STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
OFFICE OF GENERAL COUNSEL
William R. Snodgrass, TN Tower
312 Rosa L. Parks Avenue, 2nd Floor
Nashville, Tennessee 37243

This document is undergoing legal review and revision. Please continue to use it as guidance for your submissions. If you have any specific questions, please reach out to Angela Jones, manager of the Engineering Services Unit, at Angela.Jones@tn.gov.

COMMUNITY

PUBLIC WATER SYSTEMS

DESIGN CRITERIA

Division of Water Resources

Tennessee Department of Environment and Conservation

2018

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INTRODUCTION

This publication is a revised edition of our Design Criteria for Community Public Water Systems. They have been prepared as a guide to water systems, design engineers, and our own staff. There has been no attempt to address every situation. We also know that there will be occasions when these criteria will not apply. Exceptions will be handled on an individual basis.

The Tennessee Safe Drinking Water Act of 1983 requires The Department of Environment & Conservation to:

> "Exercise general supervision over the construction of public water systems throughout the state. Such general supervision shall include all the features of construction of public water systems which do or may affect the sanitary quality or the quantity of the water supply. No new construction shall be done nor shall any change be made in any public water system until the plans for such new construction or change have been submitted and approved by the department."
> (Extract of part of Section 68-221-706, Tennessee Code)

Where the terms shall and must are used, it is intended to be a mandatory requirement. Other terms such as should, recommend, preferred, and the like, are intended to show desirable equipment, procedures, or methods.

We encourage development of new methods and equipment. However, any new developments must be demonstrated to be satisfactory before we can approve their use. Operating data from other installations, or demonstration of the equipment by a manufacturer's representative, or both, may be needed for our review.

These criteria are a compilation of information from a number of sources. The principle source, however, is Recommended Standards for Water Works, 1982 Edition. This publication is a report of "The Committee of the Great Lakes Upper Mississippi River Board of State Sanitary Engineers" and is commonly known as Ten-State Standards.

Part 1 - SUBMISSION OF ENGINEERING DOCUMENTS

1.0 GENERAL - All reports, final plans and specifications should be submitted at least 30 days prior to the date on which action by the Department is desired. Per Division of Water Resources Regulation 0400-45-1-.32, the appropriate plans review fee payment (payable to TDEC) must be submitted with the engineering documents. Preliminary plans and the engineer's report should be submitted for review prior to the preparation of final plans when the project will significantly change the distribution system or alter the treatment plant. No approval for construction will be issued until final, complete, detailed plans and specifications have been submitted to the Department and found to be satisfactory. All submittals must be signed by a responsible official of the water utility or its designated representative and the name of the system must be clearly identified. Documents submitted for formal approval shall include but not be limited to:

a. summary of the basis of design,

b. hydraulic calculations and profiles,

c. operation requirements, where applicable,

d. general layout,

e. detailed plans,

f. specifications (See Section 1.3).

At least four copies of the reports, final plans and specifications are required. Submittals should be addressed to:

Engineering Manager, Drinking Water Unit
Division of Water Resources
312 Rosa Parks Avenue, 11th Floor
Nashville, TN 37243
Phone: (615) 532-0191
Fax: (615) 532-0686

1.1 ENGINEER'S REPORT - In general, the engineering report for water works improvements shall clearly present:

a. a statement of the problem,

b. a summary of the alternative solutions, if applicable,

c. recommendations.

Where pertinent, the following information should be included in the report:

1.1.1 General information, including

a. description of the existing water works facilities,

b. identification of the municipality or areas served,

c. name and mailing address of the owner(s) or responsible official(s).

1.1.2 Extent of water works system, including

a. description of the nature and extent of the area to be served,

b. provisions for extending the water works system to include additional areas,

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

1.1.3 Alternate plans - Where two or more solutions are considered for providing public water supply facilities, each of which is feasible and practical, discuss the alternate plans and give reasons for selecting the one recommended, including financial considerations.

1.1.4 Soil, ground water conditions, and foundation problems, including

a. description of the character of the soil through which water mains are to be laid,

b. description of foundation conditions prevailing at sites of proposed structures,

c. description of the approximate elevation of ground water in relation to subsurface structures.

1.1.5 Water consumption, including

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,

b. present and future water consumption values used as the basis of design, including number of proposed service connections,

c. hydraulic calculations and hydraulic profiles,

d. distribution of storage capacities,

e. water losses in system.

1.1.6 Fire flow requirements

1.1.7 Wastewater system available - Describe the existing wastewater system and wastewater treatment works, with special reference to their relationship to existing or proposed water works structures which may affect the operation of the water supply system, or which may affect the quality of the supply.

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

a. Surface water sources

1. hydrological data, stream flow and weather records,

2. safe yield, including all factors that may affect it, e.g. downstream flow necessary to assimilate wastewater,

3. summarized quality of raw water with special references to fluctuations in quality, changing meteorological conditions, sources of contamination, etc.

b. Ground water sources

1. sites considered,

2. advantages of site selected,

3. elevations with respect to surroundings,

4. probable character of formations through which source is to be developed,

5. unusual geologic conditions affecting site,

6. summary of source exploration, test well depth, and method of construction, placement of liners or screen, pumping test, hours, capacity, water levels and specific yield; water quality,

7. possible sources of contamination,

8. data which document the expected available flow in spring such as the 3-day, 20-year minimum flow,

9. evaluation of the ground water source for direct influence of surface water.

1.1.9 Proposed treatment processes - Summarize and establish the adequacy of proposed processes for the treatment of the specific water under consideration. Pilot studies may be required. Provide design criteria of the treatment unit including, where applicable:

a. treatment basin capacities,

b. retention times of basins and clearwell,

c. treatment unit loadings,

d. filter area and proposed filtration rate,

e. backwash rate,

f. feeder capacities and ranges.

1.1.10 Waste disposal - Discuss the various wastes from the water treatment plant, their volumes, proposed treatment and points of discharge.

1.1.11 Project sites, including

a. discussion on various sites considered and advantages of the recommended ones,

b. proximity of residences, industries, and other establishments,

c. presence of any potential sources of pollution that may influence the quality of the supply or interfere with the effective operation of the water works system, such as wastewater absorption systems, septic tanks, privies, cesspools, sink holes, refuse and garbage dumps, sanitary landfills, etc.

1.1.12 Distribution System, including

a. Map of overall distribution system showing existing and proposed

1. location and size of water lines,
2. location, size, and elevation of storage tanks,
3. location, and size of pumps.

b. Preliminary hydraulic gradient or calculations and data to provide hydraulics of system (this may be deferred until plans are submitted).

1.1.13 Financing, including

a. estimated cost of integral parts of system,

b. detailed estimated annual cost of operation,

c. proposed methods to finance both capital charges and operating expenses. Include water rate structure, present and proposed.

1.1.14 Future expansion - Summarize planning for future needs and service for the next 5-10 years.

1.2 PLANS - Plans for water works improvements should, where pertinent, provide the following:

1.2.1 General layout, including

a. title,

b. name of water system, and county in which located,

c. area or institution to be served,

d. scale, in feet, not less than 1 inch = 200 feet for urban areas, and not less than 1 inch = 400 feet for rural areas,

e. north direction,

f. datum used,

g. boundaries of the municipality or area to be served,

h. date, address, name, and phone number of the designing engineer,

i. signed and dated imprint of professional engineer's seal,

j. legible prints suitable for reproduction, preferably all sheets same size,

k. location and size of existing water mains, adjacent to proposed construction,

l. location and nature of existing water works structures and appurtenances affecting the proposed improvements, noted on one sheet.

1.2.2 Detailed plans, including

a. stream crossings, providing profiles with elevations of the stream bed and the normal and extreme high and low water levels, if this information is available,

b. profiles, if needed, having a horizontal scale of not more than 100 feet to the inch and a vertical scale of not more than 10 feet to the inch, with both scales clearly indicated,

c. location and size of the property to be used for the ground water development with respect to known references such as roads, streams, section lines, and streets,

d. topography and arrangement of present or planned wells or structures, with contour interval not greater than 2 feet,

e. elevation of highest known flood level, floor of structure, upper terminal of protective casing, and outside surrounding grade, using United States Coast and Geodetic Survey, United States Geological Survey or equivalent elevations where applicable as reference,

f. plat and profile drawings of well construction, showing diameter and depth of drill holes, casing and liner diameters and depths, grouting depths, elevations and designation of geological formations, water levels and other details to describe the proposed well completely.

g. location of all sources of pollution within 250 feet of the source and 100 feet of underground treated water storage facilities,

h. size, length, identity, and location of wastewater lines, drains, water mains, and plant structures,

i. schematic flow diagrams and hydraulic profiles showing the flow through various plant units.

j. piping in sufficient detail to show flow through plant, including waste lines,

k. location of all chemical feeding equipment and points of chemical application (see Section 5.0.1),

1. all appurtenances, specific structures, equipment, water treatment plant waste disposal units and points of discharge, having any relationship to the plans for water mains and/or water works structures,

m. location of sanitary or other facilities, such as lavatories, showers, toilets, and lockers, when applicable,

n. location, dimensions and elevations of all proposed plant facilities,

o. adequate description of any features not otherwise covered by the specifications.

1.2.3. Detailed plans for distribution systems, including

a. a vicinity map showing location of project, if system map is not included,

b. key map, showing location of detailed drawings, when project is comprehensive,

c. location of proposed water lines in relation to roads, bridges, and other identifiable objects,

d. location of valves, fire hydrants, tees, and reducers/enlargers,

e. hydraulic profile or data and computations showing hydraulics of proposed additions to the distribution system.

1.3 SPECIFICATIONS

1.3.1 Complete detailed, technical specifications shall be supplied for the proposed project unless alternate specifications are referenced (see Section 1.3.2). These shall include, where pertinent:

a. laboratory facilities and equipment, as well as sampling taps and their locations,

b. number and design of chemical feeding equipment (see Section 5.0.1),

c. materials or proprietary equipment for sanitary or other facilities including any necessary backflow or backsiphonage protection.

1.3.2 The following alternate specifications may be referenced in lieu of submitting new specifications as long as these are applicable to the project:

a. current, approved standard specifications for the water system on file in our office,

b. Local Government Public Works Standards and Specifications published by University of Tennessee Municipal Technical Advisory Service, if legally adopted by the water system and record of such adoption is on file in our office.

1.4 REVISIONS TO APPROVED PLANS - Any significant 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 the Department before such changes are made. Revised plans or specifications must 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.

1.5 AS-BUILT PLANS - As-built plans shall be submitted to the Department for new water treatment plants or any significant addition or modification to an existing water plant.

Part 2 - GENERAL DESIGN CONSIDERATIONS

2.1 PLANT LAYOUT - System design shall consider:

a. functional aspects of plant layout,

b. provisions for future plant expansion,

c. access roads,

d. site grading,

e. site drainage,

f. walks,

g. driveways and parking,

h. chemical delivery,

i. security.

2.2 BUILDING LAYOUT - Design shall provide:

a. adequate ventilation, which is screened for insect protection,

b. adequate lighting,

c. adequate heating and air-conditioning,

d. adequate drainage,

e. dehumidification equipment as needed,

f. accessibility of equipment for operation, servicing, and removal,

g. flexibility of operation,

h. operator safety, including safety railings,

i. convenience of operation,

j. consideration of chemical storage and feed equipment in separate rooms to reduce dust problems,

k. separate facilities for laboratory procedures and office/lunch activities.

2.3 STANDBY POWER - Standby power generation may be required by the Department so that water may be treated and/or pumped to the distribution system during periods when there is a power outage.

2.4 AUTOMATIC EQUIPMENT - Adequate facilities must be provided for the maintenance and servicing of automatic equipment.

2.5 STORAGE AND SHOP SPACE - Adequate facilities shall be included for shop space and storage consistent with the designed facilities.

2.6 PROVISIONS FOR FUTURE EXPANSION - Consideration shall be given to providing extra wall castings built into the structure to facilitate expansion and unknown future uses whenever pipes pass through walls of concrete structures.

2.7 METERING - All water systems shall have some means of metering the raw and finished water.

Part 3 - SOURCE DEVELOPMENT

3.0 GENERAL - In selecting the source of water to be developed, the designing engineer must show to the satisfaction of the Department that the water which is to be delivered to the consumers will meet the current requirements of the Department with respect to bacteriological, physical, chemical and radiological qualities. The Division of Water Resources Field Offices evaluate and approve proposed new sources.

3.1 SURFACE WATER - A surface water source includes all tributary streams and drainage basins, natural lakes and artificial reservoirs or impoundments above the point of water supply intake.

3.1.1 Quantity - The quantity of water at the source shall:

a. be adequate to supply the water demand of the service area,

b. provide a reasonable surplus for anticipated growth over a design period of 10 to 20 years,

c. be adequate to compensate for all losses,

d. be evaluated for dependable capacity during drought,

e. be evaluated for impacts on downstream uses.

3.1.2 Quality - A sanitary survey and study should be made of the factors, both natural and man made, which will affect quality. Such survey and study shall include, but shall not be limited to:

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

b. assessing degree of hazard to the supply from upstream discharges and by accidental spillage of materials that may be toxic, harmful or detrimental to treatment processes.

3.1.3 Structures - Intake structures design shall:

a. provide withdrawal of water from more than one level,

b. provide adequate protection against rupture by dragging anchors, ice, etc.

c. have motors and electrical controls located above grade and 100-year flood level, except when submersible pumps are approved,

d. be accessible,

e. be designed against flotation,

f. be equipped with removable or traveling screens before the pump suction well,

g. provide chemical feed facilities for raw water transmission main if necessary for water quality control or prevention of infestation by clams, mussels etc.,

h. have intake valves and provisions for backflushing and testing for leaks, where practical,

i. have provisions for surges where necessary,

j. have provisions for sand or gravel removal, 3.1.4 Impoundments and Reservoirs

a. Site preparation should provide for:

1. removal of brush and trees to high water elevation,

2. protection from floods during construction,

3. clearing and grubbing small reservoirs.

b. Construction may require:

1. approval of safety features for stability and spillway design of any structures to be obtained from the Department,

2. permit for controlling stream flow or structure on bed of navigable stream or interstate water, to be obtained from the appropriate agency.

3.2 GROUND WATER - A ground water source includes all water obtained from drilled wells or springs. Drilled wells shall meet requirements for construction and development delineated in the latest AWWA A-100 Standards. Springs shall meet the requirements for protection established by the Department on a case-by-case basis. Ground water sources must be evaluated for direct influence of surface water.

a. Drilled Wells - Two important design questions are involved. One is the provision for the proper depth to which the well casing shall be installed as a watertight conduit. The other is provision for positive sealing of the annulus between the outside of the well casing to prevent seepage of water vertically along the outside of the pipe.

1. Water tight construction of the cased portion of a well shall be carried to such depth as may be required by the Department to prevent polluted or inferior quality water from entering the well.

i. Wells completed in an unconsolidated aquifer such as sand, gravel, or what is commonly referred to as overburden shall be designed with watertight casing extending from the land surface to a depth of at least 10 feet below the lowest expected pumping level. Where the pumping level is less than 25 feet from the surface, the casing shall extend no less than 20 feet below the lowest pumping level.

ii. Wells completed in consolidated rock formations having little or no primary permeability such as limestone, dolomite, sandstone, siltstone and shale shall be designed with watertight casing extending through all overburden material and firmly seated in the bedrock. Where applicable the casing shall extend below any crevices that would release water of inferior quality into the well.

2. Provisions shall be made in the construction of a well for grouting and sealing the annular space between the borehole and the outside of the well casing. This normally means planning an oversize borehole to the proper depth to provide an annulus into which suitable grouting material can be placed. To assure a proper seal, the grout must be placed by a positive displacement method such as pumping or pressure injection from the bottom of the annulus to the top in one continuous operation.

b. Springs

1. Use of springs as a source of supply shall be considered only when it is not feasible to develop an acceptable well or surface supply.

2. Spring supplies shall be protected from entry of surface water.

3. Spring intakes shall be housed in permanent structures.

4. Spring supplies must be evaluated for direct influence of surface water. If determined to be under the direct influence of surface water, treatment must be provided in accordance with Division of Water Supply Filtration and Disinfection rules.

5. Spring supplies must be evaluated for dependable capacity during drought.

6. Downstream impacts of water withdrawals from springs must be considered and appropriate environmental permits obtained.

3.3 GENERAL WELL CONSTRUCTION REQUIREMENTS

a. Location - the Department shall be consulted as to required separation between sources of pollution and the ground water development.

b. Casing and liner pipe of wrought iron or steel:

   1. shall be prime pipe meeting AWWA, ASTM, or APT standard specifications,

   2. shall be surrounded by grout,

   3. shall be capable of withstanding forces to which they are subjected,

   4. shall have additional thickness and weight if standard thickness is not considered sufficient to assure reasonable life expectancy of well,

   5. shall have welded or threaded pipe joints.

c. Pipe other than wrought iron or steel must be adaptable to the stresses to which they will be subjected during installation and to the corrosiveness of the water.

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

e. Screens shall:

   1. be constructed of material which will not be damaged by chemical action of ground water or future cleaning operations,

   2. have size of openings to be based on sieve analysis, or based on size of gravel if an artificial gravel pack is installed,

   3. be installed so that exposure above pumping level will not occur,

   4. be designed and installed to permit removal or replacement without adversely affecting watertight construction of well.

f. Yield and drawdown test requirements:

1. Every well shall be tested for yield and drawdown,

2. The method of testing shall be clearly stated in the specifications and shall be subject to the approval of the Department. Acceptable methods include but are not limited to the following:

   i. Constant discharge method - This type of test is preferred for wells completed in unconsolidated aquifers. It is made by maintaining a constant rate of discharge equal to or greater than the desired yield of the well throughout the entire period of pumping. Measurements of pumping rate and water level shall be made every minute for the first 10 minutes of the test, every 2 minutes for the next 10 minutes, every 5 minutes for the next 40 minutes, every 15 minutes for the next hour, every 30 minutes for the next 3 hours, hourly for the remainder of the pumping period. Recovery water-level measurements shall be made with the same frequency beginning with the cessation of pumping and continuing until complete recovery has occurred or until sufficient data have been collected to extrapolate full recovery.

   ii. Variable discharge method - This type of test can be used for wells completed in either consolidated or unconsolidated aquifers. It is made by setting the pump intake at a predetermined level and operating the pump at full capacity until it breaks suction. Thereafter the pump discharge is reduced until the pumping level stabilizes approximately 2 feet above the pump intake for a period of 5 to 10 minutes. The pumping rate shall then be decreased 5 percent and the well pumped at this rate until the pumping level stabilizes or the pump breaks suction again. Should the pump break suction a second time repeat the procedure given above until the pumping level stabilizes for a period of not less than four hours or for the remainder of the test period, whichever is longer. The final pumping rate shall be considered the available production from the well and the observed pumping level during the test shall be considered the production well's pumping level.

   iii. Step drawdown method - This method is preferred for wells completed in consolidated rock formations. It involves the well being "step" tested at rates approximately 1/2, 1, and l-1/2 times the design capacity of the well. Each step should consist of equal periods of pumping except the final step may be continued for a longer period of time if desired by the owner. The pump is operated continuously for the entire period of the test. The discharge must be controlled with a gate valve, if electric driven, or a gate valve and throttle if engine driven. The discharge is controlled and maintained at approximately the desired discharge for each step with an accuracy of ± 5 percent. Pump discharge is measured with a meter such as a circular orifice meter that will permit instantaneous determination of the discharge rate. A half-inch I.D. or larger pipe is installed from a point about 2 feet above the pump intake to the well head. The top of the pipe is readily accessible to insert, remove and read the depth to water using either a steel tape or 2-wire electric sonde. Measurements of pumping rate and water level are made for each step of the test according to the schedule given in the constant discharge method. Recovery water-level measurements are made with the same frequency until the well has fully recovered or until sufficient data have been recovered to extrapolate full recovery.

3. The test pump shall be capable of pumping 150 percent of the desired yield of the well.

4. The pumping equipment shall be capable of operating continuously without interruption for the maximum period contemplated for the test.

5. The duration of the test depends on a number of factors including but not limited to the following:

   (i) Local experience - Where wells have been operated nearby and in the same formation so that the water-yielding character of similar wells is fairly well known, the minimum period of testing shall be not less than 8 hours.

   (ii) Intermittent pumping - If it is anticipated that the well will be pumped for 12 hours or less each day, the minimum period of testing shall be not less than 24 hours.

   (iii) Limited draft - If the capacity of the permanent pump to be installed in the well is to be one-fourth or less of the demonstrated output of the well, the minimum period of testing shall be not less than 8 hours.

   (iv) Season of the year - If the well is tested during the winter and spring months, the minimum period of testing shall be extended by 50 percent of the time otherwise required.

6. Data shall be provided to the Department's central office and appropriate basin office as follows:

   (i) static water level, measurements prior to starting the pump,

   (ii) pumping rates and duration of each period of pumping,

   (iii) water-level measurements during test, and graph of drawdown vs. time,

   (iv) recovery water level measurements, and graph of recovery vs. time,

   (v) depth of pump setting,

   (vi) analytical results of water samples collected during the test,

   (viii) summary of determinations of well capacity, efficiency, aquifer characteristics, safe pumping rates, pump settings and water treatment needs.

g. Grouting requirements:

1. Types of grout:

   (i) Concrete Grout - A mixture of Portland Cement (ASTM C150), sand and water in the proportion of at least 5 bags of cement per cubic yard of concrete to not more than 7 shall be used. Size of gravel should be no greater than 1/3 the diameter of the annular space.

   (ii) Sand Cement Grout - A mixture of Portland Cement (ASTM C150), sand and water in the proportion of not more than two parts by weight of sand to one part of cement with not more than 7 gallons of water per cubic foot of cement shall be used.

(iii) Neat Cement Grout - A mixture of Portland Cement (ASTM C150) and not more than 7 gallons of water per cubic foot of cement shall be used.

The use of additives to reduce permeability, increase fluidity or control time of set may be used up to 5 percent by weight.

2. Placement of grout - To assure that grout will provide a satisfactory seal it must be introduced at the bottom of the annular space to be filled and placed in one continuous operation. Acceptable methods include the following:

(i) Tremie method - Grout material is placed by tremie pouring (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). The tremie method shall only be used where there is a minimum annular space of 3 inches between the outside surface of the inside casing and the inside surface of the borehole. The minimum size tremie pipe utilized shall be 2 inches inside diameter. Where concrete grout is used the minimum size tremie pipe used shall be three inches inside diameter. When making a tremie pour, the tremie pipe shall be lowered to the bottom of the zone being grouted, and raised slowly as the grout material is introduced. The tremie pipe shall be kept full continuously from start to finish of the grouting procedure with the discharge end of the tremie pipe being continuously submerged in the grout until the zone to be grouted is completed filled.

(ii) Positive placement exterior method - Grout material is placed by a positive displacement method such as pumping or forced injection by air pressure (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). Grout is injected in the annular space between the inner casing and the borehole. The annular space must be a minimum of l½ inches for sand-and-cement or neat cement grout, and not less than three times the size of the largest coarse aggregate used. The grout pipe shall extend from the surface to the bottom of the zone to be grouted. The grout pipe shall have a minimum inside diameter of one inch for sand cement or neat cement grout. It shall have a minimum diameter of 1-1/2 inches for concrete grout. Grout shall be placed, from bottom to top, in one continuous operation. The grout pipe may be slowly raised as the grout is placed but the discharge end of the grout pipe must be submerged in the emplaced grout at all times until grouting is completed. The grout pipe shall be maintained full, to the surface, at all times until the completion of the grouting of the entire specified zone. In the event of interruption in the grouting operations, the bottom of the pipe should be raised above the grout level and should not be resubmerged until all air and water have been displaced from the grout pipe and the pipe flushed clean with clear water.

(iii) Positive placement - interior method - two plug - Grout is placed by the two-plug cementing method (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). The first spacer plug, which is a drillable plug such as a plaster type material, shall then be inserted and the casing capped. A measured volume of grout is pumped in which is a sufficient quantity to grout the casing in place. The casing is then uncapped, the second plug is inserted, and the casing recapped. A measured volume of water slightly less than the volume of the casing shall then be pumped into the casing until the second plug is pushed to the bottom of the casing, expelling the grout from the casing up and <u>into</u> the annular space. The water in the casing shall be maintained constant to prevent backflow until the grout has set. Pressure shall be maintained for a minimum of 24 hours or until such time as a sample of the grout indicates a satisfactory set. Cement grout shall be used for this procedure with a minimum annular space thickness of l½ inches completely surrounding the casing. Concrete grout cannot be used with this method.

(iv) Positive placement - interior method - upper plug - Grout is placed by the upper plug casing method (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). A measured quantity of grout, sufficient to grout the casing in place, shall be pumped into the capped casing. Because this grout is in direct contact with the drilling fluid there will be a narrow zone of weak grout between the drilling fluid and the good grout. The casing is uncapped, and a drillable plug, constructed of plastic or other suitable material is inserted on top of the grout and the casing recapped. A measured volume of water, equal to the volume of the casing, is pumped into the casing, forcing the plug to the bottom of the casing and expelling the grout into the annular space surrounding the casing. Utilizing this method the weak grout zone at the interface of grout and drilling fluid will not be located at the critical position at the bottom of the casing. The water in the casing shall be maintained under pressure to prevent back flow until the grout has set. Pressure shall be maintained for a minimum of 24 hours or until such time as a sample of the grout indicates a satisfactory set. Neat cement or sand-cement grout is used for this procedure, with a minimum annular space opening of l½ inches completely surrounding the casing. Concrete grout cannot be used with this method.

(v) Positive placement - interior method - capped casing Grout is placed by pumping or air pressure injection through the grout pipe installed inside the casing from the casing head to a point 5 feet above the bottom of the casing (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). The grout pipe extends airtight, through a sealed cap on the casing head of the well casing. The casing head is equipped with a relief valve and the drop pipe is equipped at the top with a valve permitting injection. The lower end of the drop pipe and the casing is open. Clean water is injected down the grout pipe until it returns through the casing head relief valve. The relief valve is then closed and injection of water is continued until it flows from the bore hole outside of the casing to be grouted in place. This circulation of water is intended to clean the hole and condition it to better take the grout. Without significant interruption, grout is substituted for water and, in a continuous manner, injected down the grout pipe until it returns to the surface outside of the casing. A small amount of water, not to exceed 17 gallons per 100 feet of 2-inch drop pipe may be used to flush the grout pipe, but pressure shall be maintained constant on the inside of the grout pipe and the inside of the casing until the grout has set. Pressure shall be maintained for at least 24 hours, or until such time as a sample of the grout indicates a satisfactory set. Neat cement or sand-cement grout is used for this procedure with a minimum annular space of l½ inches completely surrounding the casing.

(vi) Continuous injection method - Grout is placed by the float shoe continuous injection method (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). The bottom of the casing is fitted with a suitable drillable float shoe equipped with a back pressure valve. Tubing or pipe is run to the float shoe to which it is connected by a bayonet fitting, left hand thread coupling, or similar release mechanism. Water or other drilling fluid is circulated through the tubing and up through the annular space outside the casing. when the annular space is clean and open, grout is pumped down the pipe or tubing and forced by continual pumping out into the annular space surrounding the casing. Pumping continues until the entire zone to be grouted is filled. The grout pipe is then detached from the float shoe and raised to the surface for flushing. After the grout has set the float shoe, back pressure valve, and any concrete plug remaining in the bottom of the casing is drilled out. A neat cement or sand-cement grout is used for this procedure with a minimum annular space of 1.5 inches completely surrounding the casing.

(vii) Grout displacement method - The hole is filled with the estimated volume of grout required for the purpose intended. The casing fitted at the bottom with a drillable back pressure valve, metal plate, or similar seal shall be lowered through the grout to the bottom of the hole. If necessary to maintain the bottom of the casing at the bottom of the hole, the casing shall be filled with water, or drilling fluid, and in some cases by applying a load on the bottom with drill pipe. The load is maintained until the grout has set, after which the bottom plug is drilled out and the well deepened. Use of this method is limited to wells not more than 100 feet in depth.

3. Location of grout

(i) Surface formation seal - The annular space to be grouted and surrounding the permanent well casing at the upper terminus of the well, shall be not less than a nominal 2 inches. The length of the grout seal shall be whatever is necessary to prevent the entrance of surface water or undesirable subsurface water into the well. In any circumstance, the length of seal shall not be less than the minimum specified in the state or locally applicable construction code. The entire space to be grouted must be open and available to receive the grout at the time the grouting operation is performed. If a section of larger pipe (conductor pipe) is installed to keep the entire space open (in caving materials), this larger pipe must be removed, as the grout is installed, from the zone where the seal is required. The effective length of grout seal (for sanitary purposes) shall be that distance measured from the deepest limit of the seal up, to the depth of frost penetration. If a pitless adapter or unit is to be installed, the upper limit of the seal shall be one foot below the field connection of the adapter or unit.

(ii) Bottom seal grouting - Grout shall be placed in the annular space surrounding the bottom of the casing by the method specified.

(iii) Selected interval grouting - All zones containing water of unsuitable quality shall be grouted from a point at least 5 feet below, to a point at least 5 feet above the unsuitable zone. The annular space surrounding the casing between grouted zones shall be filled with sand or other suitable granular material.

(iv) Continuous grouting - Grout shall be placed in the annular space surrounding the casing by the method specified. Grouting shall be continuous from the bottom of the permanent casing to the land surface; or, where a filter pack has been installed, from the top of the pack (following development) to the land surface; or, where a well screen only has been installed, from a point 5 feet above the screen to the land surface. When a pitless adapter or unit is to be installed, the grout shall extend from such depth to within one foot of the field connection of the adapter or unit.

4. Guides or centralizers

(i) protective casing must be provided with sufficient guides or centralizers attached or welded to casing to permit unobstructed flow and uniform thickness of grout.

(ii) Guides or centralizers shall be attached to the bottom of the casing and at intervals not greater than 25 feet.

h. Plumbness and alignment requirements:

1. every well shall be tested for plumbness and alignment,

2. test method shall be clearly stated in specifications and shall be in accordance with the latest AWWA A100 standard,

3. test results shall be submitted to the Department prior to permanent pump installation.

i. Geological data shall:

1. be determined from samples collected at 10 foot intervals and at each pronounced change in formation,

2. be recorded and submitted to the Department,

3. be supplemented with information on accurate record of drillhole diameters and depths, assembled order of size and length of casings and liners, grouting depths, formations penetrated, and water levels.

4. be supplemented with complete pumping test data.

j. Upper terminal of well, requirements:

1. protective casing for all ground water sources must project not less than 6 inches, and preferably 12 inches, above pumphouse floor or cover installed,

2. site not subject to flooding must have floor of pumphouse at least one foot above original ground surface,

3. site subject to flooding must have the floor of the pumphouse at least two feet above the highest known flood elevation and be surrounded by earth fill as required by the Department.

k. Capping requirements:

1. properly fitted, firmly driven, solid wooden plug is the minimum acceptable method of capping a well until pumping equipment is installed,

2. a welded metal plate is preferred for capping a well,

3. well must be protected during construction.

l. Bacteriological quality:

1. every new, modified or reconditioned ground water source shall be disinfected upon completion of construction and after placement of final pumping equipment in accordance with AWWA A100 standards,

2. one or more water samples shall be submitted to a state certified laboratory for bacteriological analysis, with the results reported to the Department.

m. Chemical quality:

1. every new, modified or reconditioned ground water source shall be examined for chemical characteristics by tests of a representative sample in a state-certified laboratory with the results reported to the Department,

2. samples shall be collected and tested as soon as practical,

3. determination of pH and C02 shall be made in the field,

4. samples for iron analysis must be acidified,

5. in addition to standard tests, examination shall be made for hydrogen sulfide and methane where these gases are suspected.

n. Water level measurement:

1. provisions shall be made for periodic measurement of static and pumping water levels in completed production wells,

2. installation shall be made in such manner as to prevent entrance of foreign material,

3. reference data shall be stamped on plate affixed to pump base.

o. Well abandonment:

1. test wells and ground water sources which are not in use shall be sealed by such methods as to restore the controlling geological conditions which existed before they were constructed,

2. Wells to be abandoned shall:

(i) be sealed to prevent exchange of water from one geological strata to another, ideally mimicking the existing geological strata through which the well was drilled,

(ii) be filled with clay and sand, clay and concrete, or other suitable impermeable material,

(iii) if filled with concrete the latter shall not be dropped through water.

p. Observation wells:

1. shall be constructed in accordance with the requirements for permanent wells if to remain in service after completion of ground water supply,

2. shall be protected at the upper terminal to preclude entrance of foreign material.

Part 4 - TREATMENT

4.0 GENERAL - The design of treatment processes and devices depends on evaluation of the nature and quality of the particular water to be treated and the desired quality of the finished water. Surface water treatment plants must provide treatment for cryptosporidium, giardia, bacteria and viruses in accordance with the requirements of Division of Water Resources surface water treatment rules. Surface water treatment plants must provide for taste and odor control if there is any history or potential of taste and odor problems/complaints. Surface water treatment plants must be designed for control and reduction of disinfection by-products and their precursors.

4.1 CLARIFICATION - Plants designed for processing surface waters should:

a. provide duplicate units for flocculation and sedimentation,

b. be constructed to permit units to be taken out of service without disrupting operation.

4.1.1 Pre-sedimentation - Waters containing high turbidity or silica particles may require pretreatment, usually sedimentation either with or without the addition of coagulation chemicals.

a. Basin Design - Pre-sedimentation basins should be designed to hold maximum 3-day usage.

b. Inlet - Incoming water shall be dispersed across the full width of the line of travel as quickly as possible; short circuiting must be prevented.

c. Bypass - Provisions for bypassing pre-sedimentation basins shall be included.

4.1.2 Mixing (Flash or Quick):

a. Equipment - Basins should be equipped with mechanical mixing devices; other arrangements, such as baffling, and in-line mixers may be acceptable.

b. Mixing - The detention period shall not exceed 30 seconds. Concrete blocks may be placed in the flash mix temporarily to maintain this detention period if the plant is expected to be expanded in the near future.

c. Velocity gradient - The minimum shall be 300 (ft/sec)/ft.

4.1.3 Flocculation (Slow Mixing):

a. Basin Design - Inlet and outlet design shall prevent short circuiting and destruction of floc. A drain shall be provided.

b. Detention - The detention time for floc formation must be at least 30 minutes, with a detention time of 45 minutes being recommended.

c. Equipment - Agitators shall be driven by variable speed drives with the peripheral speed of paddles ranging from 0.5 to 2.0 ft/sec. The speed of each successive agitator should be less than the previous one.

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 be not less than 0.5 nor greater than 1.5 ft./sec. 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 the Department. Minimum flow-through velocity shall be not less than 0.5 nor greater than 1.5 ft./sec. with a detention as noted above.

4.1.4 Sedimentation - Sedimentation shall follow flocculation. 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 number of basins required is dependent upon the turbidity, color and colloidal matter and taste and odor causing compounds to be removed.

a. Detention Time - Plants with conventional sedimentation shall provide a minimum of 4 hours of settling time, except for iron removal plants which shall have a minimum of 3 hours.

b. Depth - Should be based on an average depth of 8 ft. However, calculations using surface area, overflow rate and detention time should be used.

c. Rectangular tanks - A length to width ratio of 4:1 should be used.

d. Tube Settlers - Detention time required for sedimentation basins may be reduced to a minimum of 1 hour if tube settlers are installed. The maximum loading rate on the tube settlers shall be no greater than 2.5 gpm/ft2. Provisions shall be made for more frequent removal of sludge from the basins than is required for conventional sedimentation.

e. Plate Settlers – shall be designed, installed and loaded per the manufacturers recommendations.

f. Inlet Devices - Inlets shall be designed to distribute the water equally and at uniform velocities. Open ports, submerged ports, or similar entrance arrangements are required. 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. Velocity is not to exceed 0.25 ft/sec.

g. Surface overflow Rate - Shall be between 0.25 - 0.38 gpm/sq. ft. for conventional sedimentation. When tube settlers are used design of effluent weirs or pipes shall minimize carry over of floc from the tubes.

h. Velocity - The velocity through settling basins shall not exceed 0. 5 feet per minute. The basins must be designed to minimize short circuiting. Baffles must be provided as necessary. Not applicable if tube settlers are used.

i. 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 required. Drain lines shall be designed to empty the basin in 4 hours or less.

j. Weir Overflow Rate - An overflow weir should be installed which will establish the maximum water level desired on top of the filters. Adjustable V-notch weirs are preferred. Weir overflow rates shall be between 8 - 10 gpm/ft. for raw water with low turbidity and 10 - 15 gpm/ft. for raw water with high turbidity. It shall discharge with a free fall at a location where the discharge can be observed. Other methods will be considered when presented.

k. Safety - Permanent ladders or handholds should be provided for safety on the inside walls of basins above water level. Guard rails shall be included. Flushing lines or hydrants must not include interconnection of the potable water with non-potable water.

l. Sludge Collection - Mechanical sludge collection equipment should be provided.

m. Sludge Disposal - Facilities are required by the Department for disposal of sludge. See Section 4.11. Provision shall be made for operator to observe or sample sludge being withdrawn from unit.

4.1.5 Solids Contact Unit - Solids contact units are acceptable for clarification and/or softening. 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. The following are design criteria for consideration, but any design shall be submitted in detail to be reviewed on a case-by-case basis.

a. Installation of equipment - Supervision by a representative of the manufacturer should be provided with regard to all mechanical equipment at the time of:

1. installation, and

2. initial operation.

b. Operating equipment - The following should be provided for plant operation:

1. a complete outfit of tools and accessories,

2. necessary laboratory equipment,

3. adequate piping with suitable sampling taps so located as to permit the collection of samples of water from critical portions of the units.

c. Chemical feed - Chemicals should be applied at such points and by such means as to insure satisfactory mixing of the chemicals with the water.

d. Mixing - Mixing devices employed should be so constructed as to:

1. provide good mixing of the raw water with previously formed sludge particles, and

2. prevent deposition of solids in the mixing zone.

e. Flocculation - Flocculation equipment should:

1. be adjustable,

2. provide for coagulation to occur in a separate chamber or baffled zone within the unit,

3. provide the flocculation and mixing period to be not less than 30 minutes.

f. Sludge concentrators - The equipment should provide either internal or external concentrators in order to obtain a concentrated sludge with a minimum of waste water.

g. Sludge removal - Sludge removal design should provide that:

1. sludge pipes shall be not less than three 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. operator may observe or sample sludge being withdrawn from the unit,

5. backflow from sanitary sewer systems be impossible.

h. Cross-connections:

1. blow-off outlets and drains should terminate and discharge at places satisfactory to the Department.

2. cross-connection control should be included for the potable water lines used to backflush sludge lines.

i. Detention period - Systems using a sludge blanket should have a minimum detention time of 1 hour with the flow rate not to exceed 1.0 gpm/ft2.

j. Suspended slurry concentrate - Units should be designed so that continuous slurry concentrates of 1% or more, by weight, can be satisfactorily maintained.

k. Water Losses

1. units should be provided with suitable controls for sludge withdrawal,

2. total water losses should not exceed:

(i) 5% for clarifiers,

(ii) 3% for softening units.

3. solids concentration of sludge bled to waste should be:

(i) 3% by weight for clarifiers,

(ii) 5% per cent by weight for softeners,

l. Weirs or orifices - The units should be equipped with either overflow weirs or orifices. Weirs shall be:

1. adjustable,

2. at least equivalent in length to the perimeter of the tank,

3. constructed so that surface water does not travel over 10 feet horizontally to the collection trough.

m. Weir loading - Should be same as conventional settling.

4.2 <u>FILTRATION</u> - Acceptable filters include, at the discretion of the Department, the following types:

a. gravity filters,

b. pressure filters.

The application of any one type must be supported by water quality data representing a reasonable period of time to characterize the variations in water quality. Experimental treatment studies may be required to demonstrate the applicability of the method of filtration proposed.

4.2.1 Gravity Filters

a. Number - At least two units shall be provided. Where declining rate filtration is provided, the variable aspect of filtration rates, and the number of filters must be considered when determining the design capacity for the filters.

b. Rate of Filtration

1. Standard Rate Filtration - The permissible rate of filtration shall be determined by the quality of the raw water, the degree of pretreatment provided, the filter media provided the quality of operation provided and other considerations required by the Department. The nominal rate shall be 2 gpm/ft2 of filter area for turbidity removal plants, and 3 gpm/ft2 of filter area for iron removal plants,

2. High Rate Filtration - Filtration rates for turbidity or iron removal plants of up to 4 gpm/ft^2 are acceptable with the following.

i. Mixing, flocculation, and sedimentation must meet the requirements of section 4.1.

ii. Dual or mixed filter media must be used.

iii. Additional instrumentation for coagulation control may be required for those plants with filter rates greater than 3 gpm/ft2. (Examples: raw and settled water continuous monitoring turbidimeters, pilot filter or zetameter.)

iiii. Filtration rates above 4 gpm/ft2 will be considered on a case-by-case basis with a trial period to demonstrate effective treatment at the increased rate.

c. Declining Rate Filtration - This is a design where no rate-of-flow controllers are installed. The rate of flow through the filter media is greatest when the media has just been back washed and gradually declines as the media becomes filled with contaminants.

1. The design must include means to insure that the water level during operation will not fall below the level of the top of the media.

2. The filtration rate must not exceed 6 gpm/ft2 when the filter is clean (immediately following back wash) and uses dual or mixed media.

3. This design is normally appropriate only when four or more filters are used in the plant.

d. Direct Filtration - will be considered on a case-by-case basis depending on the quality and variability of the source water. All filters shall have dual or mixed media. A flash mix shall be provided and flocculation basins may also be required.

e. Structural Details and Hydraulics - The filter structure shall be so designed as to provide for:

1. vertical walls within the filter, unless otherwise approved,

2. no protrusion of the filter walls into the filter media,

3. enclosure in a building,

4. head room to permit normal inspection and operation,

5. minimum depth of filter of 8-1/2 feet,

6. minimum water depth over the surface of the sand 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 fps,

11. minimal disturbance of the media from incoming water,

12. washwater drain capacity to carry maximum flow,

13. walkways around filters, to be not less than 24 inches wide,

14. no common wall between settling basins and filters.

f. Washwater Troughs - Washwater troughs shall be so designed to provide:

1. the bottom elevation above the maximum level of expanded media during washing,

2. the top elevation above the filter surface not to exceed 30 inches,

3. a 2-inch freeboard at the maximum rate of wash,

4. the top or edge to be level,

5. spacing so that each trough serves the same number of square feet of filter area,

6. maximum horizontal travel of suspended particles to reach trough not to exceed 3 feet.

g. Filter Material - installation of media shall be in accordance with current AWWA standards.

1. Sand - The media shall be clean silica sand having:

i. a depth of at least 30 inches,

ii. an effective size of from 0.35 mm to 0.55 mm, depending upon the quality of the raw water, and

iii. a uniformity coefficient not greater than 1.70.

2. Dual Media (Sand/Anthracite) - a combination of sand and clean crushed anthracite may be used. The anthracite shall have:

i. an effective size of 0.8 mm - 1.2 mm, and

ii. a uniformity coefficient not greater than 1.85.

iii. anthracite layer shall not exceed 20 inches in 30-inch bed.

iv. Granular activated carbon may be substituted for anthracite if approved by the Division of Water Supply

3. Mixed Media - To be approved by the Department.

4. A 3-inch layer of torpedo sand may be used as a supporting media for the filter sand; such torpedo sand shall have:

   i. an effective size of 0.8 mm to 2.0 mm, and,

   ii. a uniformity coefficient not greater than 1.7.

5. Gravel - Gravel, when used as the supporting media, shall consist of hard, rounded particles.

   i. The minimum gravel size of the bottom layer should be 3/4 inch or larger.

   ii. For proper grading of intermediate layers:

      (1) the minimum particle size of any layer should be as large as the maximum particle size in the layer next above and

      (2) within any layer the maximum particle size should not be more than twice the minimum particle size.

   iii. The depth of any gravel layer should not be less than 2 inches or less than twice the largest gravel size for that layer, whichever is greater. The bottom layer should be thick enough to cover underdrain laterals, strainers, or other irregularities in the filter bottom.

   iv. The total depth of gravel above the underdrains should not be less than 10 inches.

6. Reduction of gravel depths may be considered upon justification to the Department when proprietary filter bottoms are installed.

7. Media retention systems with no support gravel will be considered for approval on a case-by-case basis.

h. 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. The design of manifold type collection systems shall be such as to:

   1. minimize loss of head in the manifold and laterals,

   2. assure 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 systems to the area of the filter at about 0.003,

4. provide the 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 l-1/2 to 2 times the total area of the laterals.

i. Surface Wash - Surface or subsurface wash facilities are required except for filters used exclusively for iron or manganese removal, and may be accomplished by a system of fixed nozzles or a revolving-type apparatus.

1. All surface wash devices shall be designed with:

i. provisions for water pressures of 45 to 75 psi,

ii. air vacuum relief valve or a reduced pressure backflow preventer if the surface wash supply is provided through a separate line from the high service line,

iii. air wash can be considered based on experimental data and operating experiences.

j. Appurtenances - The following shall be provided for every filter:

1. sampling tap on the effluent line,

2. indicating loss-of-head gauge,

3. indicating flow-rate control; a modified rate controller which limits the rate of filtration to a maximum rate may be used,

4. provisions for draining the filter to waste with appropriate measures for backflow prevention (see Section 4.11.),

5. turbidimeter with recorder reading in NTU's on effluent line of each filter when raw water is from a surface source or ground source is in an area where turbidity may be a problem.

6. a 1 to l½ inch pressure hose and storage rack on the operating floor for washing filter walls. The hose connection shall be protected with a vacuum breaker.

k. Backwash - Provisions shall be made for washing filters as follows:

1. a rate to provide for a 50 percent expansion of the media is recommended; for a sand filter, a minimum rate of 18.75 gpm/ft2 is required, consistent with water temperatures and specific gravity of the filter media;

2. filtered water provided at the required backwash rate by washwater tanks, a washwater pump, from the high service main, or a combination of these;

3. washwater pumps in duplicate unless an alternate means of obtaining washwater is available,

4. water supply to back wash one filter for at least 15 minutes at the design rate of wash,

5. 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. rate-of-flow indicator on the main washwater line, located so that it can be easily read by the operator during the washing process,

7. after washwater pumps are turned off and influent line is opened, a rewash cycle shall be performed for about 5 minutes during which water is filtered to the drain; piping must be provided for this purpose.

8. upon written request to this Department, if filter operation is automatic, the maximum permissible filter rate may be exceeded through remaining filters when one is being backwashed such that the plant flow would remain the same.

1. Miscellaneous - Roof drains shall not discharge into the filters or basins and conduits preceding the filters. All filters must be enclosed.

4.2.2 Pressure Filters - The use of these filters may be considered for iron and manganese removal and for turbidity removal from ground water sources. Pressure filters shall not be used in the filtration of surface waters or following lime soda softening.

a. General - Minimum criteria relative to number, rate of filtration, structural details and hydraulics, filter media, etc., provided for gravity filters also apply to pressure filters where appropriate.

b. Details of Design - The filters shall be designed to provide for:

1. head gauges on the inlet and outlet pipes of each filter,

2. an easily readable meter or flow indicator on each battery of filters; a flow indicator is recommended for each filtering unit,

3. filtration and backwashing of each filter individually with an arrangement of piping as simple as possible to accomplish these purposes,

4. 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,

5. the top of the washwater collection trough to be at least 18 inches above the surface of media,

6. the underdrain system to collect efficiently the filtered water and to distribute the backwash water at a rate not less than 15 gpm/ft2 of filter area,

7. backwash flow indicators and controls that are easily readable while operating the control valves,

8. air release valve on the highest point of each filter,

9. accessible manhole to facilitate inspections and repairs,

10. means to observe the wastewater during backwashing,

11. construction to prevent cross-connection,

12. depth of filter media shall be the same as for gravity filters.

4.3 PACKAGE TREATMENT PLANTS, MEMBRANES AND OTHER TECHNOLOGIES - Will be reviewed on a case-by-case basis based on demonstrated performance criteria.

4.3.1 Package Treatment Plants – may be acceptable for source waters that are generally low in turbidity and do not experience large or frequent turbidity spikes. Filter backwash and clarifier flush/rinse frequencies along with water production efficiency must be considered for each application. Adequate detention times must be evaluated for oxidation processes, coagulation, TOC reduction and taste & odor control.

4.3.2 Membrane Filtration – is generally acceptable for turbidity/particulate removal. Each membrane module must have a continuous filtrate turbidity monitor and provisions for direct integrity testing. Other treatment processes such as coagulation, flocculation and oxidation must be used in conjunction with membranes where dissolved constituents such as TOC, iron and manganese are present in sufficient quantities to require treatment/removal. Clarification/sedimentation should be provided prior to membrane filtration where turbidity and suspended solids are very high in the raw water.

4.3.3 Cartridge and Bag Filters – will be considered for approval on a case-by-case basis depending on raw water quality and the size of the water system.

4.4 DISINFECTION - Chlorine is the preferred disinfecting agent. Other agents will be considered by the Department, provided reliable feeding equipment is available and testing procedures for a residual are recognized in "Standard Methods for the Examination of Water and Wastewater," latest edition. Continuous disinfection is recommended for all water supplies and is required at all community public water systems serving more than 50 connections or 150 persons.

4.4.1 Equipment

a. Type - Solution feed gas type chlorinator and hypochlorite feeders of the positive displacement type are acceptable (see Part 5). Alternative chlorine feeders such as tablet chlorinators may be considered for some applications.

b. Capacity - The chlorinator capacity shall be such that a free chlorine residual of at least 2 mg/L can be attained in the water after a contact time of at least 30 minutes when maximum flow rates coincide with anticipated maximum chlorine demands. The equipment shall be of such design that it will operate accurately over the desired feeding range.

c. Dual Chlorination - Two chlorinator shall be provided and operated simultaneously such that each feeds approximately half the chlorine requirement.

d. Spare Parts - Spare parts shall be provided so that either unit could be equipped to supply the entire chlorine requirement.

e. Automatic Switchover - Automatic switchover of chlorine cylinders should be provided where necessary to assure continuous disinfection. This does not take the place of having dual chlorination.

f. Automatic Proportioning - Automatic proportioning chlorinator will be required where the rate of flow either is not reasonably constant or where the quality of the water is subject to rapid changes.

4.4.2 Contact Time and Point of Application

a. Due consideration shall be given to the contact time of the chlorine in water with relation to pH, ammonia, taste producing substances, temperature, bacterial quality, trihalomethanes formation potential and other pertinent factors. Chlorine should be applied at a point which will provide adequate contact time. All basins used for disinfection must be designed to minimize short-circuiting.

b. At plants treating surface water, provisions should be made for applying chlorine to the raw water, top of filters, and filtered water.

c. At plants treating groundwater, provision should be made for applying chlorine to the clearwell inlet and the high lift pump suction.

d. Free residual (breakpoint) chlorination is required; 30 minutes contact time should be provided for ground waters and 2 hours for surface waters.

4.4.3 Chlorinator Piping

a. The water supply piping shall be designed to prevent contamination of the treated water supply by source of questionable quality.

b. Pipe material - The pipes carrying elemental liquid or dry gaseous chlorine under pressure and liquid chlorine must be schedule 80 seamless steel tubing or other materials recommended by the Chlorine Institute (never use PVC). Rubber, PVC, polyethylene, or other materials recommended by the Chlorine Institute must be used for chlorine solution piping and fittings. Nylon products are not acceptable for any part of the chlorine solution piping system.

c. Backflow Protection - All chlorine solution lines feeding into water having less than a full cycle of treatment (ahead of filters) shall be vented to the outside atmosphere. This venting shall be provided in such a manner that backflow into treated waters is prevented. Vacuum breakers and other mechanical devices shall not be substituted for a vent. Vents for chlorine lines shall:

1. be the same size as the solution line piping,

2. be connected to the solution line at a point where it is elevated a minimum of 6 feet above the maximum water level in the receiving basin,

3. have no shut off valves,

4. be extended to a high enough elevation outside the building that overflow from the vent tube during surges is prevented,

5. have a nylon or other suitable insert screen covering the vent which has been turned downward near its end,

6. not be subject to back pressures.

d. Distribution Panels - The Department recommends the use of chlorine solution distribution panels to ease the change of chlorine solution application points or the change of chlorine feed equipment. If a distribution panel is installed all chlorine solution lines except those feeding into the clear well or filter effluent must be vented as specified in section 4.4.3c. This venting is to be located between the distribution panel discharge and the point of application. Where chlorine solution from one chlorine feed unit is to be split to feed at more than one application point, a suitable rotameter shall be installed to allow accurate proportioning of the total flow among the application points.

4.4.4 Housing - Adequate housing must be provided for the chlorination equipment and for storing the chlorine supply (See Section 5.3).

4.4.5 Chlorine Dioxide – may be used for oxidation, disinfection and/or treatment of tastes and odors. Chlorine dioxide may be considered in conjunction with other treatment processes for meeting surface water treatment requirements or as an alternative to raw water chlorination where disinfection by-products must be reduced. Water systems that add chlorine dioxide must monitor for chlorine dioxide residual and chlorite.

4.4.6 UV Light - may be used for disinfection at water treatment plants in conjunction with chlorination and other treatment processes to meet surface water treatment requirements. UV light may also be used at groundwater treatment plants. Water systems using UV light must also provide chlorination for residual disinfection.

4.4.7 Ozone – may be used at water treatment plants for oxidation, disinfection, and meeting surface water treatment requirements. Water systems using ozone must monitor for bromate.

4.4.8 Hydrogen Peroxide – may be used at water treatment plants for raw water oxidation and/or disinfection. Hydrogen peroxide may be used to replace raw water chlorination where disinfection by-products must be reduced.

4.4.9 Permanganates – potassium permanganate or sodium permanganate may be used for raw water oxidation and/or disinfection. Permanganates may be used to replace raw water chlorination where disinfection by-products must be reduced.

4.4.10 Chloramines – will be considered for use in water distribution systems if other methods to reduce disinfection by-products have failed to achieve compliance. Effects of chloramination on water chemistry, corrosivity and microbiological water quality must be evaluated.

4. 5 SOFTENING - In all but a very few locations in Tennessee softening of available raw water is not needed. Unless there is a demonstrated need, softening should be avoided because of the additional expense and because of the increased sodium content of the water when ion exchange softening is used.

4.5.1 Lime-Soda Process - The applicable design standards for mixing, flocculation and sedimentation are the same for the lime-soda process as for conventional clarification. Where softening is included as a treatment process in conjunction with clarification, the clarification criteria shall govern(see sections 4.1.2, 4.1.3 and 4.1.4). For criteria pertaining to softening with solids contact units see section 4.1.5.

a. Aeration - Determinations should be made for the C02 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 (See Section 4.6).

b. Stabilization - Equipment for stabilization of water softened by the lime-soda process is required.

c. Sludge Collection - Mechanical sludge removal equipment shall be provided in the sedimentation basin (see section 4.11 for sludge disposal).

d. Sludge Disposal - Provisions must be included for proper disposal of softening sludges(See Section 4.11).

e. Disinfection - The use of excess lime shall not be considered an acceptable substitution for chlorination or any other approved method of disinfection (See Section 4.4).

4.5.2 Cation Exchange Process - Iron, manganese, or a combination of the two, in the oxidized state or unoxidized state, 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.

a. Design - The units may be of pressure or gravity type, using automatic or manual regeneration. Automatic regeneration is suggested for small plants.

b. 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 kilogram of hardness removed..

c. Depth of Media - The depth of the exchange material should not be less than 3 feet.

d. Flow Rates - the rate of softening should not exceed 7 gallons per square foot per minute and the backwash rate should be 6 to 8 gallons per square foot per minute. Rate-of-flow controllers or the equivalent must be installed for the above purposes.

e. Freeboard - The freeboard will depend upon the specific gravity of the media. Generally, the washwater collector should be 24 inches above the top of the media.

f. Underdrains and Supporting Gravel - The bottoms strainer systems, and support for the exchange material shall conform to criteria provided for rapid rate gravity filters (See Sections 4.2.lg and 4.2.1h).

g. Brine Distribution - Facilities should be included for even distribution of the brine over the entire surface.

h. Cross Connection Control - Backwash, rinse and air relief discharge pipes should be installed in such a manner as to prevent any possibility of back-siphonage.

i. Bypass - A bypass shall be provided around softening units to produce a blended water of desirable hardness. Meters should 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.

j. Additional Limitations - Waters having 1.0 units or more turbidity should not be applied directly to the cation exchange softener. Silica gel materials 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. The cation exchange material shall be a type that is not damaged by residual chlorine. Phenolic resin should not be used.

k. Sampling Taps - Smooth-nose sampling taps must be provided for the collection of representative samples for both bacteriological and chemical analyses. The taps shall be located to provide for sampling of the softener influent, softener effluent, and the 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.

1. Brine and Salt Storage Tanks

1. Salt dissolving or brine tanks and wet storage tanks must be covered and must be corrosion resistant.

2. The make-up water inlet must be protected from back siphonage. 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 railcar. 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 is to 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.

m. Storage Capacity - Salt storage basins should have sufficient capacity to store in excess of l-1/2 carloads or truckloads of salt, and to provide for at least 30 days of operation.

n. Stabilization - Stabilization for corrosion control shall be provided (See Section 4.9).

o. Waste Disposal - Suitable disposal must be provided for brine waste (See Section 4.11).

p. Construction Material - Pipes and contact materials must be resistant to the aggressiveness of salt. Plastic and red brass are acceptable piping material. Steel and concrete must be coated with a non-leaching protective coating which is compatible with salt and brine.

q. Housing - Salt Storage tanks and feed equipment should be enclosed and separated from other operating areas in order to prevent damage to equipment.

4.6 AERATION - Aeration treatment devices as described herein may be used for oxidation, separation of gases or for taste and odor control.

4.6.1 Natural Draft Aeration - Design should provide that:

a. water is distributed uniformly over the top tray,

b. water is discharged through a series of three or more trays with separation of trays not less than 12 inches,

c. trays are loaded at a maximum rate of 20 gpm for each square foot of the top tray area,

d. trays have heavy wire mesh or perforated bottoms,

e. perforations are 3/16 to 1/2 inches in diameter, spaced 1 to 3 inches on centers, when perforations are used,

f. 8 to 12 inches of inert media are used, such as coke or limestone, that will not disintegrate due to freezing cycles,

g. aerated water receives disinfection treatment,

h. sufficient trays to reduce carbon dioxide to 10-15 mg/L,

i. location to take advantage of prevailing wind direction.

4.6.2 Forced or Induced Draft Aeration - Devices shall be designed to:

a. provide adequate countercurrent of air through enclosed aeration column,

b. be insect proof and lightproof,

c. be such that air introduced into column shall be screened through insect tight screen and be as free of dust as possible,

d. insure that water outlet is adequately sealed to prevent unwanted loss of air,

e. be such that sections of the aerator can be easily reached and removed for maintenance.

4.6.3 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 and mechanical aeration. The treatment processes must be designed to meet the particular needs of the water to be treated and are subject to the approval of the Department.

4.6.4 Wind Protection - Aerators that discharge through the atmosphere should be protected by being placed in a louvered enclosure so designed as to provide easy access to the interior.

4.6.5 Protection from Contamination - 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 and birds.

4.6.6 Bypass - A bypass shall be provided for all aeration units.

4.6.7 Corrosion Control - The aggressiveness of the water after aeration should be determined and corrected by additional treatment, if necessary (See Section 4.9).

4. 7 <u>IRON AND MANGANESE CONTROL</u> - 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, and receive the approval of the Department. It may be necessary to operate a pilot plant in order to gather all information pertinent to the design.

4.7.1 Removal by Oxidation, Detention and Filtration.

a. Oxidation - Oxidation may be by aeration, as indicated in Section 4.6, or by chemical oxidation with chlorine or potassium permanganate.

b. Detention - A minimum detention of 20 minutes shall be provided following oxidation by aeration in order to insure that the oxidation reactions are as complete as possible. The detention basin shall be designed as a holding tank with no provisions for sludge collection but with sufficient baffling to prevent short circuits. Sedimentation basins should 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.

c. Filtration - Filters shall conform to Section 4.2, except nominal rate shall not exceed 3 gpm/ft2 of filter area.

4.7.2 Removal by Lime-Soda Process - See Section 4.5.1.

4.7.3 Removal by Units Using Continuous Potassium Permanganate "Regeneration" - This process, consisting of a continuous feed of potassium permanganate to the influent of a manganese green-sand filter, is more applicable to the removal of manganese than to the removal of iron, due to economic considerations. The following apply:

a. The permanganate should be applied as far ahead of the filter as practical.

b. other oxidizing agents or processes such as chlorination or aeration may be used prior to the permanganate feed to reduce the cost of the chemical.

c. Anthracite media cap of at least six inches shall be provided over manganese treated greensand.

d. Normal filtration rate is 3 gpm/ft2.

e. Normal wash rate is 8 to 10 gpm/ft2.

f. Air washing should be provided.

g. Sample taps should be provided:

   1. prior to application of permanganate,

   2. immediately ahead of filtration,

   3. at point between anthracite coal media and the manganese treated greensand,

   4. halfway down the manganese treated greensand,

   5. at the filter effluent.

4.7.4 Sequestration by polyphosphates - This process is only suitable only for concentrations of iron and manganese that are below the respective MCL’s. The dosage should not exceed 10 mg/L. Where phosphate treatment is used, satisfactory chlorine residuals should be maintained in the distribution system.

a. Feeding equipment shall conform to requirements of Part 5.

b. Stock phosphate solution must be kept covered and disinfected by carrying approximately 10 mg/L chlorine residual.

c. The point of application should be prior to any aeration or oxidation if no iron or manganese removal treatment is provided.

d. Phosphate chemicals must be food grade and meet or exceed AWWA Specifications.

4.7.5 Sampling Equipment - 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.

4.7.6 Testing Equipment - Testing equipment shall be provided for all plants. 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 0.05 mg/L.

4.8 FLUORIDATION - Commercial sodium fluoride, sodium silicofluoride and hydrofluosilicic acid shall conform to the applicable AWWA Standards. Other chemicals which may be made available must be approved by the Department.

4.8.1 Fluoride Compound Storage - Compounds shall be stored in covered or unopened shipping containers. Bulk storage units and day tanks, including carboys and drums in use for hydrofluosilicic acid, shall be vented to the atmosphere at a point outside any building.

4.8.2 Dry Conveyers - Provision must be made for the proper 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.

4.8.3 Chemical Feed Installations

a. shall conform to Part 5,

b. shall provide scales or loss-of-weight recorders for dry or acid chemical feeds. Dry volumetric feeders are to have percent-of-cycle timer or variable speed SCR drive. A minimum of 35-gallon dissolver with mechanical agitation,

c. shall have an accuracy that actual feed will be within 5% of that intended,

d. shall be such that the point of application of hydrofluosilicic acid, if into a pipe, shall be in the lower third of the pipe and project upward,

e. downflow saturators are not acceptable,

f. shall provide adequate anti-siphon devices for all fluoride feed lines,

g. piping from bulk storage to day tank should be schedule 80 PVC.

4.8.4 Protective Equipment - Suitable protective equipment shall be provided.

4.8.5 Dust Control Equipment - Suitable equipment shall be provided for wet-mopping and hosing dust that might accumulate in the plant.

4.8.6 Testing Equipment - Equipment shall be provided for measuring the quantity of fluoride ion in the water. Such equipment shall be subject to the approval of the Department.

4.9 CORROSION CONTROL - corrosion is caused by a reaction between the pipe material and the water in direct contact with each other. Consequently, there are three basic approaches to corrosion control:

a. Using pipe materials and designing the system so it is not corroded by a given water,

b. Modifying the water quality so it is not corrosive to the pipe material,

c. Placing a protective barrier or lining between the water and the pipe.

4.9.1 System design

a. Choose compatible materials throughout system where possible to avoid forming galvanic cells,

b. Avoid dead ends and stagnant areas,

c. Reduce mechanical stress, sharp turns and elbows,

d. Provide adequate insulation and avoid uneven heat distribution,

e. Eliminate grounding of electrical circuits to system.

4.9.2 Cathodic Protection - Metal tanks and reservoirs should be considered for protection from corrosion by this method.

4.9.3 Modification of Water Quality

a. pH adjustment by addition of lime, caustic soda or soda ash, in order to stabilize the water with regard to calcium carbonate.

b. Control of oxygen. Advantages of aeration for iron, H2S Or C02 removal should be balanced against the fact that dissolved oxygen is a corrosive agent.

4.9.4 Use of inhibitors. These may be used as appropriate.

a. Addition of lime or alkalinity increases the tendency of water to deposit CaCO3 forming a protective coating inside of pipe.

b. Inorganic phosphorus. Care is needed to select a chemical which not only masks the symptoms, but also reduces corrosion. (Sodium hexametaphosphate in low dosages of 2-4 mg/L <u>only</u> masks the symptoms while corrosion continues). Recent developments indicate the addition of zinc with a phosphate is effective in both inhibiting corrosion and controlling red water.

c. Sodium silicate. Effective in water with low hardness, alkalinity and pH less than 8.4 under relatively high velocity conditions.

4.9.5 Coatings and linings - Metal distribution system components' surfaces in contact with water shall be protected by being coated or lined.

a. Pipe linings include coal tar enamels, epoxy paint, and cement mortar.

b. Storage tanks are protected by such coatings as coal tar enamels, paints, vinyls, and epoxy.

4.10 TASTE AND ODOR CONTROL

4.10.1 Chlorination - Chlorination can be used for the removal of some objectionable odors. Adequate contact time must be provided to complete the chemical reactions involved.

4.10.2 Chlorine Dioxide - Chlorine dioxide has been generally recognized as a treatment for tastes 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. Provision shall be made for proper storing and handling of sodium chlorite, so as to eliminate any danger of explosion (See Part 5).

4.10.3 Powdered Activated Carbon

a. Powdered activated carbon may be added prior to coagulation to provide maximum contact time, although facilities to allow the addition at several points is preferred, but not near the point of chlorine application.

b. The carbon can be added as a pre-mixed slurry or by means of a dry-feed machine as long as the carbon is properly "wetted".

c. Agitation is necessary to keep the carbon from depositing in the mixing chamber.

d. Provision shall be made for adequate dust control.

e. The required dosage of carbon in a water treatment plant depends upon the tastes and/or odors involved, but provision shall be made for adding 0 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 nearly 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.

4.10.4 Granular Activated Carbon Adsorption Units - Granular activated carbon units shall not be used in place of filters described in Section 4.2. Rates of flow shall be consistent with the type and intensity of the problem. The design used must be supported by the results of pilot plant studies when granular activated carbon units are used for organic removal.

4.10.5 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 in obtaining a uniform distribution:

a. if alkalinity is less than 50 mg/L, dose at 0.9 lb/acre foot,

b. if alkalinity is greater than 50 mg/L, dose at 5.4 lb/acre foot.

4.10.6 Aeration - See Section 4.6.

4.10.7 Potassium Permanganate - Application of potassium permanganate may be considered provided the point of application is prior to filtration.

4.10.8 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.

4.10.9 Other Methods - The decision to use any other methods of taste and odor control should be made only after careful laboratory tests and on consultation with the Department.

4.10.10 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.

4.11 WASTE DISPOSAL - Provisions must be made for proper disposal of water treatment plant waste such as sanitary, laboratory, clarification, softening and ion sludges, filter backwash, and brines. The quantity of waste produced in water treatment shall be minimized by choice of treatment processes and chemicals. If supernatant water from backwash/sludge holding tanks or lagoons is to be recycled through the treatment plant, potential impacts on the treatment process must be considered. Recycled water must be returned to the head of the treatment plant or to an alternate location approved by the Division of Water Supply. Recycled water should be settled/clarified to reduce contaminants that may be concentrated in sludges and backwash water.

4.11.1 Waste Water and Sludge - The following means of waste and sludge disposal may be considered:

a. Lagoons - Design should provide:

1. location free from flooding,

2. when necessary, dikes, deflecting gutters, or other means of diverting surface water,

3. a minimum usable depth of 4 to 5 feet with adequate freeboard,

4. 3 to 5 years solids storage volume,

5. multiple cells,

6. adjustable decanting devices,

7. convenient cleaning,

8. effluent sampling point,

9. adequate safety provisions.

b. Sludge Beds - Beds for lime softening sludges should provide for an application of slurry of at least 12 inches. Multiple beds should be provided so designed as to permit a minimum of one year's total storage. The storage capacity should be based on assumption that for each part per million of hardness removed there will be two parts per million of dry solids, and the accumulated sludge density being 120 pounds per cubic foot. Distribution channels are required for spreading sludge over the entire area. Provisions must be made for easy access and for paved loading ramps and underdrains. See Section 4.11.1.1 for provisions on flooding and surface water diversion.

c. Disposal to Sanitary Sewer System

1. Approval must be obtained from sewer system officials.

2. Consideration shall be given to the effects the water plant waste will have at the sewer plant including:

i. effect on the sewage treatment process,

ii. additional sludge to be handled.

3. Consideration shall be given to the effects of disposal into the sewage collection system. A schedule for disposal shall be determined in conjunction with sewer system officials.

d. other methods - These include holding tanks, vacuum filters, centrifuging, and recalcining. Detailed studies should be made to justify their use.

4.11.2 Sanitary Waste - The sanitary waste from water treatment plants, pumping stations, etc., must receive treatment. Waste from these facilities must be discharged either directly to a sanitary sewer system or to an individual waste disposal facility providing suitable treatment.

Part 5 - CHEMICAL APPLICATION

5.0 GENERAL - Plans and specifications describing water treatment plants (new, modified or expanded) shall include the chemicals and chemical feed equipment to be used in the treatment process.

5.0.1 These plans and specifications 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,

f. descriptions of testing equipment and procedures.

5.0.2 Chemical shall be applied to the water at such points and by such means as to:

a. provide maximum flexibility of operation through various points of application, when appropriate, and

b. prevent backflow at all points of feed.

5.1 FEED EQUIPMENT

5.1.1 Number of Feeders

a. Where chemical feed is essential to the production of safe drinking water or necessary for continuous operation

1. a minimum of two feeders shall be provided,

2. a standby unit or combination of units of sufficient capacity should be available to replace the largest unit during shut-downs.

b. Spare parts shall be available for all feeders to replace parts which are subject to wear and damage.

5.1.2 Design and Capacity - Design and capacity shall be such that:

a. feeders will be able to supply, at all times, the necessary amounts of chemical at an accurate rate, throughout the range of feed;

b. feeders are adjustable to handle all plant flow rates;

c positive displacement type solution feed pumps shall be used to feed liquid chemicals, and shall not be used to feed chemical slurries;

d. chemical solutions cannot be siphoned into the water supply;

e. service water supply cannot be contaminated by chemical solutions by:

1. equipping the supply line with backflow prevention devices (see Section 5.l.8.c), or

2. providing an air gap between supply line and solution tank.

f. chemical-contact materials and surfaces are resistant to the aggressiveness of the chemical solution;

g. dry chemical feeders will:

1. measure chemicals volumetrically or gravimetrically,

2. provide effective solution of the chemical in the solution pot,

3. provide gravity feed from solution pots, in open troughs when feasible,

4. completely enclose chemicals to prevent emission of dust to any of the operating areas (see Section 5.2.3d).

h. no direct connection exists between any sewer and a drain or overflow from the feeder or solution chamber or tank.

5.1.3 Location - chemical feed equipment

a. shall be conveniently located near points of application to minimize length of feed lines;

b. shall be readily accessible for

1. servicing, repair and calibration, and

2. observation of operation;

c. shall be located and protective curbing provided, so that chemicals from equipment failure, spillage or accidental drainage shall not enter the water through conduits, treatment or storage basins, or result in hazardous discharge.

5.1.4 Control

a. Feeders may be manually or automatically controlled, with automatic control reverting to manual control as necessary.

b. Process must be manually started following shutdown, unless otherwise approved by the Department.

c. Feed rates proportional to flow must be provided.

d. Automatic chemical dose or residual analyzers may be approved for use and must provide

1. alarms for critical values, and

2. recording charts.

5.1.5 Solution Tanks

a. Means shall be provided in a solution tank to maintain uniform strength of solution, consistent with the nature of the chemical solution; continuous agitation is necessary to maintain slurries in suspension.

b. Two solution tanks may be required for a chemical, of specific capacity, to assure continuity of supply in servicing a solution tank.

c. Each tank shall be provided with a drain;

   1. No direct connection between any tank or drain and a sewer shall be permitted, and

   2. Any drain must terminate at least two pipe diameters above the overflow rim of a receiving sump, conduit or waste receptacle.

d. Means shall be provided to indicate the solution level in the tank.

e. Make-up water shall enter the tank from above the maximum solution level, providing an air gap of two pipe diameters but not less than six inches, or shall be protected with an approved backflow prevention devices (see Section 5.1.8.c).

f. Chemical solutions shall be kept covered. Large tanks with access openings shall have such openings curbed and fitted with tight covers.

g. Subsurface locations for solution tanks shall:

   1. be free from sources of possible contamination.

   2. assure positive drainage for ground waters, accumulated water, chemical spills and overflows.

h. Overflow pipes, when provided, should:

   1. be turned downward, with end screened.

   2. have free discharge, and

   3. be located where noticeable.

5.1.6 Weighing Scales

a. shall be provided for weighing cylinders, at all plants utilizing chlorine gas; for large plants, indicating and recording type are desirable;

b. shall be provided to measure the amount of fluoride fed with the exception of the use of a saturator, which shall have a water meter;

c. should be provided for volumetric dry chemical feeders;

d. should be accurate to measure increments of 0.5% of load;

5.1.7 Feed Lines

a. should be as short as possible in length of run, and

1. of durable, corrosion-resistant material,

2. easily accessible throughout entire length,

3. protected against freezing,

4. easily cleaned,

5. lime feed lines should be designed so they can be readily replaced, and

6. avoiding sharp bends when possible.

b. should slope upward from chemical source to feeder, when conveying gases;

c. should introduce corrosive chemicals in such manner as to minimize potential for corrosion;

d. shall be designed consistent with scale-forming or solids depositing properties of the water, chemical, solution or mixture conveyed;

e. shall not carry chlorine gas beyond chlorine storage and feeder room(s) except under vacuum;

f. should be color coded.

5.1.8 Service Water Supply

a. 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 (see Section 5.1.8c),

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.

b. Where a booster pump is required, duplicate equipment should be provided and, when necessary, standby power.

c. Back-flow 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, or

2. an approved reduced pressure backflow preventer, consistent with the degree of hazard, aggressiveness of chemical solution, back pressure sustained, and available means for maintaining and testing the device, or

3. a satisfactory vacuum relief device.

5.2 <u>CHEMICALS</u>

5.2.1 Quality

a. Chemical containers shall be fully labeled to include:

1. chemical name, purity and concentration,

2. supplier name and address, and

3. expiration date where applicable.

b. Chemicals shall be listed under ANSI/NSF Standard 60(or equivalent) and meet American Water Works Association specifications, where applicable.

c. Provisions should be made for assay of chemicals delivered.

d. Chemicals shall not impart any toxic material to the water under recommended dosages.

5.2.2 Storage

a. Space should be provided for:

1. at least 30 days of chemical supply,

2. convenient and efficient handling,

3. dry storage conditions,

4. a minimum of 1-1/2 truck loads storage volume where purchase is by truck load lots,

5. protection against excessive, damaging or dangerous extremes in temperature.

b. Cylinders of chlorine shall be:

1. isolated from operating areas,

2. restrained in position to prevent upset,

3. stored inside for sufficient time before being connected to chlorinator that temperature has been approximately equalized,

4. provided shade from direct sun and given physical security if stored outside of building.

c. 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,

3. provide for protection against freezing and/or loss from solution due to temperature drop.

d. Special precautions must be taken with:

   1. sodium chlorite, to eliminate any danger of explosion;

   2. activated carbon, which is a potentially combustible material, requiring isolated, fireproof storage and explosion-proof electrical outlets, lights and motors in areas of dry handling.

   3. calcium hypochlorite and potassium permanganate, which may ignite spontaneously on contact with combustible substances;

   4. hydrofluosilicic acid, which is extremely corrosive. Fumes or spillage may damage equipment or structures.

   5. liquid caustic (50% sodium hydroxide solution) which is hazardous and may be lost from solution at low temperature.

   6. gaseous chlorine (see Sections 5.3.4-5.4).

   7. on-site generation of sodium hypochlorite. Provisions must be included for dilution and venting of potentially explosive hydrogen gas.

e. Chemicals shall be stored in covered or unopened shipping containers, unless the chemical is transferred into an approved covered storage unit.

f. Solution storage or day tanks supplying feeders directly should have sufficient capacity for one day of operation.

g. Acid storage tanks must be vented to the outside atmosphere, but not through vents in common with day tanks.

5.2.3 Handling

a. Provisions shall be made for

   1. measuring quantities of chemicals used to prepare feed solutions, and

   2. for easy calibration of solution pumps measured from the suction side.

b. Storage tanks and pipelines for liquid chemicals shall be specific to the chemicals and not for alternates.

c. Chemicals that are incompatible shall not be fed, stored or handled together.

d. Provisions must be made for the proper transfer of dry chemicals from shipping containers to storage bins or hoppers, in such a way 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 conveyer systems, or

   2. facilities for emptying shipping containers in special enclosures, or

   3. exhaust fans and dust filters which put the hoppers or bins under negative pressure.

e. Precautions shall be taken with electrical equipment to prevent explosions, particularly in the use of sodium chlorite and activated carbon.

f. Acids shall:

1. be kept in closed, acid-resistant shipping containers or storage units;

2. not be handled in open vessels, but should be pumped in undiluted form from original containers, through suitable hose, to the point of treatment or to a covered day tank.

g. Carts, elevators and other appropriate means shall be provided for lifting chemical containers to minimize excessive lifting by operators.

h. Provisions shall be made for disposing of empty bags, drums or barrels, by approved procedures which will minimize exposure to dusts.

5.3 HOUSING

5.3.1 Structures, rooms and areas accommodating chemical feed equipment shall provide convenient access for

a. servicing and repair,

b. observation of operation.

5.3.2 Floor surfaces shall be smooth and impervious, slip-proof and well-drained with 2.5% slope, minimum.

5.3.3 open basins, tanks and conduits shall be protected from chemical spills or accidental drainage.

5.3.4 Chlorine gas feed and storage shall be:

a. enclosed and separated from other operating areas in order to prevent injury to personnel and damage to equipment; separate chlorine feed and storage rooms may be required for large installations;

b. provided with an inspection window to permit viewing of the interior of the room and the equipment;

c. provided with doors opening outward with a crash bar, assuring ready means of exit; doors opening to the building exterior only shall be provided.

d. provided with locks to prevent general public access.

5.3.5 Where chlorine gas is used, ventilation for each room shall be provided for one complete air change per minute; and

a. The air outlet from the room shall be near the floor and the point of discharge shall be so located as not to contaminate air inlets to any rooms or structures, or adversely affect the surrounding environment;

b. air inlets shall be through louvers near the ceiling, and temperature controlled to prevent adverse affect on chlorinator;

c. switches for fans and lights shall be outside of the room, at the entrance; signal light indicating fan operation shall be provided at each entrance when fan can be controlled from more than one point;

d. vents from feeders and storage shall discharge to the outside atmosphere, above grade.

5.3.6 Chlorinator rooms should be heated to 60 degrees F, but should be protected from excess heat; cylinders and gas lines should be protected from temperatures above that of the feed equipment.

5.3.7 Gaseous feed chlorine installations shall be equipped with a gas detection device connected to an audible alarm to prevent undetected, potentially dangerous leakage of chlorine gas.

5.4 OPERATOR SAFETY

a. Gases from feeders, storage and equipment exhausts shall be conveyed to the outside atmosphere, above grade and remote from air intakes.

b. Special provisions shall be made for ventilation of chlorine feed and storage rooms (see Section 5.3.5).

c. A M-S-A air mask, Model 401, Catalog No. 01-95066 or equal, complete with storage cabinet and 30 minute air cylinder shall be provided along with a 30 minute backup cylinder to prevent loss of utility while the primary air cylinder is being refilled or tested. The air mask shall be cabinet-mounted close by but not inside the chlorine room, and shall be easily accessible to the operator.

d. A bottle of ammonium hydroxide shall be available for chlorine leak detection during cylinder change.

e. All gaseous feed chlorine installations shall be equipped with appropriate leak repair kits.

f. At least one pair of rubber gloves with long gauntlets, a dust respirator of a type approved by the U.S. Bureau of Mines for toxic dusts, and an apron or other protective clothing shall be provided for each operator in any shift who will handle dry chemicals.

g. Rubber gloves with long gauntlets, rubber roots, goggles, rubber apron or other suitable protective clothing shall be provided for each operator preparing chemical solutions, or cleaning up spills.

h. Facilities shall be provided for washing of face, gloves and protective equipment.

i. A safety shower shall be provided in areas where hazardous chemicals are handled.

j. On-site generation of sodium hypochlorite must include dilution and venting of hydrogen gas.

Part 6 - LABORATORY FACILITIES

6.0 GENERAL - Laboratory equipment and facilities shall be compatible with the raw water source, intended design of the treatment plant, and the complexity of the treatment process involved. Recognized laboratory procedures must be utilized. See Parts 4 and 5 for related criteria.

6.1 EQUIPMENT – Laboratory and analytical equipment shall be provided to conduct all daily water quality testing as specified by the Department.

6.2 LABORATORY SPACE AND FACILITIES

6.2.1 Laboratory facilities shall be located in a separate room from office/lunch activities and from the treatment units. Facilities shall be isolated by doors and not be located in the main traffic pattern.

6.2.2 Sufficient bench space, adequate ventilation, adequate lighting, storage room, laboratory sink, and auxiliary facilities shall be provided.

6.2.3 The bacteriological laboratory, if provided, shall have about 6-10 feet of counter space and shall be located in a separate room or area.

6.3 SAMPLE TAPS - Sample taps shall be provided so that water samples can be obtained from each water source and from appropriate locations in each unit operation of treatment. Taps shall be consistent with sampling needs and not be of petcock type. Sample lines and pumps where applicable shall be sized to minimize time lag between point of sampling and point of sample collection.

Part 7 - PUMPING FACILITIES

7.0 GENERAL - 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 pumping station shall be subject to flooding.

7.1 LOCATION - The pumping station shall be so located that the proposed site will meet the requirements of the sanitary protection of the water quality, hydraulics of the system and be protected against interruption of service by fire, flood or any other hazard.

7.1.1 Site Protection - The station shall be:

a. elevated to a minimum of one foot above the 100-year flood elevation, or protected to such elevation;

b. accessible at all times unless permitted to be out of service for period of inaccessibility;

c. graded around station so as to lead surface drainage away from the station;

d. protected to prevent vandalism and entrance by unauthorized persons or animals.

7.2 GROUND WATER FACILITIES - Where pumping facilities are used, wells and springs shall be vented by properly hooded and screened pipe extending at least 12 inches above the pump floor. Where necessary, provision 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.

7.2.1 Drilled Wells - Pumping stations located over drilled wells shall;

a. have riser pipe or casing extending at least 6 inches, and preferably 12 inches, above the floor, and be equipped with flange or suitable stuffing box;

b. have riser pipe or casing firmly connected to the pump structure to provide a water tight connection.

c. have base of pump not less than 6 inches above pump room floor;

d. have pump foundation and base designed to prevent water from coming into contact with the joint.

7.2.2 Submersible Pumps - Where a submersible pump is used, the top of the casing shall be effectively sealed against entrance of water under all conditions of vibration or movements of conductors or cables.

7.2.3 Discharge Piping - Discharge piping should be provided with means to pump to waste but shall not be directly connected to a sewer. The discharge line shall:

a. have control valves located above pump floor;

b. be protected against freezing;

c. be valved to permit testing and control of each well;

d. have watertight joints;

e. have all exposed valves protected.

7.3 <u>SURFACE WATER FACILITIES</u> - Pump stations normally associated with surface water sources, either as raw or finished water pump stations, shall:

a. have adequate space for the installation of additional units if needed, and for the safe servicing of all equipment;

b. be of durable character, fire and weather resistant and with outward opening doors;

c. have floor elevation of at least 6 inches above finished grade;

d. have underground structure waterproofed;

e. have all floors drained without impairing the quality of water being handled and if equipment is contained on the floor, the floor shall have sufficient slope to drain adequately.

f. provide suitable outlet for drainage from-pump glands without discharging onto the floor.

7.3.1 Suction Well - Suction wells shall:

a. be watertight;

b. have floors sloped to permit removal of water and entrained solids;

c. be covered or otherwise protected against contamination; including pump lubricant.

7.3.2 Equipment Servicing - Pump facilities shall be provided with;

a. crane-ways, hoist beams, eye bolts, or other adequate facilities for servicing or removal of pumps, meters or 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.

7.3.3 Stairways and Ladders - Stairways or ladder shall

a. be provided between all floors, in pits or compartments which must be entered.

b. have handrails on both sides, and treads of non-slip material.

Stairs 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.

7.3.4 Heating - Provision shall be made for adequate heating for:

a. comfort of the operator;

b. the safe and efficient operation of the equipment.

In pump houses not occupied by personnel, only enough heat need be provided to prevent freezing of equipment or treatment process.

7.3.5 Ventilation - Adequate ventilation shall be provided for all pumping stations. Forced ventilation of at least 6 changes of air per hour shall be provided for:

a. all rooms, compartments, pits and other enclosures below grade floor;

b. any area where unsafe atmosphere may develop or where excessive heat may be built up.

7.3.6 Dehumidification - In areas where excess moisture could cause hazards to safety or damage to equipment means for dehumidification shall be provided.

7.3.7 Lighting - Pump stations shall be adequately lighted throughout. All electrical work shall conform to the requirements of the American Insurance Association and related agencies and to relevant State and/or local codes.

7.3.8 Sanitary and Other Conveniences - Pumping stations which are manned for extended periods shall be provided with potable water, lavatory and toilet facilities. Plumbing must be so installed as to prevent contamination of a public water supply. Wastes shall be discharged in accordance with Section 4.11 of these standards.

7.3.9 Pumps - At least 2 pumping units shall be provided. Each pumping unit shall be capable of carrying the peak demand. If more than 2 units are installed, they shall have sufficient capacity so that any 1 pump can be taken out of service and the remaining pumps are capable of carrying the peak demand. The pumping units shall:

a. have ample capacity to supply the peak demand without dangerous overloading;

b. be driven by a prime mover able to operate against the maximum head and air temperature which may be encountered;

c. have spare parts and tools readily available.

3600 RPM pumps are not desirable and should be avoided if at all possible.

7.3.10 Suction Lift - Suction lift pumps will be considered on an individual basis based on justification of design engineer.

7.4 BOOSTER PUMPS - Booster pumps shall be located or controlled so that:

a. they will not produce negative pressure anywhere in the distribution system;

b. the pressure in the suction line shall be maintained at or above 20 psi by the use of a pressure sustaining valve or low pressure cutoff device.

c. automatic or remote control devices shall have a range between the start and cutoff pressure which will prevent excessive cycling.

7.4.1 In-line Booster Pumps - In addition to the other requirements of this section, in-line booster pumps shall be accessible for servicing and repairs.

7.4.2 The criteria in this section also apply to fire pumps.

7.4.3 Booster pumps shall not serve more than 50 service connections unless gravity storage is provided or service pressure can be maintained above 20 psi without the pumps running.

7.5 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 National Electrical Code.

7.6 APPURTENANCES

7.6.1 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 2½ 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 shutoff valve.

7.6.2 Piping - In general, piping shall:

a. be designed so that the friction head will be minimized;

b. not be subject to contamination;

c. have watertight joints;

d. be protected against surge or water hammer;

e. be such that each pump has an individual suction line or the lines shall be so manifolded that they will insure similar hydraulic and operation conditions.

7.6.3 Gauges and Meters - Each pump shall:

a. shall have a standard pressure gauge on its discharge line;

b. shall have a compound gauge on its suction line;

c. shall have recording gauges in larger stations;

d. should have a means for measuring the discharge.

The larger stations should have indicating, totalizing and recording metering of the total water pumped.

7.6.4 Water Seals - Water seals shall not be supplied with water of a lesser sanitary quality than that of the water being pumped.

7.6.5 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, provision shall be made for proper alternation. Provision shall be made to prevent operation of the pump during the backspin cycle. Electrical controls should be located above grade.

7.6.6 Power - When power failure would result in cessation of minimum essential service, power supply shall be provided from at least two independent sources or standby or auxiliary source shall be provided.

7.6.7 Auxiliary Power Supply - When automatic pre-lubrication of pump bearings is necessary, and an auxiliary power supply is provided, the pre-lubrication line shall be provided with a valved by-pass around the automatic control.

Part 8 - FINISHED WATER STORAGE

8.0 GENERAL - 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 structures shall follow the current AWWA standards concerning steel tanks, standpipes, reservoirs, and elevated tanks wherever they are applicable. Prestressed concrete tanks shall meet applicable AWWA Standards. Other materials of construction are acceptable when properly designed to meet the requirements of this part.

8.0.1 Location

a. The bottom of ground-level reservoirs should be placed at the normal ground surface and above maximum flood level.

b. Where the bottom must be below normal ground surface, it should be placed above the ground water table. Sewers, drains, standing water, and similar sources of contamination must be kept at least 50 feet from the reservoir. Mechanical-joint water pipe, pressure tested in place to 50 psi without leakage, may be used for gravity sewers at lesser separations.

c. The top of a ground-level reservoir should not be less than 2 feet above normal ground surface and any possible flood level. Clearwells constructed under filters may be excepted from this requirement when the total design gives the same protection.

8.0.2 Protection - All new finished water storage structures shall have suitable watertight roofs or covers which exclude birds, animals, insects, and excessive dust.

8.0.3 Protection from Trespassers - Fencing, locks on access manholes, and other necessary precautions shall be provided to prevent trespassing, vandalism, and sabotage.

8.0.4 Drains - No drain on a water storage structure may have a direct connection to a sewer or storm drain. Splash pad and drainway shall be provided to prevent erosion.

8.0.5 Overflow - The overflow pipe of a water storage structure should be brought down near the ground surface and discharged over a drainage inlet structure or a splash plate and flow onto a drainway which is rip-rapped or otherwise protected to minimize erosion. No overflow may be connected directly to a sewer or storm drain.

a. When an internal overflow pipe is used, it shall be located in the access tube.

b. The overflow of a ground-level structure shall be high enough above normal or graded ground surface to prevent the entrance of surface water.

c. The overflow shall be protected with a twenty-four mesh non-corrodible screen and a flap valve.

8.0.6 Access - Finished water storage structures shall be designed with reasonably convenient access to the interior for cleaning and maintenance. Manholes on scuttles above waterline:

a. shall be framed at least 4 inches, and preferably 6 inches, above the surface of the roof at the opening; on ground-level structures manholes should be elevated 24 to 36 inches above the top or covering sod;

b. shall be fitted with a solid watertight cover which overlaps the framed opening and extends. down around the frame at least 2 inches;

c. should be hinged at one side;

d. shall have a locking device,

e. shall be a minimum of 20 inches in diameter or equivalent.

8.0.7 Vents - Finished water storage structures shall be vented by special vent structures. Open construction between the side wall and roof is not permissible. These vents:

a. shall prevent the entrance of surface water;

b. shall exclude birds and animals;

c. shall exclude insects and dust, as much as this function can be made compatible with effective venting; for elevated tanks and standpipes, 4-mesh non-corrodible screen may be used;

d. shall, on ground-level structures, terminate in an inverted U construction, the opening of which is 24 to 36 inches above the roof of sod and is covered with 24-mesh non-corrodible screen cloth.

8.0.8 Roof and Sidewall - The roof and sidewalls of all 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.

a. Any pipes running through the roof or sidewall of a finished water storage structure must be welded or properly gasketed in metal tanks, or should be connected to standard wall castings which were poured in place during the forming of a concrete structure; these wall castings should have flanges embedded in the concrete.

b. openings in a storage structure roof or top, designed to accommodate control apparatus or pump columns, shall be curbed and sleeved with proper additional shielding to prevent the access of surface or slop water to the structure.

c. Valves and controls should be located outside the storage structure so that valve stems and similar projections will not pass through the roof or top of the reservoir.

8.0.9 Drainage for Roof or Cover - The roof or cover of the storage structure should be well drained, but downspout pipes 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.

8.0.10 Safety - The safety of employees must be considered in the design of the storage structure. As a minimum, such matters shall conform to pertinent laws and regulations.

a. Ladders, ladder guards, balcony railings, and safe location of entrance hatches shall be provided where applicable.

b. Elevated tanks with riser pipes over 8 inches in diameter shall have protective bars over the riser openings inside the tank.

8.0.11 Freezing - All 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 functioning.

8.0.12 Grading - The area surrounding a ground-level structure should be graded in a manner that will prevent surface water from standing within 50 feet of the structure.

8.0.13 Silt stop - The discharge pipe of the reservoir shall be located in a manner that will prevent the flow of sediment into the distribution systems. Either a permanent or removable silt stop shall be provided at least 4 inches above the bottom of the storage structure.

8.0.14 Painting and/or Cathodic Protection - Proper protection should be given to metal surfaces by paints or other protective coatings, by cathodic protective devices, or by both.

a. Paint systems consistent with current American Water Works Association standards, or otherwise acceptable to the Department shall be used. All paints must be acceptable to FDA and EPA for contact with potable water.

b. Cathodic protection should be designed and installed by competent technical personnel.

8.0.15 Turnover of water - If the storage reservoir is sized larger than required for initial demand and there is more than 2 days storage, provisions shall be made for turnover of the water in the tank and/or booster chlorination. Internal piping arrangements to prevent water stratification in ground level standpipes are recommended. For large, ground level tanks/reservoirs, piping and/or check valves can be installed to force water in and out of the tank at different locations in order to minimize dead/stagnant water zones.

8.0.16 Sampling - A suitable sampling tap should be provided on all storage structures and be protected from public access.

8.0.17 Disinfection - Finished water storage structures shall be disinfected in accordance with AWWA Standard C652 before being put in service.

8.1 PLANT STORAGE - The applicable design standards of this part shall be followed for plant storage.

8.1.1 Washwater Tanks - If washwater tanks are used, they shall be sized, in conjunction with available pump units and finished water storage, to give the back wash water required by Section 4.2.1.K.

a. Consideration must be given to the possibility of having to wash more than one filter at a time, or several filters in succession.

8.1.2 Clearwell - Clearwell storage should be sized, in conjunction with distribution system storage, to relieve the filters from having to follow fluctuations in water use to meet peak demands, including filter backwash water. Design shall include features to minimize short circuiting.

a. When finished water storage is used to provide proper contact time for chlorine, (see Section 4.4.2), special attention must be given to size and baffling.

b. An overflow shall be provided and must be protected with a screen and flap valve.

8.1.3 Adjacent Compartments - finished water must not be stored or conveyed in a compartment adjacent to unsafe water when the two compartments are separated by a single wall.

8.1.4 Basins and Wet-Wells - Receiving basins and pump wet-wells for finished water shall be designed as finished water storage structures.

8.2 PRESSURE TANKS - Hydropneumatic (pressure) tanks may be acceptable in some circumstances where the number being served is 50 connections or less. When used, they shall meet ASME code requirements or equal which comply with the requirements of state and local laws and regulations for the construction and installation of unfired pressure vessels.

8.2.1 Location - The tank should be located above normal ground surface and be completely housed, or earth-mounted with one end projecting into an operating house, to prevent freezing.

8.2.2 Bypass - tank should have bypass piping to permit operation of the system while the tank is being repaired or painted.

8.2.3 Appurtenances - Each tank should have an access manhole, a drain, a control equipment consisting of pressure gage, water sight glass, automatic or manual air blow-off, mechanical means for adding air, and pressure-operated start-stop controls for the pumps.

8.2.4 Sizing -

a. The capacity of each well and/or pump in a hydropneumatic system should be at least ten times the average daily consumption rate of the community or the maximum peak demand whichever is greater.

b. The gross volume of the hydropneumatic tank, in gallons, should be at least 20 times the capacity of the largest pump, rated in gallons per minute.

8.2.5 Auxiliary power - Auxiliary power with automatic takeover capability shall be provided when positive pressures are not available from system gravity flow.

8.3 DISTRIBUTION STORAGE - The applicable design standards of this part shall be followed for distribution storage.

8.3.1 The purpose of system storage is to have sufficient water available to provide adequate flow and pressure at peak demand as well as to provide for fire flows when needed. For most water systems a satisfactory rule-of-thumb to meet these needs is to provide at least the average 24-hour demand in elevated storage. In the absence of an acceptable engineering study of the amount of water the system needs to meet customer demand and to provide for fire emergencies, the projected 24-hour demand at the end of the planning period will be the minimum requirement for elevated storage. This requirement may be reduced when the source, treatment facilities and pumps have sufficient capacity with standby power capability to supplement peak demands of the system.

8.3.2 Pressure Variation - System pressure variation on account of changes in level of water in storage structures should be minimized. Elevated storage tanks or large diameter ground tanks located on high ground should be the usual choices. Standpipes will not normally be approved and must be completely justified if proposed.

8.3.3 Drainage - Storage structures which float on the distribution system should be designed to drain for cleaning or maintenance without necessitating loss of pressure in the distribution system. The drains should discharge to the ground surface with no direct connection to a sewer or storm drain. (See Section 8.0.4). A nearby fire hydrant may be considered as a drain as long as service is not interrupted and suitable erosion protection is provided.

8.3.4 Level Controls - Adequate controls shall be provided to maintain levels in distribution system storage structures.

a. Telemeter equipment should be used when pressure-type controls are employed and 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 structures on the system.

c. Overflow and low-level warnings or alarms should be located at places in the community where they will be under responsible surveillance on a 24-hour basis.

Part 9 - DISTRIBUTION SYSTEMS

9.0 SYSTEM DESIGN

9.0.1 Minimum Pipe Size

a. The minimum size of pipe for principal water mains and for water mains where fire hydrants are to be attached shall be 6-inch diameter.

b. Size of water mains shall be justified by hydraulic analysis. 2-inch water mains will only be considered for short cul-de-sacs and permanent dead-ends where future growth is not feasible. The length of 2-inch mains shall be restricted to 3000 feet in any one direction.

c. 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 system shall be designed to maintain a minimum pressure of 20 psi at ground level at all points in distribution system under all conditions of flow.

d. Wide variations in pressure above the minimum requirement of 20 psi may be inherent in the design of a distribution system but pressures no greater than 100 psi should be delivered to the customer (unless higher pressures are requested.). Main line pressure reducing valves can be used to reduce pressures below 100 psi where feasible. Where water pressures over 100 psi are necessary to the operation of the distribution system, customers must have individual pressure reducing valves.

e. All assumptions and any flow data used must be clearly documented and submitted with the hydraulic analysis. if actual flow data is not available theoretical calculations shall be based on all storage facilities half-full and the Hazen-Williams friction factor appropriate for type of pipe being used but in no case greater than 130.

f. Water distribution lines should be designed and sized for an instantaneous peak demand of 2 gpm per connection for water lines serving up to 100 residential connections. Peak design demands can be reduced to 1.5 gpm per connection for 150 residential connections, 1.0 gpm per connection for 300 residential connections, 0.75 gpm per connection for 500 residential connections, and 0.5 gpm per connection for 1000 or more residential connections.

9.0.2 Fire Protection

a. The minimum pipe size to which a fire hydrant may be connected is 6-inch.

b. Ordinarily fire hydrants shall not be connected to water mains which are not capable of providing a flow of 500 gpm at 20 psi. When a municipality or county enacts a restrictive use ordinance prohibiting pumper trucks from connecting to restricted fire hydrants which are painted a distinctive color and when a copy of this ordinance in on file at this office, we will permit fire hydrants to be connected to 6-inch mains which do not have the required pressure and flow.

c. When fire protection is to be provided, system design should consider the recommendations of the state Insurance Services Organization.

d. Fire hydrants shall meet current AWWA Standard C502.

9.0.3 Dead Ends

a. Dead ends shall be minimized.

b. Where dead-end mains occur they should be provided with a fire hydrant, when fire flows are available, or blow-off for flushing purposes. The blow-off shall be at least 2 inches in diameter, but should provide flushing velocities of 2 feet per second or greater.

c. No flushing device shall be directly connected to any sewer nor be subject to flooding or plugging.

9.1 INSTALLATION OF MAINS

9.1.1 Adequate support shall be provided for all pipes.

9.1.2 A continuous and uniform bedding shall be provided in the trench for all buried pipe.

9.1.3 Rock Excavation - Stones found in the trench shall be removed for a depth of at least six inches below the bottom of the pipe.

9.1.4 Cover - All distribution mains shall be provided with sufficient earth or other suitable cover to prevent freezing. This shall not be less than 30 inches measured above the top of the pipe.

9.1.5 Hydrostatic Tests

a. Pressure and leakage tests shall be performed in accordance with current AWWA Standard C600 and/or manufacturer's installation procedures.

b. The test pressure of the installed pipe shall be a minimum of 150 psi or 1.5 times the working pressure, whichever is greater.

c. Allowable leakage shall be no greater than as calculated in $L = SD\sqrt{P}/133{,}200$ where L is allowable leakage in gallons/hour, S is the length of pipe tested in feet, D is pipe diameter in inches and P is test pressure in psi.

9.1.6 Disinfection of New Water Mains - The specifications shall include detailed procedures for the adequate flushing, disinfection, and (Total Coliform) bacteriological testing of all new water mains. Disinfection as described in current AWWA Standard C651 will be accepted.

9.1.7 Disinfection When Cutting into or Repairing Existing Mains:

a. Shall be performed when mains are wholly or partially dewatered;

b. Shall follow current AWWA C651 procedures including trench treatment, swabbing with hypochlorite solution, flushing and/or slug chlorination as appropriate;

c. Bacteriological testing should be done after repairs are complete but the water main may be returned to service prior to completion of testing to minimize the time customers are out of water;

d. Leaks or breaks that are repaired with clamping devices while mains remain full of water under pressure require no disinfection.

9.1.8 When non-metallic pipe is installed, detection tape or other acceptable means of detection shall be installed.

9.2 SEPARATION OF WATER MAINS AND SEWERS

9.2.1 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 the horizontal and vertical separations;

e. space for repair and alterations of water and sewer pipes;

f. off-setting of pipes around manholes;

g. water mains and sanitary or storm sewers shall not be laid in the same trench.

9.2.2 Parallel Installation

a. Normal conditions - Water mains shall be laid at least 10 feet horizontally from any sanitary sewer, storm sewer or sewer manhole, whenever possible; the distance shall be measured edge-to-edge.

b. Unusual conditions - When local conditions prevent a horizontal separation of 10 feet, a water main may be laid closer to a storm or sanitary sewer provided that:

1. the bottom of the water main is at least 18 inches above the top of the sewer;

2. where this vertical separation cannot be obtained, the sewer shall be constructed of materials and with joints that are equivalent to water main standards of construction and shall be pressure tested to assure water-tightness prior to backfilling.

9.2.3 Crossings

a. Normal conditions - Water mains crossing house sewers, storm sewers or sanitary sewers shall be laid to provide a separation of at least 18 inches between the bottom of the water main and the top of the sewer, whenever possible.

b. Unusual conditions - when local conditions prevent a vertical separation as described in Section 9.2.3a, the following construction shall be used:

1. Sewers passing over or under water mains should be constructed of the materials described in Section 9.2.2b2.

2. Water mains passing under sewers shall, in addition, be protected by providing:

i. a vertical separation of at least 18 inches between the bottom of the sewer and the top of the water main;

ii. adequate structural support for the sewers to prevent excessive deflection of joints and settling on and breaking the water mains;

iii. that the length of water pipe be centered at the point of crossing so that the joints will be equidistant and as far as possible from the sewer.

iv. both the sewer and the water main shall be constructed of water pipe and tested in accordance with Section 9.1.5.

9.2.4 Sewer manholes - No water pipe shall pass through or come into contact with any part of a sewer or sewer manhole.

9.3 SURFACE WATER CROSSINGS - Surface water crossings, both over and under water, present special problems which should be discussed with the Department before final plans are prepared.

9.3.1 Above-water crossings - The pipe shall be:

a. adequately supported;

b. protected from damage and freezing;

c. accessible for repair or replacement.

9.3.2 When crossing water courses which are greater than 15 feet in width:

a. The pipe shall be of special construction, having flexible, watertight joints;

b. Valves shall be provided at both ends of water crossing so that the section can be isolated for test or repair; the valves shall be easily accessible and not subject to flooding;

c. Sampling taps should be available at each end of the crossing;

d. Permanent taps should be made for testing and locating leaks.

9.4 CROSS CONNECTIONS

a. There shall be no physical connection between the distribution system and any pipes, pumps, hydrants, or tanks whereby unsafe water and other contaminating materials may be discharged or drawn into the system.

b. The approval of the Department shall be obtained for interconnections between potable water supplies.

c. Neither steam condensate nor cooling water from engine jackets or other heat exchange devices shall be returned to the potable water supply.

9.5 WATER SERVICES AND PLUMBING - Water services and plumbing shall conform to relevant local and/or state plumbing codes, or to the Standard Plumbing Code.

9.6 MATERIALS - GENERAL

a. Pipe selected shall have been manufactured in conformity with the latest standards issued by the American Water Works Association, if such standards exist, and be acceptable to the Department.

b. in the absence of such standards, pipe meeting applicable ASTM and ANSI criteria and acceptable to the Department may be selected.

c. Used water mains that meet these standards may be used again, after the pipe has been thoroughly cleaned and restored practically to its original condition.

d. Packing and jointing materials used in the joints of pipe shall meet the standards of the American Water Works Association or the Department.

e. Mechanical joints or slip-on joints with rubber gaskets are preferred.

9.7 PIPE

9.7.1 Ductile iron and cast iron pipe shall meet the latest requirements of ANSI/AWWA - C106 or CIO8 for cast iron pipe and C151 for ductile iron pipe.

9.7.2 Concrete pressure pipe shall meet the latest requirements of AWWA C300 or AWWA C301.

9.7.3 PVC pipe - 2 inch through 12 inch

a. PVC pipe meeting the standards set forth in AWWA C-900 (latest edition) will be accepted for those working pressures as designated by class. (Note that C-900 refers only to 4-inch through 12-inch pipe).

b. SDR 21, Class 200 pressure rated pipe may be used where the working pressure does not exceed 135 psi. The pipe must meet all the requirements set forth in ASTM Standard D 2241 for 2-inch through 12-inch pipe designated SDR 21. The pipe must bear the National Sanitation Foundation Testing Laboratories, Inc. seal of approval for potable water, or an approved equal.

c. Provision must be made for contraction and expansion at each joint with flexible ring gaskets made from rubber or other suitable material. Gasket materials shall meet the requirements established in ASTM F477.

d. Joints for PR 200 (pressure rated) pipe (ASTM D2241) shall be manufactured in accordance with ASTM D3139. Section 5.3.1 of this standard refers to 2000-hour tests. If pipe is manufactured in accordance with that section, the testing must be done by an independent laboratory with the results being furnished to this Department. Note also that a separate test is required for each different type of gasket provided.

e. All fittings such as tees, ells, etc. using welded joints shall be factory welded and shall meet the same specifications as the welded bell section.

f. Lubricants shall be non-toxic and shall not promote biological growth.

g. Solvent cemented joints in the field are not permitted.

h. Forty-foot lengths will be permitted when the engineering specifications contain special conditions for handling such pipe lengths. These conditions shall include provisions for transporting pipe from storage areas to the installation area on specially designed racks to prevent the ends of the pipe from dragging.

i. This policy does not apply to plastic service lines.

9.7.4 Fiberglass Composite Pipe shall be composed of an inner core of PVC overwrapped with fiberglass bonded with epoxy. 350 Pressure Rated shall be in accordance with ASTM D-2992 and D-2996.

9.7.5 Polyethylene pipe for water distribution lines shall meet the requirements of AWWA C906.

9.7.6 Molecular oriented PVC pipe shall meet the requirements of AWWA C909.

9.7.7 Any pipe material which is not specifically covered in this section will be considered on an individual basis.

9.8 VALVE, AIR RELIEF, METER AND BLOW-OFF CHAMBERS

a. Sediment accumulations may be removed through a standard fire hydrant, and compressed air and pumping may be used for dewatering mains through hydrants.

b. At high points in water mains where air can accumulate, provisions shall be made to remove the air by means of hydrants or air relief valves. Automatic air relief valves shall not be used in situations where flooding of the manhole or chamber may occur.

c. Chambers of pits containing valves, blow-offs, meters or other such appurtenances to a distribution system, shall not be connected directly to any storm drain or sanitary sewer, nor shall blowoffs or air-relief valves be connected directly to any sewer.

d. Such chambers or pits shall be drained to the surface of the ground where they are not subject to flooding by surface water, or to absorption pits underground.

e. Valves are to be placed at all intersections of water mains but at no time greater than 4000 feet apart.

f. Gate valves shall meet current AWWA standards.