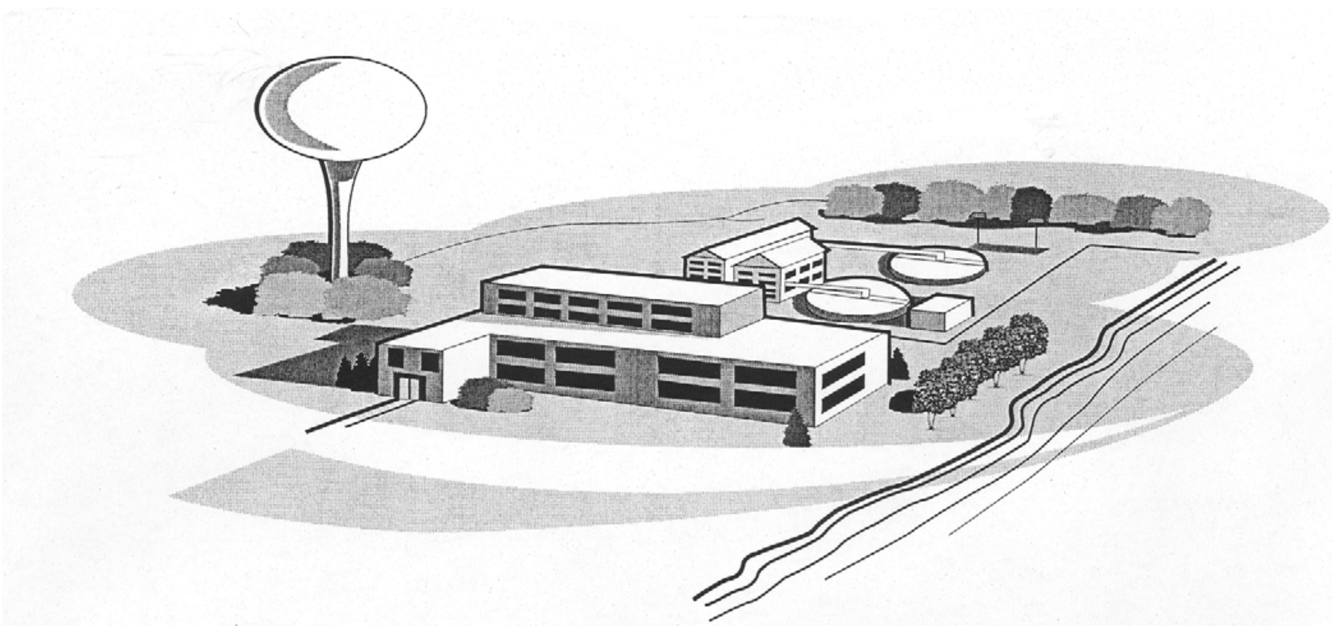
Public Water Supply Manual

383-2125-108



PART II
COMMUNITY SYSTEM DESIGN STANDARDS

COMMONWEALTH OF PENNSYLVANIA
Department of Environmental Protection
For more information, visit DEP's Web site
at www.depweb.state.pa.us/, Keyword: "Drinking Water."

DEPARTMENT OF ENVIRONMENTAL PROTECTION
Bureau of Water Standards and Facility Regulation

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TITLE:	Public Water Supply Manual - Part II Community System Design Standards
EFFECTIVE DATE:	May 6, 2006
AUTHORITY:	Pennsylvania's Safe Drinking Water Act (35 P.S. §721.1 *et seq*.) and regulations at Title 25 Pa. Code Chapter 109
POLICY:	Department of Environmental Protection (DEP) staff will follow the guidance and procedures presented in this document to direct and support implementation of permitting activities for community water systems (CWSs) under the Drinking Water Management program.
PURPOSE:	The purpose of this document is to establish a rational and reasonable basis for staff decisions which will promote quality, timely and consistent service to the public and regulated community.
APPLICABILITY:	This guidance will apply to all CWSs.
DISCLAIMER:	The policies and procedures outlined in this guidance are intended to supplement existing requirements. Nothing in the policies or procedures shall affect regulatory requirements. The policies and procedures herein are not an adjudication or a regulation. There is no intent on the part of DEP to give the rules in these policies that weight or deference. This document establishes the framework within which DEP will exercise its administrative discretion in the future. DEP reserves the discretion to deviate from this policy statement if circumstances warrant.
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DEFINITIONS:	See Title 25 Pa. Code Chapter 109

USER'S GUIDE

The *Public Water Supply Manual* is a comprehensive publication designed to provide necessary, useful information to public water suppliers (PWSs) concerning Pennsylvania's Safe Drinking Water Program administered by the Department of Environmental Protection (DEP). The manual contains essentially everything the PWS will need to know about the Safe Drinking Water Program, including design and construction standards; water quality standards; monitoring, reporting and operating requirements; emergency measures; and information on government agency programs and contacts.

Technical guidance documents are on DEP's world wide website (www.depweb.state.pa.us) at the public participation center.

The "Final Documents" heading is the link to a menu of the various DEP bureaus and from there to each bureau's final technical guidance documents.

The "Draft Technical Guidance" heading is the link to DEP's draft technical guidance documents.

DEP encourages the use of the internet to view guidance documents. When this option is not available, persons can order a bound paper copy of the latest inventory or an unbound paper copy of any of the final documents listed on the inventory by calling DEP at 717-783-3795.

The following is a summary of the *Public Water Supply Manual* Parts. Following the summary is a Table of Contents for each part in the *Public Water Supply Manual*.

Part I - *Summaries of Key Requirements*

Part I is no longer published as a compilation of all the summaries of key requirements. The summaries of key requirements are available as individual documents. Additional summaries are added as new rules and regulations are adopted.

Part II - *Community System Design Standards*, DEP ID: 383-2125-108, available on DEP's website

Part II provides detailed design and construction standards for all CWSs except bottled water systems, bulk water haulers, vended water systems and retail water facilities. Part II also contains instructions for submitting a PWS permit application.

Part III – *Design Standards for Bottled Water, Bulk Water Hauling, Water Vending Machines and Retail Water Facilities*, DEP ID: 383-2126-303, available on DEP's website

Part III provides detailed design and construction standards for bottled water systems, bulk water haulers, vended water systems and retail water facilities, including information on submitting a PWS permit application.

Part IV - *Noncommunity System Design Standards*, DEP ID: 383-2128-108, available on DEP's website

Part IV provides detailed design and construction standards for noncommunity water systems (NCWs), including information on the procedures to be followed to obtain DEP's approval.

Part V - *Operations and Maintenance*, DEP ID: 383-3110-111, available on DEP's website

Part V provides the needed information to develop an Operations and Maintenance Plan as required under Section 109.702 of DEP's Safe Drinking Water Regulations. This is a comprehensive guidance document covering all aspects of PWS operations, including operation and maintenance standards.

Part V has been developed as two separate documents. Each is designed for specific type systems:

- Sections I and II are for surface water systems and the larger groundwater systems.
- Appendix A, *Operations and Maintenance for Small Groundwater Systems*, DEP ID: 383-3110-211, is a condensed version containing information needed by small groundwater systems having limited treatment (disinfection and corrosion control).

Part VI - *Emergency Response*, DEP ID: 383-5900-111, available on DEP's website

Part VI discusses the measures which a water supplier should take to prepare for emergency circumstances and explains how to prepare an emergency response plan.

Part VII - *Cross-Connection Control/Backflow Prevention*, DEP ID: 383-3100-111, available on DEP's website

Part VII provides the basic information needed by a PWS to establish an effective cross-connection control program.

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I. APPLICATIONS FOR PERMITS

A. Permit Requirements

Under the provisions of Subchapter E, Permit Requirements, of DEP's Rules and Regulations at Title 25 Pa. Code Chapter 109, no person may construct or operate a PWS without first obtaining a permit from DEP. Furthermore, no person may substantially modify a PWS operated under a PWS permit without first obtaining a permit amendment from DEP.

The purpose of this section is to provide guidelines on the procedures which must be followed when submitting an application for a CWS permit.

1. Coverage

   The following projects must be submitted to DEP for review and approval:

   a. All facilities of any new system

   b. Any addition to or modification of an existing system which will or may affect the quality and/or quantity of the supply. The following major modifications require the submission of a complete permit application as outlined in Section I.B.3. Minor modifications must be discussed with the appropriate regional water supply engineer to determine the extent of the information which must be submitted to obtain DEP's approval.

Major Modifications	**Minor Modifications**
New sources	Changes in treatment chemicals
Additions or deletions of treatment techniques	Replacement of storage tank or reservoir linings
Pumping stations	Covering of Reservoirs
Storage reservoirs	Construction for prefabricated storage tanks
	Transmission mains
	Interconnections
	Permit transfers

2. Application Fees

   Applications for a permit for a major modification as outlined in Section I.A.1.b. must be accompanied by a check in the amount of $750 payable to the *"Commonwealth of Pennsylvania."* No fee is required from a PWS serving less than 100 persons, from a state regulatory agency or for an application for an emergency permit.

Applications for construction permits or major permit amendments for corrosion control treatment facilities require the payment of a fee based on system size.

It is recommended that all applicants contact the appropriate regional office (Table 1.1) to determine the application fee that must accompany the permit application.

3. Construction and Operation Permits

In administering the permit requirements of DEP's Safe Drinking Water Regulations, the Bureau of Water Standards and Facility Regulation (BWSFR) has implemented a two-part approval process. Upon approval of the plans, modules and other design documents, a construction permit will be issued approving the construction or modification in accordance with the approved plans. This approval will be valid for a period of 2 years unless substantial work is initiated or DEP renews it. Upon completion, the system is required to submit a certificate of construction completion to DEP stating that construction or modification was completed in accordance with approved plans and specifications. This statement must be signed by the professional engineer or other person responsible for the work. Upon receipt of the certificate, DEP will inspect the facility and issue an operations permit where the construction has been satisfactorily completed.

4. Revisions to Approved Plans

Any deviations from approved plans or specifications affecting capacity, hydraulic conditions, operating units, the functioning of water treatment processes, or the quality of water to be delivered must be approved by DEP before such changes are made. Revised plans or specifications should be submitted in time to permit the review and approval of such plans or specifications before any construction work, which will be affected by such changes, is begun.

5. DEP Review and Permit Coordination

Under the requirements of the Safe Drinking Water Regulations, DEP must grant or deny a permit within 120 days of receipt of an application. In order to comply with this requirement, DEP will not accept an application for review until the application is determined to be complete. As other state or interstate environmental agencies may require approvals, applicants and their consultant engineers are advised to hold a preliminary engineering conference with the regional water supply staff to identify and coordinate these approvals. Failure to satisfy any permit coordination requirements could result in the refusal of an application or the denial of a permit.

B. Procedures for Obtaining a Permit

An application for a PWS permit shall be submitted in writing on forms provided by DEP and shall be accompanied by plans, specifications, engineer's and geologist's reports, water quality analyses and other data, information or documentation reasonably necessary to enable DEP to adequately evaluate the proposed design. Applications must be submitted to the appropriate regional office listed in Table 1.1.

1. Licensed Professional Engineer and Geologist

The party desiring to construct, add to, or modify a water supply shall engage the services of a licensed professional engineer who is legally qualified to practice in Pennsylvania, and who is competent in the design and construction of water supply facilities. When the proposed source is a groundwater source, the party shall also engage the services of a licensed professional geologist who is legally qualified to practice in Pennsylvania. The geologist shall be competent in groundwater source siting and hydrogeologic investigations.

2. Preliminary Conference

A preliminary conference with the regional water supply staff should be held for projects which include new sources of supply or treatment facilities. At such a conference, it will be helpful if the applicant's engineer and/or geologist is prepared to set forth the water supply problems and the proposed solution in such a manner as to support their conclusions and recommendations.

a. Scope

Subjects appropriate to the project as covered in Section I.B.3.a. Engineer's Report, and Section II - Preliminary Design Considerations, should be discussed in the preliminary engineering conference.

b. Preliminary Plans

Location maps, layout sketches and other illustrative material should be included.

c. Preliminary Report

A report presenting the proposed design data should be included in the material presented in the preliminary conference. If a conference is not held, it is advisable to submit a preliminary report at least 30 days prior to preparation of final plans.

d. Preliminary Hydrogeologic Information

Prior to permitting a new source, a site survey (physical inspection) must be performed by the regional water supply hydrogeologist to determine if the proposed site is suitable. The supplier shall make reasonable efforts to obtain the highest quality sources available, and estimate the approximate Zone I wellhead protection area. If the proposed source is a spring, infiltration gallery, ranney well or crib intake, the source must undergo surface water identification protocol (SWIP) monitoring before the application is submitted.

A site survey and pre-drilling plan are necessary for proposed groundwater sources. The following information must be provided:

(1) Purpose of the project, including water quantity needed

(2) Geologic description of the project (Supply appropriate citations if taken from published literature.)

  (a) Formation name(s) and lithology of target aquifer(s)

  (b) Regional strike and dip, and other relevant structural features

  (c) Geologic map showing proposed source location and regional geology

(3) Expected total depth of well(s)

(4) Expected yield and desired yield (Address seasonal flows of spring sources.)

(5) Anticipated water quality or quantity problems from proposed source aquifer

(6) Topographic map (with U.S. Geological Survey (USGS) topographic quadrangle name) that clearly shows:

  (a) Proposed source location(s), stating exact latitude and longitude in degree-minute-second format to an accuracy of 25 m

  (b) Estimated outline of surface drainage area

  (c) Location and identification of potential pollution sources in the estimated contributing area

  (d) Municipal zoning (Act 247) and sewage facilities planning (Act 537) in the estimated surface drainage area (Indicate zoning and the planned method of sewage disposal.)

(7) Maps or plots of appropriate scale that clearly show:

(a) Production and observation point locations, with latitude and longitude in degree-minute-second format accurate to 25 m

(b) Surface waterbody locations, including potential wetlands

(c) Area to be controlled by permittee

(d) Zone I wellhead protection area

(e) Aquifer test monitoring and discharge points

(f) Fracture trace analysis

(g) Scale, north arrow and USGS quadrangle name

(h) Other groundwater withdrawal points (water supply wells, irrigation wells, quarries, etc.) within a minimum 0.5-mile radius that could be affected by pumping the production well

(i) Pre-pumping water table contours or potentiometric surface (show natural groundwater flow direction)

(j) Estimated contributing area

(k) Estimated zone of influence

(l) Sources of contamination within the contributing area

(8) A description of methods to identify and assess potential impacts that construction and use of a new source(s) will, or could have, on adjacent wetlands, surface waterbodies, public and private wells, springs, or other surface and subsurface water features

(9) Proposed construction specifications for wells - provide information that clearly describes:

(a) Method of drilling

(b) Casing

1) Size of annular opening
2) Type, diameter, weight and depth of all casing
3) Use of drive shoes and casing centralizers
4) Type of joint

(c) Grout

1) Type
2) Estimated quantity
3) Method of placement
4) Emergency procedures - lost circulation procedures, etc.

(d) Well completion

1) Type of production pump
2) Plumbness and alignment test
3) Pitless unit or adapter installation

(e) Proposed development procedure

(f) Well logging procedure

(g) Procedure for disposing of cuttings and drilling fluid ensuring that proper erosion and sedimentation controls are used

(h) All unused boreholes which should be properly abandoned or constructed as observation wells, according to PWS standards. *Note:* A certificate of abandonment, signed and sealed by the project geologist, must be included in the permit application in the event that any wells/boreholes are abandoned.

(10) Detailed construction specifications for springs, infiltration galleries, and ranney wells – these must include:

(a) Interception and collection systems

(b) Construction materials and their placement

(c) Overflow piping

(d) Surface water diversion structures

(e) Cleanout drain

(f) Access to collection system

(g) Surface catchment and intake structures

If a groundwater classification is desired, 6 months of daily SWIP monitoring will be required. In addition, two new source sampling events, reflecting a high flow and low flow condition, will be required prior to submitting the permit application. Clearly indicate the existence of a hose bib type sampling port.

(11) All new sources needing to be sampled and then analyzed for the current list of drinking water parameters by a DEP-approved laboratory

(12) The names, addresses and phone numbers of the project geologist, engineer and water supplier

(13) Other agencies such as the Water Management Program or the appropriate river basin commission which may require permits

(14) Resolution of Pennsylvania Natural Diversity Inventory (PNDI) conflicts

e. DEP Advice

Advice given by the regional water supply staff or the engineering staff of the appropriate county health department is not to be construed as representing official approval by DEP. Favorable consideration of design data submitted at a preliminary conference or in a preliminary report in no manner waives the legal requirements for the submission of final plans, specifications, and an engineer's or geologist's report in support of the application for a permit, nor does it waive the right of DEP to require modification of plans which in its judgment do not conform to good professional practice or its requirements.

3. Submission of Application

All applications, reports, final plans and specifications shall be submitted in duplicate to the appropriate regional office (see Table 1.1). The applicant should allow at least 180 days for the processing of an application for a construction permit or major modification, 90 days for a minor modification and 30 days for an operation permit. In some regions, a third copy of the application data may be necessary for submission to a county health department or river basin commission.

Documents submitted for approval of a major modification shall include:

- Application.
- Modules.
- Engineer's report.
- Geologist's report (if applicable).
- Detailed plans.

- Specifications.
- Water quality analyses.
- Permit fee.

The modules, specifications and front cover or flyleaf of each set of plans shall bear the signature and imprint of the seal of the licensed engineer by or under whom it was prepared. In addition, each plan submitted shall bear an imprint or a legible facsimile of such seal. The cover of the geologist's report shall bear the signature and imprint of the seal of the licensed geologist by or under whom it was prepared.

a. Engineer's Report

As a minimum, the engineer's report shall consist of completed copies of the appropriate modules furnished by DEP. All modules pertaining to the project must be included.

A comprehensive engineer's report, covering the following items, shall be prepared where major construction or rehabilitation of a water system is proposed.

(1) General Information

(a) A description of the existing water works

(b) An identification of the municipality or area served

(2) Extent of Water Supply System

(a) A description of the nature and extent of the area to be served

(b) Provisions for extending the water supply system to include additional areas

(c) An appraisal of the future requirements for service, including existing and potential industrial, commercial, institutional and other water supply needs

(3) Justification of Project

Where two or more alternatives exist for providing PWS facilities, each of which is feasible and practicable, discuss the alternates. Give reasons for selecting the one recommended, including financial considerations, operational requirements, operator qualifications, reliability and water quality considerations. Discuss any alternatives considered to prevent pollution, to utilize alternative energy sources, and to enhance energy efficiency.

(4) Water Use Data

(a) A description of the population trends as indicated by available records, and the estimated population which will be served by the proposed water supply system or expanded system 20 years in the future in 5 year intervals or over the useful life of critical structures/equipment

(b) Present water consumption and the projected average and maximum daily demands, including fire flow demand where provided

(c) Present and/or estimated yield of the sources of supply

(d) Unusual occurrences

(5) Fire Flow Requirements

(a) Requirements of the Insurance Services Office (or other similar agency) as to fire flows required or recommended in the service area involved

(b) Fire flows which will be made available by the proposed or enlarged system

(6) Sewerage Facilities

Describe the existing treatment facilities (i.e., onlot) and/or municipal sewage treatment works, with special reference to their location to existing or proposed water sources or structures which may affect the operation of the water supply system, or which may affect the quality of the sources.

(7) Sources of Water

Describe the proposed source or sources of water supply to be developed, the reasons for their selection, and provide information as follows:

(a) Surface Water Sources

1) Summarized data on the quality of the raw water with special reference to fluctuations in quality, changing meteorological conditions, stream flow, etc. (see Section III.B.)

2) Hydrological data, stream flow and weather records

3) Reliable yield, including all factors that may affect it

4) Maximum flood flow, together with approval for safety features of the spillway and dam, from the Bureau of Waterways Engineering

5) Description of the watershed, noting any existing or potential sources of contamination (i.e., sewerage treatment plants, industrial facilities, etc.) which may affect water quality

(b) Groundwater Sources

A separate hydrogeologic report, signed and sealed by a licensed professional geologist, is required with the permit application. See Section III.D.2.

(8) Proposed Treatment Processes

Summarize and establish the adequacy of proposed processes and unit hydraulics for the treatment of the specific water under consideration. Alternative methods of water treatment and chemical use should be considered as a means of reducing waste handling and disposal problems. Bench scale tests, pilot studies, or other demonstrations may be required to establish adequacy for some water quality standards.

(9) Project Sites

(a) Discuss the various sites considered and advantages of the recommended ones.

(b) Establish the proximity of residences, industries, and other establishments that may influence the quality of the supply or interfere with effective operation of the water supply system.

(10) Automation

Provide supporting data justifying automatic equipment, including the servicing and operator training to be provided. Manual override must be provided for any automatic controls. Highly sophisticated automation may put proper maintenance beyond the capability of the plant operator, leading to equipment breakdowns or expensive servicing. Adequate funding must be assured for maintenance of automatic equipment.

(11) Waste Disposal

Discuss the various wastes from the water treatment plant, their volume, proposed treatment and points of discharge (See Section IV.N.). If discharging to a sanitary sewerage system, verify that the system, including any lift stations, is hydraulically capable of handling the flow to the sewage treatment works, that the treatment works is capable of properly treating the wastewater and that the wastewater treatment plant operator will accept the additional loading.

(12) Soil, Groundwater Conditions and Foundation Problems

Provide a description of:

(a) The character of the soil through which water mains are to be laid.

(b) Foundation conditions prevailing at sites of proposed structures.

(c) The approximate elevation of groundwater in relation to subsurface structures.

(13) Future Extensions

Summarize planning for future needs and services.

b. Detailed Plans

Plans shall be legible and shall be drawn to a scale which will permit all necessary information to be correctly shown. The size of the plans should not be larger than 36 inches by 50 inches. The plans shall include topographic maps, general layouts, plan views, elevations, sections and supplementary views which, together with the specifications, provide the information for the contract and construction of the works. The topographic map shall include the location of the existing and potential sources of pollution listed in any reports.

The plans shall include:

(1) The datum used.

(2) The north point.

(3) Boundaries of the municipalities, water districts or specified areas to be served.

(4) Land area owned and/or controlled by the water supplier, including the Zone I wellhead protection area.

(5) Topography of the drainage area and site, including wells, springs, streams, lakes, dams and reservoirs.

(6) The location and outline form of equipment.

(7) Water levels.

(8) Flood levels.

(9) The locations and logs of test borings and wells.

(10) The diameter and depth of well casings and liners.

Each plan shall bear a suitable title showing:

(11) The name of the municipality, authority, company, water district or institution served.

(12) The scale in feet.

(13) A graphic scale.

(14) The date.

(15) The name, address and seal of the design engineer.

c. Specifications

Complete, detailed technical specifications shall be supplied for the proposed project, including:

(1) A program for keeping existing water works facilities in operation during construction of additional facilities to minimize interruption of service.

(2) All additional laboratory facilities and equipment.

(3) The type and design of chemical feed systems and grades of chemicals to be used.

(4) All paints, coatings or other materials which will come into contact with drinking water during and after construction.

(5) All procedures for flushing, disinfecting and testing, as needed, prior to placing the project in service. Disposal of disinfectant water shall be consistent with the requirements of the Clean Streams Law.

d. Water Quality Analyses

All bacteriological, chemical and radiological laboratory analyses shall be performed by laboratories certified by DEP in accordance with the analytical techniques adopted by the United States Environmental Protection Agency (EPA) under the federal act or methods approved by DEP.

C. Innovative Treatment Permits

The risk incurred in experimentation with innovative treatment processes must rest upon the proponent of the method rather than the general public. Recent developments or new equipment may be acceptable if they meet at least one of the following conditions:

- The treatment process has been thoroughly tested in full-scale comparable installations under competent supervision.
- The treatment process has been thoroughly tested in a pilot plant operation for a sufficient time to ensure the technology provides drinking water which meets DEP's drinking water standards under all conditions of raw water quality (see Section I.C.1.).
- Permits for innovative treatment technologies may be limited in duration and may impose additional monitoring, reporting or other requirements deemed necessary to protect the public health.

1. Pilot Plant Studies

Pilot plant studies which are to be conducted to determine the adequacy of new treatment technologies or the suitability of an unconventional treatment scheme must be discussed with the regional water supply engineer prior to initiating the tests. Readers should refer to DEP's *Pilot Plant Filtration Studies for Surface Water Sources Guidance,* DEP ID: 383-2000-208. In addition, the following procedures shall be followed:

a. A report outlining the purpose of the pilot study, the units to be tested and the monitoring procedures to be followed must be submitted to DEP for approval prior to conducting the study. This report must include information on the water quality parameters of concern, seasonal water quality fluctuations, flow rates, chemicals to be used or other information relevant to the specific proposal.

b. The operation, testing and evaluation shall be conducted under the control of an engineer licensed to practice in the Commonwealth and experienced in the design and operation of drinking water treatment systems.

c. A record of all operating problems and the procedures used to correct them shall be maintained and submitted to DEP with the final report summarizing the performance of the system.

D. Conformance to Codes

All installations and operations shall meet or exceed the relevant requirements of the recognized national, state, local or trade good practices codes, whichever has jurisdiction.

1. Electric Power

All electrical equipment and work shall conform to the relevant requirements of the National Fire Protection Association and to the pertinent state and/or local codes.

2. Air or Gas

When air or gas is used under pressure, equipment connected therewith shall conform to the current requirements for unfired pressure containers of the American Society of Mechanical Engineers and to other related provisions of that society's code.

3. Storage Tanks

Applicable facilities shall conform to the current requirements of American Water Works Association's (AWWA) Standards for Welded Steel Tanks for Water Storage, Factory-Coated Bolted Steel Tanks for Water Storage, Wire- and Strand-Wound Circular Prestressed Concrete Water Tanks, Circular Prestressed Concrete Water Tanks With Circumferential Tendons and Thermosetting Fiberglass-Reinforced Plastic Tanks.

4. Chemicals

Where chemicals are used, facilities for the safe storage and handling of chemicals should be provided in accordance with Manual M3, "Safety Practice for Water Utilities," of the AWWA (See Section V.).

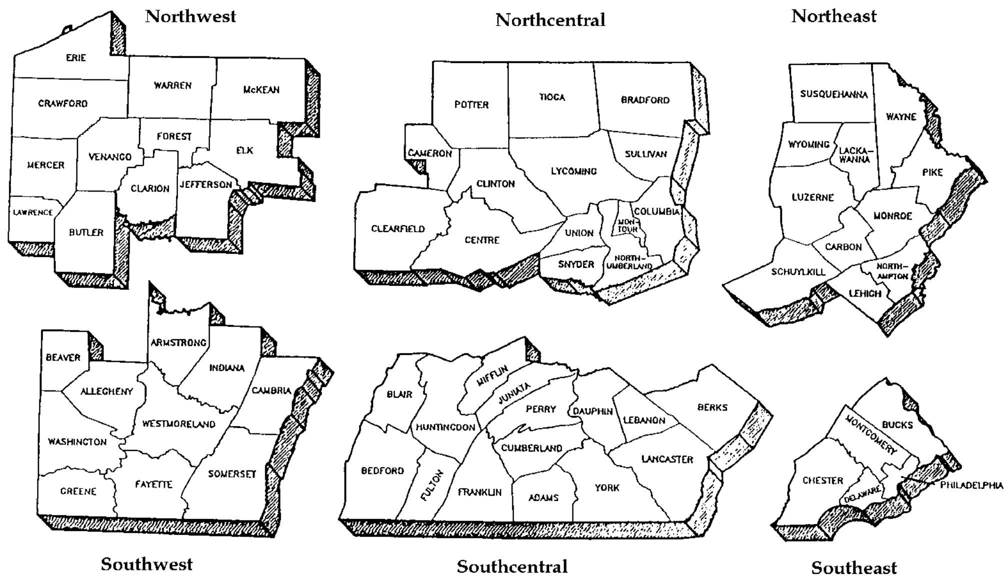
5. Disinfection

Facilities for conveying, treating or storing water which is not subsequently treated shall be disinfected in accordance with the latest edition of the American National Standards Institute (ANSI) and AWWA Standards: C651 - Disinfecting Water Mains, C652 - Disinfection of Water Storage Facilities, C653 - Disinfection of Water Treatment Plants, and C654 - Disinfection of Wells.

6. Wells

All construction materials including, but not limited to, drilling fluids, casing, screens, gravel packs, grout, sealant, etc. shall conform to the current AWWA A100 Standard for Water Wells.

Table 1.1



DEP Regional Offices

Southeast Region
2 E. Main St.
Norristown, PA 19401
Main Telephone: 484-250-5900
24-Hour Emergency: 484-250-5900

Counties: *Bucks, Chester, Delaware, Montgomery and Philadelphia*

Southwest Region
400 Waterfront Drive
Pittsburgh, PA 15222-4745
Main Telephone: 412-442-4000
24-Hour Emergency: 412-442-4000

Counties: *Allegheny, Armstrong, Beaver, Cambria, Fayette, Greene, Indiana, Somerset, Washington and Westmoreland*

Southcentral Region
909 Elmerton Ave.
Harrisburg, PA 17110
Main Telephone: 717-705-4700
24-Hour Emergency: 1-877-333-1940

Counties: *Adams, Bedford, Berks, Blair, Cumberland, Dauphin, Franklin, Fulton, Huntingdon, Juniata, Lancaster, Lebanon, Mifflin, Perry and York*

Northwest Region
230 Chestnut St.
Meadville, PA 16335-3481
Main Telephone: 814-332-6945
24-Hour Emergency: 1-800-373-3398

Counties: *Butler, Clarion, Crawford, Elk, Erie, Forest, Jefferson, Lawrence, McKean, Mercer, Venango and Warren*

Northeast Region
2 Public Square
Wilkes-Barre, PA 18711-0790
Main Telephone: 570-826-2511
24-Hour Emergency: 570-826-2511

Counties: *Carbon, Lackawanna, Lehigh, Luzerne, Monroe, Northampton, Pike, Schuylkill, Susquehanna, Wayne and Wyoming*

Northcentral Region
208 W. Third St., Suite 101
Williamsport, PA 17701
Main Telephone: 570-327-3636
24-Hour Emergency: 570-327-3636

Counties: *Bradford, Cameron, Clearfield, Centre, Clinton, Columbia, Lycoming, Montour, Northumberland, Potter, Snyder, Sullivan, Tioga and Union*

II. PRELIMINARY DESIGN CONSIDERATIONS

A. General

The design of a water supply system or treatment process encompasses a very broad area. Water supply systems must be designed to provide the best quality water for human consumption while giving due consideration to the future grouping or regionalization of water systems where this is feasible. All water treatment facilities should be designed so that they can be readily increased in capacity.

B. Sizing and Capacity

The quantity of water at the source or sources, and the transmission, treatment, storage and distribution facilities should be adequate to supply the water demand of the service area without major additions to the designated design year. For larger projects which require extensive planning, property acquisition and financing (i.e., raw water storage reservoirs), the design period should be, for example, about 50 years. For treatment works and distribution system components whose capacity can be increased without much difficulty, a shorter design period such as 10 years may be appropriate.

1. Minimum Capacities

In general, water supply facilities should be designed on the following basis:

Table 2.1

Basis of Design

System Component	Minimum Capacity
Raw water pumping & transmission facilities	Maximum daily demand with consideration to finished water storage and fire flow demands
Treatment facilities system	Shall exceed the maximum daily demand of the system
Finished water storage	To meet peak hourly demands with consideration to fire flow demands. One day's storage is the recommended minimum.
Distribution system piping, pump stations and appurtenances	Provisions for maximum daily and peak hourly demand at a minimum pressure of 20 psig (pounds per square inch, gauge)

2. Water Demands

In calculating future average, maximum and peak water demands, consideration should be given but not limited to the following:

a. History of past water usage and conservation practices

b. Past and anticipated population growth

c. Types of industry and anticipated growth

d. Fire protection needs

e. Increasing or decreasing trends in water use

f. Water metering practices

g. Availability of municipal sewerage

h. Cost of water

i. Unaccounted for water losses

j. Minimum quantity of potable water

Systems shall be designed to provide at least the minimum quantity of potable water as determined from Table 2.2, and with a minimum flow rate of 2 gallons per minute at each outlet or plumbing fixture.

Table 2.2
Recommended Water Demand Data
(In Gallons Per Day per Capita unless otherwise noted)

User Category	**Demand**
Residential	
Apartments	65
Boarding house, per boarder	75
Boarding house, per resident non-boarder	15
Manufactured housing spaces (per space)	150
Single family residences	75
Commercial	
Airports (per passenger)	3.5
Bar	
Per customer	3

User Category	Demand
Per employee	15
Beauty shops (per operator)	200
Bus service area (no food service)	5
Department stores (per public toilet)	400
Hotels (per room)	100
Laundromat (per washer)	200
Motels (per room)	100
Offices (per employee)	15
Restaurants	
Per patron	10
For bar and/or lounge, add	2
Service station (per vehicle)	10
Shopping Center, per 1,000 ft^2	250
Recreational and Seasonal	
Camps	
Day (no meals served)	15
Hunting and summer residential	50
Campgrounds, per site	
No water or sewer	30
With water only	50
With water and sewer	100
Fairgrounds, Picnic Grounds and Parks	
Toilets only	10
For showers and bathhouses, add	25
Highway rest area	5
Swimming Pools and Bath houses	10
Theater	
Movie (per seat)	5
Drive-in (per space)	5
Work or construction camps	50
Institutional	
Churches	
Per seat	3
Per meal served, add	3
Hospitals (per bed)	150

User Category	Demand
Other institutions (per bed)	100
Prisons (per inmate)	120
Rest/Retirement homes	75
Schools	
No cafeteria, gym or showers	10
With cafeteria only	15
With cafeteria, gym and showers	30
Boarding	75
Industrial	
Factories	35
Warehouses	35

k. Design by analogy

Data from similar uses may be utilized in the case of new systems; however, the designer must be able to clearly show DEP the similarities between the existing uses (whose data are being used) and the proposed facility. The designer should submit a narrative outlining the rationale for the data from similar uses.

C. Facility Siting

Evaluations of all available sites should be made to determine the most favorable location for a particular facility. In addition to considering the following, design engineers are encouraged to consult with the regional water supply engineer and/or hydrogeologist in whose region the project is located.

- Flooding potential facilities should be located above the 100-year flood plain or protected to this level.

- Potential sources of raw water pollution (i.e., sewage, industrial waste, agricultural, mining).

1. Location and Protection

Minimum distances from a well to possible sources of pollution shall be great enough to provide assurances that subsurface flow of contaminated water will not reach the well. Each proposed site should be field surveyed to evaluate the character and location of possible sources of contamination, types of geologic formations present, depth to the water bearing aquifer, direction of groundwater flow and the effect on groundwater movement by well pumping.

a. Location

DEP shall be consulted during the location of a proposed well to determine the required separation between existing and potential sources of contamination.

b. Source Protection

Water suppliers shall control all land within the Zone I wellhead protection area, which is a minimum 100 feet radius. Protection of the proposed groundwater source shall be provided through ownership, easements, deed restrictions or zoning. Activities that may have a potential adverse impact on source quality or quantity shall be prohibited within the Zone I area. Prohibited activities shall include, but not be limited to, roads, pastures, buildings, farming, sewer or stormwater lines, etc. The storage, use or disposal of potential contaminants within the Zone I area shall be discontinued unless the material is used in the production or treatment, or both, of drinking water.

D. Plant Layout and Design

1. Layout

The general layout of the plant should provide for security, functional efficiency and convenience of operation.

a. Properly select and group units to facilitate operation and to permit effective supervision

b. Centralize operations and control

c. Eliminate operational irritants such as unnecessary steps and exposure of operators to adverse weather for routine tasks

d. Provide adequate lighting, heating, ventilation and drainage

e. Provide for accessibility of equipment for operation, servicing and removal

f. Provide for future expansion

g. Provide for expansion of the plant waste treatment and disposal facilities

2. Design

Consideration shall be given to the following factors when designing a new or expanding an existing treatment facility:

a. Need for continuous monitoring and recording facilities for disinfectant residuals (see Section IV.B.) and turbidity levels (see Section IV.D.)

b. Operator safety (consider Occupational Safety and Health Administration (OSHA) requirements)

c. Flexibility of plant operations

d. Simplified chemical handling, storage and feeding

e. Appropriate use of automation

f. Economics of durable construction

g. Simplification and centralization of equipment and operation

h. Dehumidification equipment in damp areas

i. Requirements for storage, shop and laboratory space

j. Need for sanitary facilities for operators and visitors

k. Protection from oil tank or plant chemical spills

l. Use of the following piping color codes:

Table 2.3

Piping Color Codes

Water Lines

Raw or Recycle	Olive Green
Settled or Clarified	Aqua
Finished or Potable	Dark Blue

Chemical Lines

Alum or Primary Coagulant	Orange
Ammonia	White
Carbon Slurry	Black
Caustic	Yellow with Green Band
Chlorine (Gas & Solution)	Yellow
Chlorine Dioxide	Yellow with Violet Band
Fluoride	Light Blue with Red Band
Lime Slurry	Light Green
Ozone	Yellow with Orange Band
Phosphate Compounds	Light Green with Red Band
Polymer or Coagulant Aid	Orange with Green Band
Potassium Permanganate	Violet
Soda Ash	Light Green with Orange Band
Sulfuric Acid	Yellow with Red Band
Sulfur Dioxide	Light Green with Yellow Band

Waste Lines

Backwash Waste	Light Brown
Sludge	Dark Brown
Sewer (Sanitary or Other)	Dark Gray

Other

Compressed Gas	Dark Green
Gas	Red
Other Lines	Light Gray

Notes: (1)In situations where two colors do not have sufficient contrast to easily differentiate between them, a 6-inch band of contrasting color should be painted on one of the pipes at approximately 30-inch intervals.

(2)The name of the liquid or gas, with arrows indicating the direction of flow, also should be painted on the pipe.

E. Laboratory Equipment

Each system shall have its own equipment and facilities for routine laboratory testing necessary to ensure proper operation. Laboratory equipment shall be based on the characteristics of the raw water source and the complexity of the treatment process involved. Laboratory test kits which simplify procedures for making one or more tests are acceptable provided they comply with EPA-approved methods/standards specified in 40 CFR Part 141 and are acceptable to DEP.

1. Testing Equipment

As a minimum, the following laboratory equipment shall be provided:

a. Systems shall provide the necessary facilities for microbiological testing of water from both the treatment plant and the distribution system. DEP may allow deviations from this requirement where testing is conducted by a laboratory certified by DEP.

b. Systems using surface water sources shall have a nephelometric turbidimeter meeting the requirements of "Standard Methods for the Examination of Water and Wastewater" or as approved by DEP.

c. Each surface water treatment plant utilizing flocculation and sedimentation, including those which lime soften, shall have a pH meter, jar test equipment, and titration equipment for both hardness and alkalinity.

d. Each ion-exchange softening plant, and lime softening plant treating only groundwater, shall have a pH meter and titration equipment for both hardness and alkalinity.

e. In addition to the equipment required above, those systems providing for the removal of iron and manganese shall have test equipment capable of accurately measuring iron to a minimum of 0.1 milligrams per liter (mg/L), and/or test equipment capable of accurately measuring manganese to a minimum of 0.05 mg/L.

f. Systems which chlorinate shall have test equipment for determining both free and total chlorine residual by EPA-approved methods.

g. Systems which fluoridate shall have test equipment for determining fluoride by EPA-approved methods.

h. Systems which feed polyphosphates shall have test equipment capable of accurately measuring phosphates from 0.1 to 2 mg/L.

i. Systems which provide treatment for removal of nitrate shall have test equipment for determining nitrate by EPA-approved methods.

2. Monitoring Equipment

All water treatment plants should be provided with equipment to monitor and record water being discharged to the distribution system.

a. Plants treating surface water and/or groundwater under the direct influence of surface water shall have the capability to monitor and record turbidity, pH, temperature and chlorine residual at locations necessary to determine CT disinfection, and other important process control variables as determined by DEP. Continuous monitoring and recording may be required.

b. Plants treating groundwater using iron removal and/or ion exchange softening shall have the capability to continuously monitor and record chlorine residual.

c. Ion exchange plants for nitrate removal should monitor and record the treated water nitrate level daily.

F. Standby Power and Emergency Operation

1. PWSs should be designed to provide adequate water service at all times. Source contamination, transmission line failures, floods and mechanical breakdowns should be taken into account in the design of facilities.

2. Multiple water sources or interconnections with adjacent water systems should be developed wherever possible. Where pumping is necessary, multiple booster pumps which have sufficient capacity to meet peak demands plus fire demand with the largest pump out-of-service are recommended.

3. To ensure reliability under any unusual circumstances, consideration should be given to duplicate equipment, dual supply lines from different power sources, on-site power generation, alternate fuel types and sources, and duplicate substations.

   Auxiliary power units and pumps are recommended in those systems not having adequate gravity storage or supply. Consideration shall be given to the minimum needed power supply to operate all essential equipment. Carbon monoxide detectors are recommended when fuel-fired generators are housed.

4. Plant access roads and power supply lines should be located above the 100-year flood plain.

G. Disposal of Plant Wastes

Consideration shall be given to all the various wastes from the treatment plant, their volume, treatment and ultimate method of disposal. The disposal of water treatment plant wastes, including sanitary wastes, shall conform to applicable local, state and federal regulations (see Section IV.N.). Design engineers should characterize the nature of their plant wastes as accurately as possible so that the necessary approvals required by other department agencies can be expedited.

H. Package Water Treatment Plants

Package water treatment plants are increasingly being considered for production of potable water. DEP individually evaluates proposals for package water treatment plants.

Generally, package plants are pre-engineered for treatment of raw water which is of relatively constant quality. However, many such plants are currently being considered for application on waters of variable quality. Accordingly, it will be necessary to demonstrate to DEP that the desired water quality can be produced under all raw water quality conditions and system flow demands.

Automated equipment and the small size usually associated with package treatment plants may lead the water supplier, plant operator and consulting engineer to assume that these plants will operate themselves. Adequate funding and emphasis must be given to maintenance for all equipment to operate properly. Highly sophisticated automation may put proper maintenance beyond the plant operator's capability and lead to expensive servicing or equipment breakdown.

In addition, special consideration must be given to construction coordination, future budgeting, and the operation and maintenance requirements of these plants. Each water supplier and their consulting engineer must evaluate each of these items, prior to the submission of final plans and specifications.

Due to compressed treatment times, the operation of package treatment plants is even more critical than for conventional treatment plants. As with conventional water treatment plants, a qualified operator must be available at all times in order to make the necessary treatment adjustments.

I. New Technologies and Equipment

New technologies and equipment for the treatment of water are encouraged. However, any new developments must be thoroughly tested under competent supervision before approval is issued for a plant utilizing a new process or equipment. Pending the development of satisfactory performance data, no new water treatment technology or material of construction will be accepted unless the designing engineer or manufacturer presents evidence that the process or material will:

1. Satisfy the design standards, treatment technique requirements and drinking water standards established under Pennsylvania's Safe Drinking Water Act and Regulations.

2. Not impose undue problems of operation, maintenance, supervision or laboratory control.

New or innovative treatment processes or unproven equipment may require the issuance of an Innovative Treatment Technology permit as outlined in Section I.C.

J. Chemicals and Materials

Under the requirements of Section 109.606 of the Safe Drinking Water Regulations, all chemicals or materials (i.e., paints, coatings, liners, etc.) which may come into contact with the raw or finished drinking water must be acceptable to DEP.

Chemicals which may come in contact with or affect the quality of the water and which are certified for conformance with ANSI/NSF Standard 60 (Drinking Water Treatment Chemicals-Health Effects) are deemed acceptable to DEP.

Materials to be used in construction or modification of a public water system, including waterline extensions, certified by a certification agency acceptable to DEP for conformance with ANSI/NSF Standard 61 (Drinking Water System Components - Health Effects - National Sanitation Foundation) are deemed acceptable.

K. Sample Taps

Sample taps shall be provided so that water samples can be obtained from each water source and from appropriate locations for each unit operation of treatment, and from the finished water. Taps shall be consistent with sampling needs and shall not be of the petcock type. Taps used for obtaining samples for bacteriological analysis shall be of the smooth-nosed type without interior or exterior threads, shall not be of the mixing type, and shall not have a screen, aerator or other such appurtenance. Sample taps used for obtaining performance samples from a treatment process shall be located as close as practicable to the treatment process and not be influenced by subsequent treatment processes or appurtenances.

L. Safety

Consideration must be given to the safety of water plant personnel and visitors. The design must comply with all applicable safety codes and regulations. Items to be considered include noise arrestors, noise protection, confined space entry, protective equipment and clothing, gas masks, safety showers and eye washes, handrails and guards, warning signs, smoke detectors, toxic gas detectors and fire extinguishers.

M. Security

Security measures shall be installed and instituted. Appropriate design measures to help ensure the security of water system facilities shall be incorporated. Such measures, as a minimum, shall include means to lock all exterior doorways, windows, gates and other entrances to source, treatment and water storage facilities. Other measures may include fencing, signage, close circuit monitoring, real-time water quality monitoring and intrusion alarms.

III. SOURCE DEVELOPMENT AND CONSTRUCTION

A. General

Each system should maintain more than one source of supply. This may be accomplished by a combination of groundwater and/or surface water sources, or through interconnections with other systems. However, it is DEP's policy to require the use of the best available source(s) of supply with respect to both quantity and quality, taking into consideration the current technology in water treatment needed to provide a safe and potable water for human consumption. In selecting the source or sources of water to be developed, the designing engineer, and geologist, where appropriate, must prove, to the satisfaction of DEP, that an adequate quantity of water will be available and that the water which is to be delivered to the consumers will consistently meet the drinking water standards of DEP.

B. Sampling and Analysis of Proposed Sources

One of the prerequisites for achieving a sound water supply system is a thorough water quality monitoring program. This includes collecting and analyzing a sufficient number of water samples to be able to predict the source water quality under various flow and weather conditions.

1. Sampling Requirements

The minimum number of sample analyses to be performed for each water quality parameter depends on the source. The following DEP technical guidance documents provide the <u>minimum</u> sampling requirements:

New Source Sampling Requirements for Surface Water Sources, DEP ID: 383-3130-108 available on DEP's website

Community and Nontransient Noncommunity Water Systems: New Source Sampling Requirements for Groundwater Sources, DEP ID: 383-3130-208 available on DEP's website

Additional sampling should be considered for those sources that are subject to a high degree of variability. DEP may require that additional sampling be performed depending on source characteristics.

For source types that require more than one round of sampling, the samples should be taken under various meteorological and hydrological conditions. A brief description of the conditions that exist at the time of the sampling (e.g., relative stream flow, amount of recent rainfall, temperature, etc.) shall be provided to DEP with the sample results.

a. Surface Water Sources

Three sets of samples shall be taken for each parameter listed in the *New Source Sampling Requirements for Surface Water Sources*. Sample collection should be spaced such that high, average and low stream flows will be evaluated. Samples shall be taken over a minimum time interval of 6 months and preferably 1 year.

b. Groundwater Sources

At least one set of samples shall be collected at the termination of the aquifer test for the parameters listed in the technical guidance document *Community and Nontransient Noncommunity Water Systems: New Source Sampling Requirements for Groundwater Sources*. Applicants or their consultant must notify Water Supply Management's regional technical services section at least 2 weeks prior to starting the aquifer test. Applicants are further advised to contact their respective river basin commission to verify the length of the aquifer test.

c. Spring Sources, Infiltration Galleries, Ranney Wells

Sampling shall be spaced over a minimum of 1 year, and include the following:

(1) Testing for all required water quality parameters for groundwater. Two sets of samples must be taken, and include both high flow and low flow periods.

(2) Daily spring discharge (in gallons per day) and daily precipitation (to tenths of an inch) for 1 year.

(3) A minimum of 6 months of monitoring according SWIP. A monitoring plan must be approved before data collection.

(4) Additional testing may be required.

d. Karst Sources

If the groundwater source draws from a karst aquifer, dye trace studies may be required since they are the most appropriate method for determining hydrogeologic characteristics.

e. Finished Water Sources

For radionuclides, Volatile Organic Compounds (VOCs), Synthetic Organic Chemicals (SOCs) and Inorganic Compounds (IOCs), the applicant may submit the most recent results of analyses obtained from the selling water system provided the analyses were conducted within the appropriate monitoring schedule and conducted by a DEP-certified laboratory. However, the applicant must provide for their own sampling and analysis of turbidity, total coliforms and total trihalomethanes.

f. Sample Collection

In order to achieve reliable results, proper collection, preparation and storage of the water samples and use of proper sample collecting equipment and techniques is critical. For this reason, water samples shall be collected by a person properly trained by a laboratory certified by DEP for the parameters being tested. For example, the person collecting the VOC sample would require proper training from the lab performing the VOC sample.

2. Sample Analysis

Contact the Bureau of Water Standards and Facility Regulation, P.O. Box 8467, Harrisburg, PA 17105-8467 or your regional office (see Table 1.1) for the current list of DEP's Maximum Contaminant Levels (MCL). Other parameters which a sanitary survey may determine as having a potentially adverse impact on the quality of raw water also should be included in the analyses.

a. Laboratories

All analyses must be performed by a laboratory certified by DEP, except for those that may be performed by a person meeting the requirements of Title 25 Pa. Code §109.704.

C. Surface Water Sources

Surface water sources are defined as all water open to the atmosphere or subject to surface runoff, or sources which are directly influenced by surface water, which may include springs, infiltration galleries, cribs or wells. The term excludes finished water.

Direct influence by surface water may be determined on a case-by-case basis. Direct influence may be indicated by:

- Significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity or pH (which also may change in groundwater but at a much slower rate) which closely correlate to climatological or surface water conditions.

- The presence of insects or other microorganisms, algae, organic debris or large-diameter pathogens such as *Giardia lamblia* as determined by a microscopic particulate analysis.

Where surface water sources are proposed to be used as a source of drinking water, a water allocation permit must be obtained from DEP. Applicants are advised to obtain the water allocation permit prior to preparation of plans and specifications.

1. Source Quantity

The quantity of water at the source shall:

a. Be adequate to meet the maximum projected water demand of the service area as shown by calculations based on a one in 50-year drought or the extreme drought of record, and should include consideration of multiple year droughts.

b. Provide a reasonable surplus for anticipated growth.

c. Be adequate to compensate for all losses such as silting, evaporation, seepage, etc.

d. Be adequate to provide ample water for other legal users of the source.

Where water is drawn from an impounding reservoir or lake, the yield of the reservoir or lake should exceed the estimated future average daily demands for the critical duration of a drought having a recurrence interval of 50 years. Allowances should be made for required water releases, evaporation, seepage and siltation losses.

2. Source Quality

A sanitary survey and study shall be made of the factors, both natural and manmade, which will affect the quality of the water at the source. The results of the sanitary survey shall be submitted to DEP. Such survey and study shall include, but not be limited to:

a. Obtaining samples over a sufficient period of time to assess the bacteriological, physical, chemical and radiological characteristics of the water.

b. Determining future uses and effects of impoundments or reservoirs.

c. Determining the degree of control over the watershed that can be exercised by the owner.

d. Assessing the degree of hazard or vulnerability to the supply by agricultural, recreational and residential activities in the watershed, and by accidental or deliberate spillage of materials that may be toxic, harmful or detrimental to treatment processes.

3. Structures

a. Intakes

Intake structures shall:

(1) Be designed to handle the maximum anticipated daily demand with due consideration to operation under minimum head conditions throughout the design period.

(2) Shall be protected by at least two sets of removable, stationary screens, or by a traveling screen. Screen openings shall be small enough to exclude all matter which will clog.

(3) Have protection against clogging by sediment, debris or ice, and against damage due to wave action and flotation.

(4) Have a velocity of flow through the inlet structure such that frazil ice will be held to a minimum, generally not to exceed 0.5 feet per second.

(5) Have inspection manholes every 1,000 feet for pipe sizes large enough to have visual inspections.

(6) Be able to withdraw water from more than one level if quality varies with depth.

(7) Have separate facilities for release of less desirable water held in storage.

(8) Be accessible during adverse weather conditions.

b. Raw Water Pumping Wells

Raw water pumping well intakes shall:

(1) Have motors and electrical controls located above grade and preferably above the 100-year flood level.

(2) Be accessible during all adverse weather conditions.

(3) Be designed against flotation.

(4) Be equipped with removable or traveling screens before pump suction well.

(5) Provide for introduction of chlorine or other chemicals in the raw water transmission main if necessary for quality control.

(6) Have intake valves and provisions for backflushing or cleaning by a mechanical device and testing for leaks where practical.

(7) Have provisions for withstanding surges where necessary.

4. Impoundments and Reservoirs

a. Site Selection

Site selection shall give consideration to:

(1) Topography and geology.

(2) Storage capacity required.

(3) Safety.

(4) Water rights.

(5) Raw water characteristics.

(6) Proximity to sources of pollution.

(7) Accessibility during adverse weather conditions.

b. Site Preparation

Site preparation shall provide:

(1) Removal of brush and trees to a level of 10 feet above the anticipated high water elevation.

(2) Protection from floods during construction.

c. Site Construction

Where earth disturbance will occur, an Erosion Control Plan must be developed and retained at the construction site for the duration of the earth moving activities.

D. Groundwater Sources

The total developed source capacity should equal or exceed the design maximum day demand and equal or exceed the design average day demand with the largest producing source out-of-service. Groundwater includes all water from dug, drilled, bored, jetted or driven wells; infiltration galleries; or springs. Groundwater sources that are directly influenced by surface water are classified as surface sources and will require treatment as a surface source.

1. Aquifer Testing

a. Purpose

In accordance with Title 25 Pa. Code §109.503(a)(1)(iii)(C), a properly designed constant-rate (also referred to as constant-discharge) aquifer test shall be conducted on any well proposed as a new source in order to adequately define the hydraulic characteristics of the aquifer and well. Data from the test shall be subject to appropriate analysis to demonstrate the suitability of the well as a long-term source of public drinking water including, when necessary, the evaluation of significant potential impacts from the groundwater withdrawal. The analysis and interpretation of the test shall be performed by a professional geologist licensed in the Commonwealth of Pennsylvania as a component of the hydrogeologic report described in Section III.D.2. The results derived from properly conducted and analyzed aquifer tests will also provide water suppliers with the data necessary to support informed decision making on water supply management and planning issues.

As provided in the regulations, these procedures may be altered at the discretion of DEP for wells or wellfields that will be pumping less than 100,000 gallons per day. For water supply systems proposing to withdraw greater than 100,000 gallons per day, appropriate River Basin Commission regulations may also apply.

b. Design

Proper design implies that sufficient planning is undertaken to ensure that the test will provide acceptable results for the anticipated site conditions. A conceptual understanding of the hydrogeologic setting of the site is required to design and interpret aquifer test results. Information necessary to develop a conceptual model includes the lithology, depth, thickness, position, extent and structural trends of the water-bearing formations and confining strata; nature and location of hydrologic boundaries; and the regional hydrogeologic framework. Evaluation of impacts on other water resources from the proposed withdrawal must also be factored into the design of the test.

c. Observation Points

In order to allow data analysis by time-drawdown and distance-drawdown methods, the use of appropriate observation wells is required for aquifer tests. An observation point may be an existing well with appropriate construction that is not being pumped during the aquifer test or a well constructed for the sole purpose of obtaining water level measurements.

At least two observation points are required, although it is strongly recommended that a minimum of three be used as this will generally provide a more representative test and result in a better final analysis.

Situations involving vertical leakage, hydrogeologic boundaries or withdrawal impacts may warrant the use of more. The observation points should generally have screened or open intervals similar to the production well. If hydraulic connection between different formations is a concern, there should also be observation points that are screened above or below the producing aquifer as appropriate.

Observation points should be located at increasing distances from the pumping well so that at least one logarithmic cycle of distance-drawdown data is provided. A typical spacing would be approximately 100, 400 and 1,000 feet from the production well. Alignment will generally vary depending on the location of boundaries and type of aquifer. Actual distances and orientation of observation points relative to the production well may be constrained by topographic limitations or land availability. In anisotropic aquifers, no two observation points should be radially aligned with the pumping well.

The effect of withdrawal on nearby wells, springs, wetlands, streams or other surface or subsurface water features should also be monitored. As appropriate, water levels in wells should be monitored and any available information (owner, construction details, depth, diameter, geology etc.) should be included. Surface waterbodies with no outflow such as ponds and wetlands should be monitored via staff gages or piezometers. A piezometer may be installed adjacent to the surface waterbody being monitored, if the screened interval is representative of the material underlying the surface waterbody. Surface waterbodies with outflow such as streams, ponds or wetlands should be monitored in both the upstream and downstream directions via weirs, flumes, stilling wells and/or piezometers. Spring flow or stage should be monitored utilizing weirs, flumes and piezometers to characterize the hydrogeologic effect of withdrawal.

d. Testing Procedures

A successful aquifer test requires knowledge of the antecedent water level trend, a carefully controlled constant pumping rate and accurate measurements of water levels in the production well and observation points at appropriate time intervals during both drawdown and recovery periods.

The test should be scheduled to avoid heavy rain events or subsequent rapid changes in water table elevation. Two-week advance notification must be given to DEP to allow the scheduling of water quality samples and a microscopic particulate analysis at the termination of the test.

Adequate planning and design shall allow for the constant-rate aquifer test to be conducted on a properly constructed and developed production well according to these procedures:

(1) Prior to the test, background water level measurements shall be taken from the production well, all observation points and other water resources of concern at 3-hour intervals over at least a 72-hour period to establish natural water level trends. If possible, the effects from other pumping wells in the area should be controlled by having them turned off or by maintaining the pumping at a constant rate during the test. Especially for confined aquifers, antecedent barometric pressure should also be recorded, preferably on-site at the same frequency as the water levels.

(2) A step-drawdown test and analysis shall be performed to determine a sustainable pumping rate for the aquifer test. There should be at least 3 successive equal stages of increased pumping. At each step, the pumping rate is held constant generally for 1 hour to assess drawdown response. The pumping rate is increased at a constant fraction (e.g., increments of one-third for 3 steps) with the last step having a rate equal to the desired production rate. Drawdown in the pumping well should be recorded every 5 minutes during each step. When a step-drawdown test is performed prior to the aquifer test, water levels must be allowed to recover to at least 90 percent of the original pre-pumping level. The constant-rate aquifer test may not be a continuation of the last step of the step-drawdown test.

(3) The production well shall be pumped at the rate indicated by the step-drawdown test and discharge must be kept within 5 percent of the constant rate. The well will not be permitted for a pumping rate greater than the sustainable constant rate. The discharge rate must be checked frequently at the beginning of the test and periodically throughout the test. Significant variations in pumping rates may be grounds for rejecting the results of an aquifer test. The discharge must be conveyed away from the pumping well, observation wells and other monitoring points to prevent artificial recharge of the aquifer. Proper erosion and sedimentation controls shall be utilized and any necessary discharge approvals shall be obtained prior to pumping.

(4) Barometric pressure and any precipitation amounts should be recorded on-site at a frequency of every 3 hours beginning 72 hours before the test and throughout the test and recovery period. Any changes in these measurements should be factored into the aquifer drawdown data analysis.

(5) Water levels in the production well and all observation points shall be accurately measured to the nearest 0.01 foot. Drawdown shall be reported in decimal feet. More frequent measurements are critical during the early part of the test as water levels generally decline rapidly. A sample 48-hour *Constant Rate Aquifer Test Data Form* (3800-FM-WSFR0087) and *Aquifer Test Recovery*

Data Form (3800-FM-WSFR0088) should be used to provide the raw data from the test. These forms are available on DEP's website. If automated recording devices are used, manual measurements should be performed occasionally as a check and to provide backup measurements in the event of equipment malfunctions. Loss of data from recording system malfunctions and no backup measurements may be grounds for rejecting the results of an aquifer test. For other water resources of concern such as wetlands, ponds and streams, water levels or flows shall be recorded at least every 3 hours throughout the test or as pre-approved by DEP.

Table 3.1

Frequency of Water Level Measurements for the Production Well and Observation Points During an Aquifer Test

Time Since Pumping Started	Time Between Measurements
0-10 minutes	1 minute
10-30 minutes	5 minutes
30 minutes-1 hour	10 minutes
1-6 hours	30 minutes
6-24 hours	1 hour
24 hours-termination	2 hours

(6) The duration of the aquifer test for confined aquifers shall be a minimum of 48 hours if sufficient information is available prior to the test to demonstrate the aquifer is confined. Boundary conditions may require additional monitoring. For unconfined aquifers (such as most fractured-bedrock aquifers), the length of the aquifer test will be a minimum of 48 hours. A longer test may be required to evaluate aquifer boundary conditions and well capabilities, as well as potential impacts to existing water supplies and the environment. All tests should be continued until drawdown has relatively stabilized.

(7) At the conclusion of the aquifer test, water samples shall be collected from the production well for chemical analysis in accordance with DEP's New Source Sampling requirements. Also, a Microscopic Particulate Analysis (MPA) may be required if surface water identification protocol criteria is met.

(8) After termination of the test, water level recovery in the production well and observation points shall be recorded on the *Aquifer Test Recovery Data Form*, using the same frequency for drawdown measurements, with the time that pumping stops as the starting time. For other water resources of concern, water levels or flows

shall be recorded every 3 hours. The recovery period must be monitored for at least 24 hours or until water levels have recovered by 90 percent, whichever is longer.

e. Analysis and Interpretation

Various methods for the analysis of aquifer tests are available and are discussed in numerous textbooks and other publications. The selection of a method to analyze the data and subsequently interpret the results requires an understanding of the hydrogeologic system and the underlying assumptions of the analytical method. The analysis and interpretation of an aquifer test shall be performed by a professional geologist licensed by the Commonwealth of Pennsylvania. The components of the hydrogeologic report are described in Section III.D.2. The analysis and interpretation of aquifer test data shall include:

(1) All data collected during the aquifer test. Include pre-test, drawdown and recovery phases for the production well and all observation points. As appropriate, drawdown and recovery data should be corrected to compensate for any significant external influences (barometric pressure, tides, etc.).

(2) Plots of step test-drawdown (semi-log), time-drawdown (log-log and semi-log), distance-drawdown (semi-log), time-recovery (semi-log) and any other relevant plots, including a copy of any type curves and match points that are used in the analysis. Log-log plots utilizing dimensionless drawdown and time (W(u) and 1/u) must also be plotted in terms of time and drawdown.

(3) Determination of aquifer transmissivity and storage coefficient using a method best suited for the conceptual model of the site. Evaluation of the data using several methods may be necessary. The analysis should include method selected, justification of the method and how well the assumptions implicit to that method apply. Apparent boundary effects should also be identified and discussed. Equations used (including units) and calculations must be provided. Analysis of recovery data should not be overlooked as it can provide a check on the results obtained from the pumping data.

(4) Determination of the hydraulic conductivity, specific capacity and estimation of the zone of influence (horizontal extent of the cone of depression). Various analytical methods are available to calculate the radius of influence based on certain aquifer assumptions. The Jacobs distance-drawdown method is one example.

(5) Determination of a dependable yield for the well by considering the drawdown at observation points, available drawdown for the

production well, natural recharge/discharge, any well interference effects, impacts on other water resources and the hydraulic characteristics of the aquifer system. The analysis shall include the effects of 180 days of pumping with no recharge as a severe drought scenario. For complex situations involving potential impacts on other water resources, groundwater modeling should be considered.

(6) The extent of impact and how these impacts will be mitigated or remediated if impacts are noted at observation points.

2. Hydrogeologic Report

A hydrogeologic report, signed and sealed by a professional geologist licensed in the Commonwealth of Pennsylvania, should contain the following information on each proposed source:

a. Geologic setting or conceptual model of the project area with emphasis on hydrogeologic aspects (supply appropriate citations if taken from published literature.)

b. Stratigraphic log for each well drilled, identifying the following:

(1) Lithology, color, minerals, grain size and shape, sorting, nature of contact, fractures and other structural features, etc.

(2) All formation changes

(3) All water-bearing zones and associated yields

(4) Static water level

c. As-built cross section for each well, that shows:

(1) Type, size, weight and depth of all casing(s)

(2) Drive shoes and casing centralizers

(3) Amount, type and depth of grout

(4) Screened intervals/gravel pack

(5) Static water level and date measured

(6) Depth of production pump setting

(7) All water-bearing zones and associated yields

d. A copy of the completed Water Well Inventory Report.

e. Aquifer Test

The length of the aquifer test will be a minimum of 48 hours. A longer test may be required to evaluate aquifer and well capabilities, as well as potential impacts to existing water supplies and the environment. Aquifer characteristics should be determined using time and distance-drawdown methods, along with appropriate justification and discussion. Include:

(1) Pre-pumping static water level.

(2) Depth of test pump setting.

(3) Starting and ending time of test cycle.

(4) Pumping rate.

(5) Step-drawdown data and graph.

(6) Time-drawdown curves for production well and observation points.

(7) Time-recovery curves for production well and observation points.

(8) Residual drawdown vs. t/t' recovery analysis.

(9) Raw drawdown and recovery data from the production well and all observation points. Include time since pumping began (in minutes), water elevations (from below ground level), drawdown (in feet and tenths) and discharge (in gpm).

(10) Distance-drawdown curves using data from a minimum of two observation points.

(11) Precipitation events noted on each curve.

(12) Identification and explanation of irregularities, abrupt slope changes, etc. in graphs.

f. Aquifer characteristics - **show equations used and calculations.**

(1) Hydraulic conductivity

(2) Transmissivity

(3) Storage coefficient

(4) Specific capacity

g. Dependable source yield with justification.

h. Any other information that describes the hydraulic characteristics of the aquifer and demonstrates the suitability of the proposed source.

i. Proof of the supplier's ability to control the Zone I wellhead protection area.

j. Spring Information

The following information is required for springs:

(1) Geological information

(a) Results of discharge and sampling studies

(b) Topographic map of contributing watershed

(c) Description of the vertical and horizontal extent of the source aquifer

(d) Formation name

(e) Spring type (i.e., diffuse vs. conduit flow; seepage, fracture, tubular, ebbing and flowing) including justification/observations

(f) Physical characteristics of spring and immediate surroundings

(2) Construction details should include:

(a) Interception and collection systems.

(b) Diversion structures at spring discharge.

(c) Construction materials and their placement.

(d) Overflow piping.

(e) Surface water diversion structures.

(f) Cleanout drain.

(g) Access to collection system.

(h) Surface catchment and intake structures.

k. Sample Results

Include the following sampling results:

(1) New source sampling for each production source

(2) Microscopic particulate analysis, if applicable

(3) Any other additional sampling, such as dye trace results, stream monitoring, SWIP monitoring, etc.

l. Discussion of other applicable permits or approvals which may be required (Include proof of resolution of PNDI conflicts.)

m. A description of potential impacts that using the new source will, or could have, on adjacent wetlands, surface waterbodies, private or public wells, springs or other adjacent surface and subsurface water features. Discuss how the new source is hydraulically connected to the impacted feature, the anticipated extent of impact, and any proposed remediation or mitigation. The discussion must meet the requirements of DEP's *Screening Criteria on Water Quality/Quantity Impacts for Drinking Water Permits*, DEP ID: 383-2131-001, available on DEP's website.

3. General Well Construction

a. Plumbness and Alignment

Every well shall be tested for plumbness and alignment in accordance with AWWA's Standard A100 for Water Wells. The test method and allowable tolerances shall be clearly stated in the specifications.

As a minimum, a 40-foot section of pipe or rigid dummy of the same length, having an outside diameter of not more than 0.5 inch less than the inside diameter of the well casing or hole being tested, should move freely throughout the length of the well casing or hole to the lowest anticipated pump setting.

b. Minimum Protected Depths

All drinking water supply wells and observation wells shall be constructed to be watertight to such depths as may be necessary to exclude pollution from surface runoff and from polluted aquifers above the aquifer being used as a source of supply. In consolidated rock formations, if steel casing is used, the casing shall be equipped with a drive shoe and seated by driving it into the surface of the consolidated formation until a seal is obtained. If nonferrous casing is used, it must be seated into the rock for a length of at least 5 feet (1.5 meters), and must be cemented in place. In unconsolidated formations, the permanent casing and grout shall extend at least 50 feet below original or final ground elevation, whichever is lower.

c. Temporary Casings

Temporary casings used for construction shall be capable of withstanding the structural load imposed during its installation and removal.

d. Well Casing Material

Protective casing of wrought iron or steel shall have minimum weights and thickness as specified in AWWA's Standard A100 for Water Wells. Well casing material other than wrought iron or steel must be resistant to the corrosiveness of the water and to the stresses to which it will be subjected during installation, grouting and operation. Casing and grouting materials must be compatible. In general, the criteria established in AWWA's Standard A100 for Water Wells should be followed.

(1) Ferrous casings shall:

(a) Be new pipe meeting American Society for Testing and Materials (ASTM) or American Petroleum Institute (API) specifications for water well construction.

(b) Have additional thickness and weight if minimum thickness is not considered sufficient to ensure reasonable life expectancy of the well.

(c) Be capable of withstanding forces to which it is subjected.

(d) Be equipped with a drive shoe when driven.

(e) Have full circumferential welds or threaded pipe joints.

(2) Polyvinyl chloride plastic (PVC) well casing

DEP may approve the use of PVC casing for all or for limited applications. Where approved, PVC casing, as a minimum:

(a) Shall be new pipe meeting ASTM F480 and ANSI/NSF Standard 61 and be appropriately marked.

(b) Shall have a minimum wall thickness equivalent to Standard Dimension Ratio (SDR) 21 diameters of 8 inches or greater may require greater thickness to meet collapse strength requirements.

(c) Shall not be used at sites where permeation by hydrocarbons or degradation may occur.

(d) Shall be properly stored in a clean area free from exposure to direct sunlight.

(e) Shall be assembled using couplings or solvent welded joints. All couplings and solvents shall meet ANSI/NSF Standard 14, ASTM F480, or similar requirements.

(f) Shall not be driven.

(3) Other nonferrous casing shall meet appropriate ANSI/ASTM or NSF Standards for well casing applications as outlined in AWWA's Standard A100 for Water Wells. Nonferrous casing materials shall not impart taste, odor or toxic substances to the well water. Nonferrous casing, if used, shall not be driven. The casing shall be placed a minimum of 5 feet into the consolated formation with a minimum annular opening of 3 inches larger than the outside diameter of the casing so that grout can be placed in accordance with Section III.D.3.h.

e. Packers

Packers shall be of materials that will not impart taste, odor, toxic substances or bacterial contamination to the well water.

f. Screens

Well screens, when used, should:

(1) Provide the maximum amount of open area while still maintaining structural strength.

(2) Have the size of openings in the screen based on a sieve analysis of the material contained in the surrounding geological formation or gravel pack.

(3) Be constructed of materials resistant to damage by chemical action of groundwater or cleaning operations.

(4) Have sufficient diameter to provide adequate specific capacity and low aperture velocity. Usually, the entrance velocity should not exceed 0.1 feet per second.

(5) Be installed so that the pumping water level remains above the screen under all operating conditions.

(6) Be designed and installed to permit removal or replacement without adversely affecting watertight construction of the well.

(7) Be provided with a bottom plate or wash down bottom fitting of the same material as the screen.

g. Chemical Conditioning

In general, specifications covering the chemical conditioning of wells shall be submitted to DEP for approval. Chemical conditioning procedures shall be included in the specifications as to method, equipment, chemicals, testing for residuals, disposal of wastes and inhibitors used. Chemicals used during conditioning shall be acceptable to DEP. Chemicals certified under ANSI/NSF Standard 60 are deemed acceptable to DEP.

h. Grouting

All permanent well casings shall be surrounded by a minimum of 1.5 inches of grout the entire length of casing, unless prior approval is obtained from DEP. Grouting materials shall conform to AWWA standards.

(1) Application

(a) All grouting shall be performed by adding the mixture, from the bottom of the annular opening upward, in one continuous operation until the annular opening is filled.

(b) When the annular opening is less than 4 inches, grout shall be installed under pressure by means of a grout pump in one continuous operation.

(c) After grouting is applied, work on the well shall be discontinued until the grout has properly set.

(d) Alternate methods may be approved by DEP on a case-by-case basis.

(2) Guides

The protective casing must be provided with sufficient guides welded to the casing to permit unobstructed flow and uniform thickness of grout.

i. Upper Terminal Well Construction

(1) Casing length shall extend 18 inches above final grade or well house floor, whichever is greater.

(2) Where a well house is constructed, the floor surface shall be at least 6 inches above the final ground elevation.

(3) The top of the well casing at sites subject to flooding should terminate at least 3 feet above the highest known flood elevation or as may be directed by DEP.

(4) Wells shall not be constructed in pits.

j. Well Development

Every well shall be developed to remove the native silts and clays, drilling mud and/or the finer fraction of the gravel pack. Development should continue until the maximum specific capacity is obtained from the completed well.

k. Capping

A welded metal plate or bolted and locked cap shall be the minimum acceptable method of capping a well. The well shall also be equipped with a sanitary seal.

l. Well Abandonment

(1) All abandoned wells, observation points and test wells which are not to be used shall be sealed by such methods as necessary to restore the controlling hydrogeologic conditions which existed prior to construction. The well abandonment procedures outlined in AWWA's Standard A100 for Water Wells and DEP's *Groundwater Monitoring Guidance Manual*, DEP ID: 383-3000-001, available on DEP's website, should be followed. An abandonment plan should be submitted and approved prior to well abandonment.

4. Special Construction Methods

a. Radial Water Collectors

(1) Locations of all caisson construction joints and porthole assemblies shall be indicated.

(2) The caisson wall shall be reinforced to withstand the forces to which it will be subjected.

(3) Provisions shall be made to assure that radial collectors are essentially horizontal.

(4) The top of the caisson shall be covered with a watertight floor.

(5) All openings in the floor shall be curbed and protected from entrance of foreign material.

(6) The pump discharge pipe shall not be placed through the caisson walls.

b. Infiltration Lines

(1) Infiltration lines may be considered only where geological conditions preclude the possibility of developing an acceptable drilled well.

(2) The area around infiltration lines shall be under the control of the water supplier for a distance acceptable to DEP.

(3) Flow in the lines shall be by gravity to the collecting well.

(4) Water from infiltration lines shall be considered as groundwater under the direct influence of surface water unless demonstrated otherwise.

c. Dug Wells

A dug well may not be used as a source of supply for a community system.

d. Naturally Flowing Artesian Wells

(1) Flow from a naturally flowing artesian well shall be controlled.

(2) Casing shall be set in the impermeable (confining) layer.

(3) The well shall be pressure grouted to ensure a proper seal around the casing.

(4) Pitless adapters shall be welded or screwed onto the casing. Compression fittings shall not be used.

5. Well Pumps, Discharge Piping and Appurtenances

a. Line Shaft Pumps

Wells equipped with line shaft pumps shall:

(1) Have the pump structure effectively sealed to the well casing to prevent entrance of surface water.

(2) Have the casing firmly connected to the pump structure or have the casing inserted into a recess extending at least 0.5 inch into the pump base.

(3) Have the pump foundation and base designed to prevent water from coming into contact with the joint.

b. Submersible pumps

Where a submersible pump is used:

(1) The top of the casing shall be effectively sealed against the entrance of water under all conditions of vibration or movement of conductors or cables.

(2) The electrical cable should be firmly attached to the riser pipe at 20 foot intervals.

c. Discharge piping

(1) Discharge piping shall:

(a) Have control valves and appurtenances located above the pump house floor when an aboveground discharge is provided.

(b) Be protected against the entrance of contamination.

(c) Be equipped with a check valve (in addition to any check valve within the well), a shutoff valve, a pressure gauge, a means of measuring flow and a smooth nosed sampling tap located at a point where positive pressure is maintained.

(d) Where applicable, be equipped with an air release-vacuum relief valve located upstream from the check valve, with exhaust/relief piping terminating in a downturned position at least 18 inches above the floor and covered with a 24-mesh corrosion resistant screen.

(e) Be valved to permit test pumping and control of each well.

(f) Have all exposed piping, valves and appurtenances protected against physical damage and freezing.

(g) Be properly anchored to prevent movement.

(h) Be protected against surge or water hammer.

(2) The discharge piping should be provided with a means of pumping to waste, but shall not be directly connected to a sewer. Piping and valves should be installed in a manner that allows pumping of the well to waste at the permitted rate while not affecting the status of other permitted sources.

d. Pitless Well Units

(1) Pitless units shall:

(a) Be shop-fabricated from the point of connection with the well casing to the unit cap or cover.

(b) Be threaded or welded to the well casing, or use compression fittings certified by the Water Systems Council under Recommended Standards (PAS-1).

(c) Be of watertight construction throughout.

(d) Be of materials and weight at least equivalent and compatible to the casing.

(e) Have field connection to the lateral discharge from the pitless unit of threaded, flanged or mechanical joint connection.

(f) Terminate at least 18 inches above final ground elevation, or 3 feet above the highest known flood elevation, whichever is higher, or as DEP directs.

(2) The design of the pitless unit shall make provision for:

(a) Access to disinfect the well.

(b) A properly constructed casing vent meeting the requirements of Section III.D.5.e.

(c) Facilities to measure water levels in the well (see Section III.D.5.f.).

(d) A cover at the upper terminal of the well that will prevent the entrance of contamination.

(e) A contamination-proof entrance connection for electrical cable.

(f) An inside diameter as great as that of the well casing, up to and including casing diameters of 12 inches, to facilitate work and repair on the well, pump, or well screen.

(g) At least one check valve within the well casing.

(3) If the connection to the casing is by field weld, the shop-assembled unit must be designed specifically for field welding to the casing. The only field welding permitted will be that needed to connect a pitless unit to the casing.

(4) The grouting of wells using pitless well units shall conform to the applicable criteria of Section III.D.5.g. except that grout shall only be placed to a level immediately below the point where the adapter is connected to the well casing.

e. Casing Vent

Provisions shall be made for venting the well casing to the atmosphere. The vent shall terminate in a downturned position, at or above the top of the casing or pitless unit, no less than 18 inches above grade or floor or 3 feet above the highest known flood elevation, whichever is higher, or as DEP directs. The vent shall have a minimum 1.5-inch diameter opening covered with a 24-mesh corrosion resistant screen. The pipe connecting the casing to the vent shall be of adequate size to provide rapid venting of the casing. Where vertical turbine pumps are used, vents into the side of the casing may be necessary to provide adequate well venting. Installation of these vents shall be in accordance with the requirements of DEP.

f. Water Level Measurement

(1) Provisions shall be made for periodic measurement of water levels in the completed well.

(2) Installation of permanent water level measuring equipment shall be made using corrosion resistant materials attached firmly to the drop pipe or pump column and in such a manner as to prevent entrance of foreign materials.

g. Observation Points

Observation points shall be:

(1) Constructed in accordance with the requirements for permanent sources if they are to remain in service after completion of a water supply source.

(2) Protected at the upper terminal to preclude entrance of foreign materials.

h. Wellhead Security

All production and monitoring wells shall be constructed to deter vandals. At a minimum, all wellheads shall be protected by at least one of the following:

(1) Installation of a locked cap.

(2) Installation of security fencing.

(3) Enclosure within a lockable building.

IV. TREATMENT

A. General

The design of a water treatment plant must take into consideration the quality of the raw water and the desired quality of the finished water. The following sections set forth generally accepted design criteria for treatment processes which, when properly sequenced and utilized, can be expected to meet DEP's drinking water standards. The ability to respond to more stringent water quality requirements also should be considered when designing a treatment plant.

B. Disinfection

Continuous disinfection of drinking water is required of all systems. Chlorine and its compounds are the preferred disinfecting agents for the disinfection of drinking water.

Disinfecting agents other than chlorine can be used provided reliable application equipment is available and testing procedures for a residual are recognized in *Standard Methods for the Examination of Water and Wastewater*, latest edition. These methods of disinfection will be considered on a case-by-case basis. Testing and recording equipment must conform to the requirements of Section IV.B.1.k. Consideration must be given to the formation of disinfection byproducts (DBP) when selecting the disinfectant.

Systems which use surface water as a source of supply and serve 500 or more persons also must install continuous disinfectant residual monitoring and recording equipment. All systems which provide filtration of surface sources shall be designed in such a way that the combined total effect of the disinfection processes, by themselves, achieves a 99.9 percent (3 log) inactivation of *Giardia* cysts and a 99.99 percent (4 log) inactivation of enteric viruses. This is to be determined by Concentration-Time (CT) factors and measurement methods established by EPA*.

*Refer to AWWA Research Foundation's publication *Disinfectant Residual Measurement Methods*, publication no. 90528, or EPA's *Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources*.

1. Chlorination (also see Sections V.D. and V.E.)

   a. Chemical Types

      Disinfection may be accomplished with liquid chlorine, calcium or sodium hypochlorites, or chloramines.

   b. Feeding Equipment

      Solution-feed gas type chlorinators are preferred. For small supplies, hypochlorite feeders of the positive displacement type may be used.

c. Capacity

The chlorinator capacity shall be such that a free chlorine residual of at least 2 mg/L can be attained in the water once all demands are met after a minimum contact time of 20 minutes. This condition must be attainable even when maximum flow rates coincide with anticipated maximum chlorine demands. The equipment shall be of such design that it will operate accurately at both minimum and maximum flow rates without the use of standby equipment.

d. Chlorine Residuals

(1) Filtered Surface Water Sources

The design of chlorination equipment shall be such that a chlorine residual, capable of achieving a minimum 90 percent (1 log) inactivation of *Giardia* cysts following filtration, will be maintained in the water delivered to the distribution system prior to the first customer. The capabilities of the equipment and inactivation processes are to be based on the CTs (disinfectant residuals X contact time) and measurement methods established by EPA.

The minimum disinfectant residual entering the distribution system shall not be less than 0.2 mg/L and at distant points in the distribution system not less than 0.02 mg/L at any time. Higher residuals may be required depending on the pH, temperature and other characteristics of the water. Because chloramines are less effective than free chlorine, chloramine residuals should not be less than 1.0 mg/L at all points in the distribution system. The design of the disinfection facilities also must be capable of maintaining a chlorine residual of 2.5 mg/L throughout the entire distribution system to disinfect the system in the event of *Giardia* contamination.

(2) Groundwater Sources

For groundwater sources not subject to surface water influence or contamination, the minimum disinfectant residual entering the distribution system after a minimum of 20 minutes contact time, shall not be less than 0.2 mg/L and at distant points in the distribution system not less than 0.02 mg/L. Because chloramines are less effective than free chlorine, chloramine residuals should not be less than 1.0 mg/L at all points in the distribution system. Higher residuals may be required depending on the pH, temperature and other characteristics of the water.

e. Standby Equipment and Spare Parts

Standby chlorination equipment of sufficient capacity shall be available to replace the largest unit during shutdown. Spare parts and tools should be available for emergency replacements, repairs and preventive maintenance for each type of chlorinator in service and shall be provided at any chlorination facility which is operated unattended. Automatic switchover devices for chlorine cylinders are recommended to ensure continuous disinfection.

f. Contact Time and Point of Application

(1) For systems which use groundwater sources not subject to surface water influence or contamination, a minimum of 20 minutes detention shall be provided with due consideration being given to the pH, temperature, bacterial quality, ammonia content, organic levels, metals concentrations and other pertinent raw water quality factors. All detention basins used for disinfection shall be designed to minimize short-circuiting. Provisions should be made for applying chlorine prior to detention and before entering the distribution system.

(2) For systems providing filtration of surface water sources, the design of the disinfection facilities shall provide a sufficient number of chlorine application points to ensure the disinfection processes by themselves are capable of achieving a 99.9 percent inactivation of *Giardia* cysts and 99.99 percent inactivation of enteric viruses using CT values and measurement methods established by EPA. All detention basins used for disinfection shall be designed to minimize short-circuiting. Provisions shall be made for applying chlorine to the raw water, applied water, filtered water and water entering the distribution system.

(3) Where chlorination is provided at more than one stage in the treatment process, separate regulators shall be provided at each stage.

g. Automatic Proportioning

Automatic proportioning chlorinators are required where the rate of flow or chlorine demand may vary significantly.

h. Injector

Each injector must be sized and located with particular attention given to the quantity of chlorine to be added, the maximum injector waterflow, the total discharge back pressure, the injector operating pressure and the size of the chlorine solution line. Gauges for measuring water pressure and vacuum at the inlet and outlet of each injector should be provided.

i. Diffuser

Chlorine solution diffusers shall be compatible with the point of application to provide a rapid and thorough mix with all the water being treated. The center of a pipeline is the preferred application point.

j. Scales

Scales for weighing cylinders shall be provided at all water works using chlorine gas. At large water works, scales of the indicating and recording type are recommended. Where ton cylinders are used, the required number of trunnions shall be provided to allow for cylinder rotation. At small plants, at least a platform scale, including cylinder restraints, shall be provided. Scales shall be of corrosion-resistant material, and have a dial accuracy of better than 1 percent.

k. Testing Equipment

Chlorine residual test equipment recognized in the latest edition of "Standard Methods for the Examination of Water and Wastewater'' shall be provided and must be capable of measuring residuals to the nearest 0.01 mg/L in the range below 1.0 mg/L, to the nearest 0.1 mg/L between 1.0 mg/L and 2.5 mg/L and to the nearest 0.2 mg/L above 2.5 mg/L. Automatic chlorine residual recorders should be provided where the chlorine demand varies appreciably over a short period of time. Treatment plants having a capacity of 0.05 million gallons per day or greater and PWSs using surface water sources serving 500 or more persons shall be equipped with continuous recording chlorine analyzers monitoring the water entering the distribution system.

l. Water Supply for Chlorinators

An ample supply of water shall be available for operating the chlorinator. Where a booster pump is required, duplicate equipment shall be provided, and where power is subject to failure, standby power as well. Adequate protection against backflow shall be provided.

m. Chlorinator Piping

Piping arrangements should be as simple as possible and properly color-coded. Pressure gauges shall be installed on the piping to each chlorinator. The number of screwed or flanged joints should be held to a minimum. Piping systems should be well supported and adequately sloped to allow drainage; low spots should be avoided. Suitable allowance should be provided for pipe expansion due to changes in temperature. Liquid chlorine expansion chambers shall be installed where there is a danger of liquid chlorine becoming trapped in the supply lines. Spring-loaded relief valves discharging to the atmosphere shall not be used on liquid chlorine lines. Chlorine feed lines shall not carry pressurized chlorine gas beyond the chlorine room.

n. Pipe Material

Pipes carrying liquid chlorine or dry gaseous chlorine under pressure must be Schedule 80 seamless steel tubing or other materials recommended by the Chlorine Institute (never use PVC). For chlorine solution piping and fittings, rubber, PVC, polyethylene, or other materials recommended by the Chlorine Institute must be used. Nylon products are not acceptable for any part of the chlorine solution piping system.

o. Chlorine Containers

When the average daily consumption of chlorine exceeds 50 pounds, ton containers are to be considered. The containers of choice are 150 pound cylinders when the average daily consumption of chlorine does not exceed 50 pounds. Full and empty cylinders of chlorine gas should be:

(1) Stored separately.

(2) Isolated from operating areas.

(3) Restrained in position.

(4) Stored in rooms separated from ammonia storage.

(5) Stored in areas not in direct sunlight or exposed to heat.

p. Housing for Gas Chlorinators

Separate rooms for cylinders and for equipment are desirable at all installations and shall be provided at larger installations. Rooms should be on the ground floor and provide sufficient space to allow easy access to all equipment. Chlorine feed and storage rooms shall meet the requirements of Section V.E.3.c.

q. Safety Requirements

(1) Breathing Apparatus

Respiratory protection equipment, meeting the requirements of the National Institute for Occupational Safety and Health (NIOSH) and the Mine Safety and Health Administration (MSHA) shall be available where chlorine gas is handled. This equipment shall be located in a readily accessible location, but not inside any room where chlorine is used or stored. The units shall use compressed air, have at least a 30-minute capacity and be compatible with or exactly the same as the units used by the fire departments responsible for the plant.

(2) Leak Detection and Repair Kits

A bottle of concentrated ammonium hydroxide shall be available for chlorine leak detection; where chlorine containers larger than 150 pounds are used, leak repair kits of the type approved by the Chlorine Institute shall be provided. The use of automatic chlorine detectors is highly recommended for all facilities using chlorine gas.

r. Public Notification

The system shall provide public notification to advise of changes in its chloramines disinfection practices. Due to potential health hazards, it is especially important to notify hospitals and kidney dialysis facilities. Fish breeders should also be notified.

2. Other Disinfecting Agents

Although disinfecting agents other than chlorine are available, each has demonstrated shortcomings when applied to a system. Proposals to use disinfecting agents other than chlorine must be approved by DEP prior to preparation of final plans and specifications. Where appropriate, the design requirements outlined in Part IV, Section III of this manual must be followed.

a. Ozonation

Ozonation is used for disinfection, microflocculation and oxidation. All of these responses may occur together, but typically one will be the primary objective of the application with the other reactions becoming secondary benefits of the installation.

Effective disinfection from ozone is demonstrated by the fact that the CT values for inactivation of viruses and *Giardia* cysts are considerably lower than CT values using chlorine disinfectants. Microflocculation and enhanced filterability also have been demonstrated for many water supplies. Oxidation of organic compounds (i.e., color, taste and odor, and detergents) and inorganic compounds (i.e., iron, manganese, heavy metals, nitrite, arsenic and hydrogen sulfide) has been documented. The effectiveness of oxidation is varied, depending on pH and alkalinity of the water. High levels of hydroxyl radicals cause lower levels of residual ozone. Depending on the desired oxidation reaction, it may be preferable to maximize ozone residual or maximize hydroxyl radical formation. For disinfection, residual ozone is necessary for development of CT.

Bench scale studies should be conducted to determine minimum and maximum ozone dosages for disinfection CT compliance and oxidation reaction occurrences. More involved pilot plant studies should be conducted when necessary to document benefits and DBP precursor removal effectiveness. Pilot studies should be conducted for all surface waters. Care must be taken during bench and pilot scale studies to ensure accurate results. Particularly sensitive measurements include gas flow rate, water flow rate and ozone concentration.

Following the use of ozone, the application of a secondary disinfectant which maintains a measurable residual is required in order to ensure a bacteriologically safe water throughout the distribution system. However, because ozone partially degrades natural organic matter that may be precursors to disinfection by-products, the addition of chlorine, chloramine or chlorine dioxide should be withheld until after filtration. This will provide an opportunity to maximize biodegradation of the ozone-produced assimilable organic matter during the filtration process.

Furthermore, because of the more sophisticated nature of the ozone process, a higher degree of operator maintenance skills and training is required. The ability to obtain qualified operators must be evaluated in selection of the treatment process. The necessary operator training shall be provided prior to plant start-up.

The production of ozone is an energy intensive process. Substantial economies in electrical usage, reduction in equipment size and waste heat removal requirements can be obtained by using oxygen enriched air or oxygen as feed, and by operating at increased electrical frequency.

Use of ozone may result in increases in the biologically available organics content of the treated water. Biologically active filtration may be required to stabilize some treated waters. Ozone use may also lead to increased chlorinated byproduct levels if the water is not stabilized and free chlorine is used for distribution protection.

The following design considerations should be addressed:

(1) Feed Gas Preparation

(a) General

Feed gas can be air, high purity oxygen, oxygen enriched air or liquid oxygen (LOX) delivered to a storage vessel or generated on-site. Air handling equipment on conventional low pressure air-feed systems should consist of an air compressor, water/air separator, refrigerant dryer, heat reactivated desiccant dryer and particulate filters. Some "package" ozonation systems for small plants may work effectively operating at high pressure without the refrigerant dryer and with a "heatless" desiccant dryer. In all cases the design engineer must ensure that the maximum dewpoint of minus 60°C (minus 76°F) will not be exceeded at any time. For high-purity oxygen-feed systems, dryers typically are not required.

(b) Air Compression

1) Air compressors shall be of the liquid-ring or rotary lobe, oil-less, positive displacement type for smaller systems, or dry rotary screw compressors for larger systems.

2) The air compressors must have the capacity to simultaneously provide for maximum ozone demand, provide the air flow required for purging the desiccant dryers (where required), and allow for standby capacity.

3) Air feed for the compressor should be drawn from a point protected from rain, condensation, mist, fog and contaminated air sources to minimize moisture and hydrocarbon content of the air supply.

4) A compressed air filter-cooler and/or entrainment separator with automatic drain shall be provided prior to the dryers to reduce the water vapor.

5) A backup air compressor must be provided so that ozone generation is not interrupted in the event of a breakdown.

(c) Air Dryer

1) Dry, dust-free and oil-free feed gas must be provided to the ozone generator. Dry gas is essential to prevent formation of nitric acid, to increase the efficiency of ozone generation and to prevent damage to the generator dielectrics. Sufficient drying to a maximum dew point of minus 60°C (minus 76°F) must be provided at the end of the drying cycle.

2) Drying for high pressure systems may be accomplished using heatless desiccant dryers only. For low pressure systems, a refrigeration air dryer in series with heat-reactivated desiccant dryers should be used.

3) A refrigeration dryer capable of reducing inlet air temperature to 4°C (40°F) shall be provided for low

pressure air preparation systems. The dryer can be of the compressed refrigerant type or chilled water type.

4) For heat-reactivated desiccant dryers, the unit shall contain two desiccant-filled towers complete with pressure relief valves, two four-way valves and a heater. In addition, external type dryers shall have a cooler unit and blowers. The size of the unit shall be such that the specified dew point will be achieved during a minimum adsorption cycle time of 16 hours while operating at the maximum expected moisture loading conditions.

5) Multiple air dryers must be provided so that the ozone generation is not interrupted in the event of dryer breakdown.

6) Each dryer must be capable of venting dry gas to the atmosphere, prior to the ozone generator, to allow start-up when other dryers are on-line.

(d) Air Filters

1) Air filters shall be provided on the suction side of the air compressors, between the air compressors and the dryers, and between the dryers and the ozone generators.

2) The filter before the desiccant dryers shall be of the coalescing type and be capable of removing aerosol and particulates larger than 0.3 micron in diameter. The filter after the desiccant dryers shall be of the particulate type and be capable of removing all particulates greater than 0.1 micron in diameter, or smaller if specified by the generator manufacturer.

(e) Air Preparation Piping

Piping in the air preparation system can be common grade steel, seamless copper, stainless steel or galvanized steel. The piping must be designed to withstand the maximum pressures in the air preparation system.

(2) Ozone Generator

(a) Capacity

1) The production rating of the ozone generators shall be stated in pounds per day and KWh per pound (KWh per kilogram) at a maximum cooling water temperature and maximum ozone concentration.

2) The design shall ensure that the maximum concentration of ozone in the generator exit gas will not be less than 1 percent (by weight).

3) Generators shall be sized to have sufficient reserve capacity so that the system does not operate at peak capacity for extended periods of time. This can result in premature breakdown of the dielectrics.

4) The production rate of ozone generators will decrease as the temperature of the coolant increases. If there is to be a variation in the supply temperature of the coolant throughout the year, then graphs or other means shall be used to determine production changes due to the temperature change of the supplied coolant. The design shall ensure that the generators can produce the required ozone at maximum coolant temperature.

5) Appropriate ozone generator backup equipment must be provided.

(b) Electrical

The generators can be low, medium or high frequency type. Specifications shall require that the transformers, electronic circuitry and other electrical hardware be proven, high quality components designed for ozone service.

(c) Cooling

Adequate cooling shall be provided. The required water flow to an ozone generator varies with the ozone production. Normally, unit design provides a maximum cooling water temperature rise of 2.8°C (5°F). However, in cases where it is advantageous to decrease the volume of water used for cooling, up to 10°F delta temperature has been successfully employed. The cooling water must be properly treated to minimize corrosion, scaling and microbiological fouling of the water side of the tubes. A closed loop cooling water system is often used to ensure proper water conditions. Where cooling water is treated, cross-connection control shall be provided to prevent contamination of the potable water supply in accordance with Section VIII.J.

(d) Materials

To prevent corrosion, the ozone generator shell and tubes shall be constructed of Type 316L stainless steel.

(3) Ozone Contactors

The selection or design of the contactor and method of ozone application depends on the purpose for which the ozone is being used.

(a) Bubble Diffusers

1) Where disinfection is the primary application, a minimum of two contact chambers, each equipped with baffles to prevent short-circuiting and induce countercurrent flow, shall be provided. Ozone shall be applied using porous-tube or dome diffusers.

2) The minimum contact time (hydraulic detention time - HDT) shall be 10 minutes. A shorter contact time may be approved by DEP if justified by appropriate design and CT considerations.

3) For ozone applications in which precipitates are formed, such as with iron and/or manganese removal, porous diffusers should be used with caution.

4) Where taste and odor control is of concern, multiple application points and contactors shall be considered.

5) Contactors shall be separate closed vessels that have no common walls with adjacent rooms. The contactor must be kept under negative pressure, and sufficient ozone-in-air monitors shall be provided to protect worker safety. Placement of the contactor where the entire roof is exposed to the open atmosphere is recommended.

6) In contactor vessels made of reinforced concrete, all reinforcement bars shall be covered with a minimum of 1.5 inches of concrete.

7) A system shall be provided between the contactor and the off-gas destruct unit to remove froth from the off-gas and return the froth to the contactor or other location acceptable to DEP. If foaming is expected to be excessive, then a potable water spray system shall be placed in the contactor head space.

8) All openings into the contactor for pipe connections, hatchways, etc. shall be properly sealed using welds or ozone resistant gaskets such as Teflon or Hypalon.

9) Multiple sampling ports shall be provided to enable sampling of each compartment's effluent water and to confirm CT calculations.

10) A pressure relief valve shall be provided in the contactor.

11) The diffusion system shall work on a countercurrent basis such that the ozone is fed at the bottom of the vessel and water is fed at the top of the vessel.

12) The depth of water in bubble diffuser contactors shall be a minimum of 18 feet. The contactor also shall have a minimum of 3 feet of freeboard to allow for foaming.

13) All contactors shall have provisions for cleaning, maintenance and drainage of the contactor. Each contactor compartment also shall be equipped with an access hatchway.

(b) Other Contactors

Other contactors, such as venturi or aspirating turbine mixer contactor, may be approved by DEP provided adequate ozone transfer is achieved and the required contact times and residuals can be met and verified. Injectors may be acceptable as ozone contactors subject to DEP approval.

(4) Ozone Destruction Unit

(a) A system for treating the final off-gas from each contactor must be provided in order to meet safety and air quality standards. Acceptable systems include thermal destruction and thermal/catalytic destruction units.

(b) In order to reduce the risk of fires, the use of units that operate at lower temperatures is encouraged, especially where high purity oxygen is the feed gas.

(c) The maximum allowable ozone concentration in the discharge is 0.1 ppm (by volume).

(d) A sufficient number of units shall be provided so that the system is capable of handling the entire gas flow with one unit out of service.

(e) Exhaust blowers shall be provided in order to draw off-gas from the contactor into the destruct unit.

(f) Catalysts must be protected from froth, moisture and other impurities which may harm the catalyst.

(g) The catalyst and the heating elements shall be located where they can be easily reached for maintenance.

(5) Piping Materials

Only low carbon 304L and 316L stainless steels shall be used for ozone service, with the 316L preferred.

(6) Joints and Connections

(a) Connections on piping used for ozone service are to be welded where possible.

(b) Connections with meters, valves or other equipment are to be made with flanged joints with ozone resistant gaskets, such as Teflon or Hypalon. Screwed fittings shall not be used because of their tendency to leak.

(c) A positive closing plug or butterfly valve plus a leak-proof check valve shall be provided in the piping between the generator and the contactor to prevent moisture from reaching the generator.

(7) Instrumentation

(a) Pressure gauges shall be provided at the discharge from the air compressor, at the inlet to the refrigeration dryers, at the inlet and outlet of the desiccant dryers, at the inlet to the ozone generators and contactors and at the inlet to the ozone destruction unit.

(b) Electric power meters shall be provided for measuring the electric power supplied to the ozone generators. Each generator shall have a trip which shuts down the generator when the wattage exceeds a maximum preset level.

(c) Dew point monitors shall be provided for measuring the moisture of the feed gas from the desiccant dryers. Because it is critical to maintain the specified dew point, it is recommended that continuous recording charts be used for dew point monitoring which will allow the proper adjustment of the dryer cycles. Charts may not be necessary if a computer-based control system is in use. Where there is potential for moisture entering the ozone generator from downstream of the unit or where moisture accumulation can occur in the generator during shutdown, post-generator dew point monitors should be used.

(d) Air flow meters shall be provided for measuring air flow from the desiccant dryers to each of the ozone generators, air flow to each contactor and purge air flow to the desiccant dryers.

(e) Temperature gauges shall be provided for the inlet and outlet of the ozone cooling water, the inlet and outlet of the ozone generator feed gas and, if necessary, for the inlet and outlet to the ozone power supply cooling water.

(f) Water flow meters shall be installed to monitor the flow of cooling water to the ozone generators and, if necessary, to the ozone power supply.

(g) Ozone monitors shall be installed to measure ozone concentration in both the feed-gas and off-gas from the contactor and in the off-gas from the destruct unit. For disinfection systems, monitors also shall be provided for monitoring ozone residuals in the water. The number and location of ozone residual monitors shall be such that the amount of time that the water is in contact with the ozone residual can be determined.

(h) A minimum of one ambient ozone monitor shall be installed in the vicinity of the generator, and one adjacent to the first atmospherically vented process unit downstream of the contactor, if that unit is indoors. Ozone monitors also shall be installed in any areas where ozone gas might accumulate.

(8) Alarms

The following alarm/shutdown systems shall be considered at each installation:

(a) Dew Point Shutdown/Alarm - This system will shut down the generator in the event the system's dew point exceeds -60°C (-76°F).

(b) Ozone Generator Cooling Water Flow Shutdown/Alarm - This system will shut down the generator in the event that cooling water flow decreases to the point that generator damage could occur.

(c) Ozone Power Supply Cooling Water Flow Shutdown/Alarm - This system shall shutdown the power supply in the event that cooling water flow decreases to the point that damage could occur to the power supply.

(d) Ozone Generator Cooling Water Temperature Shutdown/Alarm - This system will shutdown the generator if either the inlet or outlet cooling water exceeds a certain preset temperature.

(e) Ozone Power Supply Cooling Water Temperature Shutdown/Alarm - This system will shutdown the power supply if either the inlet or outlet cooling water exceeds a certain preset temperature.

(f) Ozone Generator Inlet Feed-Gas Temperature Shutdown/Alarm - This system will shut down the generator if the feed-gas temperature is above a preset value.

(g) Ambient Ozone Concentration Shutdown/Alarm - The alarm will sound when the ozone level in the ambient air exceeds 0.1 ppm or a lower value chosen by the water supplier. Ozone generator shutdown shall occur when ambient ozone levels exceed 0.3 ppm (or a lower value) in either the vicinity of the ozone generator or the contactor.

(h) Ozone Destruction Temperature Alarm - The alarm will sound when temperature exceeds a preset value.

(9) Safety

(a) The maximum allowable ozone concentration in the air to which workers may be exposed must not exceed 0.1 ppm (by volume).

(b) Noise levels resulting from the operating equipment of the ozonation system should be reasonably controlled by special room construction and equipment isolation.

(c) High voltage and high frequency electrical equipment must meet current applicable electrical and fire codes.

(d) Emergency exhaust fans must be provided in the rooms containing the ozone generators to remove ozone gas if leakage occurs. The generating system must be shut down following detection of a leak.

(e) A portable purge air blower that will remove residual ozone in the contactor prior to entry for repair or maintenance shall be provided.

(f) A sign shall be posted indicating "No smoking, oxygen in use" at all entrances to the treatment plant. In addition, no flammable or combustible materials shall be stored within the oxygen generator areas.

(10) Construction Considerations

(a) Prior to connecting the piping from the desiccant dryers to the ozone generators, the air compressors should be used to blow the dust out of the desiccant.

(b) The contactor should be tested for leakage after sealing the exterior. This can be done by pressurizing the contactor and checking for pressure losses.

(c) Connections on the ozone service line should be tested for leakage using the soap-test method.

(d) The feed gas and ozone piping must be properly cleaned prior to start-up.

b. Chlorine dioxide

Chlorine dioxide may be considered as a primary and residual disinfectant. It may also be used to control tastes and odors, to oxidize iron and manganese, and to control hydrogen sulfide and phenolic compounds. It has been shown to be a strong disinfectant which does not form trihalomethanes (THMs) or haloacetic acids (HAAs). When choosing chlorine dioxide, consideration must be given to formation of the regulated byproducts, chlorite and chlorate.

(1) Chlorine dioxide generators

The preferred method for generating chlorine dioxide is the injection of a sodium chlorite solution into the discharge line of a solution-feed gas chlorinator with formation of the chlorine dioxide in a reaction chamber at a pH not over 4.0.

Chlorine dioxide generation equipment shall be factory assembled pre-engineered units with a minimum efficiency of 95 percent. The excess free chlorine shall not exceed 3 percent of the theoretical stoichiometric concentration required.

(2) Feed and storage facilities

Chlorine gas and sodium chlorite storage facilities shall comply with Sections V.E.3.C. and V.E.4. respectively. Sodium hypochlorite feed and storage facilities shall comply with Section V.E.5.

(3) Other design requirements

(a) The design shall comply with all applicable portions of Sections IV.B.1.b., IV.B.1.f., IV.B.1.k. and IV.B.1.m.

(b) The maximum residual disinfectant level shall not exceed 0.8 mg/L. The minimum residual disinfectant level entering the distribution system shall not be less than 0.2 mg/L and at distant points in the distribution system not less than 0.02 mg/L at any time. Higher residuals may be required depending on the pH, temperature and other characteristics of the water.

(4) Public notification

The system shall provide public notification to advise of changes in its chlorine dioxide disinfection practices. Due to potential health hazards, it is especially important to notify hospitals, kidney dialysis facilities. Fish breeders should also be notified.

C. Clarification

Clarification is generally considered to consist of any process or combination of processes which reduces the concentration of suspended matter in drinking water prior to filtration.

Water treatment facilities designed to reduce suspended solids concentrations prior to filtration shall:

- Provide a minimum of 2 units each for rapid mix, flocculation and solids removal for surface water treatment.
- Provide for flexibility in operation.
- Be constructed to permit units to be taken out of service without disrupting operation, and with drains or pumps sized to allow dewatering in a reasonable period of time.
- Provide multiple-stage treatment facilities when required by DEP.
- Be started manually following shutdown.
- Minimize hydraulic head losses between units to allow future changes in processes without the need for repumping.

1. Pretreatment

    a. Aeration

    Aeration units shall be designed in accordance with Section IV.E.

    b. Presedimentation

    Water containing high turbidity may require pretreatment, usually sedimentation with the addition of coagulation chemicals.

    (1) Basin design - Presedimentation basins should have hopper bottoms or be equipped with continuous mechanical sludge removal apparatus, and provide arrangements for dewatering.

    (2) Inlets - Incoming water shall be dispersed across the full width of the line of travel as quickly as possible. Short-circuiting shall be prevented.

    (3) Bypass - Provisions for bypassing presedimentation basins shall be included.

(4) Detention Time - 2 hours detention time is the minimum recommended. Longer detention may be required where excessively high turbidities are encountered. Laboratory tests should be conducted to design presedimentation units with hydraulic properties best suited for the raw water to be treated.

2. Coagulation

Coagulation shall mean a process using coagulant chemicals and mixing by which colloidal and suspended material are destabilized and agglomerated into settleable or filterable flocs, or both.

a. Equipment

Basins should be equipped with devices capable of providing adequate mixing for all treatment flow rates. Static mixers may be used where the flow is relatively constant and will be high enough to maintain the necessary turbulence for complete chemical reactions.

b. Mixing

The detention period should not be more than 30 seconds with mixing equipment capable of imparting a minimum velocity gradient (G) of at least 750 fps/ft. The design engineer should determine the appropriate G value and detention time through experimentation.

c. Location

The rapid mix and flocculation basin shall be as close together as possible.

3. Flocculation

Flocculation shall mean a process to enhance agglomeration or collection of smaller floc particles into larger, more easily settleable or filterable particles through gentle stirring by hydraulic or mechanical means.

a. Basin Design

Inlet and outlet design shall minimize short-circuiting and destruction of floc. Series compartments are recommended to further minimize short-circuiting and to provide decreasing mixing energy with time. Basins should be designed so that individual basins may be isolated without disrupting plant operation. A drain and/or pumps shall be provided to facilitate dewatering and sludge removal.

b. Detention

The flocculation period should be 20 to 30 minutes with consideration to using tapered (i.e., diminishing velocity gradient) flocculation. The design of flocculation units shall be based upon the value of GT (mean velocity gradient in seconds times the detention time in seconds) which is ordinarily in the range of 30,000 to 150,000. The engineer should establish the value of GT through experimentation.

c. Equipment

Agitators should be driven by variable speed drives with the peripheral speed of paddles ranging from 0.5 to 3.0 feet per second. External, nonsubmerged drive equipment is preferred.

d. Piping

Flocculation and sedimentation basins shall be as close together as possible. The velocity of flocculated water through pipes or conduits to settling basins shall not be less than 0.5 nor greater than 1.5 feet per second. Allowances must be made to minimize turbulence at bends and changes in direction.

e. Other Designs

Baffling may be used to provide for flocculation in small plants only after consultation with DEP. The design should be such that the necessary GT values will be maintained over the expected variations in flow.

f. With Tube Settlers

Where tube settlers are proposed for the sedimentation units, flocculation facilities must be closely evaluated to ensure that proper coagulation occurs before application to the settling units.

4. Sedimentation

Sedimentation shall follow flocculation unless otherwise approved by DEP. The detention time for effective clarification is dependent upon a number of factors related to basin design and the nature of the raw water. The following criteria apply to traditional gravity sedimentation basins.

a. Detention Time

Sedimentation basins should provide an average detention time of 2 to 4 hours based on an evaluation of the raw water, the character of the floc formed and the design of the basin. Reduced sedimentation time also may be approved when equivalent, effective settling is demonstrated.

b. Inlet Devices

Inlets shall be designed to distribute the water equally and at uniform velocities. Open ports, submerged ports and similar entrance arrangements are required. Where stilling walls are not provided, a baffle should be constructed across the basin close to the inlet end and should project several feet below the water surface to dissipate inlet velocities and provide uniform flows across the basin.

c. Outlet Devices

Outlet devices shall be designed to maintain velocities suitable for settling in the basin and to minimize short-circuiting. The use of submerged orifices is recommended in order to provide a volume above the orifices for storage when there are fluctuations in flow.

d. Overflow Rate

The rate of flow over the outlet weir shall not exceed 20,000 gallons per day (gpd) per foot of weir length, unless pilot studies or other performance data is submitted to justify higher rates. Where submerged orifices are used as an alternate for overflow weirs, they should not be lower than 3 feet below the flow line with flow rates equivalent to weir loadings.

e. Velocity

Flow velocity shall be reduced at the entrance to the settling basin by baffles or by directing the water into an enlarged section so that the velocity through the settling basin will not exceed 1 foot per minute. The basin must be designed to minimize short-circuiting. Fixed or adjustable baffles must be provided as necessary to achieve the maximum potential for clarification.

f. Overflow

An overflow weir or pipe should be installed which will establish the maximum water level desired on top of the filters. It shall discharge by gravity with a free fall at a location where the discharge can be readily observed.

g. Superstructure

A superstructure over the sedimentation basins should be considered where extremes in cold temperature, winds, solar radiation or other conditions may have an adverse effect on the settling process. If there is no mechanical equipment in the basins and if provisions are included for adequate monitoring under all expected weather conditions, a cover may be provided in lieu of a superstructure. Where covers are used, manholes with raised curbs and covers should be provided as well as drop-light connections, so observations of the floc can be made at several points to determine the efficiency of sedimentation.

h. Drainage

Basins must be provided with a means for dewatering. Basin bottoms should slope toward the drain not less than 1 foot in 12 feet where mechanical sludge collection equipment is not used.

i. Flushing Lines

Flushing lines or hydrants shall be provided and must be equipped with backflow prevention devices acceptable to DEP.

j. Safety

Permanent ladders or handholds should be provided for safety on the inside walls of the basins above the water level. Guidance rails are required when tanks are elevated above ground level, or when walk areas are narrow.

k. Sludge Collection

Adequate sludge collection equipment that ensures proper basin coverage shall be provided.

l. Sludge Removal

Sludge removal design shall provide that:

(1) Sludge pipes shall be not less than 3 inches in diameter and so arranged as to facilitate cleaning.

(2) Entrance to sludge withdrawal piping shall prevent clogging.

(3) Valves shall be located outside the tank for accessibility.

(4) The operator may observe and sample sludge being withdrawn from the unit.

m. Sludge Disposal

Sludge disposal and any discharge of sludge basin supernatant must be approved by DEP.

5. Solids Contact Units

Units are acceptable for combined softening and clarification where water characteristics are not variable and flow rates are uniform. Before such units are considered as clarifiers without softening, specific approval from DEP shall be obtained. Clarifiers should be designed for the maximum uniform rate and should be adjustable to changes in flow which are less than the design rate and for changes in water characteristics. A minimum of 2 units is required.

a. Installation

A representative of the manufacturer shall supervise the installation and initial operation of each unit.

b. Operating Equipment

The following shall be provided for plant operation:

(1) A complete outfit of tools and accessories. A tool shall be provided for operator use in monitoring solids depth and consistency.

(2) Adequate piping with suitable sampling taps located to permit the collection of samples of water and sludge from critical portions of the units.

(3) A detailed operation and maintenance plan describing the theory of operation, the proper collection of samples, recommended operating parameters based on those sample results, and adjustments that should be made to achieve the recommended operating conditions.

c. Chemical Feed

Chemicals shall be applied at such points and by such means to ensure satisfactory mixing of the chemicals with the water.

d. Mixing

Mixing devices employed shall be constructed to:

(1) Provide good mixing of the raw water with previously formed sludge particles.

(2) Prevent deposition of solids in the mixing zone.

e. Flocculation

Flocculation equipment:

(1) Shall be adjustable (speed and/or pitch).

(2) Must provide for coagulation in a separate chamber or baffled zone within the unit.

(3) Should provide a flocculation and mixing period of not less than 30 minutes.

f. Sludge Concentrators

(1) The equipment should provide either internal or external concentrators in order to obtain a concentrated sludge with a minimum of wastewater.

(2) Large basins should have at least two sumps for collecting sludge with one sump located in the central flocculation zone.

g. Sludge Removal

Sludge removal design shall provide that:

(1) Sludge pipes shall be not less than 3 inches in diameter and so arranged to facilitate cleaning.

(2) Entrance to sludge withdrawal piping shall prevent clogging.

(3) Valves shall be located outside the tank for accessibility.

(4) The operator may observe and sample sludge being withdrawn from the unit.

h. Cross-Connections

(1) Blow-off and drains must terminate and discharge at places satisfactory to DEP.

(2) Cross-connection control must be included for the potable water lines used to backflush sludge lines.

i. Detention

The detention time shall be established on the basis of the raw water characteristics and other local conditions that affect the operation of the unit. Based on design flows, the detention time should be:

(1) 2 to 4 hours for suspended solids contact clarifiers and softeners treating surface water.

(2) 1 to 2 hours for the suspended solids contact softeners treating only groundwater.

j. Suspended Slurry Concentrate

Softening units should be designed so that continuous slurry concentrates of 1 percent or more, by weight, can be satisfactorily maintained.

k. Water Losses

(1) Units shall be provided with suitable controls for sludge withdrawal.

(2) Total water losses should not exceed:

(a) 5 percent for clarifiers.

(b) 3 percent for softening units.

(3) Solids concentration of sludge bled to waste should be:

(a) 3 percent by weight for clarifiers.

(b) 5 percent by weight for softeners.

l. Weirs or Orifices

The units should be equipped with either overflow weirs or orifices constructed so that water at the surface of the unit does not travel over 10 feet horizontally to the collection trough.

(1) Weirs shall be adjustable, and at least equivalent in length to the perimeter of the tank.

(2) Weir loading shall not exceed:

(a) 10 gallons per minute (gpm) per foot of weir length for units used for clarifiers.

(b) 20 gpm per foot of weir length for units used for softeners.

(3) Where orifices are used, the loading per foot of launder rates should be equivalent to weir loadings. Either shall produce uniform rising rates over the entire area of the tank.

m. Upflow Rates

Unless supporting data is submitted to DEP to justify rates exceeding the following, the rates shall not exceed:

(1) 1.0 gpm per square foot of area at the sludge separation line for units used for clarifiers.

(2) 1.75 gpm per square foot of area at the slurry separation line, for units used for softeners.

6. Tube or Plate Settlers

Proposals for tube settler clarification must be discussed with the regional water supply engineer and must include pilot plant or full-scaled demonstration studies prior to the preparation of final plans and specifications.

a. General Criteria

(1) Inlet and outlet considerations – Design to maintain velocities suitable for settling in the basin and to minimize short-circuiting. Plate units shall be designed to minimize maldistribution across the units.

(2) Drainage – Drain piping from the settler units must be sized to facilitate a quick flush of the settler units and to prevent flooding other portions of the plant.

(3) Protection from freezing – Although most units will be located within a plant, outdoor installations must provide sufficient freeboard above the top of settlers to prevent freezing in the units. A cover or enclosure is strongly recommended.

(4) Application rate for tubes – A maximum rate of 2 gpm per square foot of cross-sectional area for tube settlers, unless higher rates are successfully shown through pilot plant or in-plant demonstration studies.

(5) Application rate for plates – A maximum plate loading rate of 0.5 gpm per square foot, based on 80 percent of the projected horizontal plate area.

b. Tube Placement

Tube modules shall be placed:

(1) In zones of stable hydraulic conditions.

(2) In areas nearest effluent launders in basins not completely covered by tubes.

(3) So that the top of the tubes are 2 to 4 feet below the water surface.

c. Inlets and Outlets

Inlets and outlets shall conform with Sections IV.C.4.b. and IV.C.4.c.

d. Tube Support

The tube support system should be able to carry the weight of the tube modules when the basin is drained plus the weight of a workman standing on the tube modules. The minimum bearing surface width of a support member should be 1 inch, and support members should be located about 6 inches from the module end.

e. Tube Cleaning

Provisions should be made to drop water level occasionally for tube cleaning, or provide water or air jet cleaning system for top surface of tube modules.

7. High Rate Clarification Processes

High rate clarification processes may be approved upon demonstrating satisfactory performance under on-site pilot plant conditions. Reductions in detention times and/or increases in weir loading rates shall be justified. Examples of such processes may include dissolved air flotation, ballasted flocculation, contact flocculation/clarification, and helical upflow, solids contact units.

D. Filtration

The selection of any filtration process is to be supported by the submission of raw and finished water quality data representing a reasonable period of time to characterize filter performance under all variations in applied water quality. The design of the filtration process must ensure a minimum 99 percent removal of *Giardia* cysts and 99 percent removal of *Cryptosporidium* oocysts.

Conventional filtration (which includes coagulation, flocculation, sedimentation and filtration) is considered to be the best technology to meet the above requirements.

The following processes will be considered only after the submission of sufficient engineering data to justify their use. Pilot plant studies may be required to demonstrate the applicability of the method of filtration proposed.

- Slow rate gravity filtration
- Diatomaceous earth filtration
- Direct filtration
- Membrane filtration

Other filtration processes (i.e., pressure filtration) will be approved only after pilot plant studies, as approved by DEP, demonstrate that the technology will consistently and reliably meet the minimum filtration standards specified above.

1. Slow Rate Gravity Filters

Proposals for slow rate gravity filters will be approved after engineering studies have indicated the adequacy and suitability of these methods of filtration for a specific raw water quality.

a. Quality of Raw Water

Slow rate gravity filtration shall be limited to water having maximum turbidities of 10 units, total coliform levels of 800 colonies per 100 mL and a maximum color of 5 units; such turbidities must not be attributable to colloidal clay. Microscopic examination of the raw water must be made to determine the nature and extent of algae growths and their potential adverse impact on filter operations.

b. Number of Units

At least 2 units shall be provided. Where only 2 units are provided, each shall be capable of meeting the plant design capacity (normally the projected maximum daily demand) at the approved filtration rate. Where more than 2 filter units are provided, the filters shall be capable of meeting the plant design capacity at the approved filtration rate with one filter removed from service.

c. Structural Details

Slow rate gravity filters shall be designed to provide:

(1) A cover, as determined necessary, for temperature control, exclusion of sunlight or protection from intrusion.

(2) Sufficient room to permit movement by operating personnel for scraping and sand removal. The structural strength of the underdrain system should take into consideration the possible use of heavy equipment for this purpose.

(3) Adequate manholes and access ports for handling of sand and for ventilation.

(4) An overflow at the maximum filter water level.

d. Rates of Filtration

The permissible rates of filtration shall be determined by the quality of the raw water and shall be on the basis of experimental data derived from the water to be treated. The nominal rate may be 45 to 150 gpd per square foot (0.08 to 0.25 meter/hour) of sand area, with somewhat higher rates acceptable when demonstrated to the satisfaction of DEP.

e. Underdrains

Each filter unit shall be equipped with a main drain and an adequate number of lateral underdrains to collect the filtered water. The underdrains shall be spaced so that the maximum velocity of the water flow in the lateral underdrain will not exceed 0.75 feet per second. The maximum spacing of the laterals shall not exceed 12 feet.

f. Filtering Material

Filtering materials should comply with the criteria set forth in AWWA's Standard for Filtering Material.

(1) Filter sand shall be placed on graded gravel layers for a minimum depth of 30 inches.

(2) The effective size shall be between 0.15 mm and 0.3 mm as the preferred range.

(3) The uniformity coefficient shall not exceed 2.5.

(4) The sand shall be clean and free from foreign matter.

g. Filter Gravel

Gravel used in slow rate sand filters shall be carefully selected and placed. The supporting gravel shall conform to the size and depth distribution provided for rapid rate gravity filters.

h. Depth of Water on Filter Beds

Design shall provide a depth of at least 3 feet of water over the sand. Influent water shall not scour the sand surface.

i. Control Appurtenances

(1) The following shall be provided for every filter:

(a) The necessary piping, valves and control equipment needed to filter-to-waste or recycle the effluent water at actual/current and permitted production rates at the beginning of the filter cycle

(b) A flow rate controller capable of providing gradual rate increases when placing the filters back into operation

(c) Influent and effluent sampling taps

(d) An indicating loss of head gauge

(e) An indicating rate-of-flow meter

A modified rate controller which limits the rate of filtration to a maximum rate may be used. However, equipment that simply maintains a constant water level on the filters is not acceptable, unless the rate of flow on to the filter is properly controlled. A pump or a flow meter in each filter effluent line may be used as the limiting device for the rate of filtration only after consultation with DEP.

(f) Provisions for draining the filter-to-waste with appropriate measures for backflow prevention

(2) It is recommended the following be provided:

(a) Wall sleeves providing access to each filter interior at several locations for sampling or pressure sensing

(b) A 1 to 1.5 inch pressure hose and storage rack at the operating floor for washing the filter

(c) Access to particle counting equipment as a means to enhance overall treatment operations

j. Sand Cleaning Equipment

Slow rate sand filter plants serving 500 or more persons should be equipped with portable sand ejectors operated by water under pressure, for removing dirty sand scraped from the filter. A sand-washing unit should be available to permit the washing of the sand so removed. The control building of a slow sand filtration plant shall have the necessary equipment to conduct a sieve analysis of the sand used in the filters.

k. Turbidimeters

On-line turbidimeters shall be installed on the raw water line and the effluent line from each filter. All turbidimeters shall consistently determine and indicate the turbidity of the water in Nephelometric Turbidity Units (NTUs). Turbidimeters used to monitor individual filter effluent or combined filter effluent shall be designed to accurately measure low-range turbidities. Each turbidimeter shall report to a recorder that is designed and operated to allow the operator to accurately determine the turbidity at least once every 15 minutes.

(1) Turbidimeters on individual filters should have an alarm that will sound when the effluent turbidity level exceeds 1.0 NTU.

(2) In plants that operate while unattended, the alarm at 1.0 NTU should activate an autodialer or other mechanism to immediately alert operators to the alarm condition.

(3) In plants that operate while unattended, a shut-off device shall shut down the flow of water from the plant when combined filter effluent turbidity exceeds 2.0 NTU.

l. Laboratory Equipment

The control building of a slow sand filtration plant shall include the appropriate laboratory facilities for determining the turbidity and disinfectant residual of the water as outlined in Section II.E.

2. Rapid Rate Gravity Filters

a. Pretreatment

Pretreatment is required where rapid rate gravity filters are utilized. As a minimum, the use of a primary coagulant is required during all times that the treatment plant is in operation.

b. Number of Units

At least 2 units shall be provided. Where only 2 units are provided, each shall be capable of meeting the plant design capacity (normally the projected maximum daily demand) at the approved filtration rate. Where more than 2 filter units are provided, the filters shall be capable of meeting the plant design capacity at the approved filtration rate with one filter removed from service. Where declining rate filtration is provided, the variable aspect of filtration rates and the number of filters, filtering-to-waste capabilities, must be considered when determining the design capacity for the filters.

c. Rates of Filtration

The rates of filtration shall be determined through consideration of such factors as raw water quality, degree of pretreatment, filter media and other factors as may be required by DEP. The accepted rate for a single media sand or anthracite filter is 2 gpm per square foot, and for approved dual media or multimedia beds is 4 gpm per square foot of filter area. Higher rates must be justified by the design engineer to the satisfaction of DEP.

d. Structural Details and Hydraulics

The filter structure shall be designed as to provide for:

(1) Vertical walls within the filter.

(2) No protrusion of the filter walls into the filter media.

(3) Cover by superstructure as determined necessary for temperature control or for intrusion protection where needed.

(4) Head room to permit normal inspection and operation.

(5) Minimum depth of filter box of 8.5 feet.

(6) Minimum water depth over the surface of the filter media of 3 feet.

(7) Trapped effluent to prevent backflow of air to the bottom of the filters.

(8) Prevention of floor drainage to the filter with a minimum 4-inch curb around the filters.

(9) Prevention of flooding by providing overflow.

(10) Maximum velocity of treated water in pipe and conduits to filters of 2 feet per second.

(11) Cleanouts and straight alignment for influent pipes or conduits where solids loading is heavy, or following lime-soda softening.

(12) Washwater drain capacity to carry maximum flow.

(13) Walkways around filters to be not less than 24 inches wide.

(14) Safety handrails or walls around filter areas adjacent to normal walkways.

(15) Construction to prevent cross-connections and common walls between potable and nonpotable water.

e. Washwater Troughs

Washwater troughs shall be designed to provide:

(1) The bottom elevation above the maximum level of expanded media during washing.

(2) A 2-inch freeboard at the maximum rate of wash.

(3) The top edge to be level and all at the same elevation.

(4) Spacing so that each trough serves the same number of square feet of filter area.

(5) Maximum horizontal travel of suspended particles to reach the trough not to exceed 3 feet.

f. Filter Material

For rapid rate gravity filters, coarse-to-fine beds of mixed or dual media are preferred over fine-to-coarse single media beds. The media should comply with the criteria set forth in AWWA's B100 Standard for Filtering Materials.

Water suppliers are strongly encouraged to require that the media supplier provide an affidavit of compliance which states that the media provided meets the specifications established for the installation.

Proper media installation procedures must be used to ensure that the filter will result in effective filtration. Before placement of any media, each filter cell should be thoroughly cleaned and inspected. All underdrain and backwash systems should be tested to the maximum extent possible.

Only clean, dry media, taken directly from its original shipping container should be installed. Each gravel or media layer should be installed, washed, and scraped and its depth confirmed before placement of subsequent layers.

Installers must not be allowed to walk directly on gravel or media. Boards or plywood should be used to distribute their weight.

Installation procedures should generally comply with AWWA's B100 Standard for Filter Media.

Filter media shall be clean, free from clay, dust, micaceous material, organic matter and detrimental chemical or bacterial contaminants and have the following characteristics:

(1) A total depth of not less than 24 inches and generally not more than 30 inches.

(2) A uniformity coefficient of the smallest material not greater than 1.65.

(3) A minimum of 12 inches of media with an effective size range no greater than 0.45 to 0.55 mm, and a specific gravity greater than the other filtering materials within the filter.

(4) A ratio of filter depth (in inches) to media effective size (in millimeters) greater than 40 for single- and dual-media filters, and greater than 50 for multi-media filters. If dual- or multi-media filters are used, the depth to effective size ratio shall be determined for each medium and summed to determine the ratio for the filter.

(5) Types of filter media

(a) Anthracite - Only clean crushed anthracite may be used and shall meet the following conditions:

1) When used alone, the effective size shall be in the range of 0.45 mm to 0.55 mm with a uniformity coefficient not greater than 1.65

2) When used as a cap, the effective size shall be in the range of 0.8 mm to 1.2 mm with a uniformity coefficient not greater than 1.7

3) Has a specific gravity greater than 1.4

4) Has an acid solubility less than 5 percent

5) Has an Mho's scale of hardness greater than 2.7

6) When used for iron and manganese removal from groundwater, the effective size shall not exceed 0.8 mm unless on-site pilot plant studies are conducted to justify larger sizes

(b) Sand - Sand shall consist of hard, durable and dense grains of at least 85 percent siliceous material that will resist degradation during handling and use, and shall have:

1) An effective size of 0.45 to 0.55 mm.

2) A uniformity coefficient of not greater than 1.65.

3) A specific gravity greater than 2.5.

4) An acid solubility less than 5 percent.

Larger size media may be allowed by DEP where full-scale tests have demonstrated that treatment goals can be met under all conditions.

(c) High Density Sand

High density sand shall consist of hard, durable and dense grain garnet, ilmenite, hematite, magnetite, or associated minerals of those ores that will resist degradation during handling and use, and shall:

1) Contain at least 95 percent of the associated material with a specific gravity of 3.8 or higher.

2) Have an effective size of 0.2 to 0.3 mm.

3) Have a uniformity coefficient of not greater than 1.65.

4) Have an acid solubility less than 5 percent.

(d) Granular Activated Carbon (GAC) - Full bed or full depth GAC may be used, but only after consultation with DEP in addition to the following:

1) The effective size shall be in the range of 0.45 mm to 0.75 mm with a uniformity coefficient not greater than 1.9.

2) As a minimum, disinfection of the water from the GAC filters must be provided prior to distribution.

3) Provisions must be made for replacement or regeneration where GAC is used for filtration and organics removal.

(e) Other media - Other media which meet AWWA's Standard for Filtering Material will be considered based on experimental data and operating experience.

(6) Support media

(a) Gravel - Gravel, when used as a supporting media, shall consist of hard, rounded particles and shall not include flat or elongated particles. The coarsest gravel shall be 2.5 inches in size when the gravel rests directly on the strainer system and must extend above the top of the perforated laterals. Not less than four layers of gravel shall be provided in accordance with the following size and depth distribution when used with perforated laterals:

Size	**Depth**
3/16 to 3/32 inches	2 to 3 inches
1/2 to 3/16 inches	2 to 3 inches
3/4 to 1/2 inches	3 to 5 inches
1.5 to 3/4 inches	3 to 5 inches
2.5 to 1.5 inches	5 to 8 inches

Reduction of gravel depths may be considered upon justification to DEP when proprietary filter bottoms are specified.

(b) Torpedo Sand - A 3-inch layer of torpedo sand should be used as a supporting media for filter sand where supporting gravel is used and should have:

1) An effective size of 0.8 mm to 2.0 mm.

2) A uniformity coefficient not greater than 1.7.

g. Filter Bottoms and Strainer Systems

Departures from these standards may be acceptable for high rate filters and for proprietary bottoms. Porous plate bottoms shall not be used where iron or manganese may clog them or with water softened by lime. The design of manifold-type collection systems shall be such as to:

(1) Minimize loss of head in the manifold and laterals.

(2) Ensure even distribution of washwater and even rate of filtration over the entire area of the filter.

(3) Provide the ratio of the area of the final openings of the strainer system to the area of the filter at about 0.003.

(4) Provide a total cross-sectional area of the laterals at about twice the total area of the final openings.

(5) Provide the cross-sectional area of the manifold at 1.5 to 2 times the total area of the laterals.

(6) Lateral perforations without strainers shall be directed downward.

h. Surface Wash or Subsurface Wash

Surface or subsurface wash facilities should be provided and may be accomplished by a system of fixed nozzles or a revolving-type apparatus. All devices shall be designed with:

(1) Provisions for water pressures of at least 45 psi.

(2) A properly installed vacuum breaker or other approved device to prevent back-siphonage if connected to the treated water system.

(3) Rate of flow of 2 gpm per square foot of filter area with fixed nozzles or 0.5 gpm per square foot with revolving arms.

(4) Simultaneous air and water wash may be used provided experimental data and operating experiences indicate media will not be lost. A fluidization wash at the end of the backwash cycle must be provided to restratify the media.

i. Air scouring

Air scouring can be considered in place of surface wash.

(1) Air flow for air scouring the filter must be 3-5 standard cubic feet per minute per square foot of filter area when the air is introduced in the underdrain; a lower air rate must be used when the air scour distribution system is placed above the underdrains.

(2) A method for avoiding excessive loss of the filter media during backwashing must be provided.

(3) Air scouring must be followed by a fluidization wash sufficient to restratify the media.

(4) Air must be free from contamination.

(5) Air scour distribution system should be placed below the media and supporting bed interface; if placed at the interface the air scour nozzles shall be designed to prevent media from clogging the nozzles or entering the air distribution system.

(6) Piping for the air distribution system shall not be flexible hose which will collapse when not under air pressure and shall not be a relatively soft material which may erode at the orifice opening with the passage of air at high velocity.

(7) Air delivery piping shall not pass down through the filter media nor shall there be any arrangement in the filter design which would allow short-circuiting between the applied unfiltered water and the filtered water.

(8) Consideration should be given to maintenance and replacement of air delivery piping.

(9) The backwash water delivery system must be capable of 15 gpm per square foot of filter surface area; however, when air scour is provided the backwash water rate must be variable and should not exceed 8 gpm per square foot while air is being delivered unless operating experience shows that a higher rate is necessary to remove scoured particles from filter media surfaces.

(10) The filter underdrains shall be designed to accommodate air scour piping when the piping is installed in the underdrain.

(11) Duplicate blowers should be provided.

(12) The provisions of Section IV.D.2.1. shall be followed.

j. Turbidimeters

On-line turbidimeters shall be installed on the raw water line and the effluent line from each filter. Consideration should be given to the installation of a turbidimeter on the combined filter influent so that the performance of the filters can be properly evaluated. All turbidimeters shall consistently determine and indicate the turbidity of the water in NTUs. Turbidimeters used to monitor individual filter effluent or combined filter effluent shall be designed to accurately measure low-range turbidities. Each turbidimeter shall report to a recorder that is designed and operated to allow the operator to accurately determine the turbidity at least once every 15 minutes.

(1) Turbidimeters on individual filters should have an alarm that will sound when the effluent turbidity level exceeds 0.3 NTU.

(2) In plants that operate while unattended, the alarm at 0.3 NTU should activate an autodialer or other mechanism to immediately alert operators to the alarm condition.

(3) In plants that operate while unattended, a shut-off device shall shut down the flow of water from the plant when combined filter effluent turbidity exceeds 1 NTU.

k. Control Appurtenances

(1) The following shall be provided for every filter:

(a) The necessary piping, valves and control equipment needed to filter-to-waste or recycle the effluent water at actual/current and permitted production rates at the beginning of the filter cycle.

(b) A flow rate controller capable of providing gradual rate increases when placing the filters back into operation.

(c) Influent and effluent sampling taps.

(d) An indicating loss of head gauge.

(e) An indicating rate-of-flow meter. A modified rate controller which limits the rate of filtration to a maximum rate may be used. However, equipment that simply maintains a constant water level on the filters is not acceptable, unless the rate of flow on to the filter is properly controlled. A pump or a flow meter in each filter effluent line may be used as the limiting device for the rate of filtration only after consultation with DEP.

(f) Provisions for draining the filter-to-waste with appropriate measures for backflow prevention.

(2) It is recommended the following be provided:

(a) Wall sleeves providing access to each filter interior at several locations for sampling or pressure sensing

(b) A 1 to 1.5 inch pressure hose and storage rack at the operating floor for washing the filter

(c) Access to particle counting equipment as a means to enhance overall treatment operations

l. Backwash

Provisions shall be made for washing filters as follows:

(1) A minimum rate of 15 gpm per square foot, consistent with water temperatures and specific gravity of the filter media

A rate of 20 gpm per square foot or a rate necessary to provide for a 50 percent expansion of the filter bed is recommended. A reduced rate of 10 gpm per square foot or a rate necessary to provide for a 50 percent expansion of the filter bed whichever is larger, may be acceptable for full depth anthracite or granular activated carbon filters

(2) Filtered water provided at the required maximum rate by washwater tanks, a washwater pump from the high service main or a combination of these

(3) Washwater pumps in duplicate unless an alternative means of obtaining washwater is available

(4) Not less than 15 minutes wash of one filter at the design rate of wash

(5) A washwater regulator or valve on the main washwater line to obtain the desired rate of filter wash with the washwater valves on the individual filters open wide

(6) A rate-of-flow indicator, preferably with a totalizer, on the main washwater line located so that it can be easily read by the operator during the washing process

(7) Design to prevent rapid changes in backwash water flow

m. Miscellaneous

Roof drains shall not discharge into the filters or basins and conduits preceding the filters.

3. Pressure Filtration

The use of these filters may be considered for iron and manganese removal but shall not be used in the filtration of surface waters or following lime-soda softening unless pilot plant testing demonstrates the system can meet drinking water standards at all times.

a. General

Minimum criteria relative to number of units, rate of filtration, use of a primary coagulant, structural details and hydraulics, filter media, etc., provided for rapid rate gravity filters also apply to pressure filters where appropriate.

b. Rate of Filtration

The rate shall not exceed 3 gpm per square foot of filter area except where in-plant testing as approved by DEP has demonstrated satisfactory results at higher rates.

c. Details of Design

Pressure filters shall be designed to provide for:

(1) Filtration and backwashing of each filter individually with an arrangement of piping as simple as possible to accomplish these purposes.

(2) Minimum side wall shell height of 5 feet. A corresponding reduction in side wall height is acceptable where proprietary bottoms permit reduction of the gravel depth.

(3) The top of the washwater collectors to be at least 18 inches above the surface of the media.

(4) The underdrain system to efficiently collect the filtered water and to uniformly distribute the backwash water at a rate not less than 15 gpm per square foot of filter area.

(5) Backwash flow indicators and controls that are easily readable while operating the control valves.

(6) An air release valve on the highest point of each filter.

(7) An access manhole to facilitate inspection and repairs.

(8) Means to observe the wastewater during backwashing.

(9) Construction to prevent cross-connection.

d. Turbidimeters

On-line turbidimeters shall be installed on the raw water line and the effluent line from each filter. Consideration should be given to the installation of a turbidimeter on the combined filter influent so that the performance of the filters can be properly evaluated. All turbidimeters shall consistently determine and indicate the turbidity of the water in NTUs. Turbidimeters used to monitor individual filter effluent or combined filter effluent shall be designed to accurately measure low-range turbidities. Each turbidimeter shall report to a recorder that is designed and operated to allow the operator to accurately determine the turbidity at least once every 15 minutes.

(1) Turbidimeters on individual filters should have an alarm that will sound when the effluent turbidity level exceeds 0.3 NTU.

(2) In plants that operate while unattended, the alarm at 0.3 NTU should activate an autodialer or other mechanism to immediately alert operators to the alarm condition.

(3) In plants that operate while unattended, a shut-off device shall shut down the flow of water from the plant when combined filter effluent turbidity exceeds 1 NTU.

e. Control Appurtenances

(1) The following shall be provided for every filter:

(a) The necessary piping, valves and control equipment needed to filter-to-waste or recycle the effluent water at actual/current and permitted production rates at the beginning of the filter cycle

(b) A flow rate controller capable of providing gradual rate increases when placing the filters back into operation

(c) Influent and effluent sampling taps

(d) An indicating loss of head gauge

(e) An indicating rate-of-flow meter

A modified rate controller which limits the rate of filtration to a maximum rate may be used. A pump or a flow meter in each filter effluent line may be used as the limiting device for the rate of filtration only after consultation with DEP.

(f) Provisions for draining the filter-to-waste with appropriate measures for backflow prevention

(2) It is recommended the following be provided:

(a) A 1- to 1.5-inch pressure hose and storage rack at the operating floor for washing the filter

(b) Access to particle counting equipment as a means to enhance overall treatment operations

4. Diatomaceous Earth Filtration

Installation of diatomaceous earth filtration shall not be made without a pilot plant study on the water to be treated. The use of these filters may be considered for application to surface water with low turbidity, low algae concentration, and low bacterial contamination, and may be used for iron removal from groundwater providing the pilot testing proves effective and the water is of satisfactory sanitary quality before treatment.

Only filter media certified for drinking water use under ANSI/AWWA Standard No. 60 or another DEP-approved third party shall be used.

a. Conditions of Use

Diatomaceous earth filters are expressly excluded from consideration for the following conditions:

(1) Color removal

(2) Turbidity removal where either the gross quantity of turbidity is high or the turbidity exhibits poor filterability characteristics

(3) Filtration of waters with high algae levels

b. Pilot Plant Study

Installation of a diatomaceous earth filtration system shall be preceded by a pilot plant study on the water to be treated.

(1) Conditions of the study such as duration, filter rates, head loss, slurry feed rates, turbidity removal, bacteria removal, protozoan removal, etc. must be approved by DEP prior to the study.

(2) Satisfactory pilot plant results must be obtained prior to preparation of final construction plans and specifications.

(3) The pilot plant study must demonstrate the ability of the system to meet applicable drinking water standards at all times.

c. Types of Filters

Pressure or vacuum diatomaceous earth filtration units will be considered for approval. However, the vacuum type is preferred for its ability to accommodate a design which permits observation of the filter surfaces to determine proper cleaning, damage to a filter element, and adequate coating over the entire septum or filter area.

d. Treated Water Storage

Treated water storage capacity in excess of normal requirements shall be provided to:

(1) Allow operation of the filters at a uniform rate during all conditions of system demand at or below the approved filtration rate.

(2) Guarantee continuity of service during adverse raw water conditions without bypassing the system.

e. Number of Units

See Section IV.D.2.b.

f. Pre-coat

(1) Application - A uniform pre-coat shall be applied hydraulically to each septum by introducing a slurry to the tank influent line and employing a filter-to-waste or recirculation system.

(2) Quantity - Diatomaceous earth in the amount of 0.2 lbs. per square foot of filter area or an amount sufficient to apply a 1/8- to 1/5-inch coating should be used with recirculation.

g. Body Feed

A body feed system to apply additional amounts of diatomaceous earth slurry during the filter run is required to avoid short filter runs or excessive head losses. Diatomaceous earth filtration systems should make provisions for the addition of coagulant coating (alum or polymer) to the body feed.

(1) Quantity - Rate of body feed is dependent on raw water quality and characteristics and must be determined in the pilot plant study.

(2) Operation and maintenance can be simplified by providing accessibility to the feed system and slurry lines.

(3) Continuous mixing of the body feed slurry is required.

h. Filtration

(1) Rate of filtration - The recommended nominal rate is 1 gpm per square foot of filter area with a recommended maximum of 1.5 gpm per square foot. The filtration rate shall be controlled by a positive means.

(2) Head loss - The head loss shall not exceed 30 psi for pressure diatomaceous earth filters, or a vacuum of 15 inches of mercury for a vacuum system.

(3) Recirculation - A recirculation or holding pump shall be employed to maintain differential pressure across the filter when the unit is not in operation in order to prevent the filter cake from dropping off the filter elements. A minimum recirculation rate of 0.1 gpm per square foot of filter area shall be provided.

(4) Septum or filter element - The filter elements shall be structurally capable of withstanding maximum pressure and velocity variations during filtration and backwash cycles, and shall be spaced such that no less than 1 inch is provided between elements or between any element and a wall.

(5) Inlet Design - The filter influent shall be designed to prevent scour of the diatomaceous earth from the filter element.

i. Backwash

A satisfactory method to thoroughly remove and dispose of spent filter cake shall be provided.

j. Control Appurtenances

(1) The following shall be provided for every filter:

(a) The necessary piping, valves and control equipment needed to filter-to-waste or recycle the effluent water at actual/current and permitted production rates at the beginning of the filter cycle

(b) A flow rate controller capable of providing gradual rate increases when placing the filters back into operation

(c) Influent and effluent sampling taps

(d) An indicating loss of head gauge

(e) An indicating rate-of-flow meter

A modified rate controller which limits the rate of filtration to a maximum rate may be used. However, equipment that simply maintains a constant water level on the filters is not acceptable, unless the rate of flow on to the filter is properly controlled. A pump or a flow meter in each filter effluent line may be used as the limiting device for the rate of filtration only after consultation with DEP.

(f) Provisions for draining the filter-to-waste with appropriate measures for backflow prevention

(2) It is recommended the following be provided:

(a) A 1- to 1.5-inch pressure hose and storage rack at the operating floor for washing the filter

(b) Access to particle counting equipment as a means to enhance overall treatment operations

(c) A throttling valve used to reduce rates below normal during adverse raw water conditions

(d) Evaluation of the need for body feed, recirculation and any other pumps, in accordance with Section VI.D.

k. Turbidimeters

On-line turbidimeters shall be installed on the raw water line and the effluent line from each filter. All turbidimeters shall consistently determine and indicate the turbidity of the water in NTUs. Turbidimeters used to monitor individual filter effluent or combined filter effluent shall be designed to accurately measure low-range turbidities. Each turbidimeter shall report to a recorder that is designed and operated to allow the operator to accurately determine the turbidity at least once every 15 minutes.

(1) Turbidimeters on individual filters should have an alarm that will sound when the effluent turbidity level exceeds 1.0 NTU.

(2) In plants that operate while unattended, the alarm at 1.0 NTU should activate an autodialer or other mechanism to immediately alert operators to the alarm condition.

(3) In plants that operate while unattended, a shut-off device shall shut down the flow of water from the plant when combined filter effluent turbidity exceeds 2.0 NTU.

5. Direct Filtration

Direct filtration, as used herein, refers to the filtration of a surface water without prior particulate removal. The nature of the treatment process will depend upon the raw water quality. A full-scale direct filtration plant shall not be constructed without prior pilot studies which are acceptable to DEP. In-plant demonstration studies may be appropriate where conventional treatment plants are converted to direct filtration. Where direct filtration is proposed, an engineering report shall be submitted prior to conducting pilot plant or in-plant demonstration studies. DEP at its own discretion may issue an experimental permit as outlined in Section I.C. based on the data submitted.

a. Engineer's Report

In addition to the applicable items outlined in Section I.B.3.a - Engineer's Report, the report should include a historical summary of meteorological conditions and of raw water quality with special reference to seasonal fluctuations in quality, and possible sources of contamination. The following raw water parameters must be evaluated in the report:

(1) Alkalinity

(2) Color

(3) Turbidity

(4) Bacterial concentration

(5) Microscopic biological organisms, including algae

(6) Temperature

(7) pH

(8) Total solids

(9) General inorganic chemical characteristics

(10) Additional parameters as determined by DEP which may be unique to the supply (DBPs, *Giardia,* etc.)

The report also should include a description of methods and work to be done during a pilot plant study or, where appropriate, an in-plant demonstration study.

b. Pilot Plant Studies

After approval of the engineering report, a pilot study or in-plant demonstration study shall be conducted. The study must be conducted over a sufficient time to treat all expected raw water conditions throughout the year. This study shall be conducted as outlined in Section I.C.1.and shall emphasize, but not be limited to, the following:

(1) Chemical mixing conditions, including shear gradients and detention periods

(2) Chemical feed rates, especially under varying water quality conditions

(3) Use of various coagulant aids including polymers, the results of any jar tests performed on the various chemicals shall be tabulated

(4) Flocculation conditions

(5) Filtration rates

(6) Length of filter runs

(7) Filter gradation, types of media and depth of media

(8) Length of backwash cycles

(9) Filter breakthrough conditions

(10) Quantities and make-up of the wastewater

(11) Adverse impact of recycling backwash water due to solids, algae, DBPs formation and similar problems

Prior to the initiation of design plans and specifications, a final report including the engineers' design recommendations shall be submitted to DEP.

c. Pretreatment, Rapid Mix and Flocculation

The final rapid mix and flocculation basin design should be based on the pilot plant or in-plant demonstration studies augmented with applicable portions of Section IV.C.2. - Coagulation and Section IV.C.3 - Flocculation.

d. Filtration

(1) Filters should be rapid rate gravity filters with dual- or multi-media. The final filter design should be based on the pilot plant or in-plant demonstration studies augmented by applicable portions of Section IV.D.2. - Rapid Rate Gravity Filters. Pressure filters or single-media sand filters shall not be used.

(2) Surface wash or subsurface wash shall be provided for the filters in accordance with Section IV.D.2.h.

e. Turbidimeters

On-line turbidimeters shall be installed on the raw water line and the effluent line from each filter. Consideration should be given to the installation of a turbidimeter on the combined filter influent so that the performance of the filters can be properly evaluated. All turbidimeters shall consistently determine and indicate the turbidity of the water in NTUs. Turbidimeters used to monitor individual filter effluent or combined filter effluent shall be designed to accurately measure low-range turbidities. Each turbidimeter shall report to a recorder that is designed and operated to allow the operator to accurately determine the turbidity at least once every 15 minutes.

(1) Turbidimeters on individual filters should have an alarm that will sound when the effluent turbidity level exceeds 0.3 NTU.

(2) In plants that operate while unattended, the alarm at 0.3 NTU should activate an autodialer or other mechanism to immediately alert operators to the alarm condition.

(3) In plants that operate while unattended, a shut-off device shall shut down the flow of water from the plant when combined filter effluent turbidity exceeds 1 NTU.

f. Control Appurtenances

(1) The following shall be provided for every filter:

(a) The necessary piping, valves and control equipment needed to filter-to-waste or recycle the effluent water at actual/current and permitted production rates at the beginning of the filter cycle

(b) A flow rate controller capable of providing gradual rate increases when placing the filters back into operation

(c) Influent and effluent sampling taps

(d) An indicating loss of head gauge

(e) An indicating rate-of-flow meter

A modified rate controller which limits the rate of filtration to a maximum rate may be used. However, equipment that simply maintains a constant water level on the filters is not acceptable, unless the rate of flow on to the filter is properly controlled. A pump or a flow meter in each filter effluent line may be used as the limiting device for the rate of filtration only after consultation with DEP.

(f) Provisions for draining the filter-to-waste with appropriate measures for backflow prevention

(2) It is recommended the following be provided:

(a) A 1- to 1.5-inch pressure hose and storage rack at the operating floor for washing the filter

(b) Access to particle counting equipment as a means to enhance overall treatment operations

g. Siting Requirements

The plant design and land ownership surrounding the plant shall allow for the installation of conventional sedimentation basins should it be found that such are necessary.

E. Aeration

Aeration may be used to help remove offensive tastes and odors due to dissolved gases from decomposing organic matter, to reduce or remove objectionable amounts of carbon dioxide, hydrogen sulfide, etc., or to introduce oxygen to assist in iron and/or manganese removal. Designers are cautioned that the aeration process will increase the dissolved oxygen (DO) content of the water which may render some waters more corrosive than others. Stabilization may be necessary if evidence indicates the corrosivity of the water is damaging to the system.

The design criteria in this section are not meant to be used in the design of organics removal systems. Organic contaminants removal, which includes packed tower aeration, will be covered in Section IV.F.

1. Natural Draft Aeration

   The design shall provide:

   a. Perforations in the distribution pan 3/16 to 1/2 inches in diameter, spaced 1- to 3-inches on centers to maintain a 6-inch water depth.

   b. For distribution of water uniformly over the top tray.

   c. Discharge through a series of three or more trays with separation of trays not less than 12 inches.

   d. Loading at a rate of 1 to 5 gpm for each square foot of total tray area.

   e. Trays with slotted, heavy wire (1/2-inch openings) mesh or perforated bottoms.

   f. Construction of durable materials resistant to the aggressiveness of the water, dissolved gases, slime and algae growths.

   g. Eight to 12 inches of inert material, such as coke or limestone, that will not disintegrate due to freezing cycles, is used in trays.

   h. Protection from loss of spray water by wind carriage by enclosure with louvers sloped to the inside at an angle of approximately 45 degrees.

   i. Protection from insects by 24-mesh screen.

2. Forced or Induced Draft Aeration

   Devices shall be designed to:

   a. Include a blower with a weatherproof motor in a tight housing and screened enclosure.

   b. Ensure adequate counter current of air through the enclosed aerator column.

   c. Exhaust air directly to the outside atmosphere.

   d. Include a downturned and 24-mesh screened air outlet and inlet.

   e. Introduce air into the column that is as free from obnoxious fumes, dust and dirt as possible.

f. Be such that sections of the aerator can be easily reached or removed for maintenance of the interior.

g. Provide loading at a rate of 1 to 5 gpm for each square foot of total tray area.

h. Ensure that the water outlet is adequately sealed to prevent unwarranted loss of air.

i. Discharge through a series of five or more trays with separation of trays not less than 6 inches or as approved by DEP.

j. Provide distribution of water uniformly over the top tray.

k. Be of durable material resistant to the aggressiveness of water and dissolved gases.

3. Pressure Aeration

Pressure aeration may be used for oxidation purposes only if a pilot plant study indicates the method is applicable. It is not acceptable for removal of dissolved gases. Filters following pressure aeration must have adequate exhaust devices for release of air. Pressure aeration devices shall be designed to:

a. Give thorough mixing of compressed air with water being treated.

b. Provide screened and filtered air, free of obnoxious fumes, dust, dirt and other contaminants.

4. Other Methods of Aeration

Other methods of aeration may be used if applicable to the treatment needs. Such methods include, but are not restricted to, spraying, diffused air, cascades and mechanical aeration. The treatment process must be designed to meet the particular needs of the water to be treated and are subject to the approval of DEP.

5. Protection of Aerators

Aerators that are used for oxidation or removal of dissolved gases from waters that will be given no further treatment other than chlorination shall be protected from contamination from insects, birds, wind-borne debris, rainfall and water draining off the exterior of the aerator.

6. Ventilation

Ventilation shall be provided to prevent the accumulation of released gases in the building that houses the treatment facilities.

7. Bypass

A bypass should be provided for all aeration units.

8. Corrosion Control

The aggressiveness of the water after aeration should be determined and corrected by additional treatment if necessary (See Section IV.J.).

F. Organic Contaminants Removal

Packed tower aeration (PTA) and granular activated carbon (GAC) are designated by the U.S. EPA as the best available technologies (BAT) for removing organic contaminants from drinking water. Properly designed PTA and GAC facilities can achieve a high removal rate (above 90 percent) of VOCs. GAC appears to be capable of removing most SOCs, but can be a more costly technique. PTA is the designated BAT for most VOCs. PTA also can remove dissolved gases such as radon and carbon dioxide.

The Henry's coefficient of a substance is an indicator of the ability to remove that substance from water. The Henry's coefficient of a substance is defined as that substance's vapor pressure divided by that substance's water solubility. The Henry's coefficient is highly temperature dependent. In general, vapor pressures increase with increasing temperature, and water solubilities decrease with increasing temperature. Thus, an increase in temperature would lead to an increase in the Henry's coefficient. Henry's coefficients for most VOCs can be found in a variety of textbooks, technical articles, trade organization literature and the EPA Risk Reduction Engineering Laboratory (RREL) Treatability Database.

A substance with a high Henry's coefficient is more easily removed from water, via volatilization, than a substance with a lower Henry's coefficient. Substances with Henry's coefficients greater than 100 atm*mol/mol can readily be removed via PTA. Substances with Henry's coefficients less than 10 atm*mol/mol may need to be removed via GAC. Substances between 10 and 100 atm*mol/mol might be removed via PTA, but should be verified through pilot study.

1. Packed Tower Aeration (PTA)

Generally, the most suitable type of aeration for volatile organics removal is PTA. PTA involves passing water down through a column of packing material while blowing air counter-currently up through the packing. PTA is used for the removal of VOCs and radon.

The use of mechanical aeration for organics removal may be approved by DEP on a case-by-case basis; however, the effectiveness of mechanical aeration should be verified by a pilot testing program acceptable to DEP. Other types of aeration techniques, which are covered in Section IV.E., also may be approved for volatile organics removal, but should be supported by adequate pilot testing.

a. Pilot Testing Considerations

Pilot plant testing is recommended to evaluate a variety of loading rates and air/water ratios at the peak contaminant concentration. Only when there is considerable past-performance data on a previous project that featured both similar source concentration(s) and a similar design, will DEP consider approving the process based on design calculations without pilot testing. Proposals of this type must be discussed with DEP's regional office staff prior to submission of any permit applications.

Pilot testing also is recommended when the VOCs of concern have Henry's coefficients less than 100 atm*mol/mol (at about 12°C), or when either the PTA model or the vendor has an unknown performance record.

The following is a summary of the key items of a pilot test:

(1) The proposed pilot test protocol must be submitted to the appropriate regional office for approval prior to pilot testing.

(2) The influent (source) water quality should be determined for any design considerations (Section IV.F.1.b.(2)). Monitoring data should be compared to this initial quality to determine contaminant trends.

(3) Various operational parameters should be recorded with each test and submitted to the appropriate regional office for review and approval. These parameters include, but are not limited to, influent (source) and effluent water quality, height and shape of the tower, type and size of the packing, flow rates and pressure drops of the air stream, water flow rates and test times.

(4) Pilot test air flow rates should be converted to a standard pressure and temperature in order to account for test-to-test and test-to-full-scale fluctuations in these parameters.

b. Process Design Considerations

(1) Process design methods for PTA involve the determination of several parameters, including the Henry's coefficient for the contaminant, the mass transfer coefficient, air pressure drop, air and water temperatures, influent and effluent concentrations, height and cross-sectional area of unit, air/water ratio, size and configuration of the packing, packing depth and air/water loading rates.

(2) With respect to influent (source) quality, a suggested design method would be to design **separately** for various VOCs in the source quality, then choose the most stringent design. First, the VOC concentrations should be multiplied by a safety factor of 3.

Each individual VOC design should then reduce the scaled-up concentration down to the respective MCL or the Maximum Unregulated Contaminant Concentration (MUCC) of that VOC. If a VOC does not have an MCL or MUCC, then the appropriate regional office should be contacted for a suggested criteria value. If scaling-up by a factor of three does not force an MCL, MUCC, or suggested criteria exceedance, then no design is necessary.

The most stringent design should then be checked against all other VOC concentrations (scaled-up by 3) that have MCL, MUCC or suggested criteria exceedances. This will ensure that **all** VOCs present will be successfully treated to their MCLs or MUCCs (for VOCs with MCLs or MUCCs), or to conservatively low levels (for VOCs without MCLs or MUCCs). Some features of the most stringent design may include the greatest tower height, lowest hydraulic loading, greatest packing surface area and/or greatest air flow rate of all VOC designs.

An extensive database of VOC results for the source water may increase confidence in the data, thereby reducing the safety factor. Data confidence may reduce the safety factor anywhere from 3 down to a minimum of 1.5; the more confidence in the data, the closer a factor of 1.5 can be approached.

(3) The air pressure drop across the packed tower should be no greater than 1.5 inches of water per foot of tower height. This pressure drop range provides the most flexible operation and helps to avoid flooding.

(4) The ratio of the column diameter to packing diameter should be at least 7:1 for the pilot unit and at least 10:1 for the full-scale tower. The type and size of the packing used in the full-scale unit shall be the same as that used in the pilot work.

(5) The minimum volumetric air-to-water ratio at peak water flow should be 25:1. The maximum air-to-water ratio for which credit will be given is 80:1.

(6) The design should consider potential fouling problems from calcium carbonate, iron and manganese precipitation, as well as bacteria growth. The packing support plate(s) must be designed to hold the packing weight, water weight and various fouling weights. It is recommended that the packing support plate(s) be designed to hold at least five times the original dry packing weight. In cases where lighter weight plastic packings are used, it may be necessary to use a packing support factor considerably higher than five. It may be necessary to provide softening, stabilization, sequestering and/or disinfection facilities prior to and/or after PTA. Chemical

cleaning access ports should be provided. Disposal of cleaning waste also should be considered in the design.

(7) Due to an increase in DO, the effects of aeration on corrosion control should be considered.

(8) The effects of temperature should be considered since a change in air temperature can result in a change in contaminant removal efficiency.

(9) The design should establish minimum and maximum hydraulic capacities. The maximum hydraulic capacity should be equal to or exceed the source capacity.

(10) The design should provide adaptability for future off-gas treatment.

(11) Redundant capacity may be required by DEP.

c. Materials of Construction

(1) The tower can be constructed of stainless steel, concrete, aluminum, fiberglass or plastic. Uncoated carbon steel is not recommended because of corrosion.

(2) Packing materials, column shell and other internals should be resistant to corrosion by the water, dissolved gases and cleaning chemicals, and should meet NSF Standard 61. Plastic or ceramic packing materials are recommended.

(3) Paints and coatings that are in direct contact with the water supply should meet NSF Standard 61.

d. Water Flow System

(1) When influent water is injected from a single point to a column whose diameter to packing diameter ratio is less than 8, the water may tend to migrate to the column wall. Because of this, water should be distributed uniformly at the top of the tower using spray nozzles or orifice-type distributor trays. For multi-point injection, it is recommended to have one injection point for every 30 square inches of column cross-sectional area.

(2) A mist eliminator shall be provided above the water distribution system.

(3) Spacing of the redistribution rings will vary between models and manufacturers. The manufacturer's specifications for ring spacing should be followed. Rigid packings generally need water

redistribution every 3 feet. Poured packings generally do not need water redistribution under a height of 12 feet, but do so every 6 feet if over a height of 12 feet. Some PTA models need no redistribution whatsoever, regardless of packing type or tower height.

(4) The packing support plate(s) should be either of the counter-current or the separate flow passage variety. Counter-current plates include wire mesh and welded rings. Separate flow passage plates include cap-type and beam-type plates. The packing support plate(s) should be strong enough to support deep packing heights, as well as water weight and fouling buildup through normal operation. It is recommended that the plate(s) be designed to support at least 5 times the original dry weight of the packing.

(5) Sample taps must be provided in the influent and effluent piping for each PTA treatment unit.

(6) A butterfly valve shall be provided in the water effluent line in order to control flow, as well as minimize the potential for air entrainment in the finished water.

(7) The tower bottom shall contain an effluent basin with a minimum depth of 8 inches. This depth is defined specifically as the depth between the bottom of the basin and the bottom of the effluent pipe. The basin water level shall inundate the effluent pipe during blower operation. The effluent basin will serve as both an air trap for the water effluent and a settling basin for any material sloughed off the packing material. In some cases, the effluent basin also may serve as a wet well and high service sump for repumping. The effluent basin should have easy access for cleaning and be equipped with a drain valve. The drain shall not be directly connected to any type of sewer. Either an approvable cross-connection control device or an air gap must be in place.

(8) A blow-off line shall be provided to allow for discharge of water used to clean the tower.

(9) The design shall have provisions to prevent freezing. Provisions could include a drainage feature during nonflow conditions, or weather proofing (i.e., housing, insulation, heat tape).

(10) Any overflow line must be discharged 12 to 24 inches above a splash pad or drainage inlet. Overflow piping must be equipped with a 24-mesh screen.

(11) Care should be taken to avoid flooding of both the air blower and the top of the tower. Water relief ports must be provided in the air delivery line in order to protect the air blower from flooding.

Excessive air and/or water flow rates, as well as fouling buildup, may cause flooding at the top of the tower.

(12) Hydraulic loading rates (i.e., gpm per square foot) will vary between models and manufacturers. The manufacturer's specifications for hydraulic loading rates should be followed.

(13) The water influent piping should be supported separately from the PTA structural support.

e. Air Flow System

(1) If located outside, the air inlet to the blower shall, at a minimum, be protected with a 4-mesh screen prior to, and in series with, a 24-mesh screen to prevent contamination from extraneous matter.

(2) A positive air flow sensing device and pressure gauge shall be provided on the air delivery line. The positive air flow sensing device shall be part of an automatic control system that will shut down water flow if no positive air flow is detected. The pressure gauge will serve as an indicator of fouling buildup.

(3) The air blower shall be programmed to provide delayed air blowing after water shutdown. This could be accomplished by, but not limited to, an effluent sump control system or a predetermined time delay relay in the motor control circuitry.

This delayed blowing will ensure that all remaining water in the tower is adequately treated.

(4) A backup motor, with spare parts, for the air blower must be readily available. A complete spare is required if there is no other PTA unit or non-PTA sources available. If other PTA units or non-PTA sources are available, then access to a local motor distributor will suffice.

f. Other Features to be Provided

(1) A sufficient number of access ports must be provided in each section to allow inspection, media replacement, media cleaning and maintenance of the interior. A minimum of two 24- to 36-inch bolted manways, one at the distributor plate and one at the support plate, should be provided. Hinged access doors of varying heights also are acceptable.

(2) A method of cleaning the packing material must be provided when iron, manganese, biological or other types of fouling occur. This also includes the removal of the cleaning wastes before on-line

service. Chemical cleaning ports must be in place on both ends of the tower.

(3) Provisions for extending the tower height, without major reconstruction, should be provided.

(4) Protocol for maintenance downtime should provide no interruptions in final, end-of-plant demand. Either adequate storage of end-of-plant finished water, alternative PTA units or alternative non-PTA sources are required in order to supplement supply during maintenance and other operational interruptions to the PTA unit.

(5) Operation of the blower, water pumps, controls, instrumentation and all chemical feeder equipment must be maintained during power failures. This may be accomplished by an emergency generator or another alternative power source.

(6) An access ladder and safety cage should be provided for inspection of the tower, exhaust port and mist eliminator.

(7) Adequate security for the facility must be provided to prevent vandalism.

(8) Fencing and locking gates to prevent vandalism must be provided.

(9) Noise and odor control features may be necessary for PTA systems located in residential areas.

2. Granular Activated Carbon (GAC)

GAC represents one unit process with the ability to remove a broad spectrum of organic chemicals from water. GAC exhibits a wide range of effectiveness in adsorbing organic compounds and, therefore, should be evaluated on a site-specific basis. GAC is an effective adsorbent for SOCs, VOCs, DBP, and taste and odor causing organics.

a. Pretreatment and Post treatment Requirements

Pretreatment may be required depending on the quality of the source water. Lower operation cost of GAC systems may be achieved by pretreating the feed water resulting in reduced organic loading. Examples of processes which can be used for pretreatment include conventional treatment, ozonation and PTA.

Surface water sources which usually contain high amounts of natural organic matter should be pretreated by coagulation, sedimentation and filtration to increase the uptake capacity of the AC granules for the target contaminants.

For surface water sources, the use of powdered activated carbon (PAC) to remove organics and reduce the organic loading on the GAC during periods of high organic levels should be evaluated to extend the run time of the GAC contactors and/or reduce the loading on the GAC.

Ozone oxidation can affect adsorption behavior, as well as strongly influence the biodegradability of the substances present in the water. In general, preozonation immediately prior to carbon adsorption will decrease the adsorbability of the organic constituents, and can cause a major increase in the immediate breakthrough point and a general reduction in the performance throughout the column run. The feed water should not contain any oxidizer (disinfectant) in substantial amounts.

Application of chlorine to GAC filters to inhibit microbial growth is not recommended because of the tendency of chlorine to break up the activated carbon granules. Prechlorination also increases the concentration of chloro-organics, which reduces the adsorbability of the activated carbon granules for the trace organic contaminants.

Effective disinfection must be provided following GAC contactors to ensure inactivation of bacteria that may slough off from the GAC bed. The use of GAC prior to chlorination is the preferred mode of operation for several reasons. The chlorine demand will be greatly reduced, and the formation of disinfection by-products also will be minimized. The potential to form precursors which will result in the formation of dioxin and furans during the reactivation of the GAC also can be significantly reduced.

Corrosion control, when necessary, should be provided following GAC contactors. Treatment plants that currently increase the pH during pretreatment for corrosion control will need to switch to post-GAC pH adjustment. Optimum organic removal occurs at lower pH.

b. System Components

The major components of a typical GAC treatment system include:

(1) Carbon Contactors - Either common wall concrete or lined steel vessels. In either case, provisions for underdrainage, backwash and removal of spent carbon must be made.

(2) Carbon Storage - Includes storage tanks for virgin and regenerated carbon. (May not be necessary for smaller systems.)

(3) Carbon Transport Facilities - Includes piping, valves and pumps.

c. Bench and Pilot Studies

(1) General

GAC has been used to remove toxic and nontoxic (taste & odor) organic chemicals in drinking water. However, AC can be ineffective if it is not used properly. Installation of a full-scale GAC system should be preceded by a bench scale and/or a pilot plant study on the water to be treated.

During the bench and/or pilot plant studies, data should be collected for performance during typical conditions as well as during extremes of good and bad water quality. The primary result of these bench and/or pilot studies should be a determination of the type of GAC to be used, the size of the media, the design empty bed contact time (EBCT) and the expected regeneration frequency for the contaminant(s) of concern.

The influence of seasonal factors is often important and should be evaluated. Pilot plant studies may be influenced by temperature, growth of algae and diatoms, seasonal or unusual episodes of runoff and turbidity. Pilot operations also should include the variations of flow that normally exist and affect detention times and hydraulic loading rates.

(2) Bench-Scale Studies

The bench-scale, rapid small-scale column test (RSSCT), uses small GAC particle sizes and requires less time and volume of water than pilot-scale tests.

A smaller than full-scale particle size should be selected for the RSSCT and, based on the ratio of the particle sizes, operating parameters such as EBCT, flow rate and time to breakthrough can be scaled up to full-scale. Full-scale design variables, such as adsorber operation (e.g., bed in-series or in-parallel operation), EBCT and usage rate, can be determined by conducting several RSSCTs that duplicate full-scale operation.

The following guidelines should be used in setting up an RSSCT:

(a) The experimental apparatus should be constructed of glass, teflon or stainless steel to minimize adsorption of organics.

(b) The experiments should be conducted in a temperature-controlled room at temperature ranges of 10°C to 14°C.

(c) A minimum of 3 RSSCTs should be used when evaluating the effect of EBCT and adsorber configuration, such as beds in series or in parallel, on GAC usage rate.

(d) The minimum column diameter to avoid channeling should be 50 particle diameters. However, if large sample volumes are required, larger diameter columns can be used.

If the RSSCT is used in lieu of pilot-scale adsorption tests, the user should understand that the limitations of the test have not yet been clearly defined. However, two limitations which are known include:

(e) The RSSCT is performed over a short period of time compared to that required for a pilot study. If the influent adsorbate concentration is not relatively constant, the RSSCT may not be able to produce a breakthrough profile comparable to a pilot-scale profile.

(f) Selection of the appropriate equations for scaling-up the RSSCT depends upon the functional relationship between surface diffusivity and GAC particle size. Therefore, it is strongly recommended that this relationship be evaluated prior to performing the RSSCT.

(3) Pilot Plant Studies

(a) The pilot-scale adsorption studies should provide design information on adsorption of trace organics. Treatment efficiency varies with the organic character of the water. Because this differs between locations, experimentation must be done with the actual water, preferably on-site. Pilot testing should be conducted over a sufficient time period to establish that the technology is appropriate for the source water and to determine appropriate design and operating parameters.

(b) Pilot-scale columns are required to study adsorption. The general rule is to provide as many pilot columns as economically possible. A minimum of 3 columns is recommended. However, additional scale columns make test results easier to evaluate and compare since influent quality can vary from test to test.

(c) The sizing of the column is based on empty bed contact time at the selected flow rate. A pilot-scale adsorption study should incorporate several EBCTs so that an optimum can be selected.

(d) The columns should have an internal diameter of at least 1 inch (2.5 cm) to minimize sidewall effects, that is the slightly higher porosity of the medium next to the wall.

(e) In studies in which water flow is less than 10 gpm (38 L/min), equipment should be constructed from stainless steel, plastic or glass whenever possible to minimize contamination from structural materials.

(f) Sampling taps shall be provided at various depths to allow effluent sampling corresponding to selected contact times. A minimum of 3 taps are recommended.

(g) Pilot Plant Operation - GAC should be backwashed before it is put into service. Sufficient freeboard should exist to permit 30 to 50 percent bed expansion during backwash. The frequency of backwashing during the experimental study should vary depending upon factors such as head loss, turbidity and floc carried over from settling. The following routine schedule is recommended for pilot plant operation depending on the treatment objective:

1) Test for the contaminant of concern.

2) Flow adjustment (Q) should be performed at least daily.

3) Temperature, pH, turbidity, threshold odor number and color should be monitored at a frequency based on variability of applied water.

4) Low-molecular-weight halogenated organic carbon compounds should be monitored weekly.

5) Total organic carbon (TOC) should be monitored weekly.

6) DBP formation potential or possibly organic halogen analysis (TOX) should be monitored biweekly especially if the feed water contains chlorine-containing disinfectants.

d. Process Design Considerations

(1) Carbon Usage Rate

This basic design parameter, expressed as pounds/1,000 gallons, indicates the rate at which carbon will be exhausted or replaced. Carbon usage rates of organic compounds may be estimated from batch isotherm data and/or from dynamic pilot column or full-scale studies.

Freundlich isotherm constants are chemical-specific parameters that characterize the ability of certain concentrations of a substance to adsorb on to GAC. Thus, isotherm evaluations are batch tests which yield information about the maximum equilibrium organic loading on a particular carbon at a given organic concentration. Isotherms derived using high concentrations of VOCs and SOCs tend to overestimate GAC adsorption capabilities. Isotherms should be combined with pilot studies in the design process. Test results indicate that adsorption of any particular chemical by carbon is influenced by pH, temperature and type of carbon used.

The carbon usage rate for the various contaminants depends on the type and the concentration of organic substances in the influent source water, the effect of preloading of natural organics on carbon, the contact time and the maximum concentration of organics allowable in the effluent (i.e., levels at or below the MCL). If the source water contains several organics above the MCL, the design should consider the organics most difficult to remove by GAC.

(2) Empty Bed Contact Time (EBCT)

EBCT is determined by dividing the carbon bed volume (V) (including voids) by the superficial flow rate (Q) of the fluid stream through the adsorber. This design parameter provides an indication of the quantity of carbon which will be on-line at any one time, and thus reflect the capital cost for the system. The EBCT directly impacts the performance of the carbon for removing organic compounds. Pilot testing on organic removal may be conducted to determine the empty bed contact times sufficient to yield a reasonable carbon bed life. For preliminary design purposes, a 10- to 20-minute empty bed contact time is recommended for optimum carbon bed life.

(3) Contactor Configuration

The two basic modes of contactor operation are downflow and upflow. Downflow fixed bed contactors offer the simplest and most common contactor configuration for organic removal. Precautionary measures should be taken when using the contactor in an upflow mode to ensure that the GAC fines are not carried over into the treated water. The contactors may be operated either under pressure or by gravity. Pressure contactors may be more applicable to groundwater systems because of the nature of these systems. The use of gravity contactors for most groundwater systems would involve repumping the treated water to the distribution system.

The GAC adsorbers can be operated as either fixed bed adsorbers or moving bed adsorbers. In a fixed bed adsorber, the carbon contained in the adsorber remains stationary and operates in either a downflow or an upflow mode. Moving bed adsorbers, on the other hand, always operate in an upflow mode. Single or multiple adsorbers can be used depending on the application requirements. Multiple adsorbers can be arranged individually in series or in parallel, or as a combination of series units in parallel.

(a) Fixed Beds in Series

In this configuration, the flow is downward through the carbon bed for each unit in the series. When carbon is removed for reactivation, the first adsorber in the series is shut down with the next adsorber in line becoming the lead unit. Larger systems should be built with an extra adsorber on standby to become the first adsorber when the lead adsorber is taken out of service. Backwashing can be used on the lead adsorber to remove suspended solids that accumulate in the carbon bed.

(b) Fixed Beds in Parallel

In a parallel configuration, each carbon bed receives the same quantity and quality of influent stream. Start-up of the individual units should be staggered so that exhaustion of the carbon occurs sequentially. This allows the removal of all carbon from each adsorber, one at a time, for reactivation. A spare adsorber shall be provided to be brought on-line when the exhausted adsorber is taken out of service.

(c) Pulsed Beds

A pulsed bed operates in an upflow counter-current to the carbon flow. Pulsed bed adsorbers permit intermittent or continuous removal of spent carbon from the bottom of the bed, while fresh carbon is added at the top without system shutdown. The chief advantage of this system is better carbon utilization, because only thoroughly exhausted carbon will be removed.

(4) Hydraulic Loading

Hydraulic loading is the quantity of liquid flowing through the bed per square foot (gpm per square foot). Once the required contact time is selected for a given performance objective, the cross-sectional area of the adsorber is selected to ensure that hydraulic loadings are in the operating range of 2 to 10 gpm per square foot.

(5) Contactor Design

The contactor shall be designed to accommodate the maximum flow rate of the plant. Typical design surface loading rates are 2 to 6 gpm per square foot and bed depths of 5 to 15 feet. Lower or higher rates may be acceptable after careful evaluation.

The contactor should include backwashing facilities and a properly designed underdrain system to ensure uniform flow distribution.

The filter box should have freeboard adequate for 30 to 50 percent bed expansion during backwash. A rise rate of 24 to 26 in/min (60 to 66 cm/min), equivalent to a backwash application rate of 14 to 16 gpm per square foot (35 to 90 m/h) is recommended for expanding the bed 30 to 50 percent.

Contactor-to-waste facilities are required (similar to filter-to-waste) to permit additional removal of GAC fines remaining after backwashing.

e. Type and Size of Carbon

It is recommended that virgin carbon be used for initial installation of the GAC unit and replacement of the carbon.

The choice of carbon should be based on head loss, backwash characteristics, water quality and rate of adsorption. The head loss is less in the larger 8 x 30-mesh carbon, but the rate of adsorption is faster in the smaller 12 x 40-mesh carbon. The 8 x 30-mesh size may be effectively used in filter/adsorbers or gravity adsorbers while the 12 x 40-mesh size often is preferable in pressure vessels where the additional head loss is normally insignificant.

The uniformity coefficient (UC) should be less than or equal to 1.7.

The particle density wetted in water is the mass of solid activated carbon plus the mass of water required to fill the internal pores per unit volume of particle. Typical values for GAC ranges from 90 to 105 pounds per cubic foot. This parameter determines the extent of fluidization and expansion of a given size particle during backwash.

f. Materials of Construction

To prevent corrosion, construction materials should be concrete, 316 stainless steel (304 stainless steel can corrode in the presence of activated carbon), or materials coated with paints or liners suitable for contact with wet carbon. If concrete is used, the reinforcing steel should be covered by at least 2 inches (5 centimeters) of concrete.

g. System Operation

(1) Backwashing

(a) Following the initial installation of the GAC unit, the system should be backwashed to provide filter effluent clear of activated carbon fines. Provisions should be made to completely exclude air from all contactor backwash piping in order to avoid air entrainment in the GAC. These provisions should include the installation of air relief valves at the backwash pump discharge connections, as well as at high points in the piping.

(b) Frequency of backwashing usually depends on the rate of head loss buildup. The quantity of backwash water depends on the amount and characteristics of the accumulated solids. The frequency of backwash should be selected to ensure adequate solids removal and prevention of compaction of accumulated solids. A guide to selecting backwash frequency and duration is that no more than 1 percent of the treated clean water should be required for backwashing.

(c) Filtering-to-waste for a few minutes after backwashing will prevent buildup of activated carbon fines in the distribution system and, thereby, lessen potential bacteriological or aesthetic problems.

(d) Granular activated carbon is less dense than sand (1.4 grams per cubic centimeter versus 2.6 grams per cubic centimeter), so backwash water should be applied slowly initially, and then the rate gradually increased until the bed is expanded properly.

(2) GAC Storage and Transport

Separate storage facilities should be provided for the spent and regenerated or virgin make-up GAC. Storage facilities may not be required for smaller systems or where regeneration will be performed off-site. Storage capacity should be designed to ensure operational flexibility.

The selection of the type of storage tank to use and its location is a function of the quantity of carbon to be stored and the materials of construction. The tank can be sized to hold the entire contents of a carbon contactor or an amount equal to 1 or 2 days of furnace production capacity.

A conical bottom design is recommended to provide for complete removal of carbon from the tank. The angle of the cone should be adequate to ensure carbon removal, with 45 degrees as the minimum.

Since carbon, water and oxygen are corrosive to carbon steel, the materials of construction should be stainless steel or carbon steel with a 30 to 40 mil lining.

Facilities shall be provided to fluidize the GAC to permit the use of either recessed impeller slurry pumps or eductor systems. Withdrawal ports should be provided in the support plate or the sidewall to facilitate removal of spent carbon. GAC should be transported as a water slurry at a concentration of 1 to 3 pounds of GAC per gallon of water.

(3) Reactivation

Carbon Regeneration - Another basic consideration in evaluating the design of a GAC system for organics removal is the method of carbon regeneration (reactivation). The two basic approaches to regenerating the carbon are: 1) Off-site disposal or regeneration; and 2) On-site regeneration. On-site regeneration generally is not feasible for systems where the carbon exhaustion rate is less than 1,000 to 2,000 pounds per day.

Three potential reactivation techniques are chemical, steam and thermal. Thermal reactivation is the recommended procedure for on-site regeneration. Four different thermal reactivation systems are rotary kilns, hearth furnaces, fluid bed furnaces, and infrared furnaces. Multiple hearth is the traditional method of granular activated carbon reactivation, although fluidized bed and infrared furnaces are being used more frequently.

Reactivation (or regeneration) is the process of removing adsorbed organics and restoring the adsorptive characteristics of the adsorbent. It is recommended that only GAC used in drinking water treatment applications at a specific site be regenerated and reused in the same drinking water treatment facility. Thermal regeneration is recommended for facilities using on-site regeneration and should be carried out in the following scheme:

(a) The exhausted granular carbon should be backwashed.

(b) The washed granular carbon should be fed into a furnace and subjected to a controlled atmosphere of steam and oxygen at temperatures approaching 1,000°C. Air pollution devices, such as scrubbers and afterburners, shall be installed on the furnace to control off-gas pollutants.

(c) The reactivated carbon should be quenched with water and hydraulically transported back to the contactor (or storage).

(d) Virgin activated carbon (make-up) should be added to replace the attrition losses.

DEP's Bureau of Air Quality should be contacted for their regulatory requirements on air emissions.

(4) Monitoring

Quarterly performance monitoring of the GAC effluent is required for VOCs for which treatment has been installed. More frequent monitoring may be necessary as the concentration of the contaminants to be removed approaches their respective MCLs. The GAC should be replaced or reactivated when the concentration of any organic contaminant reaches its MCL.

h. Waste Disposal

Where off-site disposal of the exhausted carbon is employed, it should be slurried by gravity to a draining bin where the free water is removed and returned and properly disposed to waste. The drained carbon should be drummed and shipped for landfilling or incineration. Permission for landfill disposal or incineration must be obtained from the Bureau of Waste Management and Bureau of Air Quality respectively.

i. Safety

Oxygen may be consumed during chemical reactions such as in the absorption of oxygen by damp activated carbon in a filtration tank. This may pose a hazard to health unless appropriate oxygen measurements and ventilation are utilized.

G. Iron and Manganese Control

Iron and manganese control, as used herein, refers solely to treatment processes designed specifically for this purpose. The treatment process used will depend upon the character of the raw water. The selection of one or more treatment processes must meet specific local conditions as determined by engineering investigations, including chemical analysis of representative samples of water to be treated. It may be necessary to conduct a pilot plant study in order to gather all information to be used as the basis of design. Consideration should be given to adjusting pH of the raw water to optimize the chemical reaction.

1. Removal by Oxidation, Detention and Filtration

   a. Oxidation

      Oxidation may be by aeration, as indicated in Section IV.E. or by chemical oxidation with chlorine, potassium permanganate, ozone or chlorine dioxide.

   b. Detention

      (1) Reaction - A minimum detention time of 20 minutes shall be provided following aeration to ensure that the oxidation reactions are as complete as possible. This minimum detention may be reduced only after pilot plant studies support a reduced detention time. The detention basin may be designed as a holding tank with no provisions for sludge collection, but with sufficient baffling to prevent short-circuiting.

      (2) Sedimentation - Sedimentation basins shall be provided when treating water with high iron and/or manganese content, or where chemical coagulation is used to reduce the load on the filters. Provisions for sludge removal shall be made.

   c. Filtration

      Duplicate filters shall be provided which conform to Section IV.D.

2. Removal by Lime-Soda Softening Process

   See Section IV.H.1.

3. Removal by Manganese Greensand Filtration

   This process generally consists of the continuous or batch feed of potassium permanganate to the influent of a manganese greensand filter. Duplicate units shall be provided as outlined in Section IV.D.2.b.

   a. Provisions should be made to apply the permanganate as far ahead of the filter as practical and to a point immediately before the filter.

   b. Other oxidizing agents or processes such as chlorination or aeration may be used prior to the permanganate feed to reduce chemical costs.

   c. An anthracite media cap of at least 6 inches shall be provided over manganese greensand.

   d. Normal filtration rate is 3 gpm per square foot except where in-plant testing can demonstrate satisfactory results at higher rates.

e. Minimum wash rate should be 12 gpm per square foot at 60°F water temperature.

f. Air washing should be provided.

g. Sample taps shall be provided:

(1) Prior to addition of any oxidants.

(2) Immediately ahead of filtration.

(3) Halfway down the manganese greensand.

(4) At the filter effluent.

4. Removal by Ion-Exchange

This process of iron and manganese removal should not be used for water containing more than 0.3 mg/L of iron, manganese or a combination thereof. This process is not acceptable where either the raw water or washwater contains DO.

5. Sequestration by Polyphosphates

This process shall not be used when iron, manganese or a combination thereof exceeds 1.0 mg/L. The total phosphate applied shall not exceed 10 mg/L as PO_4. The product feed rate shall not exceed the limit established under ANSI/NSF Standard No. 60, or as otherwise established by DEP. Where phosphate treatment is used, satisfactory free chlorine residuals must be maintained in the distribution system. Polyphosphate treatment may be less effective for sequestering manganese than for iron.

a. Feeding equipment shall conform to the requirements of Section V.

b. Stock phosphate solution must be kept covered and disinfected by carrying approximately 10 mg/L free chlorine residual, unless the phosphate is not able to support bacterial growth and the phosphate is being fed from the covered shipping container. Phosphate solutions having a pH of 2.0 or less may also be exempted from this requirement by DEP.

c. Polyphosphates shall not be applied ahead of iron and manganese removal treatment. The point of application shall be prior to any aeration, oxidation or disinfection if no iron or manganese removal treatment is provided.

d. Phosphate chemicals must be acceptable to DEP. Chemicals certified under ANSI/NSF Standard 60 are deemed acceptable to DEP.

6. Sequestration by Sodium Silicates

Sodium silicate sequestration of iron and manganese is appropriate only to groundwater supplies prior to air contact. On-site pilot tests are required to determine the suitability of sodium silicate for the particular water and the minimum feed needed. Rapid oxidation of the metal ions (e.g., by chlorine or chlorine dioxide) must accompany or closely precede the sodium silicate addition. Injection of sodium silicate more than 15 seconds after oxidation may cause detectable loss of chemical efficiency. Dilution of feed solutions much below 5 percent silica as SiO_2 should be avoided for the same reason. Sodium silicate treatment may be less effective for sequestering manganese than for iron.

a. Silicate addition is applicable to waters containing up to 2 mg/L of iron, manganese or a combination thereof.

b. Chlorine residuals shall be maintained throughout the distribution system to prevent biological breakdown of the sequestered iron.

c. The amount of silicate added shall be limited to 20 mg/L as SiO_2, but the amount of added and naturally occurring silicate shall not exceed 60 mg/L as SiO_2. The product feed rate shall not exceed the limit established under ANSI/NSF Standard No. 60, or as otherwise established by DEP.

d. Feeding equipment shall conform to the requirements of Section V.

e. Silicate shall not be applied ahead of iron or manganese removal treatment.

f. Sodium silicate must be acceptable to DEP. Chemicals certified under ANSI/NSF Standard 60 are deemed acceptable to DEP.

7. Sampling Taps

Smooth-nosed sampling taps shall be provided for control purposes. Taps shall be located on each raw water source, each treatment unit influent and each treatment unit effluent line.

8. Testing Equipment

Testing equipment shall be provided for all plants.

a. The equipment should have the capacity to accurately measure the iron content to a minimum of 0.1 mg/L and the manganese content to a minimum of 0.05 mg/L.

b. Where polyphosphate sequestration is practiced, appropriate phosphate testing equipment shall be provided.

H. Softening

The softening process selected must be based upon the mineral qualities of the raw water and the desired finished water quality in conjunction with requirements for disposal of sludge or brine waste, cost of plant, cost of chemicals and plant location. Applicability of the process chosen shall be demonstrated.

1. Lime or Lime-Soda Process

Design standards for rapid mix, flocculation and sedimentation are the same as for conventional water purification (See Section IV.C.), except that the mixing and flocculation period should be at least 40 minutes. Additional consideration must be given to the following process elements.

a. Hydraulics

When split treatment is used, the bypass line should be sized to carry total plant flow, and an accurate means of measuring and splitting the flow must be provided.

b. Aeration

Determinations should be made for the carbon dioxide content of the raw water. When concentrations exceed 10 mg/L, the economics of removal by aeration as opposed to removal with lime should be considered if it has been determined that the DO level in the finished water will not cause corrosion problems in the distribution system. Aeration systems shall be designed in accordance with Section IV.E.

c. Chemical Feed Point

Lime and recycled sludge should be fed directly into the rapid mix basin.

d. Rapid Mix

Rapid mix basins must provide not more than 30 seconds detention time with adequate velocity gradients to keep the lime particles dispersed.

e. Stabilization

Equipment for stabilization of water softened by the lime or lime-soda process is required (See Section IV.J.).

f. Sludge Collection

(1) Mechanical sludge removal equipment shall be provided in the sedimentation tank.

(2) Sludge recycling to the rapid mix should be provided.

g. Sludge Disposal

Provisions must be included for proper handling and disposal of softening sludges.

h. Disinfection

The use of excess lime shall not be considered an acceptable substitute for disinfection (See Section IV.B.).

i. Plant Start-Up

The plant processes must be manually started following shut-down.

2. Cation Exchange Process

Alternative methods of hardness reduction should be investigated when the sodium content and dissolved solids concentration is of concern.

a. Pretreatment Requirements

Iron, manganese, or a combination of the two, should not exceed 0.3 mg/L in the water as applied to the ion exchange resin. Pretreatment is required when the content of iron, manganese, or a combination of the two is 1 mg/L or more (See Section IV.G.). Waters having 5 units or more turbidity should not be applied directly to the cation exchange softener.

b. Design

The units may be of pressure or gravity type of either an upflow or downflow design. Automatic regeneration based on volume of water softened should be used unless manual regeneration is justified and is approved by DEP. A manual override shall be provided on all automatic controls. Final sodium concentration and its health impact on the water system users must be a consideration if sodium chloride is used to regenerate the ion exchange beds.

c. Exchange Capacity

The design capacity for hardness removal should not exceed 20,000 grains per cubic foot when resin is regenerated with 0.3 pounds of salt per kilograin of hardness removed.

d. Depth of Resin

The depth of the exchange resin should not be less than 3 feet.

e. Flow Rates

The rate of softening should not exceed 7 gpm per square foot of bed area and the backwash rate should be 6 to 8 gpm per square foot of bed area. Rate-of-flow controllers or their equivalent must be installed on the backwash and rinse water lines.

f. Freeboard

The freeboard will depend upon the size and specific gravity of the resin and the direction of water flow. Generally, the washwater collector should be 24 inches above the top of the resin on downflow units.

g. Underdrains and Supporting Gravel

The bottoms, strainer systems and support for the exchange resin shall conform to criteria provided for rapid rate gravity filters (See Sections IV.D.2.f. and IV.D.2.g.).

h. Brine Distribution

Facilities should be included for even distribution of the brine over the entire surface of both upflow and downflow units.

i. Cross-Connection Control

Backwash, rinse and air relief discharge pipes shall be installed in such a manner as to prevent any possibility of back-siphonage. An air gap shall be provided at any connection to a sanitary sewer system.

j. Bypass Piping and Equipment

A bypass must be provided around softening units to produce a blended water of desirable hardness. Totalizing meters must be installed on the bypass line and on each softener unit. An automatic proportioning or regulating device and shut-off valve should be provided on the bypass line. In some installations, it may be necessary to treat the bypassed water to obtain acceptable levels of iron and/or manganese in the finished water.

k. Additional Limitations

Silica gel resins should not be used for waters having a pH above 8.4 or containing less than 6 mg/L silica and should not be used when iron is present. When the applied water contains a chlorine residual, the cation exchange resin shall be a type that is not damaged by residual chlorine. Phenolic resins should not be used.

l. Sampling Taps

Smooth-nose sampling taps must be provided for the collection of representative samples. The taps shall be located to provide for sampling of the softener influent, effluent and blended water. The sampling taps for the blended water shall be at least 20 feet downstream from the point of blending. Petcocks are not acceptable as sampling taps. Sampling taps should be provided on the brine tank discharge piping.

m. Brine and Salt Storage Tanks

(1) Salt dissolving or brine tanks and wet salt storage tanks must be covered and must be corrosion-resistant.

(2) The make-up water inlet must be protected from back-siphonage. An air gap is the preferred method of protection. Water for filling the tank should be distributed over the entire surface by pipes above the maximum brine level in the tank. The tanks should be provided with an automatic declining level control system on the make-up water line.

(3) Wet salt storage basins must be equipped with manholes or hatchways for access and for direct dumping of salt from truck or rail car. Openings must be provided with raised curbs and watertight covers having overlapping edges similar to those required for finished water reservoirs.

(4) Overflows, where provided, must be turned down, have a proper free fall discharge, and be protected with corrosion-resistant screens or self-closing flap valves.

(5) Two wet salt storage tanks or compartments designed to operate independently should be provided.

(6) The salt shall be supported on graduated layers of gravel under which is a suitable means of collecting the brine.

(7) Alternative designs which are conducive to frequent cleaning of the wet salt storage tank may be considered.

n. Brine and Salt Storage Capacity

Total salt storage should have sufficient capacity to store in excess of 1½ carloads or truckloads of salt, and provide for at least 30 days of operation. Brine storage should be adequate to regenerate the softeners for 24 hours of operation without being replenished.

o. Brine Pump or Eductor

An eductor may be used to transfer brine from the brine tank to the softeners. If a pump is used, a brine measuring tank or means of metering should be provided to obtain proper dilution.

p. Stabilization

The need for stabilization for corrosion control shall be evaluated. An alkali feeder shall be provided except when exempted by DEP (See Section IV.J.).

q. Waste Disposal

Suitable disposal must be provided for brine waste (See Section IV.N.). Where spent brine disposal must be reduced, consideration may be given to using a part of the spent brine for a subsequent regeneration.

r. Construction Materials

Pipes and contact materials must be resistant to the aggressiveness of salt. Plastic and red brass are acceptable piping materials. Steel and concrete must be coated with a nonleaching protective coating which is compatible with salt and brine.

s. Housing

Bagged salt and dry bulk salt storage shall be enclosed and separated from other operating areas in order to prevent damage to equipment.

t. Water Quality Testing Equipment

Test equipment for alkalinity, total hardness, carbon dioxide content and pH should be provided to determine treatment effectiveness.

I. Taste and Odor Control

Provisions shall be made for the addition of taste and odor control chemicals at all surface water treatment plants. Chemicals shall be added sufficiently ahead of other treatment processes to ensure adequate contact time for an effective and economical use of the chemicals. Where severe taste and odor problems are encountered, in-plant and/or pilot plant studies are required. In addition, a complete chemical and biological analysis of the raw water to identify the cause of the problem should be conducted.

1. Flexibility

Plants treating water that is known to have taste and odor problems should be provided with equipment that makes several of the control processes available so that the operator will have flexibility in operation.

2. Chlorination

Chlorination can be used for the removal of some objectionable odors. Adequate contact time must be provided to complete the chemical reactions involved. Excessive potential DBP production through this process should be avoided by adequate bench testing prior to design.

3. Chlorine Dioxide

Chlorine dioxide has been generally recognized as a treatment for tastes or odors caused by industrial wastes, such as phenols. However, chlorine dioxide can be used in the treatment of any taste or odor that is treatable by an oxidizing compound. Provisions shall be made for proper storing and handling of the sodium chlorite to eliminate any danger of explosion.

4. Powdered Activated Carbon

a. Powdered activated carbon should be added as early as possible in the treatment process to provide maximum contact time. Flexibility to allow the addition of carbon at several points is preferred. Activated carbon should not be applied near a point of chlorine or other oxidant application.

b. The carbon can be added as a pre-mixed slurry as by means of a dry-feed machine as long as the carbon is properly wetted.

c. Continuous agitation or resuspension equipment is necessary to keep the carbon from depositing in the slurry storage tank.

d. Provision shall be made for adequate dust control.

e. The required rate of feed of carbon in a water treatment plant depends upon the tastes and/or odors involved, but provision should be made for adding from 0.1 mg/L to at least 40 mg/L.

f. Powdered activated carbon shall be handled as a potentially combustible material. It should be stored in a building or compartment as fireproof as possible. Other chemicals should not be stored in the same compartment. Carbon feeder rooms should be equipped with explosion-proof electrical outlets, lights and motors.

5. Granular Activated Carbon Adsorption Units

Rates of flow must be consistent with the type and intensity of the problem. The rate used shall be supported by the results of pilot plant studies (See Section IV.D.2.g.).

Replacement of anthracite with GAC may be considered as a control measure for geosmin and methyl isoborneol (MIB) taste and odors from algae blooms. Demonstration studies may be required by DEP.

6. Copper Sulfate and Other Copper Compounds

Continuous or periodic treatment of water with copper compounds to kill algae or other growths shall be controlled to prevent copper in excess of 1.0 mg/L (as copper) in the plant effluent or distribution system. Care shall be taken to ensure an even distribution within the treatment area to prevent excessive concentrations which may be toxic. Approval for the dose proposed must be obtained from DEP before applying copper compounds.

7. Aeration

See Section IV.E.

8. Potassium Permanganate

Application of potassium permanganate may be considered providing the treatment is designed so that the products of the reaction are not visible in the finished water.

9. Ozone

Ozonation can be used as a means of taste and odor control. Adequate contact time must be provided to complete the chemical reactions involved. Ozone is generally more desirable for treating water with high threshold odors. Ozone systems shall be designed in accordance with Section IV.B.2.b.

10. Other Methods

The decision to use any other method of taste and odor control should be made only after careful laboratory and/or pilot plant tests and on consultation with DEP.

J. Stabilization

Water may be unstable (i.e., change its chemical composition after prolonged contact with water system components such as treatment, distribution or storage facilities) due to carbon dioxide, low pH, oversaturation with calcium or magnesium bicarbonates and high levels of total dissolved solids. Subsequent corrosion may also be caused by galvanic or biochemical action. Water that is unstable due either to natural causes or to subsequent treatment should be stabilized. The chemical quality of all additives used to stabilize water must be acceptable to DEP. Chemicals which may come in contact with or affect the quality of the water and which are certified for conformance with ANSI/NSF Standard 60 (Drinking Water Treatment Chemicals-Health Effects) are deemed acceptable to DEP.

1. Acid and/or Base Addition

   a. Chemical feed equipment shall conform to Section V.

   b. Adequate precautions shall be taken for safety, such as those outlined in Sections V.D. and V.E.

2. Phosphates

   The feeding of phosphates may be applicable for sequestering calcium, corrosion control, and in conjunction with alkali feed following ion-exchange softening.

   a. Feed equipment shall conform to Section V.

   b. Manufacturer specifications for handling, storage and use shall be followed.

   c. Stock phosphate solution must be kept covered and disinfected by carrying approximately 10 mg/L free chlorine residual unless the phosphate is not able to support bacterial growth and the phosphate is being fed from the covered shipping container. Phosphate solutions having a pH of 2.0 or less may also be exempted from this requirement by DEP.

   d. Satisfactory disinfectant residuals shall be maintained in the distribution system when phosphates are used to ensure bacteriological safety of the water.

3. Alkali Feed

   Unstable water created by ion-exchange softening shall be stabilized by an alkali feed. An alkali feeder shall be provided for all ion-exchange water softening plants except when exempted by DEP.

4. Carbon Dioxide Reduction by Aeration

   The carbon dioxide content of an aggressive water may be reduced by aeration. Aeration devices shall conform to Section IV.E.

5. Split Treatment

   Under some conditions, a lime-softened water treatment plant can be designed using “split treatment” in which raw water is blended with lime-softened water to partially stabilize the water. Treatment plants designed to utilize “split treatment” also should contain facilities for further stabilization by other methods. Bypassing part of the flow from surface sources without equivalent complete treatment will not be allowed.

6. Carbon Dioxide Addition

   a. Recarbonation basin design should provide:

      (1) A total detention time of 20 minutes.

      (2) Two compartments, each with a depth of 8 feet, as follows:

         (a) A mixing compartment having a detention time of at least 3 minutes

         (b) A reaction compartment

   b. The practice of on-site generation of carbon dioxide is discouraged.

   c. Where liquid carbon dioxide is used, adequate precautions must be taken to prevent carbon dioxide from entering the plant from the recarbonation process.

   d. Recarbonation tanks shall be located outside or be sealed and vented to the outside with adequate seals and adequate purge flow of air to ensure worker's safety.

   e. Provision shall be made for draining the recarbonation basin and removing sludge.

7. Water Unstable Due to Biochemical Action in Distribution System

   Unstable water resulting from the bacterial decomposition of organic matter in water (especially in dead end mains), the biochemical action within tubercles, and the reduction of sulfates to sulphides should be prevented by the maintenance of a free chlorine residual throughout the distribution system.

8. Other Treatment

   Other treatment for controlling corrosive waters by the use of sodium silicate or calcium precipitation may be used where necessary. Any proprietary compounds must receive the specific approval of DEP before use. Chemical feeders shall be as required in Section V.

9. Cathodic Protection

   Cathodic protection should be considered to help prevent or minimize corrosion on the outer surfaces of metal conduits.

10. Control

   Laboratory equipment shall be provided for determining the effectiveness of stabilization treatment and the concentration of chemicals in the treated water.

K. Fluoridation

Fluoridation of the public water supply may be used to reduce tooth decay.

1. Fluoride Compounds

   Commercial sodium fluoride, sodium silicofluoride and hydrofluosilicic acid shall conform to the applicable AWWA standards and ANSI/NSF Standard 60. Other fluoride compounds which may be available must be approved by DEP. The proposed method of fluoride feed should be discussed with DEP prior to preparation of final plans and specifications.

2. Fluoride Compound Storage

   Fluoride chemicals should be isolated from other chemicals to prevent contamination. Compounds shall be stored in covered or unopened shipping containers and should be stored inside a building. Unsealed storage units for hydrofluosilicic acid should be vented to the atmosphere at a point outside the building and shall dissipate in an area remote from any air intakes. Bags, fiber drums and steel drums should be stored on pallets.

3. Chemical Feed Equipment and Methods

   In addition to the requirements in Section V., fluoride feed equipment shall meet the following requirements:

   a. Scales, loss-of-weight recorders or liquid level indicators shall be provided for each chemical feed system.

   b. Feeders shall be accurate to within 5 percent of any desired feed rate.

   c. Fluoride compounds shall not be added before lime-soda softening. Fluoride compounds should be added after filtration to avoid losses which can be caused by pretreatment chemicals.

   d. The point of application of hydrofluosilicic acid, if into a horizontal pipe, shall be in the lower half of the pipe.

   e. A fluoride solution shall be applied by a positive displacement pump having a stroke rate not less than 20 strokes per minute, and at a feed rate not less than 20 percent of the rated capacity of the feed pump.

   f. Anti-siphon devices shall be provided for all fluoride feed lines and dilution water lines.

   g. A device to measure the flow of water to be treated is required.

   h. Water used for sodium fluoride dissolution shall be softened if the hardness exceeds 75 mg/L.

i. Fluoride solutions shall not be injected to a point of negative pressure.

j. Consideration shall be given to providing a separate room for fluorosilicic acid storage and feed.

4. Secondary Controls

Secondary control systems for fluoride chemical feed devices may be required by DEP as a means of reducing the possibility for overfeed.

5. Protective Equipment

Protective equipment, as outlined in Section V.D., shall be provided for all operators handling fluoride compounds.

6. Dust Control

a. Provision must be made for the transfer of dry fluoride compounds from shipping containers to storage bins or hoppers in such a way as to minimize the quantity of fluoride dust which may enter the room in which the equipment is installed. The enclosure shall be provided with an exhaust fan and dust filter which place the hopper under a negative pressure. Air exhausted from fluoride handling equipment shall discharge through a dust filter to the outside atmosphere of the building.

b. Provision shall be made for disposing of empty bags, drums or barrels in a manner which will minimize exposure to fluoride dusts. A floor drain should be provided to facilitate the hosing of floors.

7. Testing Equipment

Equipment shall be provided for measuring the quantity of fluoride in the water. Testing equipment shall be colorimetric or electrode type subject to the approval of DEP.

L. Microscreening

A microscreen is a mechanical supplement capable of removing suspended matter from the water by straining, usually prior to other treatment. It may be used to reduce nuisance organisms and organic loadings. Microscreening shall not be used in place of coagulation, in the preparation of water for filtration or filtration.

1. Design

a. Design shall give due consideration to:

(1) Nature of the suspended matter to be removed.

(2) Corrosiveness of the water.

(3) Effect of chlorination when required as pretreatment.

(4) Duplication of units for continuous operation during equipment maintenance or breakdown.

(5) Automated backflushing operation.

b. Design shall provide:

(1) A durable, corrosion-resistant screen.

(2) Bypass arrangements.

(3) Protection against back-siphonage when potable water is used for washing.

(4) Proper disposal of washwater (See Section IV.N.).

M. Membrane Treatment Processes

1. General

Membrane processes are water conditioning processes by which particulates, dissolved minerals, or ions, are removed from water by the use of semi-permeable membranes. Membrane processes can be used to remove excess dissolved solids, a variety of organic contaminants and, to a lesser extent, radionuclides from drinking water. Membrane processes can be used specifically for the removal of particulate material, including microorganisms such as protozoa (*Giardia* and *Cryptosporidium*), bacteria and viruses.

Membrane processes differ in the types of membranes, the driving forces, and the operating conditions used to accomplish the separations, as well as in the general nature of the feed stream treated (e.g., aqueous-organic, liquid-gaseous). Five predominant membrane processes include: reverse osmosis (RO), nanofiltration (NF), electrodialysis reversal (EDR), ultrafiltration (UF) and microfiltration (MF). The last two are considered filtration processes.

These treatment processes are not commonly encountered in most community water systems. However, these methods are expected to increase in popularity to accommodate future demand for higher drinking water quality.

Four membrane configurations currently available are spiral-wound, hollow fine fiber, tubular and plate frame. However, only the spiral-wound and hollow fine fiber types are employed in potable water treatment.

Because of the specialized design, operation and maintenance required for these processes, design of these systems should not commence until the proposal has been discussed with DEP.

The design of membrane systems must take into consideration:

- The quantity and quality of the raw water.
- The pretreatment and posttreatment processes.
- Corrosiveness of the finished water.
- Concentrate disposal.

Materials used in construction of a membrane treatment process which are certified for conformance with ANSI\NSF Standard 61 (Drinking Water System Components-Health Effects-National Sanitation Foundation) are acceptable to DEP.

a. Pilot Studies

Installation of a full-scale membrane system must be preceded by a bench-scale and/or pilot plant study to evaluate and provide performance data on the specific system to be used. Pilot testing must be conducted over a sufficient time period to establish that the technology is appropriate for the source water and to determine appropriate design and operating parameters. Bench-scale studies, requiring less time and expense should be considered a preliminary evaluation tool to verify process feasibility and to evaluate individual membrane elements. The pilot study proposal must be submitted to the appropriate DEP regional office for approval prior to initiating the pilot study. The following should be factored into a proposed pilot study:

(1) All pilot study units should include a membrane feed pump.

(2) Taps should be provided on-line to provide supplies for sampling, particle monitor, particle counter and turbidimeter.

(3) The bench-scale unit should have instrumentation and controls needed to establish system hydraulic operation and monitoring.

(4) The pilot plant unit shall have on-line instrumentation for continuous measurement of turbidity and particle count of the membrane feedwater and permeate.

(5) During the period of the pilot study, operational conditions and water quality should be monitored.

b. Raw Water Source and Pretreatment

One of the most important aspects of membrane treatment plant selection and design is the source and character of the proposed raw water. The main water quality parameters which affect membrane production are turbidity, TOC and algae content. Membrane processes can be used to treat turbid waters but may result in higher operation and maintenance costs and possibly more frequent replacement for some membrane types.

Chlorine and its byproducts have often proven to be a major cause of membrane failures. Thin film composites are the most intolerant while the polyvinylidenedifluoride (PVDF) and Teflon ones are the most resistant. The mode of failure is degradation of the membrane surface by oxidation. System designers must know the properties of the specific membranes to be used in the system to prevent this type of problem.

When thin film composite membranes are used in the membrane process, the feed stream must be dechlorinated to prevent premature failure of the membrane. Ultraviolet (UV) disinfection is recommended as a safe alternative disinfectant to chlorine and other oxidants.

c. Posttreatment

Posttreatment of the membrane-filtered water is an important consideration when designing and selecting a membrane process. Posttreatment of product water should be done to remove toxic gases, improve taste and odor, prevent corrosion in the distribution system, and prevent bacteria growth in the distribution system.

d. Membrane Cleaning

The RO and NF membranes should be cleaned periodically to maintain high average flux levels without excessive pressure drops. The cleaning method and frequency depend on the type of membrane and its chemical resistance. Hydraulic cleaning of the membrane prior to chemical cleaning is recommended.

Monthly cleaning at start-up is recommended for EDR plants. However, cleaning should be provided more frequently when the applied voltage must be increased to maintain the amperage and resultant ion movement.

More extensive cleaning is required for standard EDR systems. The cleaning is generally accomplished by pumping an acid or a caustic solution through the system (depending on the deposits to be removed) and then flushing the system with product water. The cleaning frequency should be weekly or monthly, as determined by experience.

UF and MF systems should be cleaned periodically to maintain flux levels. Most UF and MF membranes are more resistant to chemicals and pH extremes than are RO and NF membranes and thus can be subjected to harsher cleaning environments.

Detailed information concerning the manufacturer's cleaning requirements and types of cleaning chemicals should be submitted to DEP as part of the application. Chemicals which may come in contact with the water or affect the quality of the water and which are certified for conformance with ANSI/NSF Standard 60 (Drinking Water Treatment Chemicals - Health Effects) are deemed acceptable to DEP.

In addition to routine cleaning, regular flushing of all membrane-based systems is recommended.

e. Brine Disposal

Where applicable, a detailed description of the brine disposal procedures is to be submitted to DEP as part of the permit application. Normally accepted methods include discharge to the municipal sewers or to evaporation ponds. Disposal on land or to surface water requires appropriate permits from DEP.

f. Waste Disposal

Three wastestreams are generated in the EDR process: the concentrate stream, the off-specification product stream and the liquid electrode wastestream. Each of these three wastestreams may be recycled. Because EDR systems can attain relatively high recoveries, the concentrate concentrations can be much higher than for RO and NF processes. Wastestreams for the standard electrodialysis (ED) process include the concentrate stream and the liquid electrode wastestream.

The only species in the feedwater that are rejected by the UF and MF membranes are those larger than the effective pore size of the membrane, which might be particulates, microorganisms and some organics.

A detailed description of the disposal procedures shall be submitted to DEP as part of the permit application. Normally accepted methods include recycling of the wastestream or discharge to municipal sewers or evaporation ponds. Disposal on land or to surface water requires appropriate permits from DEP.

2. Reverse Osmosis (RO)

a. General

Reverse osmosis is a pressure-driven process that retains virtually all ions and passes water. The pressure applied exceeds the osmotic pressure of the salt solution against a semipermeable membrane, thereby forcing pure water through the membrane and leaving salts behind. RO units may utilize either spiral-wound or hollow fine fiber membranes. RO units are very effective for seawater desalting, brackish water desalting and fresh water treatment.

The reverse osmosis process should not be used to treat waters having a total dissolved solids concentration exceeding 12,000 mg/L for low pressure (400 psi) membranes or 30,000 mg/L for high pressure (1,000 psi) membranes without justification. Detailed information shall be submitted to DEP concerning required feedwater quality and anticipated performance capabilities of the reverse osmosis process.

b. Pretreatment System

Pretreatment systems should be capable of producing feed water of a quality recommended by the manufacturer of the reverse osmosis unit. Detailed information, including the manufacturer's feed water requirements, proposed pretreatment equipment and evidence that this pretreatment system is capable of producing the desired feed water quality, should be included in the permit application. Generally, cartridge filtration immediately prior to the membrane is recommended.

Pretreatment for groundwater should include acid and antiscalants to inhibit the formation of scale precipitates.

Pretreatment for surface waters should include disinfection for microbiological contaminants and some form of coagulation-flocculation and filtration for removal of suspended and colloidal matter. UF and MF processes may be used as pretreatment to extend membrane life.

Pretreatment of the feed water shall be provided to remove suspended matter or iron and manganese if the feed water contains 5 NTU or more turbidity or 0.3 mg/L or more of iron and manganese. Adjustment of the feed water pH to 5.5 is recommended when cellulose acetate (spiral-wound) modules are used. Softening or pH adjustment is satisfactory pretreatment for hollow fiber modules.

Where the feed water pH is altered, stabilization of the finished water is mandatory (See Section IV.J.). Stabilization is optional in other cases.

c. Design Criteria

The following criteria apply to the design of an RO system:

(1) Two RO units should be provided with each unit capable of meeting the system's design capacity.

(2) Appurtenant equipment which should be considered in the design of the RO system includes the following items:

(a) A polishing membrane filter (less than or equal to 8 microns for hollow fiber modules, or less than or equal to 25 microns for a spiral-wound module) should be provided before the RO unit. Pressure gauges are required on the upstream and downstream side of the filter. The filter should be located to facilitate changes of the filtering membrane.

(b) All units shall have feed water and permeate water pressure gauges and have the capability to measure flow rates of permeate and concentrate water.

(c) Taps for sampling permeate, concentrate and blended (if practiced) flows should be provided. A conductivity meter must be provided at each installation. A continuous conductivity meter, if installed, shall be constructed so that it may be disconnected from the pipe system for calibration with standard solutions.

(3) The maximum flux rate should be 2.5 gpd per square foot of membrane per 100 pounds per square inch applied pressure. Higher flux rates will be considered upon the presentation of satisfactory evidence of reliability and performance.

(4) An in-line turbidity meter should be provided on each stage.

(5) A maximum 36 month membrane life should be assumed until satisfactory on-site data is generated.

(6) An automatic high temperature alarm or cutoff switch is to be installed if the feed water is heated. The maximum temperature setting is generally between 80°-90°F depending on the membrane used.

(7) All units should be equipped with alarms or automatic controls to shut-down the system during high effluent turbidities, high pressure differential or membrane failure (low pressure differential).

(8) Cleaning in place is usually accomplished at lower pressures but at two to three times the normal flow velocity on the concentrate side. Chelating agents as well as citric acid are acceptable provided the unit is adequately flushed following cleaning.

(9) A blending bypass shall be provided around the RO unit to produce the desired mineral concentration if necessary.

d. Posttreatment

Treated effluents from the RO process are usually low in pH and solids, high in carbon dioxide and are normally corrosive. Detailed information should be submitted to DEP concerning the anticipated corrosiveness of the product water and the methods proposed for stabilizing this water according to DEP's requirements under Subchapter K, lead and copper.

Disinfection of the treated water is required.

3. Nanofiltration (NF)

a. General

NF or membrane softening is an ion rejection process capable of rejecting divalent ions while passing monavalent ones. It is capable of passing only particles smaller than 1 nm (0.001 µm), yet exhibiting some characteristics of both a UF membrane and an RO membrane.

NF units may utilize either spiral-wound or hollow fine fiber membranes. Current applications of the NF process include the removal of organics, precursors for DBPs and oxygen demanding materials.

b. Pretreatment System

Pretreatment schemes for a given type of water are fairly similar to those of RO units. Exceptions may occur because of local water characteristics. All processes should include some form of cartridge filtration immediately prior to the membrane.

Pretreatment for groundwater should include acid and antiscalants to inhibit the formation of scale precipitates.

Pretreatment for surface waters should include disinfection for microbiological contaminants and some form of coagulation-flocculation and filtration for removal of suspended and colloidal matter. UV disinfection is recommended as a safe alternate disinfection to chlorine and other oxidants. UF and MF processes may be used as pretreatment to extend membrane life.

Where the feed water pH is altered, stabilization of the finished water is mandatory (See Section IV.J.). Stabilization is optional in other cases.

c. Design Criteria

(1) Two NF units should be provided, with each unit capable of meeting the system design capacity.

(2) A maximum 36-month membrane life should be assumed until satisfactory on-site data is generated.

(3) Appurtenant equipment which should be considered in the design of NF systems includes the following items:

(a) All units should have a feed water and permeate water pressure gauge and have the capability to measure flow rate of permeate and concentrate water.

(b) Taps for sampling permeate, concentrate and blended (if practiced) flows should be provided. A conductivity meter should be provided at each installation. A continuous conductivity meter, if installed, should be constructed so that it may be disconnected from the pipe system for calibration with standard solutions.

(4) An in-line turbidity meter should be provided on each stage.

(5) The units should be equipped with alarms or automatic controls to shut down the system during high effluent turbidities, high pressure differential or membrane failure (low pressure differential).

d. Posttreatment

Posttreatment of product water may be necessary to remove toxic gases, improve taste and odor and prevent bacteria growth in the distribution system. Detailed information should be submitted to DEP concerning the anticipated corrosiveness of the product water and the methods proposed for stabilizing this water according to DEP's requirements under Subchapter K, lead and copper.

Disinfection of the treated water is required.

4. Electrodialysis and Electrodialysis Reversal Processes (ED-EDR)

a. General

ED units usually have high maintenance costs relative to the RO method. Where maintenance is readily available, ED-EDR may be cost effective. Experience has shown stacks must be disassembled and cleaned every 2 to 4 weeks depending on the source quality and operating conditions. Generally 10 to 30 percent of the feed water is required to carry off the concentrated waste products. ED-EDR units are very effective for brackish water desalting; however, they are not quite as effective for seawater desalting and fresh water treatment. The designer should be cautioned that ED-EDR membranes may be damaged by the presence of chlorine.

b. Pretreatment for ED-EDR Systems

Appropriate pretreatment must be done if excessive colloids or organics are present in feed water. The turbidity limits are generally more stringent than those for hollow fine fiber RO membranes (NTU<2.0). The following are recommended pretreatment for ED-EDR units:

(1) The pretreatment necessary for ED is generally the same as for RO (See Section IV.M.2.c.). However, feed water may be heated to nearly 180°F to improve performance. Water should be free of iron, manganese or organics.

(2) For EDR systems, cartridge filtration should be employed as pretreatment. For surface waters, a media should be used which guard against silt deposits and other particulates. Oxidation pretreatment should be used for groundwater with iron content greater than 0.3 ppm or manganese content greater than 0.1 ppm. This treatment might be accomplished by a chlorine and media filter system, by a manganese zeolite system or by a manganese greensand system.

(3) Chlorination may be used as part of the pretreatment process. The membranes may be exposed to a maximum of 0.5 ppm chlorine continuously.

(4) In cases of high levels of hydrogen sulfide (H_2S) in the feedwater for EDR systems, oxidation (aeration, gasification or chlorine) followed by a filter should be employed to protect the membrane stack from internal oxidation and precipitation of sulfides.

c. Design Criteria

(1) The design shall include the ability to measure plant flow rates, measure feed temperature if the water is heated (a high temperature automatic cutoff is required to prevent membrane damage), and measure DC voltage at the first and second stages as well as on each of the stacks. Sampling taps shall be provided to measure the conductivity of the feed water, blowdown water and product water. DC and AC kilowatt-hour meters to record the electricity used should also be provided.

(2) All units should be equipped with alarms or automatic controls to shut down the system during high effluent turbidities, high pressure differential or membrane failure (low pressure differential).

(3) With proper care, membrane life can be assumed to average nearly 10 years.

d. Posttreatment for ED-EDR Systems

The specific posttreatment for product water depends on the feed water characteristics. Posttreatment of product water typically requires only chlorination and sometimes pH adjustment.

5. Ultrafiltration (UF) and Microfiltration (MF) Systems

a. General

UF and MF differ from RO and NF in the use of a much more permeable membrane. UF membranes are porous in structure and the mechanism is considered a sieving one. The apparent pore size of the membrane may be as small as 1 nm and are larger than RO membrane pores. In applications where the removal of dissolved minerals, TOC or DBP precursors is not critical, UF and MF technology may be appropriate. These membrane processes can effectively remove from solution species such as larger organics, colloids and microorganisms including viruses, bacteria and cysts. Both UF and MF processes may be used as pretreatments for RO and NF systems.

Depending on the particular raw water quality, membrane fouling can be a problem, resulting in high energy requirements, and membrane replacement. Pilot testing is required for all new applications of MF.

b. Pretreatment For UF and MF Systems

Pretreatment should include disinfection. UV disinfection is recommended as a safe alternative to chlorine and other oxidants.

For applications involving removal of various organics, including total organics, DBP precursors, disinfection byproduct precursors and SOCs, pretreatment shall include the addition of activated carbon or coagulation, or both.

c. Design Criteria

(1) Two UF or MF units should be provided, with each unit capable of meeting the systems design capacity.

(2) A maximum 36-month membrane life should be assumed until satisfactory on-site data is generated.

(3) The design should include the ability to measure the plant flow rate of permeate and concentrate water.

(4) All units shall be equipped with a feed water and concentrate pressure gauge. The units should also be equipped with a permeate water pressure gauge.

(5) Taps for sampling feed (raw) and finished water, permeate and concentrate shall be provided.

(6) A flux rate of 20 gpd per square foot of membrane per 125 pounds per square inch applied pressure is recommended. Higher or lower flux rates may be considered upon the presentation of satisfactory evidence of reliability and performance.

(7) A 95 percent recovery is recommended.

(8) On-line instrumentation for hydraulic and water quality characteristics should be provided for membrane feed water, permeate and concentrate.

(9) On-line instrumentation should be provided to measure flow and pressure every 4 hours, and pH, temperature and conductivity every 4 hours.

(10) Automatic controls should be provided to shut down the system during high effluent turbidities, high pressure differential or membrane failure (low pressure differential).

d. Posttreatment for UF and MF Systems

For applications in which the UF and MF processes are used to directly produce drinking water, posttreatment may include removal of toxic gases, improvement of taste and odor, and protection of the distribution system from corrosion and bacteria growth where necessary. For pretreatment applications of UF and MF for RO or NF, the product water from the UF or MF process may be fed directly to the RO or NF system.

N. Treatment Plant Wastes

With the exception of sanitary sewage, the wastes generated during the operation of water filtration plants constitute industrial wastes, and their temporary storage and handling is subject to DEP's rules and regulations. Provisions must be made for the proper storage and disposal of water treatment plant wastes such as laboratory wastes, sludges, brines and filter backwash waters. In locating waste disposal or dewatering facilities, due consideration shall be given to preventing potential contamination of the water supply. Alternative methods of water treatment and chemical use should be considered as a means of reducing filter plant wastes. Appropriate backflow protection must be provided on waste discharge piping as needed to protect the public water supply. Subsequent discharges to the waters of the Commonwealth and the ultimate disposal of waste solids also must be approved by DEP. Applicants should contact the regional water supply engineer for specific information on how to obtain these approvals.

1. Sanitary Wastes

The sanitary waste from treatment plants, pumping stations, etc. must receive treatment. Wastes from these facilities must be discharged directly to a sanitary sewer system when feasible, or if that option is not available, to an adequate on-site waste treatment facility or holding tanks. The water supplier shall obtain approval from DEP for its proposed method of dealing with sanitary wastes. Sanitary wastes may not be recycled or introduced into the potable water treatment facilities in any manner.

2. Treatment Plant Sludges and Backwash Wastes

Wastewater and sludges from treatment plants vary in quantity and characteristics depending on the treatment process and the chemical characteristics of the water being treated. Waste treatment facilities must be designed by taking into consideration the total amount of chemicals used plus a factor for turbidity. Sludge thickening should be taken into consideration as a means of reducing waste handling and disposal problems.

a. Lagoons

Lagoons are a common method of handling water treatment plant wastes. Operating costs for this technique are low but land requirements are high. Lagoons take advantage of natural temperatures (for evaporation and freezing) to aid in the dewatering of alum and lime sludges. Backwash water lagoons are not so much a disposal method as one for dewatering, thickening and temporary storage.

Where lagoons are proposed for the storage or as a method of treatment for filter plant backwash wastes, they shall conform to DEP's rules and regulations, Title 25 of the Pennsylvania Code Chapter 289, Residual Waste Disposal Impoundments available on the web at www.PACode.com Approval for the construction and use of lagoons must be obtained from DEP.

(1) Sludge holding lagoons which do not have a discharge should provide for:

(a) Location free from flooding.

(b) When necessary, dikes, deflecting gutters or other means of diverting surface water so that it does not flow into the lagoon.

(c) A minimum usable depth of 5 feet.

(d) A freeboard of at least 2 feet at all times.

(e) Adequate safety provisions.

(f) Parallel operation.

(2) Backwash lagoons used for treating brine and other backwash waste shall provide the following additional features:

(a) At least an 8-hour retention period.

(b) Be designed with a volume ten times the total quantity of wash water from the filter during any 24-hour period.

(c) A length four times the width, and the width at least three times the depth, as measured at the operating water level.

(d) Outlet to be at the end opposite the inlet.

(e) An adjustable weir overflow device at the outlet end with weir length equal to or greater than depth.

(f) Velocity to be dissipated at the inlet end.

(g) An effluent sampling point.

b. Sand Drying Beds

In determining the size of drying beds, attention shall be given to climatic conditions, the method and frequency of solids removal, and the greater land requirements. Sand drying beds should have the following features:

(1) Total filter area, regardless of the volume of water to be handled, should be no less than 100 square feet. Unless the drying bed is small enough to be cleaned and returned to service in 1 day, 2 or more cells are required.

(2) The filter shall not be subject to flooding by surface runoff or flood waters. Finished grade elevation shall be such as to facilitate maintenance, cleaning and removal of surface sand as required.

(3) The drying bed media should consist of a minimum of 12 inches of sand, 3 to 4 inches of supporting small gravel or torpedo sand and 9 inches of gravel in graded layers. All sand and gravel should be washed to remove fines.

(4) Filter sand should have an effective size of 0.3 to 0.5 mm and a uniformity coefficient not to exceed 3.5. The use of larger-sized sand must be justified by the designing engineer to the satisfaction of DEP.

(5) The drying bed should be provided with an adequate under drainage collection system to permit satisfactory discharge of filtrate.

(6) Provisions shall be made for the sampling of the filter effluent.

(7) Where freezing is a problem, provisions should be made for covering the filters during the winter months.

(8) "Red Water" (i.e., iron and manganese waste) filters shall have sufficient capacity to contain, above the level of the sand, the entire volume of wash water produced by washing all the production filters in the plant, unless the production filters are washed on a rotating schedule and the flow through the production filters is regulated by rate-of-flow controllers. Then sufficient volume must be provided to properly dispose of the wash water involved.

(9) Sufficient filter surface area should be provided so that during any one filtration cycle, no more than 2 feet of backwash water will accumulate over the sand surface.

(10) Overflow devices from "Red Water" filters shall not be permitted.

(11) "Red Water" drying beds shall comply with the common wall provisions contained in Sections VII.B.3. and VIII.J. which pertain to the possibility of contaminating treated water with an unsafe water. DEP must be contacted for approval of any arrangement where a separate structure is not provided.

c. Stream Discharges

Waste filter wash waters, waste from ion exchange plants and demineralization plants, etc., may be disposed of by discharge to a stream after adequate treatment is provided. Approval for stream discharges and the construction/operation of treatment facilities must be obtained from DEP prior to the construction of any treatment facilities.

d. Discharge to Community Sanitary Sewers

Filter backwash waters and sludges can be discharged to community sewer systems. However, approval of this method will depend on obtaining approval from the owner/operator of the sewerage treatment system before final designs are made. Special consideration must be given to the nature of sludges so as not to adversely effect the sewage treatment process or cause hydraulic problems in the sewer lines. A holding tank is recommended to prevent overloading of sewerage treatment systems. Design shall prevent cross-connections and there shall be no common walls between potable and nonpotable water.

e. Land Disposal

(1) Farmland - The application of liquid sludges to farmland may be considered as a method of ultimate disposal. Approval for this method of disposal must be obtained from DEP.

(2) Sanitary Landfill - Disposal of solid or liquid sludges at a landfill is the recommended ultimate disposal procedure provided the landfill is approved to accept such wastes. Letters of acceptance must be obtained from the landfill owner/operators along with a letter of concurrence from DEP.

f. Recycling

The recycling of filter-to-waste water, filter plant backwash water, thickener supernatant, liquids from the dewatering process and other process wastewater streams is an acceptable method of water conservation and minimizing chemical usage. However, the recycling of wastewater may, at times, adversely affect the water treatment process by recycling substances which produce taste and odors, increase pathogen concentrations, increase chlorine demand, or otherwise add to the difficulty of treating the water. In order to prevent possible adverse effects to the water treatment process, an evaluation of the chemical characteristics and quantity of wastewater to be recycled must be made to ensure its acceptability for reuse. When recycling is proposed, the water supplier shall:

(1) Operate the facility to minimize production of the wastewater streams to be recycled.

(2) Provide instrumentation needed to be able to measure and record the instantaneous flow rates of both the raw water and all recycle streams. If the recycle streams are combined prior to their return, it is sufficient to measure and record their combined flow rate.

(3) Control the rate of recycling to minimize the impact to the treatment process and finished water quality. The maximum instantaneous rate of recycling should be maintained at 10 percent of the raw flow rate, or less.

(4) Provide on-line instrumentation to allow operators to determine the impact of recycling upon raw water quality and its chemical treatment requirements. A turbidimeter or streaming current detector and, when appropriate, a pH meter shall be provided downstream of the location where the recycle stream is returned to the process. If the configuration of the facility prevents installation of such equipment on the blended water line prior to subsequent treatment, the supplier may install separate equipment to monitor

the raw and recycled flows and then use this information to determine the blended water treatment requirements.

(5) Operators of conventional or direct filtration facilities shall recycle spent filter backwash water, thickener supernatant, and liquids from dewatering processes before or concurrent with the point of primary coagulant addition, or at an alternate location approved by DEP.

V. CHEMICALS AND CHEMICAL HANDLING

A. General

No chemicals shall be applied to drinking waters unless specifically permitted by DEP. Chemicals which may come in contact with or affect the quality of the water and which are certified for conformance with ANSI/NSF Standard 60 (Drinking Water Treatment Chemicals-Health Effects) are deemed acceptable to DEP.

1. Plans and Specifications

   Plans and specifications shall be submitted for review and approval, as provided for in Section I.B.3. and shall include:

   a. Descriptions of feed equipment, including maximum and minimum feed ranges.

   b. Location of feeders, piping layout and points of application.

   c. Storage and handling facilities.

   d. Specifications for chemicals to be used.

   e. Operating and control procedures including proposed application rates.

   f. Descriptions of testing equipment and procedures.

2. Chemical Application

   Chemicals shall be applied to the water at such points and by such means as to:

   a. Ensure maximum efficiency of treatment.

   b. Ensure maximum safety to consumer.

   c. Provide maximum safety to operators.

   d. Ensure satisfactory mixing of the chemicals with the water.

   e. Provide maximum flexibility of operation through various points of application, when appropriate.

   f. Prevent backflow or back-siphonage between multiple points of feed through common manifolds.

B. Facilities Design

1. Design and Capacity

   The design of chemical feed equipment shall be such that:

   a. Feeders will be able to supply, at all times, the necessary amounts of chemicals at an accurate rate, throughout the range of feed, considering initial and ultimate treatment plant capacity.

   b. Equipment surfaces and any appurtenances which contact chemicals are resistant to the aggressiveness of the chemical.

   c. Corrosive chemicals are introduced in such a manner as to minimize potential for corrosion.

   d. Chemicals that are incompatible are not fed, stored or handled together.

   e. All chemicals are conducted from the feeder to the point of application in separate conduits.

   f. Chemical feeders are as near as practical to the feed point.

   g. Chemical feeders and pumps operate within the feed range recommended by the manufacturer.

   h. Chemicals may be fed by gravity where practical.

2. Number of Feeders

   a. Where chemical feed is necessary for the protection of the supply, such as chlorination, coagulation, corrosion control or other essential processes:

      (1) A minimum of two feeders shall be provided.

      (2) The standby unit or a combination of units of sufficient capacity should be available to replace the largest unit during shutdowns.

      (3) Where a booster pump is required, duplicate equipment and, when necessary, standby power shall be provided. The standby power shall be capable of taking over with minimal delay in the event of a power outage in order to keep booster pumps in service.

   b. A separate feeder shall be used for each chemical applied.

   c. Spare parts shall be available for all feeders to replace parts which are subject to wear and damage.

3. Control

a. Feeders may be manually or automatically controlled, with automatic controls being designed to allow override by manual control.

b. Automatic chemical dose or residual analyzers should provide:

(1) Alarms for critical values.

(2) Recording charts, or a digital readout with computerized data recorder.

c. Chemical feed rates shall be proportional to the rate of flow, especially where the water flow rate is not constant.

d. A means to measure water flow must be provided in order to determine chemical feed rates.

e. A method of ensuring complete mixing of treatment chemicals with the treatment plant influent water shall be provided. Mixing gradients for various treatment chemicals shall be as follows:

(1) Coagulation with low molecular weight polymer: 200-400 sec^{-1}

(2) Coagulation without polymer: 300-1,000 sec^{-1}

(3) Disinfection: 500-1,000 sec^{-1}

(4) Corrosion Control: 500-1,000 sec^{-1}

f. Provisions shall be made for measuring the quantities of chemicals used.

g. Weighing scales:

(1) Shall be provided for weighing cylinders at all plants utilizing chlorine gas; for larger plants, the indicating and recording type are desirable.

(2) May be required for fluoride solution feed.

(3) Should be provided for volumetric dry chemical feeders.

(4) Should be accurate to measure increments of 0.5 percent of load.

4. Dry Chemical Feed Systems

Dry chemical feed systems shall:

a. Completely enclose stored dry chemicals to prevent emission of dust to the operating room. Dry chemical storage silos and hoppers shall be designed to prevent chemical bridging and uncontrolled discharge. Hopper sidewall angle should be at least 60 degrees from the horizontal.

b. Measure chemicals volumetrically or gravimetrically.

(1) Volumetric dry feeders - When dosing accuracy is a significant consideration, a rotating table design with a circular groove and adjustable knife height should be used. A vibrating bin with a screw-type conveyor should not be used when dosing accuracy is a significant consideration.

(2) Gravimetric dry feeders - Where ease of operation and accurate dosing are essential, gravimetric feeders should be used.

c. Provide adequate solution water and agitation of the chemical in the solution pot.

(1) When inorganic chemicals are used, the solubility of the chemical at lowest water temperature at the maximum dosage rate should determine the size and water supply rate for a solution tank for a continuous dissolving system.

(2) For dry polymers, the aging tank following the wetting tank and preceding the feed tank shall be sized to provide a 30-minute to 1-hour detention time.

5. Positive Displacement Solution Pumps

Positive displacement type solution feed pumps should be used to feed liquid chemicals, but shall not be used to feed chemical slurries. Pumps must be capable of operating at the required maximum rate against the maximum head conditions found at the point of injection.

6. Liquid Chemical Feed Systems

a. Liquid chemical feeders shall be such that chemical solutions cannot be siphoned or overfed into the water supply by ensuring discharge at a point of positive pressure, or other suitable means or combinations as necessary (See Section V.B.9.c.).

b. A metering pump equipped with a calibration chamber shall be used in a liquid feeding system.

c. Chemical metering pumps should be equipped with a pulsation dampener (when pulsation-type pump is used), back pressure valve, pressure relief valve and a pressure waterline to flush chemicals from the metering pump.

d. The pressure increase across the pump should be at least 10 to 20 psi.

7. Cross-Connection Control

Cross-connection control must be provided to ensure that:

a. The service water lines discharging to solution tanks shall be properly protected from backflow (See Section V.B.9.c.).

b. Liquid chemical solutions cannot be siphoned through solution feeders into the water supply as required in Section V.B.6.

c. No direct connection exists between any sewer and a drain or overflow from the feeder, solution chamber or tank by providing that all drains terminate at least 6 inches or 2 pipe diameters, whichever is greater, above the overflow rim of a receiving sump, conduit or waste receptacle.

8. Chemical Feed Equipment Location

Chemical feed equipment shall:

a. Be located in a separate room to reduce hazards and dust problems.

b. Be conveniently located near points of application to minimize length of feed lines.

c. Be provided with protective curbings so that chemicals from equipment failure, spillage or accidental drainage will not enter the water in conduits, treatment or storage basins.

d. Be readily accessible for servicing, repair and observation of operation.

9. Service Water Supply

a. In-plant water used for dissolving dry chemicals, diluting liquid chemicals or operating chemical feeders shall be:

(1) Only from a safe, approved source.

(2) Protected from contamination by appropriate means.

(3) Ample in supply and adequate in pressure.

(4) Provided with means for measurement when preparing specific solution concentrations by dilution.

(5) Properly treated for hardness when necessary.

(6) Obtained from a location sufficiently downstream of any chemical feed point to ensure adequate mixing.

b. Where a booster pump is required, duplicate equipment and, when necessary, standby power shall be provided. The standby power shall be capable of taking over with minimal delay in the event of a power outage in order to keep booster pumps in service.

c. Backflow prevention shall be achieved by appropriate means such as:

(1) An air gap between fill pipe and maximum flow line of solution or dissolving tank equivalent to 2 pipe diameters but not less than 6 inches.

(2) An approved reduced pressure zone backflow preventor, consistent with the degree of hazard, aggressiveness of chemical solution, back-pressure sustained, and available means for maintaining and testing the device.

(3) A satisfactory vacuum release device.

10. Solution Tanks

a. A means which is consistent with the nature of the chemical solution shall be provided in a solution tank to maintain a uniform strength of solution. Continuous agitation shall be provided to maintain slurries in suspension.

b. Two solution tanks of adequate volume may be required for a chemical to ensure continuity of supply in servicing a solution tank.

c. Means shall be provided to measure the solution level in the tank.

d. Chemical solutions shall be kept covered. Large tanks with access openings shall have such openings curbed and fitted with overhanging covers.

e. Subsurface locations for solution tanks shall:

(1) Be free from sources of possible contamination.

(2) Ensure positive drainage for groundwater, accumulated water, chemical spills and overflows.

f. Overflow pipes, when provided, shall:

(1) Be turned downward, with the end screened.

(2) Have a freefall discharge.

(3) Be located where noticeable.

g. Acid storage tanks must be vented to the outside atmosphere, but not through vents in common with day tanks.

h. Each tank shall be provided with a valved drain, protected against backflow in accordance with Sections V.B.6. and V.B.7.

i. Solution tanks shall be located and protective curbings provided so that chemicals from equipment failure, spillage or accidental drainage shall not enter the water in conduits, treatment or storage basins.

11. Day Tanks

a. Day tanks shall be provided where bulk storage of liquid chemical is provided.

b. Day tanks shall meet all of the requirements of Section V.B.10.

c. Day tanks should hold no more than a 30-hour supply.

d. Day tanks shall be scale-mounted, or have a calibrated gauge painted or mounted on the side if liquid level can be observed in a gauge tube or through translucent sidewalls of the tank. In opaque tanks, a gauge rod extending above a reference point at the top of the tank attached to a float may be used. The ratio of the area of the tank to its height must be such that unit readings are meaningful in relation to the total amount of chemical fed during a day.

e. Hand pumps may be provided for transfer from a carboy or drum. A tip rack shall be used to permit withdrawal into a bucket from a spigot. Where motor-driven transfer pumps are provided, a liquid level limit switch and an overflow from the day tank must be provided.

f. A means which is consistent with the nature of the chemical solution shall be provided to maintain uniform strength of solution in a day tank. Continuous agitation shall be provided to maintain chemical slurries in suspension.

g. Tanks shall be properly labeled to designate the chemical contained.

12. Feed Lines

a. Feed lines shall be designed consistent with scale-forming or solids-depositing properties of the water, chemical, solution or mixtures conveyed. Duplicate feed lines should be considered where blockages are likely.

b. Feed lines should be as short as possible and:

(1) Of durable, corrosion-resistant material.

(2) Easily accessible throughout the entire length.

(3) Protected against freezing.

(4) Readily cleanable.

c. Feed lines should slope upward from the chemical source to the feeder when conveying gases.

d. Feed lines should be color coded (See Section II.D.2.).

Table 5.1

Chemical Storage and Handling Materials

Chemical	Acceptable	Nonacceptable
Calcium Hydroxide	Carbon Steel PVC 304 Stainless	Alumina Ceramic
Sodium Hydroxide 50% (Potassium Hydroxide)	Carbon Steel PVC 304 Stainless	Alumina Ceramic Viton
Sodium Carbonate	304 Stainless Hastelloy C Alumina Ceramic PVC	Carbon Steel
Sodium Bicarbonate	304 Stainless Hastelloy C Alumina Ceramic PVC	Carbon Steel
Sodium Silicate	304 Stainless Hastelloy C Alumina Ceramic PVC	Carbon Steel
Phosphoric Acid	Hastelloy C Alumina Ceramic PVC Kynar	Carbon Steel 304 and 316 Stainless Hypalon
Calcium Hypochlorite	Glass Rubber Stoneware Wood	All metals
Sodium Hypochlorite	Ceramics Glass Plastic Rubber	All metals

C. Chemicals

The handling, storage and use of chemicals requires careful attention. Consideration shall be given to methods of handling shipping containers, especially those containing compressed gases, oxidants and corrosive materials. Height of ceilings for overhead hoists and floors of sufficient construction for ease in the handling of mechanical equipment should be provided. Storage and use areas shall be properly ventilated so as to minimize possible accidental reaction of chemicals involved based on their characteristics.

1. Quality

   a. Chemical containers shall be fully labeled to include:

      (1) Chemical name, purity and concentration.

      (2) Supplier's name and address.

      (3) Precautions in handling.

   b. Chemicals shall meet AWWA specifications and/or ANSI/NSF Standard 60 where applicable, and all packaging shall be marked accordingly.

   c. Provisions should be made to assay the chemicals delivered where the quality is in doubt.

   d. Chemicals having a distinguishing color may be used, providing the coloring material is not toxic in concentrations used and will not impart taste, odor or color to the finished water.

2. Storage

   a. Space should be provided for:

      (1) A separate storage area for each chemical.

      (2) At least 30 days of chemical supply.

      (3) Convenient and efficient handling of chemicals.

      (4) Dry storage conditions.

   b. Storage tanks and pipelines for liquid chemicals shall be specific to the chemicals and not for alternates. Offloading areas must be clearly labeled to prevent accidental cross-contamination.

   c. Chemicals shall be stored in covered or unopened shipping containers, unless the chemical is transferred into an approved storage unit.

   d. Liquid chemical storage tanks must:

      (1) Have a liquid level indicator.

      (2) Have an overflow and a receiving basin or drain capable of receiving accidental spills or overflows; a common receiving basin may be provided for each group of compatible chemicals that provides sufficient containment volume to prevent accidental discharge in the event of failure of the largest tank.

e. Solution storage or day tanks supplying feeders directly should have sufficient capacity for 1 day of operation.

f. Acid storage tanks should be vented to the outside atmosphere but not through vents in common day tanks.

3. Housing

In addition to the following general equipment requirements, facilities for housing specific chemicals shall be designed in accordance with the applicable requirements of Sections V.D. and V.E.

a. Structures, rooms and areas accommodating chemical feed equipment shall provide convenient access for:

(1) Servicing and repair.

(2) Observation of operation.

b. Floor surfaces shall be smooth and impervious, slip-proof and well drained.

c. Open basins, tanks and conduits shall be protected from chemical spills or accidental drainage.

4. Handling

a. Carts, elevators and other appropriate means shall be provided for lifting chemical containers to minimize excessive lifting by operators.

b. Provisions shall be made for disposing of empty bags, drums or barrels by an approved procedure which will minimize exposure to dusts.

c. Provisions must be made for the proper transfer of dry chemicals from shipping containers to storage bins or hoppers, in such ways as to minimize the quantity of dust which may enter the room in which the equipment is installed. Control should be provided by use of:

(1) Vacuum pneumatic equipment or closed conveyor systems.

(2) Facilities for emptying shipping containers in special enclosures.

(3) Exhaust fans and dust filters which put the hoppers or bins under negative pressure.

d. Provisions shall be made for measuring quantities of chemicals used to prepare feed solutions.

D. Operator Safety

In addition to the following requirements, the AWWA's Manual M-3, *Safety Practices for Water Utilities* should be used as a guide for operator safety.

1. Ventilation

   Special provisions shall be made for ventilation of chemical feed and storage rooms. Exhaust systems must:

   a. Not exhaust into fresh air intakes.

   b. Not exhaust contaminants into areas where they may represent a hazard to employees.

   c. Not draw contaminants through employee work areas.

   d. Be in operation continually when needed.

2. Respiratory Protection Equipment

   Respiratory protection equipment, meeting the requirements of NIOSH and MSHA shall be available where gases are handled, and shall be stored at a convenient location, but not inside any room where the gas is used or stored. The units shall use compressed air, have at least 30-minute capacity, and be compatible with or exactly the same as units used by the fire department responsible for the plant.

3. Protective Equipment

   a. At least 1 pair of rubber gloves, a dust respirator of a type certified by NIOSH or MSHA for toxic dusts, an apron or other protective clothing, and goggles or face mask shall be provided for each operator. A deluge shower and/or eye washing device should be installed where strong acids or alkalis are used or stored.

   b. A water holding tank that will allow water to come to room temperature must be installed in the water line feeding the deluge shower and eye washing device. Other methods of water tempering will be considered on an individual basis.

   c. Other protective equipment should be provided as necessary.

4. Chlorine Leak Detection

   A bottle of ammonium hydroxide, 56 percent ammonia solution, shall be available for chlorine leak detection. Where 150 lb. cylinders, ton containers, tank cars and stationary storage tanks are used, a leak repair kit as approved by the Chlorine Institute, Inc. shall be provided. Continuous chlorine leak detection equipment is recommended. Where a leak detector is provided, it shall be equipped with both an audible alarm and a warning light. Masks and equipment should be tested at least annually.

E. Specific Chemicals

1. Acids and Caustics

a. Acids shall be kept in closed corrosion-resistant shipping containers or storage units.

b. Acids and caustics shall not be handled in open vessels, but should be pumped in undiluted form from original containers through a suitable hose to the point of treatment or to a covered day tank.

c. Systems designed to add strong acids or caustics shall include a flow sensor or other secondary mechanism to provide redundant controls that will ensure the acid or caustic will not be pumped into the system when there is inadequate water flow to provide dilution.

2. Activated Carbon

Activated carbon is a potentially combustible material requiring isolated storage. Storage facilities should be fire proof and equipped with explosion-proof electrical outlets, lights and motors in areas of dry handling. Bags of powdered carbon should be stacked in rows with aisles between in such a manner that each bag is accessible for removal in case of fire.

3. Chlorine (Also see Section IV.B.1.)

While neither explosive nor flammable in its elemental form, chlorine is capable of supporting combustion of other substances. Therefore, chlorine must be stored away from other compressed gases, organic matter or other flammable material.

a. Calcium Hypochlorite

The storage of calcium hypochlorite is a major safety consideration. It should never be stored where it is subject to heating or allowed to contact any organic material of an easily oxidized nature. The decomposition of calcium hypochlorite is exothermic, and will proceed rapidly if any part of the material is heated to 350°F.

b. Liquid Chlorine

Liquid chlorine is a skin irritant and can cause severe injury resembling burns to body tissue. Since the liquid form vaporizes to gas rapidly at atmospheric temperature and pressure, the procedures for using liquid chlorine shall be the same as for gas chlorine.

c. Gas Chlorine

(1) Chlorine gas feed and storage shall be enclosed and separated from other operating areas. The chlorine room shall be:

(a) Provided with a clear, gas-tight, shatter-resistant inspection window installed in an interior wall to permit the chlorination system to be viewed without entering the room.

(b) Constructed in such a manner that all openings between the chlorine room and the remainder of the plant are sealed.

(c) Provided with doors equipped with panic hardware, ensuring ready means of exit. Doors opening outward to the building exterior are recommended.

(2) Full and empty cylinders of chlorine gas should be:

(a) Isolated from operating areas.

(b) Restrained in position to prevent upset.

(c) Stored in rooms separate from ammonia storage.

(d) Stored in areas not in direct sunlight or exposed to excessive heat.

(3) Where chlorine gas is used, the room shall be constructed to provide the following:

(a) Each room shall have a ventilating fan with a capacity which provides one complete air change per minute when the room is occupied; where this is not appropriate due to the size of the room, a lesser rate may be considered.

(b) The ventilating fan shall take suction near the floor as far as practical from the door and air inlet, with the point of discharge so located as not to contaminate air inlets to any rooms, buildings or other areas where people may gather.

(c) Air inlets should be through louvers near the ceiling.

(d) Louvers for air intake and exhaust shall facilitate airtight closure.

(e) Separate switches for the fan and lights shall be located at each entrance to the chlorine room and at the inspection window. Outside switches shall be protected from vandalism. A signal light indicating fan operation shall be provided at each entrance when the fan can be controlled from more than one point.

(f) Vents from feeders and storage shall discharge to the outside atmosphere, above grade.

(g) The room location should be on the prevailing downwind side of the building away from entrances, windows, louvers, walkways, etc.

(h) Floor drains are discouraged. Where provided, the floor drains shall discharge to the outside of the building and shall not be connected to other internal or external drainage systems.

(4) Chlorinator rooms should be heated to 60°F and be protected from excessive heat. Cylinders and gas lines should be protected from temperatures above that of the feed equipment.

(5) Pressurized feed lines shall not carry chlorine gas beyond the chlorinator room.

4. Sodium Chlorite

Sodium chlorite is a strong oxidizing agent which can be ignited by friction, heat, shock or contamination with organic matter. Provisions shall be made for proper storage and handling the sodium chlorite to eliminate any danger of explosion.

5. Sodium Hypochlorite

Sodium hypochlorite storage and handling procedures should be arranged to minimize the slow natural decomposition process either by contamination or by exposure to more extreme storage conditions. In addition, feed rates should be regularly adjusted to compensate for this progressive loss in chlorine content.

a. Storage

(1) Sodium hypochlorite shall be stored in the original shipping containers or in sodium hypochlorite compatible containers.

(2) Storage containers or tanks shall be sited out of the sunlight in a cool area and shall be vented to the outside of the building.

(3) Wherever reasonably feasible, stored hypochlorite shall be pumped undiluted to the point of addition. Where dilution is unavoidable, deionized or softened water should be used.

(4) Storage areas, tanks and pipe work shall be designed to avoid the possibility of uncontrolled discharges and a sufficient amount of appropriately selected spill absorbent shall be stored on-site.

(5) Reusable hypochlorite storage containers shall be reserved for use with hypochlorite only and shall not be rinsed out or otherwise exposed to internal contamination.

b. Feeders

(1) Positive displacement pumps with hypochlorite compatible materials for wetted surfaces shall be used.

(2) To avoid air-locking in smaller installations, small diameter suction lines shall be used with foot valves and degassing pump heads.

(3) In larger installations, flooded suction shall be used with pipe work arranged to ease escape of gas bubbles.

(4) Calibration tubes or mass flow monitors which allow for direct physical checking of actual feed rates shall be provided.

(5) Injectors shall be made removable for regular cleaning where hard water is to be treated.

6. Ammonia

Ammonia for chloramine formation may be added to water as a water solution of ammonium sulfate, as aqua ammonia (ammonia gas in water solution), or as anhydrous ammonia (purified 100 percent ammonia in liquid or gaseous form). Special provisions required for each form of ammonia are listed below.

a. Ammonium Sulfate

A water solution is made by addition of ammonium sulfate solid to water with agitation. The tank and dosing equipment contact surfaces should be made of corrosion-resistant nonmetallic materials. Provision should be made for removal of the agitator after dissolving the solid. The tank should be fitted with a lid and vented outdoors. Injection of the solution should take place in the center of treated water flow at a location where there is high velocity movement.

b. Aqua Ammonia (ammonium hydroxide)

Aqua ammonia feed pumps and storage shall be enclosed and separated from other operating areas. The aqua ammonia room shall be equipped as in Section V.E.3.c. with the following changes:

(1) A corrosion-resistant, closed, unpressurized tank shall be used for bulk storage, vented through an inert liquid trap to a high point outside and an incompatible connector or lockout provisions shall be made to prevent accidental addition of other chemicals to the storage tank.

(2) The storage tank shall be fitted either with cooling/refrigeration and/or with provision without opening the system to dilute and mix the contents with water to avoid conditions where temperature increases cause the ammonia vapor pressure over the aqua ammonia to exceed atmospheric pressure.

(3) An exhaust fan shall be installed to withdraw air from high points in the room and make-up air shall be allowed to enter at a low point.

(4) The aqua ammonia feed pump, regulators and lines shall be fitted with pressure relief vents discharging outside the building away from any air intake and with water purge lines leading back to the headspace of the bulk storage tank.

(5) The aqua ammonia shall be conveyed directly from storage to the treated water stream injector without the use of a carrier water stream unless the carrier stream is softened.

(6) The point of delivery to the main water stream should be placed in a region of rapid, preferably turbulent, water flow.

(7) Provisions should be made for easy access for removal of calcium scale deposits from the injector.

(8) Provision of a modestly-sized scrubber capable of handling occasional minor emissions should be considered.

c. Anhydrous Ammonia

Anhydrous ammonia is readily available as a pure liquefied gas under moderate pressure in cylinders or as a cryogenic liquid boiling at -15º Celsius at atmospheric pressure. The liquid causes severe burns on skin contact.

(1) Anhydrous ammonia and storage feed systems (including heaters where required) shall be enclosed and separated from other works areas and constructed of corrosion-resistant materials.

(2) Pressurized ammonia feed lines should be restricted to the ammonia room.

(3) An emergency air exhaust system, as in Section V.E.1.c. but with an elevated intake, shall be provided in the ammonia storage room.

(4) Leak detection systems shall be provided in all areas through which ammonia is piped.

(5) Special vacuum breaker/regulator provisions must be made to avoid potentially violent results of backflow of water into cylinders or storage tanks.

(6) Carrier water systems of soft or presoftened water may be used to transport ammonia to the finished water stream and to assist in mixing.

(7) The ammonia injector should use a vacuum eductor or should consist of a perforated tube fitted with a closely fitting flexible rubber tubing seal punctured with a number of small slits to delay fouling by lime deposits.

(8) Provisions should be made for the periodic removal of scale/lime deposits from injectors and carrier piping.

(9) Consideration shall be given to the provision of an emergency gas scrubber capable of absorbing the entire contents of the largest ammonia storage unit whenever there is a risk to the public as a result of potential ammonia leaks.

VI. PUMPING FACILITIES

A. Design

Pumping facilities shall be designed to maintain the sanitary quality of pumped water. Subsurface pits or pump rooms and inaccessible installations should be avoided. No pump station shall be subject to flooding.

B. Location

The pumping station shall be located so that the proposed site will meet the requirements for sanitary protection of water quality, hydraulics of the system and protection against interruption of service by fire, flood or any other hazard.

1. Site Protection

   The station shall be:

   a. Elevated to a minimum of 3 feet above the 100-year flood elevation or 1 foot above the highest recorded flood level or protected to such elevation.

   b. Readily accessible at all times unless permitted to be out-of-service for the period of inaccessibility.

   c. Graded around the station to lead surface drainage away from the station.

   d. Protected to prevent vandalism and entrance by animals or unauthorized persons.

C. Pumping Stations

Both raw and finished water pumping stations shall:

- Have adequate space for the installation of additional units, if needed, and for the safe servicing of all equipment.
- Be of durable construction, fire and weather resistant, and with outward-opening doors. The use of tamper-proof hinges is recommended at remote locations.
- Have floor elevation of at least 6 inches above finished grade.
- Have underground structure waterproofed.
- Have all floors drained in such a manner that the quality of the potable water will not be endangered. All floors shall slope at least 3 inches in every 10 feet to a suitable drain.

- Provide a suitable outlet for drainage from pump glands without discharging onto the floor.

- Be reasonably protected against vandalism.

1. Suction well

   Suction wells shall:

   a. Be watertight.

   b. Have floors sloped to permit removal of water and settled solids.

   c. Be covered or otherwise protected against contamination, including pump lubricants.

2. Equipment Servicing

   Pump stations shall be provided with:

   a. Craneways, hoist beams, eye bolts or other adequate facilities for servicing or removal of pumps, motors or other heavy equipment.

   b. Openings in floors, roofs or wherever else needed for removal of heavy or bulky equipment.

   c. A convenient tool board or other facilities as needed for proper maintenance of the equipment.

   d. Walkways for servicing or lubricating points of equipment if these are located at intermediate points between floors.

3. Stairways and Ladders

   Stairways and ladders are preferred in areas where there is frequent traffic or where supplies are transported by hand. They shall have risers not exceeding 9 inches and treads wide enough for safety. Where ladders are used, intermediate landings should be provided if the vertical distance exceeds 10 feet.

   Stairways and ladders shall:

   a. Be provided between all floors and in pits or compartments which must be entered.

   b. Have handrails on both sides with treads of nonslip material.

4. Heating

In pump houses not occupied by personnel, only enough heat need be provided to prevent freezing of equipment or treatment processes.

Provisions shall be made for adequate heating for:

a. The comfort of the operator.

b. The safe and efficient operation of the equipment.

5. Ventilation

Ventilation shall conform to existing local and/or state codes. Adequate ventilation shall be provided for all pump stations for operator comfort and dissipation of excess heat from the equipment. Switches for operation of ventilation equipment should be conveniently located, marked and protected from vandalism, where appropriate.

Forced ventilation of at least 6 changes of air per hour shall be provided for:

a. All rooms, compartments, pits and other enclosures below ground level.

b. Any area where unsafe atmosphere may develop or where excessive heat may be built up.

6. Dehumidification

In areas where excess moisture could cause hazards to safety or damage to equipment, means for dehumidification shall be provided.

7. Lighting

Pump stations shall be adequately lighted throughout. All electrical work should conform to the requirements of the National Electric Code or related agencies and to the relevant state and/or local codes.

8. Sanitary and Other Conveniences

All pumping stations that are manned for extended periods should be provided with potable water, lavatory and toilet facilities. Plumbing must be installed to prevent contamination of a public water supply. Wastes shall be discharged in accordance with Section IV.L.

D. Pumps

At least 2 pumping units shall be provided. With any pump out-of-service, the remaining pump or pumps shall be capable of providing the maximum daily pumping demand of the system. The pumping units shall:

- Have ample capacity to supply the peak demand without dangerous overloading.
- Be driven by a prime mover able to meet the maximum horsepower requirements of the pump.
- Have spare parts and tools readily available.
- Be served by control equipment that has proper heater and overload protection for air temperatures encountered.

1. Suction Lift

   Suction lift shall:

   a. Be avoided, if possible.

   b. Be within allowable limits, preferably less than 15 feet.

   If suction lift is necessary, provisions shall be made for priming the pumps. Water level sensors should be considered to prevent pump operation when the suction well is dry.

2. Priming

   Prime water must not be of lesser sanitary quality than that of the water being pumped. Means shall be provided to prevent back-siphonage. When an air-operated ejector is used, the screened intake shall draw clean air from a point at least 10 feet above the ground or other source of possible contamination unless the air is filtered by an apparatus approved by DEP. Vacuum priming may be used. Priming water sensors should be installed to prevent the operation of a pump if it is unprimed.

3. Submersible Pumps

   See Section III.D.5.b.

4. Discharge Piping

   Discharge piping shall be designed in accordance with Section III.D.5.c.

E. Booster Pumps

Booster pumps should be located and controlled so that:

- They will not produce negative pressure in their suction lines.
- Pumps installed in the distribution system shall maintain inlet pressure as required in Section VIII.B.1. under all operating conditions. Pumps taking suction from storage tanks shall be provided adequate net positive suction head.
- Automatic shutoff or low pressure controller shall maintain at least 20 psi in the suction line under all operating conditions, unless otherwise acceptable to DEP. Pumps taking suction from ground storage tanks shall be equipped with automatic shutoffs or low pressure controllers as recommended by the pump manufacturer.
- Automatic or remote control devices shall have a range between the start and cutoff pressure which will prevent excessive cycling.
- A bypass is available.

1. Duplicate Pumps

   Each booster pumping station shall contain not less than 2 pumps with capacities such that peak demand can be satisfied with the largest pump out-of-service.

2. Metering

   All booster pumping stations shall be fitted with a flow rate indicating and totalizer meter.

3. In-line Booster Pumps

   In addition to the other requirements of this section, in-line booster pumps shall be accessible for servicing and repairs.

4. Individual Residential Booster Pumps

   Private booster pumps shall not be allowed for any individual residential service from the public water supply main unless:

   a. Adequately protected against backflow.

   b. There is an adequate suction supply.

   c. They are sized to provide an adequate volume of water at the required pressures.

   d. They are owned and properly maintained by the water supplier.

F. Intakes

Intakes shall be of a type appropriate to the pumping station, and shall be protected to prevent deterioration of the sanitary quality of the water to be pumped.

1. Groundwater Facilities

   Where pumping facilities are used, wells and springs shall be vented by properly hooded and screened pipe extended at least 18 inches above the pump floor or the final ground elevation. Where necessary, provisions shall be made for lubricating the pump from a point at least 6 inches above the top of the well cover, by means which will prevent contamination of the water supply.

   a. General Well Pump House Construction Requirements

      The well pump house floor or apron surrounding the well shall:

      (1) Be of good quality concrete with adequate reinforcement.

      (2) Be a minimum of 6 inches in thickness.

      (3) Extend a minimum of 3 feet in all directions from the well.

      (4) Slope 1/4 inch per foot towards a screened 4-inch floor drain to atmosphere.

   b. General Well Appurtenances

      The following well appurtenances are required:

      (1) A sanitary seal shall be provided on the top of the well casing.

      (2) A properly screened vent with the end elbowed downward shall be provided for the well casing.

      (3) A sampling tap shall be provided for raw water sampling which discharges in a downward direction and away from the well casing.

      (4) Adequate control switches, etc. for the pumping equipment shall be provided.

      (5) A pump discharge water meter is required to determine water production.

      (6) The well casing shall extend at least 18 inches above the concrete floor or apron surrounding the well.

      (7) Adequate support for the well pump and drop pipe shall be provided.

c. Drilled wells with the prime mover mounted on the casing shall:

(1) Have the casing extended 18 inches above the floor and be equipped with a flange or suitable sanitary seal.

(2) Have the casing firmly connected to the pump structure or have the casing inserted into a recess extending at least 1 inch into the base of the pump if a watertight connection is not provided.

(3) Have the base of the pump not less than 18 inches above the pump room floor or apron.

(4) Have the pump foundation and base designed to prevent water from coming into contact with the joint between the casing and the prime mover.

2. Surface Water Facilities

Intakes which draw water from surface streams or open reservoirs shall have adequate protection against clogging by sediment, debris or ice, and against flotation, wind and wave pressure. Where the depth of water permits, intakes should be placed at various elevations. The velocity at an intake port should be not greater than 2 feet per second and the depth of water over the port should be at least 3 diameters of port opening. Intake ports should be placed so that if one or more ports are blocked, another one can be opened. Where practicable, an emergency intake is desirable (See Sections III.C.3.a. and III.C.3.b.).

G. Automatic and Remote Controlled Stations

All automatic stations should be provided with automatic signaling apparatus which will report when the station is out-of-service. All remote controlled stations shall be electrically operated and controlled and shall have signaling apparatus of proven performance. Installation of electrical equipment shall conform with the applicable state and local electrical codes and the National Electrical Code.

H. Appurtenances

1. Valves

Pumps shall be adequately valved to permit satisfactory operation, maintenance and repair of the equipment. If foot valves are necessary, they shall have a net valve area of at least 2.5 times the area of the suction pipe and they shall be screened. Each pump shall have a positive-acting check valve on the discharge side between the pump and the shutoff valve. Surge relief valves or slow acting check valves shall be designed to minimize hydraulic transients.

2. Piping

In general, piping shall:

a. Be designed so that the friction losses will be minimized.

b. Not be subject to contamination.

c. Be sloped in one direction to drains.

d. Have watertight joints.

e. Have adequate cleanouts.

f. Be protected against surge or water hammer.

g. Be such that each pump has an individual suction line or that the lines shall be manifolded so that they will ensure similar hydraulic and operating conditions.

h. Be protected against freezing.

3. Gauges and Meters

Each station shall have indicating, totalizing and recording metering of the total water pumped. Each pump shall have:

a. A standard pressure gauge on its discharge line.

b. A compound gauge on its suction line.

c. A recording gauge in the larger stations.

d. A means for measuring the discharge.

4. Water Seals

Water seals shall not be supplied with water of a lesser sanitary quality than that of the water being pumped. Where pumps are sealed with potable water and are pumping water of lesser sanitary quality, the seal shall:

a. Be provided with a break tank open to atmospheric pressure.

b. Have an air gap of at least 6 inches or 2 pipe diameters, whichever is greater, between the feeder line and the spill line of the tank.

5. Controls

Pumps, their prime movers and accessories shall be controlled in such a manner that they will operate at rated capacity without dangerous overload. Where two or more pumps are installed, provisions shall be made for alternate operation. Provisions shall be made to prevent energizing the motor in the event of a backspin cycle. Electrical controls should be located above grade. Protection against low voltages, power surges and phase failure also should be provided.

6. Power

When power failure would result in cessation of minimum essential services, means for emergency operation (i.e., portable generators, etc.) shall be provided. All main pumping stations shall be provided with an auxiliary source of power where insufficient finished water storage is available to meet an average day's demand. Consideration must be given to fire flow needs and the station's vulnerability to flooding. Power supply should be available from at least two independent sources. Carbon monoxide detectors are recommended when generators are housed within pump stations.

7. Water Prelubrication

When automatic prelubrication of pump bearings is necessary and an auxiliary direct drive power supply is provided, the prelubrication line shall be provided with a valved bypass around the automatic control so that the bearings can, if necessary, be lubricated manually before the pump is started or the prelubrication controls shall be wired to the auxiliary power supply.

I. Cross-Connections/Interconnections

There shall not be, at any point in the pumping station, any cross-connection or interconnection between a potable water supply and any supply which has not been approved by DEP. Steam engine exhaust shall not be returned, nor shall the cooling water from engine jackets or any other heat-exchange devices be returned to the potable supply. No plumbing fixtures or devices shall be installed which will provide interconnection or make possible the backflow of sewage or wastes into the water supply system.

J. Protection of Clear Wells

Finished water shall not be stored adjacent to or below an unsafe water compartment when only a single wall or floor separates the two.

VII. FINISHED WATER STORAGE

A. Design and Construction

The materials and designs used for finished water storage structures shall provide stability and durability as well as protect the quality of the stored water. Steel and concrete structures shall comply with the current editions of the AWWA standards concerning tanks, standpipes, reservoirs and elevated tanks wherever they are applicable. Other materials of construction are acceptable when properly designed to meet the requirements of this section.

1. Sizing

   Storage facilities should have sufficient capacity, as determined from engineering studies, to meet domestic demands, and where fire protection is provided, fire flow demands.

   a. Fire flow recommendations established by the Insurance Services Office should be satisfied where fire protection is provided.

   b. The minimum storage capacity (or equivalent capacity) for systems not providing fire protection shall be equal to 1 day's average consumption. This requirement may be reduced when the source and treatment facilities have sufficient capacity with standby power to supplement peak demands of the system.

   c. Excessive storage capacity should be avoided to prevent potential water quality deterioration problems.

2. Location of Ground-Level Reservoirs

   a. Consideration should be given to maintaining water quality when locating water storage facilities.

   b. The bottom of ground-level reservoirs and standpipes should be placed at the normal ground surface and shall be above the 100-year flood or the highest flood of record.

   c. If the bottom elevation of a storage reservoir must be below normal ground surface, it shall be placed above the groundwater table. At least 50 percent of the water depth should be above grade. Sewers, drains, standing water and similar sources of possible contamination must be kept at least 50 feet from the reservoir. Gravity sewers constructed of water main quality pipes, pressure tested in place without leakage, may be used at distances greater than 20 feet and less than 50 feet.

   d. The top of a partially buried storage structure shall not be less than 2 feet above normal ground surface. Clear wells constructed under filters may be exempted from this requirement where the design provides adequate protection from contamination.

3. Protection from Contamination

All finished water storage structures shall have suitable watertight roofs which exclude birds, animals, insects and excessive dust. The installation of appurtenances, such as antenna, shall be done in a manner that ensures no damage to the tank, coatings or water quality, or corrects any damage that occurred.

4. Protection from Trespassers

Fencing, locks on access manholes or external ladders, and other necessary precautions shall be provided to prevent trespassing, vandalism and sabotage.

5. Drains

No drain on a water storage structure shall have a direct connection to a sewer or storm drain. The design shall allow draining the storage facility for cleaning or maintenance without causing loss of pressure in the distribution system.

6. Stored Water Turnover

The system should be designed to facilitate turnover of water in the reservoir. Consideration should be given to separate inlet and outlet pipes, baffle walls or other acceptable means to avoid stagnation.

7. Overflow

All water storage structures shall be provided with an overflow which is brought down to an elevation between 12 and 24 inches above the ground surface, and discharges over a drainage inlet structure or a splash plate. No overflow may be connected directly to a sewer or a storm drain. All overflow pipes shall be located so that any discharge is visible. Disposal of overflow water must be consistent with the requirements of the Clean Streams Law (CSL).

a. When an internal overflow pipe is used on elevated tanks, it should be located in the access tube. For vertical drops on other types of storage facilities, the overflow pipe should be located on the outside of the structure.

b. The overflow for a ground-level storage reservoir shall open downward and be screened with a 24-mesh noncorrodible screen. The screen shall be installed within the overflow pipe at a location least susceptible to damage by vandalism. If a flapper valve is used, a screen shall be provided inside the valve.

c. The overflow for an elevated tank shall open downward and be screened with a 4-mesh, noncorrodible screen. The screen shall be installed within the overflow pipe at a location least susceptible to damage by vandalism. If a flapper valve is used, a screen shall be provided inside the valve.

d. The overflow pipe shall be of sufficient diameter to allow wasting of water in excess of the filling rate.

8. Access

Finished water storage structures shall be designed with reasonably convenient access to the interior for cleaning and maintenance. At least 2 manholes shall be provided above the waterline at each compartment where space permits.

a. Elevated Storage Structures

(1) At least one of the access manholes shall be framed at least 4 inches above the surface of the roof at the opening. They shall be fitted with a solid watertight cover which overlaps the framed opening and extends down around the frame at least 2 inches, shall be hinged on one side, and shall have a locking device.

(2) All other manholes or access ways shall be bolted and gasketed according to the requirements of the reviewing authority, or shall meet the requirements of (1).

b. Ground Level Structures

(1) Each manhole shall be elevated at least 24 inches above the top of the tank or covering sod, whichever is higher.

(2) Each manhole shall be fitted with a solid watertight cover which overlaps a framed opening and extends down around the frame at least 2 inches. The frame shall be at least 4 inches high. Each cover shall be hinged on one side, and shall have a locking device.

9. Vents

Finished water storage structures shall be vented. The overflow pipe shall not be considered a vent. Open construction between the sidewall and roof is not permissible. Vents:

a. Shall prevent the entrance of surface water and rain water.

b. Shall exclude birds and animals.

c. Should exclude insects and dust, as much as this function can be made compatible with effective venting.

d. Shall, on ground level structures, open downward with the opening at least 24 inches above the roof or sod and covered with a 24-mesh noncorrodible screen. The screen shall be installed within the pipe at a location least susceptible to vandalism.

e. Shall, on elevated tanks and standpipes, open downward, and be fitted with either 4-mesh noncorrodible screen, or with finer mesh noncorrodible screen in combination with an automatically resetting pressure-vacuum relief mechanism, as required by DEP.

f. Shall be located and sized to avoid blockage during winter conditions.

10. Roof and Sidewall

The roof and sidewalls of all water storage structures must be watertight with no openings except properly constructed vents, manholes, overflows, risers, drains, pump mountings, control ports, or piping for inflow and outflow. Particular attention shall be given to the sealing of roof structures which are not integral to the tank body.

a. Any pipe running through the roof or sidewall of a metal storage tank must be welded, or properly gasketed. In concrete tanks, these pipes shall be connected to standard wall castings which were poured in place during the forming of the concrete. These wall castings should have seepage rings imbedded in the concrete.

b. Openings in the roof of a storage structure, designed to accommodate control apparatus or pump columns, shall be curbed and sleeved with proper additional shielding to prevent contamination from surface or floor drainage water.

c. Valves and controls should be located outside the storage structure so that the valve stems and similar projections will not pass through the roof or top of the reservoir.

d. The roof of the storage structure shall be well drained. Downspout pipes and drains from access hatches shall not enter or pass through the reservoir. Parapets, or similar construction which would tend to hold water and snow on the roof, will not be approved unless adequate waterproofing and drainage are provided.

e. Reservoirs with pre-cast concrete roof structures must be made watertight with the use of a waterproof membrane or similar product.

11. Construction Materials

The material used in construction of reservoirs shall be acceptable to DEP. Porous material, including wood and concrete block, are not suitable for potable water contact applications.

12. Safety

Safety must be considered in the design of a storage structure. The design shall conform to pertinent laws and regulations of the area where the water storage structure is constructed.

a. Ladders, ladder guards, balcony railings and safely located entrance hatches shall be provided where applicable.

b. Ladders having an unbroken length in excess of 20 feet should be provided with appropriate safety devices. This requirement applies both to interior and exterior reservoir ladders.

c. Elevated tanks with riser pipes over 8 inches in diameter shall have protective bars over the riser opening inside the tank.

d. Railings or handholds shall be provided on elevated tanks where persons must transfer from the access tube to the water compartment.

13. Freezing

Finished water storage structures and their appurtenances, especially the riser pipes, overflows and vents, shall be designed to prevent freezing which will interfere with proper function. Equipment used for freeze protection that will come into contact with the potable water shall meet ANSI/NSF Standard 61 or be approved by DEP. If a water circulation system is used, it is recommended that the circulation pipe be located separately from the riser pipe.

14. Internal Catwalk

Every catwalk over finished water in a storage structure shall have a solid floor with sealed raised edges designed to prevent contamination from shoe scrapings and dirt.

15. Prevention of Internal Contamination

The internal superstructure (i.e., rafters, ridgepole) or other facilities as covered in Sections VII.A.11 and VII.A.13 shall not be constructed of materials treated with any chemical which is toxic or can otherwise degrade the quality of the finished drinking water.

16. Silt Stop

Discharge pipes from all reservoirs shall be located in a manner that will prevent the flow of sediment into the distribution system. Removable silt stops should be provided.

17. Grading

The area surrounding a ground level structure shall be graded in a manner that will prevent surface water from standing within 50 feet of it.

18. Liners and Flexible Covers

Where liners or flexible covers are proposed, they shall be of a material acceptable to DEP. Careful attention must be given to the chemical characteristics of the adhesive or bonding material, if used, to ensure that no toxic contaminants are imparted to the stored water. DEP shall be consulted prior to the installation or use of any materials of unknown or questionable characteristics.

19. Painting and/or Cathodic Protection

Proper protection shall be given to metal surfaces by paints or other protective coatings, by cathodic protective devices, or by both.

a. Paint systems shall meet ANSI/NSF Standard 61 and be acceptable to DEP. Interior paint must be applied, cured and used in a manner consistent with the ANSI/NSF approval. After curing, the coating shall not transfer any substance to the water which will be toxic or cause taste or odor problems. Prior to placing in service, an analysis for VOCs is advisable to establish that the coating is properly cured. Consideration should be given to 100 percent solids coatings.

b. Wax coatings for the tank interior shall not be used on new tanks. Recoating with a wax system is strongly discouraged. Old wax coatings must be completely removed before using another tank coating.

c. Cathodic protection should be designed and installed by competent technical personnel and a maintenance contract should be provided.

20. Disinfection

All new, cleaned, repaired or repainted steel tanks, standpipes, reservoirs and elevated tanks used for finished water shall be disinfected in accordance with the current addition of AWWA’s Standard C652 for Disinfection of Water Storage Facilities. Two or more successive sets of samples taken at 24-hour intervals shall indicate microbiologically satisfactory water before the facility is placed into operation.

Note: The disposal of heavily chlorinated water should be done as outlined in AWWA’s Standard C652 for Disinfection of Water Storage Facilities and in a manner which will not create a hazard or cause damage to the environment. DEP should be contacted to determine the appropriate disposal requirements.

B. Treatment Plant Storage

The applicable design standards of Section VII.A shall be followed for plant storage.

1. Filter Wash Water Tanks

   Filter wash water tanks shall be sized, in conjunction with available pump units and finished water storage, to provide the backwash water required by Section IV.D.2.1. and IV.D.3.c. Consideration must be given to the backwashing of several filters in rapid succession.

2. Clear Well

   Clear well storage should be sized, in conjunction with distribution system storage, to relieve the filters from having to follow fluctuations in water use. Clear wells also should be designed so that 50 percent of the clear well can be isolated for routine cleaning, inspection and maintenance.

   a. When finished water storage is used to provide disinfection contact time, special attention must be given to tank size and baffling.

   b. An overflow and vent shall be provided.

3. Adjacent Storage

   Finished or treated water shall not be stored adjacent to or below an untreated or partially treated water compartment when only a single wall or floor separates the two.

4. Other Treatment Plant Storage Tanks

   Other treatment plant storage tanks/basins such as detention basins, backwash reclaim tanks, receiving basins and pump wet wells for finished water shall be designed as finished water storage structures.

C. Hydropneumatic Systems

Hydropneumatic (pressure) tanks, when provided as the only water storage, are acceptable only in smaller water systems. Systems serving more than 50 homes, ground or elevated storage designed in accordance with Section VII.A.1 should be provided. Hydropneumatic tank storage is not permitted for fire protection purposes. Pressure tanks shall meet American Society of Mechanical Engineers (ASME) code requirements or an equivalent requirement of state and local laws and regulations for the construction and installation of unfired pressure vessels.

1. Location

The tank should be located above normal ground surface and be completely housed, or earth-mounded with one end projecting into an operating house to prevent freezing.

2. System Sizing

The capacity of the wells and pumps in a hydropneumatic system should be a least ten times the average daily consumption rate. The gross volume of the hydropneumatic tank, in gallons, should be at least 10 to 15 times the capacity of the largest pump, rated in gpm, unless other measures (e.g., variable speed drives in conjunction with the pump motors) are provided to meet the maximum demand.

Where a hydropneumatic tank is used for chlorine contact, separate inlet and outlet pipes shall be provided. Those pipes shall be separated both horizontally and vertically to the maximum extent possible.

Sufficient storage must be available to provide the required 20-minute disinfectant contact time under maximum flow conditions.

3. Piping

The hydropneumatic tank(s) shall have bypass piping to permit operation of the system while the tank is being repaired or painted.

4. Appurtenances

Each tank shall have an access manhole, a drain and control equipment consisting of a pressure gauge, water sight glass, automatic or manual air blow-off, means for adding air and pressure operated start-stop controls for the pumps. Where practical, the access manhole should be 24 inches in diameter.

D. Distribution System Storage

The applicable design standards of Section VII.A shall be followed for distribution system storage.

1. Pressures

The maximum variation between high and low levels in storage structures providing pressure to a distribution system should not exceed 30 feet. The minimum working pressure in the distribution system shall be 25 psig and a normal working pressure should be approximately 60 psig. When static pressures exceed 120 psig, pressure reducing devices should be provided on mains in the distribution system.

2. Drainage

Finished water storage structures which provide pressure directly to the distribution system shall be designed so they can be isolated from the distribution system and drained for cleaning or maintenance without causing a loss of pressure in the distribution system. Drains shall discharge to the ground surface with no direct connection to a sewer or storm drain. Disposal of drainage water shall be consistent with the requirements of the Clean Streams Law.

3. Level Controls

Adequate controls shall be provided to maintain levels in distribution system storage structures. Level indicating devices should be provided at a central location.

a. Pumps should be controlled from tank levels with the signal transmitted by telemetering equipment when any appreciable head loss occurs in the distribution system between the source and the storage structure.

b. Altitude valves or equivalent controls may be required for a second and subsequent structure on the system.

c. Overflow and low-level warnings or alarms should be located where they will be under responsible surveillance 24 hours a day.

VIII. DISTRIBUTION SYSTEMS

A. Materials

1. Standards, Materials Selection

   All materials including pipe, fittings, valves and fire hydrants shall conform to the latest standards issued by AWWA, ANSI/NSF, American Standards Association, ASTM and be acceptable to DEP. All plastic pipe for potable water use also must be approved by NSF and bear the logo "NSF-pw" indicating such approval. DEP may approve materials for which there are no accepted standards provided acceptable supporting information can be provided. Special attention must be given to selecting materials which will protect against both internal and external corrosion and, where appropriate, reduce as much as possible the oxidation potential between dissimilar metals.

2. Permeation by Organic Compounds

   Where distribution systems are installed in areas of groundwater contaminated by organic compounds:

   a. Pipe and joint materials which do not allow permeation of the organic compounds shall be used.

   b. Nonpermeable materials shall be used for all portions of the system including pipe, joint materials, hydrant leads and service connections.

3. Used Materials

   Only water mains which have been used previously for conveying potable water may be reused provided they meet the above standards and have been restored practically to their original condition.

4. Joints

   Packing and jointing materials used in the joints of pipe shall meet the standards of the AWWA. Mechanical joints or slip-on joints with resilient gaskets are preferred. Gaskets containing lead shall not be used. Manufacturer approved transition joints shall be used between dissimilar piping materials.

B. System Design

1. Pressure

   All water mains, including those not designed to provide fire protection, shall be sized after a hydraulic analysis based on flow demands and pressure requirements. The pipe system and its appurtenances shall be designed to maintain a minimum pressure of 20 psig at ground level at all points in the distribution system under all conditions of flow. The normal working pressure in the distribution system should be approximately 60 psig.

2. Diameter

The minimum size of water main which provides for fire protection and serving fire hydrants shall be 6-inch diameter. Larger sized mains will be required if necessary to allow the withdrawal of the required fire flow while maintaining the minimum residual pressure of 20 psig.

The minimum size of water main in the distribution system where fire protection is not to be provided should be a minimum of 3-inch diameter. Any departure from minimum requirements shall be justified by hydraulic analysis and future water use, and can be considered only in special circumstances.

3. Fire Protection

When fire protection is to be provided, system design should be such that fire flows and facilities are in accordance with the requirements of the State Insurance Services Office.

4. Dead Ends

Dead ends shall be minimized by looping all mains whenever practical. Where dead end lines are necessary in the first stage of construction of a distribution system, the lines shall be provided with the appropriate flushing devices as outlined in Section VIII.B.5.

5. Flushing

Where dead end mains occur, they shall be provided with an approved blow-off or flushing hydrant for flushing purposes. Flushing devices should be sized to provide flows which will give a velocity of at least 2.5 feet per second in the water main being flushed. Fire hydrants may be used for this purpose provided they comply with all of DEP's requirements on fire hydrant installation. No flushing device shall be directly connected to any sewer.

C. Shut-Off Valves

A sufficient number of valves shall be provided on water mains to minimize inconvenience and sanitary hazards will be minimized during repairs. Valves should be located at not more than 500 foot intervals in commercial districts and at not more than one block or 800 foot intervals in other areas of the distribution system.

D. Hydrants

Where freezing temperatures prevail, hydrants of the dry barrel type are preferred. Hydrants of this type should comply with the criteria set forth in AWWA's Standard

C502 for Dry Barrel Fire Hydrants. Wet barrel fire hydrants, where used, should comply with AWWA's Standard C503 for Wet Barrel Fire Hydrants.

1. Location and Spacing

Hydrants should be provided at each street intersection and at intermediate points between intersections as recommended by the State Insurance Services Office. Generally, hydrant spacing may range from 350 to 600 feet depending on the area being served.

Water mains not designed to carry fire flows shall not have fire hydrants installed. It is recommended that flushing hydrants be provided on these systems. Flushing devices shall meet the requirements of Section VIII.B.5.

2. Hydrant Valves and Nozzles

Fire hydrants should have a bottom valve size of at least 5 inches, one 4.5-inch pumper nozzle and two 2.5-inch nozzles.

3. Hydrant Leads

The hydrant leads shall be a minimum of 6 inches in diameter. Auxiliary valves shall be installed in all hydrant leads.

4. Hydrant Drainage

Hydrant drains shall be plugged where groundwater rises above the drain port. When the drains are plugged, the barrels must be pumped dry after use during freezing weather. If there is any question as to whether the barrel can be kept dry, a nontoxic solution, which is acceptable to DEP, can be used to prevent freezing and cracking of the barrel. Where hydrant drains are not plugged, a gravel pocket or dry well shall be provided unless the natural soils will provide adequate drainage. Hydrants with open drains shall not be located within 50 feet of leach fields. Hydrant drains shall not be connected to or located within 10 feet of sanitary sewers, storm sewers or storm drains.

E. Air Relief Valves and Piping

1. Air Relief Valves

At high points in water mains where air can accumulate, provisions shall be made to remove the air by means of air relief valves. Automatic air relief valves shall not be used in situations where flooding of the manhole or chamber may occur.

2. Air Relief Valve Piping

The use of manual air relief valves is recommended wherever possible. The pipe from a manually operated valve should be extended to the top of the pit and provided with a screened, downward-facing elbow if drainage is provided for the manhole. The open end of an air relief pipe from automatic valves should be extended to at least 1 foot above grade and provided with a screened, downward-facing elbow. Discharge piping from air relief valves shall not connect directly to any storm drain, storm sewer or sanitary sewer.

F. Valve, Meter and Blow-Off Chambers

Chambers, pits or manholes containing valves, blow-offs, meters or other such appurtenances to a distribution system shall not be located in areas subject to flooding or in areas of high groundwater. Such chambers or pits should drain to the ground surface, or to absorption pits underground. The chambers, pits and manholes shall not be connected directly to any storm drain or sanitary sewer. Blow-offs shall not be connected directly to any storm drain or sanitary sewer.

G. Installation of Water Mains

1. Standards

   Specifications shall incorporate the provisions of the appropriate AWWA standards and/or manufacturers' recommended installation procedures.

2. Bedding

   A continuous and uniform bedding shall be provided in the trench for all buried pipe. Backfill material shall be tamped in layers around the pipe and to a sufficient height above the pipe to adequately support and protect the pipe. Stones found in the trench shall be removed for a depth of at least 6 inches below the bottom of the pipe. If coarse bedding is used, it should be interrupted every 250 feet by an earth dike or barrier to prevent dewatering or drainage from the entire upland area of the bedding.

3. Cover

   All water mains shall be covered with sufficient earth or other insulation to prevent freezing. A metallic tracer strip should be buried 1 foot above all nonmetallic pipe.

4. Blocking

   All tees, bends, plugs and hydrants shall be provided with reaction blocking, tie rods or joints designed to prevent movement.

5. Pressure and Leakage Testing

   All types of installed pipe shall be pressure tested and leakage tested in accordance with the latest edition of AWWA Standard C-600.

6. Disinfection

All new, cleaned or repaired water mains shall be disinfected in accordance with AWWA's Standard C651 for Disinfecting Water Mains. The specifications shall include detailed procedures for the adequate flushing, disinfection and microbiological testing of all water mains. At least one satisfactory bacteriological sample must be obtained from the water main and analyzed by a certified laboratory before the main is placed into service. Where the main must be returned to service as soon as possible, the "slug" method may be used.

H. Separation Distances from Contamination Sources

1. General

The following factors should be considered in providing adequate separation:

a. Materials and type of joints for water and sewer pipes

b. Soil conditions

c. Service and branch connections into the water main and sewer line

d. Compensating variations in horizontal and vertical separations

e. Space for repair and alterations of water and sewer pipes

f. Off-setting of pipes around manholes

2. Parallel Installation

a. Water mains shall be laid at least 10 feet horizontally from any existing or proposed sewer, septic tank or soil treatment system. The distance shall be measured edge-to-edge.

b. In cases where it is not practical to maintain a 10-foot separation, DEP may allow deviation on a case-by-case basis (See Section VIII.H.4.), if supported by data from the design engineer. Such deviation may allow installation of the water main closer to a sewer, provided that the water main is laid in a separate trench or on an undisturbed earth shelf located on one side of the sewer at such an elevation that the bottom of the water main is at least 18 inches above the top of the sewer.

3. Crossings

a. Whenever water mains must cross building drains, storm drains or sanitary sewers, the water main shall be laid at such an elevation that the bottom of the water main is 18 inches above the top of the drain or sewer. This vertical separation shall be maintained for the portion of the water main located within 10 feet horizontally of any sewer or drain it crosses. The

10 feet is to be measured as a perpendicular distance from the drain or sewer line to the water line.

b. At crossings, one full length of water pipe shall be located so both joints will be as far from the sewer as possible. Special structural support for the water and sewer pipes may be required.

4. Exception

When it is impossible to obtain the proper horizontal and vertical separation as stipulated in Sections VIII.H.2 and VIII.H.3, both the water main and sewer line shall be constructed of cast iron, ductile iron, galvanized steel or protected steel pipe having mechanical joints. Other types of joints of equal or greater integrity may be used at the discretion of DEP. Thermoplastic pipe may be used provided mechanical or solvent weld pipe joints are used. These shall be pressure-tested to ensure watertightness before backfilling. Where water mains must cross under a sewer, additional protection shall be provided by:

a. A vertical separation of at least 18 inches between the bottom of the sewer and the top of the water line.

b. Adequate structural support for the sewers to prevent excessive deflection of the joints and the settling on and breaking of the water line.

d. The length of the water line being centered at the point of the crossing so that the joints shall be equidistant and as far as possible from the sewer.

DEP shall be consulted when any of the above conditions cannot be met to discuss the use of double casing or concrete encasement of sewer and/or water lines as possible alternatives.

5. Sewer Manholes

No water pipe shall pass through or come in contact with any part of a sewer manhole. Water mains should be located at least 10 feet from sewer manholes.

I. Surface Water Crossings

In accordance with Chapters 105 and 106 of DEP's Rules and Regulations, all stream crossings, headwalls, pipelines, aerial crossings and other analogous structures which are placed in, along, across, over or under the regulated waters of the Commonwealth of Pennsylvania, are defined as encroachments or obstructions and, as such, require a permit from DEP. The Bureau of Waterways Engineering must be contacted before final plans are prepared.

1. Aerial Crossings

In addition to the general criteria for stream crossings as outlined in Section 105.311 of DEP's Rules and Regulations, Title 25 Chapter 105, "Dam

Safety and Waterway Management" (available at www.pacode.com) aerial crossings shall be adequately supported and anchored, protected from damage and freezing, and accessible for repair or replacement.

2. Underwater Crossings

Pipelines under stream beds shall be located such that there will be a minimum of 3 feet of cover between the top of the pipe or encasement and the lowest point in the stream bed; provided that, if the pipeline is in rock, it shall have the depth of granular soil plus 6 inches for cover, but never less than 1 foot of total cover. In addition, the following shall apply when crossing water courses which are greater than 15 feet in width:

a. The pipe shall be of special construction, having flexible restrained or welded watertight joints.

b. Valves shall be provided at both ends of water crossings so that the section can be isolated for testing or repair; the valves shall be easily accessible, and not subject to flooding.

c. Permanent taps or other provisions to allow insertion of a small meter to determine leakage and for sampling purposes and obtain water for samples shall be made on each side of the valve closest to the supply source.

d. Pipelines under the stream bed shall be as near to horizontal as possible.

J. Cross-Connections

There shall be no physical connection between the distribution system and any pipes, pumps, hydrants or tanks which are supplied from, or which may be supplied or contaminated from, any source except as approved by DEP. Neither steam condensate nor cooling water from engine jackets or other heat exchange devices shall be returned to the potable water supply. Backflow prevention devices of the type specified in Part V shall be installed where water supply mains are connected to residential, commercial and industrial customers which present a potential contamination hazard to the public water supply system.

K. Water Services and Plumbing

1. Plumbing

Water services and plumbing shall conform to relevant local plumbing codes or to the International Plumbing Code.

2. Booster Pumps

Individual booster pumps shall not be allowed for any individual residential service from the public water supply mains unless adequately protected against backflow. Where permitted for other types of services, booster pumps shall be designed in accordance with Section VI.E.

L. Service Meters

Each service connection should be individually metered.

M. Water Loading Stations

Water loading stations present special problems since the fill line may have been used for filling both potable water vessels and other tanks or contaminated vessels. To prevent contamination of both the public supply and potable water vessels being filled, the following principles shall be met in the design of water loading stations:

- There shall be no backflow to the public water supply.
- The piping arrangement shall prevent contaminants from being transferred from a hauling vessel to others subsequently using the station.
- Hoses shall not be contaminated by contact with the ground.