actively involved in planning for the system. Efforts should include both short-term and long-range planning horizons. The system should have a process for developing and updating plans required under applicable regulations, such as compliance monitoring, source protection, and cross-connection control, as well as other plans integral to a well-functioning water system, such as annual and long-term budgets, equipment purchases, and facility expansion.

3. Does open, effective communication occur between management and system personnel?

Open, effective communication between management and operations staff is integral to the achievement of a system's water quality goals for the production of a reliable, high-quality water supply. System personnel should have a means of adequately conveying to management the need for additional equipment and personnel and changes in facility policies and procedures, and for providing input to budgeting and system expansion plans. Management needs to be receptive to staff input and committed to seeking it and using it.

4. What kind of attitude is portrayed by the system personnel?

If system personnel portray a negative attitude, it may be an indication of poor relations between system management and operations staff. Negative employee attitudes may stem from inadequate investments in employee training or compensation, or inadequate investment in facilities/equipment used or operated by employees. The inspector should attempt to determine the reason(s) for a negative attitude to the degree that such attitudes may adversely affect system performance.

3.7.4 Water System Staffing

The inspector should determine if a list of job descriptions for system personnel is available. The inspector can use this information to assess whether or not the system seems to have an adequate number of qualified personnel to perform all the necessary work within the system from operations to maintenance. One indicator of sufficient personnel is that little or no overtime is required to adequately perform operations and maintenance. The inspector should also evaluate the relative distribution of personnel between operations and maintenance positions. If a system has only one individual to maintain the water treatment facilities and distribution system and 10 operators with no maintenance responsibilities within their job descriptions, there are too many operators and not enough maintenance personnel and a lack of maintenance is likely to be very noticeable. To have a well operated and maintained facility, there should be a good mix of responsibilities and personnel, and personnel should have some cross-training between operations and maintenance.

Suggested assessment criteria for system staffing include:

1. **Is the number of personnel adequate to perform the work required?**

   The size of the facility and the types of treatment largely determine what level of personnel is sufficient. The system should have enough personnel to enable continuous operation of the treatment plant at all times, including periods when some staff are absent (e.g., vacations, weekends, holidays). Staff should be able to perform operations and maintenance tasks regularly with little or no overtime hours. In addition to having an adequate number staff overall, the system should have staff appropriately assigned to operations tasks and maintenance tasks.

2. **Is plant coverage adequate given the alarm systems used by the plan? Do variations in finished water quality when the plant is unattended indicate the need for additional plant coverage?**

   During periods when the plant is unattended or treatment processes are monitored by alarm systems rather than personnel, fluctuations in finished water quality may increase. The inspector should evaluate whether the system's personnel and its use of alarm systems are adequate to promptly address variations in finished water quality.

3. **Do staff have clearly defined responsibilities and the decisionmaking authority necessary to carry out their responsibilities?**

   System staff need to clearly understand their responsibilities and have the authority to make any decisions, such as hiring and scheduling personnel and altering elements of treatment plan operation (e.g., equipment shutdowns for maintenance, changes to chemical doses), that are necessary to fulfill their responsibilities in a timely manner. System staff should also sufficiently understand the responsibilities of other personnel so they know who to approach with issues or questions.

4. **Is there cross-training required of the individuals within the system?**

   Some cross-training of employees between operations and maintenance provides the facility with staffing options during unexpected periods of staff absences (e.g., illnesses) and times when the work load balance between operations and maintenance shifts. Cross-training may also enable staff to better carry out their responsibilities because they have a better understanding of other aspects of water treatment.

3.7.5 O&M Manuals and Procedures

Operation and maintenance (O&M) manuals, standard operating procedures (SOPs), and standard maintenance procedures (SMPs) provide direction for the operation and maintenance of system facilities. They can also provide a quick means of teaching new staff about the system, how it operates, and what should be done to keep the system operating successfully. The O&M manual contains a general discussion of system components and their operation and maintenance, while SOPs and SMPs provide a more detailed, step-by-step description of the procedures that should be followed to carry out operations and maintenance tasks. Many O&M manuals also contain the SOPs and SMPs for a system.

The O&M manual, SOPs, and SMPs should include the following information:

- General description of all components within the system/facility, and its purpose;
- Performance goals for the plant;
- Design criteria for all components;
- Detailed description of the operation of each component (step-by-step);
- Procedures for monitoring and adjusting plant performance;
- Detailed description of the maintenance of each component (step-by-step), including emergency and preventative maintenance;
- Laboratory requirements – equipment, test procedures, and calibration methods;
- Safety program – spill response, emergency telephone numbers, procedures, etc.;
- Education and training responsibilities and opportunities;
- Procedures for communicating problems; and
- Records – plant and regulatory requirements.

The O&M manual, SOPs, and SMPs should be written by the staff, when possible, because they are the ones that best know the system and its requirements. They should be written in a manner that provides a clear and accurate understanding of the operation and maintenance of facilities.

Suggested assessment criteria for operation and maintenance manuals, SOPs, and SMPs include:

1. **Is there an O&M manual for the system? Are there SOPs and SMPs for the system? Are these documents complete and accurate?**

   The system O&M manual and associated SOPs and SMPs are vital to ensuring consistent operation and maintenance of the facility from operator to operator and across maintenance staff. The inspector should assess whether the documents appear adequate (e.g., are sufficiently detailed) and address all aspects of the facility treatment processes. Information on the facility (e.g., system maps) and all equipment (e.g., literature received from the manufacturer or supplier) should be organized and easily accessible so that equipment can be properly operated and serviced.

2. **Do system personnel use the documents and implement the practices described in them? Where are copies of the manual, SOPs, and SMPs kept?**

   O&M manuals, SOPs, and SMPs are of little value if they are not used by system personnel. The documents need to be readily available to all staff, and staff need to be aware of where the manuals are kept and encouraged to use them.

3.7.6 Water System Funding

When reviewing the budget and rate structure, one of the most important questions to consider to determine adequacy is "Is the system a self-supporting utility?" A self-supporting utility means that the revenues are such that all budgetary requests are met, with some excess reserves remaining for future improvements or emergencies. These reserves would normally stay within the utility budget. However, some systems may apply these reserves to other portions of the overall budget of the city or board. In other words, the water system may subsidize other departments within the city or board.

After reviewing the budget and revenues to determine if the system is self-supporting, the budget should be reviewed to determine that there is adequate funding allocated to the maintenance of the equipment within the system, as well as for providing an adequate number of personnel to operate and maintain the system properly. Data from other systems may help in this analysis. In comparing two similarly sized systems, any significant differences between the two systems can be evaluated to see if they may be part of the reason for any problems being experienced.

Suggested assessment criteria for adequacy of revenues/budget include:

1. **Is the system self-supporting?**

   Water rates should be set at a level such that fees collected adequately cover operating, maintenance, and replacement costs. If there is an imbalance, the inspector should evaluate how the imbalance may be impacting the system's performance and its ability to provide a reliable supply of high-quality water.

2. **Are there adequate monies to provide the appropriate maintenance and to support the number of personnel to operate the system correctly?**

   System funding needs to adequately support facility operation and maintenance, and should include funding for an appropriate level of staff that are properly trained. Funds need to be budgeted for future expenses such as equipment purchases and facility expansion, as well as current expenses associated with staff salaries and training, electricity, chemical stocks and equipment replacement parts, and other day-to-day expenses. The system should have a method for prioritizing its needs so that funds are expended on the most essential items first. The inspector should ask operations and maintenance staff about its procedures for and past experiences with obtaining needed supplies, equipment, and staff to determine if staff encounter difficulties due to budget problems. The system should have a reserve or sinking fund where excess revenues are held and accumulated for use on future purchases and improvements and emergencies.

3. **Does the water system subsidize other departments within the city or board? If so, is funding that is returned to the water utility sufficient to meet operation and maintenance requirements and address future growth?**

   To assess this, the inspector should interview personnel that are responsible for the water system budget, ask operator about plant funding, and examine the budget.

4. **How does this system compare to others?**

   If the inspector has financial data on other systems, comparisons can be made that may aid in determining the adequacy of a system's budget/revenues.

3.7.7 Priority Criteria

The following criteria related to the water system management/operation element of the sanitary survey are considered high priority based on their potential for impacting public health:

- **Water System Management –** Management provides the direction, policies, and budget for the staff to work by and with to meet regulatory requirements and produce quality drinking water. Management can foster a positive morale that can lead personnel to strive for excellence in operation and maintenance tasks and thus higher quality water. Management that is knowledgeable about water systems is likely to make better decisions about policies and expenditures for staff and equipment (Section 3.7.3).

- **Water System Staffing –** Adequate staff is required for the proper operation and management of the system (Section 3.7.4).
- **Water System Funding –** Adequate funding for operation, maintenance, and expansion is required to assure system viability (Section 3.7.6).

3.8 Operator Compliance with State Requirements

The need for qualified professionals to operate and maintain water systems is becoming increasingly important in the water supply industry. This need is because the operation of a water system is becoming more complicated and difficult with ever changing regulations that require the quality of drinking water to improve. System personnel must be aware of any deteriorating conditions from the source water supply to the consumer's tap, know what changes are required to correct the conditions, and be ready to implement the change at a short notice. The overall goal of a water system is to provide an adequate supply of safe drinking water to the consumer at an acceptable pressure. To meet this goal and the associated challenges, surface water system personnel need to be adequately trained.

3.8.1 Certification of Operators

Personnel involved in providing consumers with drinking water need to know what is required to provide a safe and adequate supply of water. One of the ways to assure the consumer that trained and knowledgeable individuals are working in the water system is through operator certification. Most states require a certain level of operator certification befitting the size of the system.

The requirements for operator certification vary from state to state, but they all require a certain amount of in-class (school) as well as on-the-job training and experience. As an individual advances, the training requirements increase also. In addition, operator certification is renewable and a certain degree of training is required just to maintain a level of certification.

Suggested assessment criteria for operator certification include:

1. **Does the system employ an operator(s) of the appropriate certification level(s), as specified in state requirements?**

   Proper operation and maintenance of a water system requires staff that are trained and knowledgeable about the facility and water treatment. One means of ensuring that system personnel have a certain minimum level of knowledge is through operator certification. States establish operator certification requirements so that operators without this knowledge are prevented from posing a potential health risk to consumers through improper treatment plant operation resulting in poor quality water. A system should have an operator(s) that possesses certification at the level(s) specified in state requirements. The inspector should ask for proof of certification if it is not openly displayed.

2. **Are operator certifications current for all system personnel? Are all personnel meeting the minimum renewal requirements for operator certification?**

   In reviewing the system's proof of certification, the inspector should verify that all operator certifications are current and that operators are meeting any state requirements for certification renewal.

3.8.2 Competency of Operators

Like all professions, some people know all the right answers according to the book and others know what the right answer is based on experience. Operators need to know both. During the survey, the inspector should question the operators about various aspects of the operation and maintenance of the system. Through this questioning, the inspector should be able to determine if system personnel are adequately trained, as well as informed about the system.

The inspector can also see how well the system is operated and maintained. Generally, if the system is well operated and maintained, the operators are competent and know what is needed to operate the system correctly.

Suggested assessment criteria for competency of operators include:

1. **Do the operators know how to operate and maintain the various components of their water system from the source to the tap? Does the system appear to be well-operated and maintained?**

   The inspector should evaluate the competency of operators throughout the entire site visit, both by visual observation and by asking the operators questions about water treatment and distribution, the facility and equipment, and procedures for operations and maintenance tasks. Questions the inspector cannot ask to probe the operator's knowledge include, "Show me how you...," "What does this do?," and "How often do you...?" The appearance of the facility is an indication of whether the operators properly operate and maintain the system.

2. **Are system personnel appropriately trained?**

   The system should have a regular training program that includes both new personnel and existing staff. Training can be done both in-house and through training classes offered by the state, EPA, universities, and drinking water associations. Operators should be trained in applicable operations and maintenance procedures, water treatment concepts, drinking water regulations, safety procedures, emergency response, and other essential issues that have a direct impact on plant personnel and the quality of drinking water.

3.8.3 Priority Criteria

The following criterion related to the operator compliance with state requirements element of the sanitary survey is considered a high priority based on its potential for impacting public health:

- **Competency of Operators –** Competent operators are essential to a well run, operated and maintained water system. Operators make operation, maintenance and administrative decisions that affect plant performance and system reliability (Section 3.8.2).

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4. COMPILING THE SANITARY SURVEY REPORT

This chapter provides guidelines for preparing the sanitary survey report and suggestions for keeping adequate documentation of the sanitary survey. The sanitary survey report is a final written report that is used to notify water system owners and operators of the system's deficiencies and assists in facilitating corrective action where deficiencies are noted. Final written reports should be prepared for every sanitary survey in a format that is consistent statewide. Once a sanitary survey has been conducted, appropriate documentation is needed for follow-up activities and for development of reports. Not only does documentation need to be complete, but the results of surveys should be interpreted consistently from one surveyor to another. Specifically, as part of documentation and follow-up, the inspector should complete the following activities:

- Complete documentation and prioritize sanitary risks that were identified during the onsite investigation;
- Notify the water utility of any variances in the sanitary survey report from that provided in the oral debriefing at the site;
- Complete the formal sanitary survey report;
- Notify appropriate organizations of the results;
- Provide options for correcting the sanitary risks, including sources of technical assistance;
- Follow-up on questions asked by water utility personnel; and
- Assess whether the system should be considered to have outstanding performance.

The remainder of this chapter provides additional detail on compiling the sanitary survey report. Areas addressed include: preparing the sanitary survey report; preparing adequate sanitary survey documentation; categorizing the findings; developing corrective actions; and determining outstanding performance.

4.1 Sanitary Survey Report

The sanitary survey report officially communicates the results of the survey to the owners and operators of the water system. The purposes of the survey report are to:

- Notify the water system owners and operators of system deficiencies;
- Request corrective action under a specified schedule;
- Provide a written record for future inspections (including a recommendation on outstanding performance since this can affect the frequency of future surveys);

- Provide important information that may be useful in emergencies.

The report can be as brief as an extensive letter, but should be detailed enough to provide the water utility with sufficient information on what deficiencies exist and what corrective actions are needed. The survey report should indicate why corrective actions are necessary. Compliance schedules are required for all sanitary survey reports that identify significant deficiencies.

The survey report provides a record for future inspecting parties and provides technical information that may be useful during emergency situations. It is also an important tool for tracking compliance with the SDWA and for evaluating a particular system's compliance strategy. The sanitary survey report needs to contain adequate documentation of survey results. Types of documentation are discussed in Section 4.2.

The report should be completed promptly and reflect the information provided to water utility personnel at the end of the onsite evaluation. If the written evaluation is different from the oral debriefing, the water system manager should be notified of such changes.

At a minimum, the survey report should include the following elements:

- Date and time of survey;
- Name(s) of survey inspector(s);
- Name(s) of those present during the survey, besides the inspector(s);
- A schematic drawing of the system and, where appropriate, photographs of key system components;
- A statement of system capacity, including source, treatment, and distribution;
- A summary of survey findings, with the signatures of survey personnel;
- A listing of deficiencies based on a regulatory reference;
- A summary of all analyses and measurements done during the sanitary survey;
- Recommendations for improvement, in order of priority, with a timeline for compliance;
- A copy of the survey form; and
- A recommendation on whether a system has outstanding performance.

The report needs to identify all the deficiencies noted during the inspection. The sanitary survey report should provide more detailed information when a system has a significant problem that could affect human health. The report should also provide options for corrective actions that the system may take to address any significant deficiencies. As part of the follow-up activities for sanitary surveys, the system must respond to deficiencies outlined in the state's sanitary survey report within 45 days, indicating how and on what schedule the system will address significant deficiencies noted in the survey. The system may also provide its own recommendations for corrective action. The sanitary survey report should describe the actions that the state will take if the deficiencies that require action by the system owner/operator are not corrected within the timetable provided.

The state should develop standard language ("boilerplate") for use in sanitary survey reports and correspondence with water systems after a sanitary survey. This standard language includes the text which will not change significantly from report to report. The standard language should be used, when applicable, to save report preparation time and to maintain uniformity in correspondence between the state agency and water systems. Standard language could be developed for sanitary survey report discussions pertaining to each of the eight elements of a sanitary survey. For example, a state could develop standard language that describes its operator certification requirements and says whether or not the water system operator(s) meets those requirements. The inspector would insert the applicable language based on the results of the inspection. A state should consider consulting with its legal staff to ensure that the standard boilerplate language is accurate within its authorities.

4.2 Sanitary Survey Documentation

Adequate documentation of survey results is essential in the sanitary survey process, especially if the survey may result in corrective or enforcement actions. It is the inspector's responsibility to the water system and to the public to provide an accurate and detailed description of improper operations or system deficiencies in the sanitary survey report. Detailed documentation should be recorded in a sanitary survey report and sanitary survey forms. Some example forms are included in Appendix A.

The suggested minimum documentation for sanitary survey record files includes:

- A cover memorandum or letter with a list of deficiencies, if any, and pertinent information and recommended actions. The list of deficiencies should be accompanied by references to regulatory provisions pertaining to the deficiencies. The first page of the list of deficiencies should begin with the header below. The items shown in italics should be provided for the particular system. Following the header, each deficiency should be ordered by number. The list should be prioritized by severity from the most critical to the least critical.

LIST OF DEFICIENCIES	
System: *System's Name*	**Survey Date:** *Inspection Date*
I.D.#: *Water System's ID Number*	**Surveyed By:** *Inspector's Name/Affiliation*
Location: *County Name, State*	**Region:** EPA *Region Number*

- A completed survey form or checklist for the water system (if used by the state).
- Any necessary additional pages of comments, drawings or sketches, and water sampling data.
- A copy of the USGS 7.5 minute topographical quadrangle map showing the location of the system.
- A summary of the components of the water system. This summary should identify any modifications made to the system.
- A listing of system operators, including the certification status.

4.3 Categorizing the Findings

The findings of a sanitary survey can range in severity from minor administrative deficiencies to situations where continued operation of the water delivery system could pose a serious health threat to the population. The inspector needs to determine which deficiencies are significant and thus require the system to take immediate corrective action (all deficiencies should ultimately be addressed). In general, significant deficiencies include those defects in a system's design, operation, or maintenance, as well as any failures or malfunctions of its treatment, storage, or distribution system, that the state determines to be causing or have the potential to cause the introduction of contamination into water delivered to customers.

For statewide consistency from survey to survey and inspector to inspector, a state should establish its own definition of a significant deficiency and a list of what deficiencies it generally considers significant. An inspector should determine which deficiencies of a system meet the state's definition of significant, and should also identify any other deficiencies that may pose a serious threat and should be considered significant for that system. The priority criteria provided in Chapter 3 can help the inspector determine which deficiencies pose a serious health threat and therefore need to be considered significant.

Table 4-1 illustrates one possible approach to categorization of some of the common deficiencies by the degree of their threat to public health. The below listing includes examples of deficiencies that may be considered significant public health issues. This list is not intended to be comprehensive, but serves as a guide to the state for categorizing significant deficiencies. Other deficiencies could be deemed significant public health issues.

Table 4-1. Example of Sanitary Survey Deficiencies*

Finding	Minor	Moderate	Significant
No approved construction drawings		✓	
Failure to update the water distribution map	✓		
Stopping work on system improvements		✓	
Failure to meet distribution system pressure requirements			✓
Failure to meet water treatment requirements			✓
Failure to meet water quality MCLs			✓
System continues to operate in a noncompliance mode			✓
System has reached the maximum number of services allowed		✓	
System not operating in compliance with water system plan		✓	
System violated coliform or VOC MCLs			✓

* This table is for illustrative purposes only and does not represent any federal or state policy.

The following list presents some additional examples of potential significant deficiencies that may be identified during a sanitary survey. Significant deficiencies of surface water and ground water under the direct influence of surface water systems may include, but are not limited to, the following types of deficiencies:

- Source
  - Location of intake is near pollution source (e.g., POTWs, CSO discharges)
  - Not having a secured protective radius around a reservoir
  - Wells of improper construction
  - Springs of improper construction.

- Treatment
  - The hatch to a pressure filter has not been opened on a yearly basis to clean the media, and to check for media loss and the condition of the underdrain system
  - Filter does not have adequate depth of media (e.g., less than 24 inches)
  - No SOP for taking a filter out of service for backwashing, for performing the backwash or returning the filter to service
  - No process control plan for coagulant addition
  - Inadequate application of treatment chemicals
  - Chemical feed rates not adjusted for varying raw water quality conditions or changes in plant flow rate
  - Inadequate disinfection CT.

- Distribution Systems
  - TCR sampling plan not representative of distribution system
  - Negative pressures at any time
  - System not flushed periodically
  - No disinfectant residual, or HPC levels greater than 500/ml, repeatedly at same sites
  - Inadequate monitoring of disinfectant residual, when required
  - Inadequate cross connection controls, either at the treatment facility or in the distribution system (or failure to have a cross connection control program, when one is required)
  - Unacceptable system leakage that could result in entrance of contaminants.

- Finished Water Storage
  - Inadequate internal cleaning and maintenance of storage tank
  - Improper venting of tank
  - Lack of proper screening of overflow pipe and drain
  - Inadequate roofing (e.g., holes in the storage tank, improper hatch construction).

- Pumps/Pump Facilities and Controls
  - Ponding of water in pump housing
  - Inadequate pump capacity
  - Lack of redundant mechanical components.

- Monitoring/Reporting/Data Verification
  - Failure to properly monitor water quality
  - Failure of system operator to address customer complaints regarding water quality or quantity issue
  - TCR sampling plan not available or not being followed
  - Chronic TCR coliform detections with inadequate remediation.

- Water System Management/Operation
  - Lack of properly trained or licensed staff as required by the state
  - Lack of approved emergency response plan
  - Failure to meet water supply demands/interruptions to service (inadequate pump capacity, unreliable water source, lack of auxiliary power)
  - Inadequate follow-up to deficiencies noted in previous inspection/sanitary surveys.

- Operator Compliance with State Requirements
  - Operator does not have the correct level of certification as required by the state.

If a significant public health issue is determined to exist, compliance action must be required. State inspectors may judge other problems as significant enough from a public health viewpoint to require establishment of a compliance schedule with follow-up action.

4.4 Corrective Action

There are a number of problems or deficiencies that may be considered significant public health issues. If a significant public health issue is determined to exist, corrective action must be required. At a minimum, the sanitary survey report should identify the deficiencies noted during the inspection and notify the system of the actions that the state may take if the deficiencies that require action by the system owner/operator are not corrected. To ensure that the sanitary risks are minimized, the sanitary survey report should provide the water utility with options for correcting significant defects. The suggestions for corrective actions should not be overly specific and should be sufficiently conservative, since the inspector does not have the detailed knowledge of the system's engineer or other plant personnel.

Depending upon the nature of the defect, there may be a number of adequate corrective actions that may be applied to a significant defect. The system should be given discretion in selecting the most appropriate corrective action, and made ultimately responsible for selecting an appropriate action(s).

There are three basic approaches which may be taken to ensure significant defects are corrected:

- ***Correction of problems by the water system staff, their consulting engineers, and/or contractor***

  Many deficiencies can be addressed by water system staff and their consultants. The inspector should assess whether the water system appears to have trained and competent staff available before suggesting approaches that involve water system personnel in alleviating most deficiencies. The inspector should consider the cause of the deficiencies (how and why they developed) and judge whether it is reasonable to expect the water system operator or manager to correct the problems promptly.

- ***Technical assistance to the water utility by the regulatory agency, organizations that specialize in training and technical assistance, and/or peers at other water systems***

  Many water systems may need assistance in determining the cause(s) of their performance problems and in developing a set of actions to eliminate the problems. The inspector may be able to offer approaches the water system can use to assess and address problems. Assistance may result in training, onsite system specific technical assistance, and referrals to other available resources at the state and federal levels (at the primacy agency, other organizations, and at state environmental training centers).

- ***Implementation of a composite correction program (CCP) applicable to surface water treatment plants***

  The CCP is a type of technical assistance that is specific to surface water systems. A CCP consists of a comprehensive performance evaluation (CPE) and a comprehensive technical assistance (CTA) program. A CPE determines inadequacies and performance limiting factors, and prioritizes deficiencies. A CTA attempts to correct the deficiencies and involves onsite, system-specific technical assistance.

A combination of these approaches may be appropriate, based on the type and severity of the sanitary deficiencies.

4.5 Outstanding Performance

As noted in Chapter 1, community systems that are classified as having outstanding performance are eligible for having future sanitary surveys conducted at the less frequent interval of at least once every five years, rather than at least once every three years. Based on the findings of a sanitary survey, an inspector should include in the report a recommendation on whether a system should be considered to have outstanding performance at the time of the survey. This recommendation should be based on the state's specifications for determining if a system has outstanding performance. The state was required to develop these specifications as part of its application for primacy. Along with the inspector's recommendation, the report should include standard state language ("boilerplate") noting that the recommendation for outstanding performance status is contingent upon the system continuing to meet the states' specifications for that status.

In general, outstanding performance means that a system is well-operated and managed, has a good record of performance in past sanitary surveys, and has not had any violations (at least in recent years). A state's specifications for outstanding performance may include factors such as the following:

- No violations of MCLs since the last sanitary survey;
- No violations of monitoring and reporting requirements since the last sanitary survey;
- No violations of primary drinking water regulations during the past five years (or similar time period);
- No waterborne disease outbreaks attributable to the water system during a specified period;
- Past sanitary surveys containing no significant deficiencies;

- Existence of emergency preparedness measures and backup facilities;
- Meeting exceptional performance standards (e.g., 0.1 NTU) a specified high percentage of the time;
- Expert management of system (e.g., managers are knowledgeable about providing quality drinking water; low staff turnover and positive staff morale; well-established water quality goals);
- Expert operation of the system (e.g., skilled, certified personnel) in adequate numbers; existence of quality O&M manuals that are used by the staff; adequate budget and revenues);
- Success under the Partnership for Safe Water Program, Phase III program;
- Effective cross-connection program developed and implemented;
- Recognized in-house research programs applicable to improved system performance;
- Active public outreach programs (e.g., citizen participation committees);
- Stable water source (no interruptions in supply);
- Source water supply drawn from a reservoir or pre-sedimentation facility that effectively dampens raw water quality variations;
- No identified significant risk of future violations or problems (e.g., equipment past its service life);
- System capacity sufficient to meet anticipated growth; and
- CPE has been performed by a third party during the past three years, and the water system has adequately addressed all Performance Limiting Factors identified by the CPE.

As noted above, each state should have its own specifications for determining if a system has outstanding performance. The state may choose to use some or all of the above factors, different factors that have been developed by the state, or a combination of both.

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5. REPORT REVIEW AND RESPONSE

The previous chapters of this guidance manual described how to prepare, conduct, and report the results of a sanitary survey. This chapter describes the follow-up actions that should be undertaken by the water system operator and the state in response to the findings of a sanitary survey, including those actions that must be taken to correct any identified deficiencies. In general, the findings of the inspector should be transmitted to the system owner or operator soon after completion of the inspection. In turn, the system operator must respond to the sanitary survey findings within 45 days of state notification. The state then needs to monitor the water system's implementation of corrective actions to ensure that deficiencies are resolved. The remainder of this chapter discusses these follow up actions.

5.1 State Actions

For a state to be granted primacy authority, it must submit evidence to EPA that the state has met the requirements for a determination of primacy enforcement responsibility found in 40 CFR 142.10. These requirements are summarized in Figure 5-1. This regulatory authority effectively outlines the range of options that the state possesses in responding to the findings in a sanitary survey report.

Deficiencies of a minor nature may require no more response than to notify the system operator of the violation and set a time frame for the operator to correct the situation. A moderate deficiency could prompt the state to require the operator to respond within 30 days with a proposed solution to the deficiency and a schedule for correcting the situation. For significant deficiencies, the state must immediately inform the system operator of the deficiency. In some cases, the deficiency may be such that a boil water notice must be issued to the customers in order to protect public health. In all cases, the state should indicate the required time frame for a response, the required action for the response, and the consequences of failing to respond. The consequences could include revocation of the operating permit, suspension of the permit until the deficiency is corrected, and fines or penalties levied against the system operator. When significant deficiencies exist, a consent agreement, administrative order, or litigation by the appropriate court may be necessary to ensure prompt and proper correction. The state should make regular and continued inspections of the facility until all deficiencies have been corrected.

Other state activities include maintaining a tracking system for enforcement. The 1995 *EPA/State Joint Guidance on Sanitary Surveys* states that the deficiencies disclosed in a survey must be followed up on to ensure that timely corrective action is taken, especially to correct deficiencies that have the potential to substantially affect public health. States should develop a program for following up on recommendations made in their sanitary surveys. A computer tracking system of deficiencies may be a useful tool for states to use in tracking follow-up and enforcement actions.

Summary of CFR 142.10

Requirement for a Determination of Primacy Enforcement Responsibility

1. State has adopted drinking water regulations which are no less stringent than the National Primary Drinking Water Regulations.

2. State has adopted and is implementing adequate procedures for the enforcement of such state regulations, including:

    - maintenance of an inventory of public water systems;
    - a systematic program for conducting sanitary surveys of public water systems in the state, with priority given to sanitary surveys of public water systems not in compliance with state primary drinking water regulations; and
    - the establishment and maintenance of a state program for the certification of laboratories conducting analytical measurements of drinking water contaminants.

3. The establishment and maintenance, by the state, of an activity to assure that the design and construction of new or substantially modified public water system facilities will be capable of compliance with the state drinking water regulations.

4. The state has the statutory or regulatory enforcement authority adequate to compel compliance with the state primary drinking water regulations in appropriate cases, such authority to include:

    - authority to apply state primary drinking water regulations to all public water systems in the state covered by the national primary drinking water regulations;
    - authority to sue in courts of competent jurisdiction to enjoin any threatened or continuing deficiency of the state primary drinking water regulations;
    - right of entry and inspection of public water systems;
    - authority to require suppliers of water to keep appropriate records and make appropriate reports to the state;
    - authority to require public water systems to give public notice; and
    - authority to assess civil or criminal penalties for violations of the state primary drinking water regulations.

5. The state has established and will maintain record keeping and reporting of its activities.

6. The state has adopted and can implement an adequate plan for the provision of safe drinking water under emergency situations.

Figure 5-1. Summary of 40 CFR 142.10 – Requirements for a Determination of Primacy Enforcement Responsibility

5.2 Water System Actions

As stated above, the severity of the deficiency in a sanitary survey should dictate the appropriate response required from the water system operator. When a water system applies for an operating permit, the system operators agree to operate the water system in accordance with state regulations, and to deliver water of adequate volume, pressure, and quality. A state approves the operating permit with the same understanding and with the authority to enforce against any deficiency.

The system operator, upon receipt of the sanitary survey report, should prepare a response to the state addressing the survey findings which may include deficiencies of varying degrees of severity. The water system's response should be returned to the state within 45 days, and must be returned within the 45-day timeframe when the sanitary survey findings include significant deficiencies. The response should include:

- A statement of the deficiency, including any real or potential impacts to delivered water quality;
- The approach to correcting the deficiency;
- The time required to correct the deficiency;
- The source of funding, if capital construction is required;
- Measures put in place to prevent the situation from recurring; and
- Additional follow-up actions planned.

The IESWTR does not change the requirement for a water system to maintain copies of sanitary survey written reports and correspondence associated with sanitary surveys for a period of at least 10 years, as specified in 40 CFR 141.33 (c). In addition to this requirement, the water system should follow any applicable state implementing regulations related to sanitary survey record keeping.

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