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Details:

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WISCONSIN STATE LEGISLATURE ...
PUBLIC HEARING - COMMITTEE RECORDS

2009-10

(session year)

Joint

(Assembly, Senate or Joint)

Committee for Review of Administrative Rules (JCR-AR)

COMMITTEE NOTICES ...

- Committee Reports ... **CR**
- Executive Sessions ... **ES**
- Public Hearings ... **PH**

INFORMATION COLLECTED BY COMMITTEE FOR AND AGAINST PROPOSAL

- Appointments ... **Appt** (w/Record of Comm. Proceedings)
- Clearinghouse Rules ... **CRule** (w/Record of Comm. Proceedings)
- Hearing Records ... bills and resolutions (w/Record of Comm. Proceedings)
  (**ab** = Assembly Bill) (**ar** = Assembly Resolution) (**ajr** = Assembly Joint Resolution)
  (**sb** = Senate Bill) (**sr** = Senate Resolution) (**sjr** = Senate Joint Resolution)
- Miscellaneous ... **Misc**

* Contents organized for archiving by: Stefanie Rose (LRB) (June 2012)

c. A chemical feed pump discharging without any air gap or break box may be approved by the department on a case-by-case basis if the installation is provided with a spring opposed diaphragm type anti-siphon and back pressure valve device. The back pressure valve shall be installed as close as possible to the point of chemical addition. The spring opposed diaphragm type anti-siphon and back pressure valve device shall be installed in accordance with the requirements of par. (e) 1.

(g) *Makeup water lines.* The makeup water supply lines to chemical feed tanks shall be protected from contamination by chemical solutions either by equipping the supply line with backflow or backsiphonage prevention devices, or by providing an air gap between the supply line and the top of the solution tank.

(h) *Chemical resistance.* Materials and surfaces coming in contact with chemicals shall be resistant to the aggressiveness of the chemical solution.

(i) *Dry chemical feeders.* Dry chemical feeders shall meet the following requirements:

1. Measure chemicals volumetrically or gravimetrically.

2. Provide effective dissolving and mixing of the chemical in the solution pot and provide gravity feed from solution pots, if possible.

3. Completely enclose chemicals to prevent emission of dust to the operating room.

(j) *Direct sewer connections prohibited.* No direct connection shall be made between any sanitary or storm sewer and a drain or overflow from any feeder or solution chamber or tank.

(3) LOCATION. Chemical feed equipment shall meet the following requirements:

(a) Be located near points of application to minimize length of feed lines.

(b) Be readily accessible for servicing or repair and observation of operation.

(c) Be located and have protective containment curbs so that chemicals from equipment failure, spillage, or accidental drainage may not enter the water in conduits, treatment, or storage basins.

(d) Be located within a containment basin capable of receiving accidental spills, drainage, or overflows without an uncontrolled discharge outside of the containment basin. A common containment basin may be provided for each group of compatible chemicals. At minimum, the containment basin shall be sized to contain the volume of the largest tank that could fail. Chemical containment basins shall not be provided with floor drains. Trapped and vented floor drains discharging to sanitary sewers, holding tanks or the ground surface in accordance with s. NR811.25 (1) (h) may be installed for chemical rooms outside of containment basins. Chemical feed pumps shall be located within the containment basin. Piping shall be designed to minimize or contain chemical spills in the event of pipe ruptures.

(e) Be located above grade, except if this requirement is waived by the department.

(f) Be located in accordance with s. NR 811.48 (5) if gas chlorine feeders are used.

(g) Be located in accordance with s. NR 811.51 (2) if fluorosilicic acid is used.

(4) CONTROL. Chemical feeders shall be controlled in accordance with the following requirements:

(a) Feeders may be manually or automatically controlled if the water supply pumps are manually controlled. Where pumps are automatically controlled, the feeders shall be automatically controlled. In all cases, automatic control shall be capable of reverting to manual control when necessary.

(b) The operation of the chemical feed pumps shall be interlocked with the operation of the appropriate well or service pump. Any controlled electrical outlet used for any chemical feed pump shall be clearly marked.

(c) Secondary control of chemical feed equipment shall be provided for fluoride chemical feed equipment in accordance with s. NR 811.51 (4) or when required by the department.

(d) Feeders shall be designed and controlled to provide chemical feed rates proportional to flow and for variable flow rates shall be paced by a water meter.

(e) Automatic chemical feed rate control in combination with residual analyzers which have alarms for critical values and SCADA system reporting or recording charts may be used.

(5) SOLUTION TANKS. The requirements for solution tanks, in s. NR 811.40 on storage and handling apply.

(6) WEIGHING SCALES. Weighing scales shall meet the following requirements:

(a) Be provided for weighing cylinders at all plants utilizing chlorine gas.

Note: It is recommended that indicating and recording type scales be used.

(b) Be required for other solution feed unless comparable means for determining usage is approved by the department.

(c) Be required for volumetric dry chemical feeders.

(d) Be accurate enough to measure increments of 0.5% of load.

(7) FEED LINES. Feed lines shall meet the following requirements:

(a) Be as short as possible in length of run, of durable, corrosion resistant material, easily accessible throughout the entire length, protected against freezing, and readily cleanable.

(b) Slope upward from chemical source to feeder when conveying gases.

(c) Introduce corrosive chemicals in a manner to minimize potential for corrosion.

(d) Be designed consistent with scale-forming or solids-depositing properties of the water, chemical, solution, or mixture conveyed.

(e) Not carry chlorine gas under pressure beyond the chlorine feeder room.

(f) Include corporation stops and removable injection nozzles when application is into a pipe line of adequate diameter. Injection nozzles installed in a horizontal section of pipe shall be installed up into the bottom half of the pipe.

(g) Be color coded in accordance with s. NR 811.28 (6).

(8) SERVICE AND CARRIER WATER SUPPLY. Water used for dissolving dry chemicals, diluting liquid chemicals, operating chemical feeders or as carrier water to deliver chemicals to injection locations shall be from a safe, approved source with appropriate backflow prevention provided. The department may grant an exception in cases where the finished water quality will not be affected by addition of the chemical mixed with untreated water.

NR 811.40 Storage and handling. Specific requirements regarding storage and handling are provided in the sections covering the particular chemical. Storage and handling installations shall meet the following general requirements:

(1) STORAGE FACILITIES. Storage facilities shall meet the following requirements:

(a) Space shall be provided for at least 30 days of chemical supply, convenient and efficient handling, dry storage conditions, and a minimum of 1.5 truck loads storage volume where purchase is by truck load.

(b) Covered or unopened shipping containers shall be provided for storage unless the chemical is transferred into an approved covered storage unit. Solution tanks shall have overlapping or threaded covers that provide sanitary protection for the chemical being stored. Large tanks shall be covered and those with top access openings shall have either threaded covers or the openings shall be curbed and fitted with overlapping covers. Grommets, pipe seals, or other sanitary means shall be provided to create a sanitary seal where tubes, hoses, and pipes pass through the walls or covers of chemical storage tanks.

(c) Solution storage or day tanks supplying chemical feeders directly shall have at a minimum sufficient capacity for one day of operation. If the chemical solution is prepared from a powder or slurry, two-solution tanks shall be required if necessary to assure continuity of feed.

(d) Solution storage or day tanks supplying feeders directly shall have a maximum capacity such that daily chemical solution usage is a minimum of 5% of the tank capacity. The department may approve chemical container storage volumes that will allow daily chemical solution usage less than 5% of the tank capacity if supporting information is provided to the department and the chemical storage container is placed on a scale, or another department approved method is installed, to accurately determine daily chemical usage. Graduated lines shall not be used to determine daily chemical usage in cases where the daily use is less than 5% of the tank capacity. In any case, the maximum storage volume shall not exceed 45 days for sodium hypochlorite and 60 days for all other chemicals.

(e) Storage facilities shall be constructed of, or lined with, materials compatible with the chemical being handled.

(f) Mixing equipment shall be provided where necessary to assure a uniform chemical solution strength. Continuous mixing shall be provided to maintain slurries in suspension.

(g) Means shall be provided to accurately determine the amount of chemical applied either by measurement of the solution level in the tank or by weighing scales. Graduation lines shall be in increments of approximately 2% to 3% of tank capacity. A meter shall be provided on the water fill line to a fluoride saturator.

(h) For non-bulk tanks, suction lines shall extend into the tank through the tank cover. Chemical feed pumps shall be installed at a height above the maximum liquid level in the chemical storage tank. Flooded suctions, for bulk tanks and if necessary to prevent loss of prime, may be approved by the department on a case-by-case basis.

(i) Adequate means of draining tanks shall be provided, but there may be no direct connection between any drain piping and a sanitary sewer. Chemicals shall not be discharged directly to a storm sewer. Drain piping shall terminate at least 2 pipe diameters, but not less than 3 inches, above the overflow rim of a receiving sump, conduit or waste receptacle.

(j) Overflow pipes, if provided, shall be turned downward, be appropriately screened, have a free air break discharge and be located in a conspicuous location.

(k) If subsurface locations for solution or storage tanks are approved by the department, the tanks shall be free from sources of possible contamination and located to assure positive drainage for groundwater, accumulated water, chemical spills, and overflows.

(L) The design shall insure that incompatible chemicals are not stored or handled in common areas.

(m) All buried chemical solution lines and gas lines shall be installed within protective conduit piping. Each chemical solution line shall be placed in its own protective conduit piping.

Note: When the chemical feed equipment will not be installed near the point of chemical application it is recommended that chemical solution piping be installed within protective conduit from the chemical feed equipment to the point of chemical application.

(n) Gases from feeders, storage, and equipment exhausts shall be conveyed to the outside atmosphere above grade and remote from air intakes. Liquid storage tanks shall be vented to the outside but not through vents in common with day tanks.

(o) Permanent signs identifying the chemical for each fill tube shall be posted at chemical offloading areas. Permanent signs identifying the tank contents shall be posted adjacent to or on chemical storage tanks.

(p) Compliance with local, state, and federal safety codes, including department of commerce and OSHA codes, for other applicable chemical safety and handling requirements is required.

(2) HANDLING FACILITIES. Handling facilities shall meet the following requirements:

(a) Equipment shall be provided for measuring quantities of chemicals used to prepare feed solutions.

(b) Piping for chemicals shall be compatible with the chemical being conveyed.

(c) The following equipment shall be provided for each installation where chemicals are handled:

1. Where the eyes or body of any person may be exposed to injurious corrosive materials, suitable facilities for quick drenching or flushing of the eyes and body shall be provided as required in s. Comm 32.15.

2. Rubber gloves, protective clothing, and safety goggles that form a tight seal with the face shall be provided for each operator who prepares chemical solutions.

3. A dust respirator of the prescribed type shall be provided for handling dry chemicals if required in the respective material safety data sheet or s. Comm 32.15.

(d) Provision shall be made for the transfer of dry chemicals from shipping containers to storage bins or hoppers in such a way as to minimize the quantity of dust generated. Control shall be provided by use of one of the following:

1. Vacuum pneumatic equipment or closed conveyor systems.

2. Facilities for emptying shipping containers in special containers.

3. Exhaust fans and dust filters which place the hoppers or bins under negative pressure.

(e) Carts, elevators, or other appropriate means shall be provided for lifting chemical containers to minimize lifting by operators.

(f) Electrical equipment shall be used which will prevent explosions, particularly when using sodium chlorite and activated carbon. Equipment shall comply with ch. Comm 16.

(g) Procedures for disposing of empty bags, drums, carboys, or barrels shall minimize exposure to dusts or chemicals.

(h) Acids shall be kept in closed, acid-resistant shipping containers, or storage units. Transfer from shipping containers to solution or day tanks shall be through acid resistant hose or pipe by means of a transfer pump.

(3) CHEMICALS. All chemicals used to treat or produce potable water shall meet the following requirements:

(a) Shipping containers shall be fully labeled to include chemical name, purity, applicable NSF/ANSI standard approval in conformance with par. (b), concentration and supplier name and address.

(b) Chemicals shall meet the requirements of s. NR 810.09 (1).

SUBCHAPTER VII, TREATMENT

NR 811.41 General treatment design. The design of treatment processes and devices shall depend on evaluation of the nature and quality of the particular water to be treated and the desired quality of the finished water. Treatment shall be provided by each supplier of water if necessary in order to ensure that the finished water supplied to consumers meets the primary maximum contaminant levels contained in ch. NR 809 and is not objectionable to an appreciable number of consumers. The requirements of specific treatment processes are provided in ss. NR 811.42 to 811.60.

NR 811.42 Treatment of water from surface water sources. Treatment of water from surface water sources shall meet the following requirements:

(1) GENERAL REQUIREMENTS. All public water supply systems drawing water from lakes, rivers, streams, or other surface water sources shall, after the water is drawn, treat the water as provided in this chapter. In general and at a minimum, this treatment shall include coagulation, sedimentation, and filtration plus disinfection or membrane filtration plus disinfection. Filtration is required in all cases. Total plant removal and inactivation shall provide a minimum 99.9 percent (3-log) inactivation of *Cryptosporidium* and *Giardia Lamblia* plus 99.99 percent (4-log) inactivation of viruses.

(2) TREATMENT REQUIREMENTS. The following treatment requirements shall be met:

(a) Conventional plants consisting of coagulation, sedimentation, and filtration that meet the turbidity requirements in s. NR 810.29 (1) are granted the following removal credits: 99.7 percent (2.5-log) *Giardia Lamblia*, 99.9 percent (3.0-log) *Cryptosporidium* and 99 percent (2-log) virus. The remaining 68 percent (0.5-log) *Giardia Lamblia* inactivation and 99 percent (2.0-log) virus inactivation shall be provided by CT disinfection. For conventional plants, a minimum of one-half of the required CT shall be provided after filtration.

(b) Log removal credit for membrane filtration shall be site specific as approved by the department.

(c) Additional treatment may be required by the department as provided in s. NR 810.35.

(d) The department may approve any request for a deviation from required treatment methods based on data which shows that the requirements of this chapter are unnecessary in the specific case.

(3) REDUNDANCY. All critical treatment components shall be provided with redundancy.

(4) CT VALUES. CT values for the inactivation of *Giardia Lamblia*, *Cryptosporidium*, and viruses can be found in ss. NR 810.47 to NR 810.62.

(5) CHLORINE RESIDUAL REQUIREMENTS. The free chlorine concentration in the water entering the distribution system shall be at least 0.2 mg/l at the entry point to the distribution system and detectable throughout the distribution system or the total combined chlorine concentration shall be at least 1.0 mg/l at the entry point to the distribution system and detectable throughout the distribution system. Continuous chlorine residual monitoring of the water entering the distribution system shall be provided as required in ss. NR 809.74 (2) and NR 810.38 (2) (c).

NR 811.43 Treatment of water from groundwater sources. Treatment of water from groundwater sources shall meet the following requirements:

(1) DISINFECTION CAPABILITY REQUIRED. All existing and new municipal water systems and all other-than-municipal water systems constructed or modified after the effective date of this subsection [legislative reference bureau inserts date] shall be provided with equipment and the necessary appurtenances which can continuously disinfect the water. The department may require the installation of disinfection equipment at existing other-than-municipal water systems if necessary to ensure a safe water supply.

(2) DISINFECTANT RESIDUAL REQUIREMENTS. Disinfection of water drawn from groundwater sources is to supplement and not replace proper well location, construction, and source protection. When disinfection of water drawn from a groundwater source is required to maintain bacteriologically safe water, the residual maintained in the distribution system and the residual monitoring is the same as that required for surface water in s. NR 811.42 (5).

(3) DISINFECTION REQUIREMENTS FOR WELLS. Specific disinfection requirements for wells are provided in subch. II. Any additional disinfection requirements for wells will be developed by the department if necessary on a case by case basis.

(4) DISINFECTION OF GROUNDWATER EXPOSED TO THE ATMOSPHERE. Disinfection of water drawn from groundwater sources shall be required in facilities which expose the water to the atmosphere, such as open basins, open filters, air stripping towers, or gravity aerators.

(5) REQUIRED ACTIONS FOR WELLS WITH NON-COMPLYING WATER QUALITY. One of the following actions shall be taken after consulting with the department if untreated water drawn from a groundwater source exceeds one or more of the primary maximum contaminant levels in ch. NR 809 or a department health advisory:

(a) The well shall be removed from service and permanently abandoned.

(b) The well shall be removed from service and either reconstructed or provided with permanent treatment to provide complying water quality. Wells may temporarily continue in service without reconstruction or providing permanent treatment only as approved by the department. Department approval is required prior to reconstructing the well or providing water treatment. Under emergency conditions, the department may allow temporary use of a well from which bacteriologically contaminated groundwater is drawn if disinfection adequate to ensure safe water is provided. In such cases, disinfection measures meeting the requirements of sub. (3) shall be provided. A continuous boil water notice may be required by the department during all or part of this interim period if deemed necessary by the department to protect public health.

(6) GROUNDWATER UNDER THE DIRECT INFLUENCE OF SURFACE WATER. The department may allow the use of water drawn from a groundwater source that has been determined by the department to be under the direct influence of surface water provided that treatment facilities meeting the requirements of subch. II of ch. NR 810 are provided as approved by the department. The total plant removal and inactivation shall provide a minimum 3-log inactivation of *Cryptosporidium* and *Giardia Lamblia* plus 4-log inactivation of viruses. The disinfectant residual maintained in the distribution system and residual monitoring shall be the same as required for treatment of water drawn from a surface water source in s. NR 811.42 (5). The department may approve modified treatment requirements for other-than-municipal public water systems if surface water treatment is impractical and if sufficient treatment can be provided. The supplier of water shall contact the department to determine what modified treatment will be approved.

(7) REDUNDANCY. All critical treatment components shall be provided with redundancy.

(8) CT VALUES. CT values for the inactivation of *Giardia Lamblia*, *Cryptosporidium*, and viruses can be found in ss. NR 810.47 to NR 810.62.

NR 811.44 Pilot testing. Pilot testing is required to establish effective treatment and operation requirements for new treatment methods, if revisions are proposed to existing treatment methods, if the water quality poses significant treatment issues, and if design parameters need to be determined for the first time or for the specific site conditions. The department may waive the pilot testing requirement if information on other locations where the proposed treatment methods using similar water quality are already in place and operating successfully is available or if other justification necessary to support the proposed treatment processes is submitted to the department. Pilot testing shall address the following requirements:

(1) Plans, specifications, and an engineering report detailing the proposed pilot plant design, operation, sampling, lab analyses, and any waste disposal shall be submitted to the department and the written approval of the department shall be obtained prior to constructing or operating the pilot plant. At minimum, the pilot plant proposal shall address the following issues, where they apply:

(a) Pilot plant treatment design including all operating parameters.

(b) Length of pilot plant operation. The pilot plant shall operate long enough to establish the treatment effectiveness, media run lengths, wastewater volumes and characteristics, and any other necessary operating parameters. The pilot plant shall operate through a minimum of two treatment cycles or as determined by the department.

(c) Chemicals and chemical feed equipment to be used along with chemical addition rates.

(d) Waste disposal.

(e) Operator safety.

(f) Backflow or back-siphon protection for any water system facilities that the pilot plant may be connected to.

(g) Pilot plant security.

(2) A report summarizing the results of the pilot plant testing and making recommendations for any full scale water system improvements shall be submitted to the department for review and comment by the owner or the owner's representative prior to or along with the submittal of plans and specifications for any permanent installations.

NR 811.45 Aeration. Aeration treatment devices described in this section may be used for oxidation, separation of gases, or for taste and odor control. Air stripping towers shall meet the requirements of s. NR 811.53 (2), which can be used for the removal or reduction of some volatile organic compounds. The following requirements shall be met:

(1) NATURAL DRAFT AERATION. The design for natural draft aeration shall provide that:

(a) Water is distributed uniformly over the top tray.

(b) Water is discharged through a series of 3 or more trays with separation of trays not less than 6 inches.

(c) Trays are loaded at a rate of one to 5 gallons per minute for each square foot of total tray area.

(d) Trays have slotted, heavy woven wire mesh with 0.5-inch openings or perforated bottoms.

(e) Perforations are $^{3}/_{16}$ to $^{1}/_{2}$ inches in diameter, spaced one to 3 inches on centers, when perforations are used.

(f) Construction is of durable material resistant to the aggressiveness of the water and dissolved gasses.

(g) Contamination from sources such as those listed is sub. (7) is minimized by providing down-turned, louvered or hooded, screened air inlet or outlet openings. Screens shall be constructed of 24-mesh corrosion resistant material.

(h) Exhaust air is discharged directly to the outside atmosphere and in a location that will be protective of public health.

(2) FORCED OR INDUCED DRAFT AERATION. The design for forced or induced draft aeration shall provide that:

(a) Water is distributed uniformly over the top tray.

(b) The blower and blower motor are weatherproof and are installed in a weather-tight, screened enclosure.

(c) There is an adequate countercurrent flow of air through the enclosed aeration column.

(d) Aerator trays are loaded at a rate of one to 5 gallons per minute for each square foot of total tray area.

(e) Water will discharge through a series of 5 or more trays with separation of trays not less than 6 inches or as approved by the department.

(f) Construction is of durable material resistant to the aggressiveness of the water and dissolved gasses.

(g) The aerator is insect-proof, watertight, and light-proof.

(h) The air intake is located above grade and the air introduced into the column is as free as possible from contamination sources such as those listed in sub. (7).

(i) The water outlet is adequately sealed to prevent unwanted loss of air.

(j) Interior and exterior sections of the aerator can be easily reached or removed for maintenance.

(k) Contamination from sources such as those listed in sub. (7) is minimized by providing down-turned, louvered or hooded, screened air inlet or outlet openings. Screens shall be constructed of 24-mesh corrosion resistant material.

(L) Exhaust air is discharged directly to the outside atmosphere and in a location that will be protective of public health.

(3) PRESSURE AERATION. Pressure aeration installations shall meet the following requirements:

(a) Pressure aeration may be used for oxidation purposes. Pressure aeration will not be approved for removal of dissolved gases.

(b) Filters following pressure aeration shall be provided with adequate exhaust devices for release of air.

(c) Pressure aeration devices shall be designed to cause a thorough mixing of compressed air with the water being treated.

(d) Pressure aeration devices shall provide screened and filtered air that is free of obnoxious fumes, dust, dirt, and other contaminants.

(e) Air compressors supplying pressure aerators shall be oil-less.

(4) OTHER METHODS OF AERATION. Other methods of aeration may be approved by the department only if a pilot plant study conducted in accordance with s. NR 811.44 demonstrates the method's effectiveness. Methods include

spraying, diffused air, and mechanical aeration. The treatment processes shall be designed to meet the particular needs of the water to be treated.

(5) DISINFECTION. Aerated water other than from pressure aeration shall receive continuous disinfection treatment. A corporation stop shall be provided on the inlet piping to all non-pressure aerators to allow disinfection for emergency or maintenance purposes.

(6) PROTECTION FROM WIND. Aerators that discharge through the atmosphere shall be protected by being placed in a louvered enclosure designed to provide easy access to the interior.

(7) 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, obnoxious fumes, all types of precipitation and condensation, and windborne debris or dust.

(8) BYPASS PIPING. Bypass piping and any associated valves or other appurtenances shall be installed to allow water to be bypassed around a non-pressure aerator unless the aerator is necessary to comply with primary maximum contaminant levels or the requirement is waived by the department because the water system has access to other water sources that can provide at least an average day supply of water.

(9) REDUNDANCY. Redundant aeration systems shall be provided for units installed to comply with primary maximum contaminant levels unless the requirement is waived by the department because the water system has access to other water sources that can provide at least an average day supply of water.

(10) WATER QUALITY. A metal smooth-end sampling faucet installed on the aerator outlet piping and test equipment shall be provided to test for appropriate water quality parameters following aeration such as dissolved oxygen, pH, iron, manganese, radon gas, and carbon dioxide when required by the department to insure proper operation of the aeration equipment.

NR 811.46 Arsenic removal. The following minimum requirements shall be met when the following treatment methods are employed for arsenic removal:

(1) PILOT TESTING. All process designs shall be based on information from a pilot study unless waived by the department based upon previous demonstration that the process design will effectively remove arsenic based upon the water quality to be treated. Documentation shall be submitted to the department to support any pilot test waiver.

(2) OXIDATION AND FILTRATION. Arsenic III shall be oxidized by chemical or physical processes or both to arsenic V and then filtered out.

(a) Adequate detention time shall be provided if necessary to complete the conversion to arsenic V before filtration.

(b) Ferric chloride or ferric sulfate shall be added to the water supply for water with less than a 20 to 1 ratio of iron to arsenic if necessary in order to provide adequate arsenic removal efficiency.

(3) ADSORPTIVE MEDIA. Metal oxide coated adsorptive media may be used as the sole means of removing arsenic or in cooperation with or as a polishing unit after oxidation and filtration of arsenic.

(a) The adsorptive media shall be NSF/ANSI Standard 61 approved in accordance with s. NR 810.09 (5).

(b) The pilot study and final design shall address the following issues:

1. Pre- and post-filtration adjustment of pH to enhance the arsenic removal rate and reduce water corrosivity.
2. Conversion of the arsenic III to arsenic V prior to filtration.
3. Oxidation and filtration of iron and manganese to prevent fouling of the media.
4. Concentrations of sulfate and dissolved solids in the source water and the need to remove or reduce the concentrations in order to maintain treatment efficiency and minimize media fouling.

(4) OTHER ACCEPTABLE TREATMENT METHODS. Coagulation and filtration, anion exchange, electrodialysis, membrane filtration, and lime softening are treatment methods that may also be used to remove arsenic. The pilot study and final design shall address the following issues, if applicable:

(a) Pre- and post-treatment adjustment of pH to enhance the arsenic removal rate, prevent scaling, or fouling of the treatment equipment, and reduce water corrosivity.

(b) Conversion of the arsenic III to arsenic V prior to removal.

(c) Oxidation and filtration of iron and manganese to prevent fouling of the treatment equipment.

(d) The use of ferric chloride, ferric sulfate, alum, or a polymer as coagulant aids.

(e) Concentrations of sulfate and dissolved solids in the source water and the need to remove or reduce the concentrations in order to maintain treatment efficiency and minimize treatment equipment fouling.

NR 811.47 Clarification. Plants designed to reduce suspended solids concentrations prior to filtration shall:

(1) Provide a minimum of 2 units each for rapid mix, flocculation and sedimentation.

(2) Permit operation of the units either in series or parallel.

(3) Be constructed to permit units to be taken out of service without disrupting operation with drains or pumps sized to allow dewatering in a reasonable period of time.

(4) Provide multiple-stage treatment facilities if required by the department.

(5) Be started manually following shutdown.

(6) Minimize hydraulic head losses between units to allow future changes in processes without the need for repumping.

(7) Meet the following specific requirements:

(a) *Presedimentation.* Waters containing high turbidity or having unusual treatment requirements may require pretreatment, usually sedimentation or detention either with or without the addition of coagulation chemicals.

1. 'Basin design.' Presedimentation basins shall have the following:

a. Hopper bottoms or be equipped with continuous mechanical sludge removal apparatus, and provide arrangements for dewatering.

b. Cover or superstructure.

2. 'Inlet.' Incoming water shall be dispersed across the full width of the line of travel as quickly as possible. Short circuiting shall be prevented.

3. 'Bypass.' Provisions for bypassing presedimentation basins shall be included.

4. 'Detention time.' Three hours detention is the minimum period required for presedimentation. Greater detention may be required in individual cases of chemical pretreatment.

5. 'Raw water samples.' A means for collecting raw water samples prior to any chemical addition shall be provided.

(b) *Rapid mix.* Mixing shall mean the rapid dispersion of chemicals throughout the water to be treated, usually by violent agitation. For surface water plants using direct or conventional filtration, the use of a primary coagulant is required at all times.

1. 'Mixing.' The detention period shall not be more than thirty seconds with mixing equipment capable of imparting a minimum velocity gradient (G) of at least 750 feet per second per foot. The appropriate G value and detention time shall be determined through jar testing.

2. 'Equipment.' Basins shall be equipped with mechanical mixing devices unless other methods, such as baffling, or injection of chemicals at a point of high velocity, are approved by the department after determining that the other requirements of this chapter will be met. Variable speed drive equipment is recommended.

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

(c) *Flocculation – slow mixing.* Flocculation installations shall meet all of the following requirements:

1. 'Basin design.' Inlet and outlet design shall prevent short circuiting and destruction of floc. Series compartments shall be provided to minimize short-circuiting and to provide decreasing mixing energy with time. Basins shall be designed so that individual basins may be isolated without disrupting plant operation. A drain or pumps or both shall be provided to allow dewatering and sludge removal.

2. 'Detention.' Flow-through velocity may be not less than 0.5 nor greater than 1.5 feet per minute with a detention time for floc formation of at least 30 minutes. Tapered energy with diminishing velocity gradient shall be considered in the design of the flocculation basin.

3. 'Equipment.' Agitators shall be driven by variable speed drives or other means which vary the peripheral speed of paddles in the range of 0.5 to 3.0 feet per second and the tip speed of vertical shaft impellors in the range of 6 to 10 feet per second. Uniform mixing shall be provided to prevent settling in the flocculation basin.

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

5. 'Other designs.' Baffling may be used to provide flocculation only after approval by the department. The design shall be such that the velocities and flows in this section shall be maintained.

6. 'Superstructure.' A superstructure shall be provided over the flocculation basins.

(d) *Sedimentation.* Sedimentation shall follow flocculation. The detention time for effective clarification is dependent upon factors related to basin design as well as the nature of the raw water, such as turbidity, color and colloidal matter, and taste and odor causing compounds.

1. 'Detention time.' Plants with conventional sedimentation shall provide a minimum of 4 hours of settling time. This may be reduced to 2 hours for lime-soda softening facilities treating only groundwater. Also, reduced sedimentation time may be approved when equivalent effective settling is demonstrated or when overflow rate is not more than 0.5 gallons per minute per square foot.

2. 'Inlet devices.' Inlets shall be designed to distribute the water equally and at uniform velocities. Open ports, submerged ports, and similar entrance arrangements are required. A baffle shall be constructed across the basin, close to the inlet end, and project several feet below the water surface to dissipate inlet velocities and provide uniform flows across the basin.

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

4. 'Weir overflow rate.' The rate of flow over the outlet weir may not exceed 20,000 gallons per day per foot of weir length. If submerged ports or orifices are used as an alternate for overflow weirs, they may not be lower than 3 feet below the flow line with flow rates equivalent to weir loadings. The entrance velocity through the submerged orifices shall not exceed 0.5 feet per second.

5. 'Drainage.' Basins shall be provided with a means for dewatering. Basin bottoms shall slope toward the drain not less than one foot in 12 feet where mechanical sludge collection is not provided.

6. 'Covers.' Covers or superstructures are required at all plants. Where covers are used, access hatches shall be provided as well as drop light connections so that observation of the floc can take place at the inlet, midpoint and outlet of the basin.

7. 'Velocity.' The velocity through settling basins may not exceed 0.5 feet per minute. The basins shall be designed to minimize short circuiting. Fixed or adjustable baffles shall be provided as necessary to achieve the maximum potential for clarification.

8. 'Overflow.' An overflow weir or pipe shall be installed, which will establish the maximum water level desired on top of the filters. It shall discharge by gravity with a downturned pipe elbow a minimum of one foot above a concrete splash pad and shall be covered with 4-mesh corrosion resistant screen at a location where the discharge is visible and where the water can be appropriately drained.

9. 'Safety.' Guard rails shall be installed around openings which may be hazardous to maintenance personnel. Permanent holders or handholds shall be provided on the inside walls of basins above the water level.

10. 'Sludge collection.' Mechanical sludge collection equipment may be provided.

11. 'Sludge removal.' Facilities for disposal of sludge are required by the department. Sludge removal design shall provide:

a. Sludge pipes not less than 3 inches in diameter and so arranged as to facilitate cleaning.

b. Entrance to sludge withdrawal piping to prevent clogging.

c. Valves located outside the tank for accessibility.

d. Provisions for the operator to observe and sample sludge being withdrawn from the unit.

12. 'Sludge disposal'. Sections NR 811.858 and 811.861 contain additional specific requirements for sludge disposal. Flushing lines or hydrants shall be provided to backflush sludge lines and basins or for other purposes. Protection shall be provided for all potable water lines used if potable water could become contaminated by nonpotable water.

(e) *Solids contact unit.* Units designed for combined softening and clarification, if water characteristics, especially temperature, do not fluctuate rapidly and flow rates are uniform and operation is continuous, may be used if specifically approved by the department. Units shall be designed for the maximum uniform rate and be adjustable to changes in flow, which are less than the design rate and for changes in water characteristics. A minimum of two units are required unless the department waives this requirement. For plants with multiple units, the rated capacity of the plant shall be available with one unit out of service.

1. 'Installation of equipment.' Supervision by a representative of the manufacturer shall be provided whenever mechanical equipment is installed and at the time of initial operation.

2. 'Operating equipment.' A complete outfit of tools and accessories shall be provided. Laboratory equipment to control the treatment process shall be provided at all waterworks. In addition, sampling taps with adequate piping located to permit the collection of samples of water from critical portions of the units shall be provided.

3. 'Chemical feed.' Chemicals shall be applied at points and by means as to ensure satisfactory mixing of the chemicals with the water.

4. 'Mixing.' Mixing devices employed shall be constructed to provide adequate mixing of the raw water with previously formed sludge particles and to prevent deposition of solids in the mixing zone. A rapid mix device or chamber ahead of the solids contact unit may be required by the department.

5. 'Flocculation.' Flocculation equipment shall be adjustable by speed, or pitch or both, provide for coagulation to occur in a separate chamber or baffled zone within the unit, and provide a flocculation and mixing period of not less than 30 minutes.

6. 'Sludge concentrators.' Sludge concentrators shall provide either internal or external concentrators in order to obtain a concentrated sludge with a minimum of wastewater.

7. 'Sludge removal.' Sludge removal design shall provide all of the following:

a. Sludge pipes not less than 3 inches in diameter, arranged to facilitate cleaning.

b. Entrance to sludge withdrawal piping to prevent clogging.

c. Valves located outside the tank for accessibility.

d. Facilities for an operator to observe or sample sludge being withdrawn from the unit.

8. 'Cross-connections.' Sludge blow-off outlets and drains shall terminate and discharge at places approved by the department. Cross-connection control shall be included for all potable water lines such as those used to backflush sludge lines or flush basins if potable water could become contaminated by nonpotable water.

9. 'Detention period.' The detention time shall be established on the basis of the raw water characteristics and local conditions that affect the operation of the unit. Based on design flow rates, the minimum detention time shall be 2 to 4 hours for suspended solids contact clarifiers and softeners treating surface waters, and one to 2 hours for the suspended solids contact softeners treating only groundwater.

10. 'Suspended slurry concentrate.' Softening units shall be designed so that continuous slurry concentrates of 1% or more, by weight, can be effectively maintained.

11. 'Water losses.' a. Units shall be provided with suitable controls for sludge withdrawal.

b. Total water loss may not exceed 5% for clarifiers or 3% for softening units.

c. Solids concentration of sludge discharged to waste shall be at least 3% by weight for clarifiers and 5% by weight for softeners.

12. 'Weir or orifices.' The units shall be equipped with either overflow weirs or orifices. Weirs shall be adjustable, at least equivalent in length to the perimeter of the tank, and constructed so that surface water does not travel over 10 feet horizontally to the collection trough.

13. 'Weir or orifice loading.' Weir loading may not exceed 20 gallons per minute per foot of weir length for units used for softeners, or 10 gallons per minute per foot of weir length for units used for clarifiers. Where orifices are used, the loading rate per foot shall be equivalent to weir loadings. Orifices or weirs shall produce uniform rising rates over the entire area of the tank.

14. 'Upflow rates.' Unless supporting data is submitted to the department and the department grants an exception, the following rates may not be exceeded:

a. 1.75 gallons per minute per square foot of area at the slurry separation line if units are used for softeners.

b. 1.0 gallon per minute per square foot of area at the sludge separation line if units are used for clarifiers.

(f) *Tube or plate settlers.* Proposals for settler unit clarification shall include pilot plant or a full scale demonstration or both satisfactory to the department prior to the preparation of final plans and specifications for approval. Settler units consisting of variously shaped tubes or plates which are installed in multiple layers and at an angle to the flow, may be used for sedimentation, following flocculation. Tube or plate settler installations shall meet the following:

1. 'Inlet and outlet considerations.' Design the inlets and outlets to maintain velocities suitable for settling in the basin and to minimize short-circuiting.

2. 'Drainage.' Drain piping from the settler units shall be sized to facilitate a quick flush of the settler units and to prevent flooding other portions of the plant.

3. 'Protection from freezing.' Units shall be located within a plant or within a covered basin.

4. 'Application rate for tubes.' A maximum application rate of 2 gallons per minute per square foot of cross-sectional area, unless higher rates are successfully shown through pilot plant or in-plant demonstration studies and are approved by the department.

5. 'Application rate for plates.' A maximum plate loading rate of 0.5 gallons per minute per square foot, based on 80 per cent of the projected horizontal plate area.

6. 'Flushing lines.' Flushing lines shall be provided to facilitate maintenance and shall be properly protected against backflow or back siphonage.

7. 'Placement.' Modules shall be placed in zones of stable hydraulic conditions and in areas nearest effluent launders for basins not completely covered by the modules.

8. 'Inlets and outlets.' Inlets and outlets shall conform with par. (d) 2. and 3.

NR 811.48 Chlorination. Chlorine installations shall meet the following requirements:

(1) CHLORINATION EQUIPMENT.

(a) *Type.* The following types of chemical feed equipment may be used to feed chlorine:

1. Solution-feed-gas-type chlorinators.

2. Hypochlorite feeders of the positive displacement type.

3. Digitally controlled constant stroke length positive displacement type.

4. Peristaltic type.

5. Tablet chlorinator type.

(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. Liquid chemical feed equipment shall be designed to operate in accordance with the requirements of s. NR 811.39 (2) (c). Solution-feed-gas-type chlorination chemical feed equipment shall be designed to operate between 30% and 70% of the rotameter capacity. This may require that 2 rotameters be provided, one for normal feed rates and one for emergency feed rates. For all chemical feed systems, the emergency feeder setting shall be designed to provide a minimum of 2 mg/l of chlorine.

(c) *Standby equipment.* Where chlorination is necessary for protection of the water supply, standby equipment of sufficient capacity shall be available to replace the largest unit during shut-downs. Spare parts shall be made available to replace parts subject to scaling, wear, and breakage.

(d) *Automatic proportioning.* Automatic proportioning chlorinators shall be required where the rate of flow of the water is not reasonably constant or where the rate of flow of the water is not manually controlled.

(2) POINT OF APPLICATION. Chlorine application points shall meet the following requirements:

(a) Chlorine shall be applied at a point which will provide the maximum contact time. Provisions shall be made to minimize short-circuiting.

(b) At plants treating surface water, piping provisions shall be made for applying chlorine to the raw water, settled or clarified water, filtered water, and the plant effluent.

(c) At plants treating groundwater, provision shall be made for applying chlorine to the raw water, the clearwell inlet, and the discharge piping as applicable.

(d) At plants treating groundwater where CT is required by the department, provision shall be made for applying chlorine to the raw water, at the inlet to all CT reservoir detention basins, and the high-lift pump discharge piping as required by the department.

(3) RESIDUAL TESTING EQUIPMENT. Chlorine residual testing equipment shall meet the following requirements:

(a) Chlorine residual testing methodology shall be as specified in NR 809.563 (2), Table R. The equipment shall enable measurement of residuals to the nearest 0.1 mg/l in the range below 0.5 mg/l and to the nearest 0.2 mg/l between 0.5 mg/l to 2.0 mg/l.

Note: It is recommended that all systems, at a minimum, use an instrument using the DPD colorimetric method with a digital readout and a self contained light source. Automatic chlorine residual pacers and recorders are recommended where the chlorine demand varies appreciably over a short period of time.

(b) Water systems that rely on chlorination for inactivation of bacteria or other microorganisms present in the source water shall have continuous chlorine residual analyzers and other equipment that automatically shut down the facility when the chlorine residuals required by the department are not met. The department may approve less than continuous monitoring for municipal water systems serving 3,300 or fewer people and other-than-municipal water systems on a case-by-case basis provided that replacement measures or practices are implemented to provide comparable public health protection.

(4) CHLORINATOR PIPING. The water supply piping shall be designed to prevent contamination of the treated water supply by sources of impure or unknown quality. Pipes carrying elemental liquid or dry gaseous chlorine under pressure shall be Schedule 80 seamless steel tubing or other materials recommended by the Chlorine Institute. PVC pipe may not be used. Chlorine solution piping and fittings shall be rubber, PVC, polyethylene, or other materials recommended by the Chlorine Institute.

(5) HOUSING. Chlorine gas feed and storage installations shall meet the following requirements:

(a) Chlorine gas feed and storage installations shall be separated from other operating areas by gas-tight rooms or enclosures in order to prevent injury to personnel and damage to equipment.

(b) Chlorine gas rooms shall be provided with a safety glass inspection window installed in an interior wall or exterior door to permit viewing of the interior of the room and the equipment.

(c) Chlorine gas rooms shall be provided with a minimum of one door having emergency or panic hardware opening outward to the building exterior. Rooms may have additional doors to the building exterior.

(d) Chlorine gas rooms shall be heated to prevent freezing and insure proper operation of the equipment.

(e) Chlorine gas cylinders shall be provided with restraints to prevent movement of the cylinders.

(f) Full and empty cylinders of chlorine gas shall be:

1. Isolated from operating areas.
2. Restrained in position to prevent movement of the cylinders.
3. Stored in rooms separate from ammonia storage.
4. Stored in areas not in direct sunlight or exposed to excessive heat.

(g) Pressurized chlorine feed lines may not carry chlorine gas beyond the chlorine room. Vacuum chlorine feed lines may carry gas beyond the chlorine room if the chlorine lines are either schedule 40 polyethylene tubing or schedule 80 PVC pipe. Polyethylene tubing shall be enclosed in a protective conduit running from the chlorine room to a point near the ejector. The end of the conduit in the chlorine room shall be sealed. Polyethylene tubing connections shall be made using tube adaptors especially designed for this purpose. PVC pipe joints may be socket welded using PVC cement or threaded using polytetrafluoroethylene pipe joint tape.

(h) Premanufactured chlorine cabinets may be used for retrofit situations only. These cabinets shall have an observation window, fan, air intake, and light as required in par. (b) and sub. (6) for normal chlorine gas rooms.

Note: It is recommended that these cabinets not be placed on the sunny side of the building.

(6) VENTILATION OF CHLORINE GAS ROOMS. Ventilation of chlorine gas rooms shall meet the following requirements:

(a) One complete air change per minute shall be provided when the room is occupied.

(b) The exhaust fan suction shall be near the floor as far as practical from the door and air inlet, with the point of discharge located to avoid contamination of air inlets to other rooms and structures, and to avoid being blocked by snow or other obstructions.

(c) Air inlets shall be located near the ceiling and controlled to prevent adverse temperature variations.

(d) Louvers for the chlorine room air intake and exhaust shall be corrosion resistant and shall facilitate airtight closure.

(e) The exhaust fan switch shall be located outside the entrance to the chlorine room with a signal light indicating fan operation when the fan can be controlled from more than one point. Outside switches shall be protected from vandalism. As an alternative, the fan may be controlled by an automatic door switch with manual shut-off.

Note: It is recommended that switches for fans and lights be interlocked for simultaneous operation.

(f) Vent lines from feeders and storage shall discharge to the outside atmosphere, above grade, in a downward direction, be screened, and be located as required in par. (b). In addition, vent lines shall conform with the manufacturer's installation recommendations.

(7) SAFETY EQUIPMENT. The following safety equipment shall be provided when chlorine gas is used:

(a) Respiratory protection equipment, known as gas masks, meeting the requirements of the National Institute for Occupational Safety and Health (NIOSH) shall be available where chlorine gas is handled, and shall be stored at a convenient heated location, but not inside any room where chlorine is used or stored. The gas masks shall use compressed air, have at least a 30 minute capacity, and be compatible with or exactly the same as the gas masks used by the fire department responsible for the plant. The gas masks shall be available at all installations where chlorine gas is handled and shall be placed outside every room where chlorine gas is used or stored. At installations utilizing 100- or 150-pound cylinders, an agreement with the local fire department which has an approved type of gas mask for the fire department to handle water system chlorine gas leaks may be approved by the department. Instructions for using, testing and replacing gas mask parts shall be posted. Other protective clothing shall be provided as necessary.

(b) A bottle of concentrated ammonium hydroxide, 56 per cent ammonia solution, shall be available for chlorine leak detection.

(c) If pressurized chlorine gas is present, continuous chlorine leak detection equipment shall be installed and equipped with both an audible alarm and a warning light. Automatic emergency chlorine cylinder shutdown valves shall also be provided.

(d) If ton cylinders are used, leak repair kits, approved by the Chlorine Institute, shall be available at the waterworks or a nearby fire department.

(8) AMMONIATION. Housing and ventilation for ammoniation shall meet the requirements in subs. (5) and (6) for chlorine. However, the fan inlet shall be near the ceiling and the fresh air inlet shall be near the floor. Ammonia storage and feed facilities shall be separate from chlorine facilities because of the combustion hazard. A plastic bottle of hydrochloric acid shall be available and used for leak detection.

(9) CALCIUM HYPOCHLORITE TABLET CHLORINATORS. Calcium hypochlorite tablet chlorinators shall meet the following design requirements:

(a) *Calcium hypochlorite solution formation.* The calcium hypochlorite solution shall be produced by dissolving tablets with a department approved feed water source using an erosion chamber or an upward directed spray system. The department may approve other methods or technology for producing calcium hypochlorite solution after the submittal of data from a department-approved pilot program.

(b) *Tablets.* The calcium hypochlorite tablets used in the chlorinator shall be supplied by the manufacturer of the tablet chlorinator equipment. The supplier of the calcium hypochlorite tablets shall have obtained NSF/ANSI Standard 60 certification for the tablets in accordance with s. NR 810.09.

(c) *Tablet hoppers* 1. The tablet hopper shall be sized to provide a minimum of two days of supply assuming average day consumption of the tablets.

2. Load cells shall be provided on the hopper so that the weight of the tablets consumed in a 24-hour period can be determined. The design shall allow for collection of the data necessary to determine the theoretical daily chlorine usage. The design shall allow any solution to be drained out of the hopper before weighing the tablets. The load cell equipment shall be capable of providing an alarm when the weight of the tablets approaches a one day supply based

upon an average day use. The alarm signal shall be automatically annunciated by the water system controls. A local alarm shall be sounded or signaled by an exterior red light at the pump station if the operation of the pump station is not remotely controlled.

3. The tablet hopper shall include a screened air-vacuum relief device if the possibility of a vacuum condition could develop during the operation of the tablet chlorinator.

(d) *Solution tank* 1. The open area for any pipe penetration through the walls of the solution tank shall be sealed sanitarily so that insects and foreign material cannot contaminate the chlorine solution.

2. The on and off operation of the process to produce chlorine solution from the tablets shall be controlled by float switches or sensors located in the solution tank.

3. Float switches or sensors shall be installed and wired to provide automatic shut-off and operator alarms for low and high solution level conditions. The shut-off and alarm signals shall be automatically annunciated by the water system controls. A local alarm shall be sounded or signaled by an exterior red light at the pump station if the operation of the pump station is not remotely controlled.

4. The tank shall be capable of being drained for maintenance purposes.

5. The solution tank shall be sized to keep an adequate supply of calcium hypochlorite in the tank at all times based upon the capabilities of the tablet chlorinator to produce solution and the chemical feed pump withdrawal rates necessary to achieve the required dosages.

(e) *Feed water piping requirements.* 1. The flow rate and pressure of the feed water piping shall be regulated so as to meet the design flow requirements provided by the supplier of the equipment. A shut-off valve, flow meter, and pressure gauge shall be installed on the feed water piping.

2. Pre-treatment devices shall be installed as necessary if the feed water does not meet the water quality requirements designated for the tablet chlorinator. Any pre-treatment device shall be compatible for use in a potable water system and shall not be used unless approved by the department. A strainer-filter shall be installed on the feed water piping, if necessary.

3. A check valve shall be installed on the feed water piping upstream of any treatment equipment, control valve, or solenoid valve.

4. A solenoid valve shall be installed on the feed water piping to control the flow of water into the tablet chlorinator. The operation of the solenoid valve shall be controlled based upon float switches or sensors located in the solution tank.

5. Erosion type tablet chlorinators shall be provided with a control valve capable of regulating the flow of water through the erosion cell. The submittal for review to the department for an erosion-type tablet chlorinator shall include the chlorine delivery rate versus flow rate curve for the specified model.

(f) *Chemical feed pumps.* 1. The chemical feed pump shall be wired to operate in association with the well or service pump as required by s. NR 811.39 (4).

2. A tablet chlorinator producing calcium hypochlorite solution shall use a chemical feed pump installed in compliance with s. NR 811.39 (2), or a centrifugal pump.

3. Centrifugal pumps shall be sized to match or exceed the maximum head condition at the point of injection.

4. Flow paced chemical feed pumps installed in compliance with s. NR 811.39 (2) or centrifugal pumps with variable speed motors shall be incorporated into the design if the flow rate of the water being treated may vary based upon automatic control of the well or service pump. The requirements of s. NR 811.39 (2) (d) shall be met.

(g) *Chemical injection location.* 1. Tablet chlorinator chemical feed pumps shall discharge at locations and in a manner that complies with the installation requirements of s. NR 811.39 (2) (f).

2. When a centrifugal pump will discharge at a point not under continuous positive pressure, the outlet piping between the centrifugal pump and the point of chemical injection shall be installed with a vertical pipe loop that will extend to a height that is a minimum of 12 inches above the top of the solution tank and the location of the chemical addition pipe connection with the water system piping. A vacuum relief valve shall be installed on the top of the pipe loop. As an alternative to the installation of a vertical pipe loop, an electrically operated shut-off valve on the outlet piping, wired to operate in series with the operation of the well or service pump motor and the chemical feed pump, may be installed.

(h) *Centrifugal pump discharge piping.* The outlet piping of a centrifugal pump shall also be provided with a check valve and a manually operated shut-off valve. These valves shall be installed upstream of any pipe loop or electrically operated shut-off valve as required by par. (g) 2.

(10) SODIUM CHLORITE FOR CHLORINE DIOXIDE GENERATION. Proposals for the storage and use of sodium chlorite shall be submitted to the department for approval. Department approval shall be obtained prior to the preparation of final plans and specifications. Provision shall be made for proper storage and handling of sodium chlorite to eliminate any danger of fire or explosion.

(a) *Storage.* 1. Sodium chlorite shall be stored by itself in a separate room and preferably shall be stored in an outside building detached from the water treatment facility. Sodium chlorite shall be stored away from organic materials with which it could react violently.

2. Storage structures shall be constructed of noncombustible materials.

3. If the storage structure is located in an area where a fire may occur, water shall be available to keep the sodium chlorite area cool enough to prevent heat induced explosive decomposition of the sodium chlorite.

(b) *Handling.* 1. Care shall be taken to prevent spillage of sodium chlorite.

2. An emergency plan of operation shall be available for the clean up of any spillage.

3. Storage drums containing sodium chlorite shall be thoroughly flushed and the waste shall be discharged to an acceptable location prior to recycling or disposal.

(c) *Feeders.* 1. Chemical feed pumps shall meet the requirements of s. NR 811.39 (2).

2. Tubing for conveying sodium chlorite or chlorine dioxide solutions shall be Type 1 PVC, polyethylene or materials recommended by the manufacturer.

3. Chemical feeders may be installed in chlorine gas rooms if sufficient space is provided or in separate rooms meeting the requirements of subs. (5) and (6).

4. Feed lines shall be installed in a manner to prevent formation of gas pockets and shall terminate at a point of positive pressure.

5. Check valves shall be provided to prevent the backflow of chlorine into the sodium chlorite line.

NR 811.49 Filtration – gravity. The application of any type of gravity filter and media shall be supported by water quality data representing a period of use sufficient to characterize any variations in water quality. Experimental or pilot plant treatment studies may be required to demonstrate the applicability of the method or rate of filtration proposed. Pressure filters will not be approved for surface water applications. The following specific requirements shall be met:

(1) RAPID RATE GRAVITY FILTERS. (a) *Pretreatment.* Rapid rate gravity filters may only be utilized after coagulation, flocculation and sedimentation.

(b) *Number.*. At least 2 filter units shall be provided. Provisions shall be made to meet the plant design capacity at the approved filtration rate with one filter out of service. If only 2 units are provided, each shall be capable of meeting the plant design capacity, normally the projected maximum daily demand.

(c) *Rate of filtration.* The permissible rate of filtration shall be determined after consideration of factors such as raw water quality, degree of pretreatment provided, filter media, water quality control parameters, competency of operating personnel and other factors required by the department. If effective coagulation, flocculation, sedimentation and filtration processes are to be utilized with relatively clean water sources, the following filtration rates may be approved:

Filtration Rate	**Filter Media Type**
2 gpm/ft^2	Single Media
3 gpm/ft^2	Dual Media
4 gpm/ft^2	Tri Media

In all cases, the filtration rate shall be proposed and justified by the design engineer and shall be approved by the department prior to the preparation of final plans and specifications. Higher rates than indicated in this paragraph may be approved with sufficient justification by the design engineer.

(d) *Structural details and hydraulics.* The filter structure shall be designed to provide:

1. Vertical walls within the filter.

2. No protrusion of the filter walls or other structures into the filter media or the area between the top of the media and the high water line during backwashing.

3. Cover by superstructure.

4. Head room to permit normal inspection and operation.

5. Minimum filter box depth of 8.5 feet.

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

7. Trapped effluent pipe 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 an overflow if this is not provided in a pretreatment unit.

10. Maximum velocity of treated water in the pipe and conduits to the filter of 2 feet per second.

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

12. Washwater drain capacity to carry maximum backwash flow.

13. Walkways around filters not less than 24 inches wide.

14. Safety handrails or walls around the filter areas adjacent to walkways.

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

16. Washwater troughs.

(e) *Washwater troughs.* Washwater troughs shall be designed to provide:

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

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

4. A top or edge which is all at the same elevation.

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

6. A maximum horizontal travel of suspended particles not exceeding 3 feet in reaching the trough.

(f) *Filter material.* The media shall be clean silica sand or other natural or synthetic media approved by the department and shall meet the following general requirements: a depth of not less than 24 inches; an effective size of the smallest material no greater than 0.45 mm to 0.55 mm, depending upon the quality of the raw water; a uniformity coefficient of the smallest material not greater than 1.65; a minimum of 12 inches of media with an effective size range no greater than 0.45 mm to 0.55 mm; and a specific gravity greater than other filtering materials within the filter. The following specific requirements shall be met:

1. 'Sand.' Sand shall have an effective size of 0.45 mm to 0.55 mm, a uniformity coefficient of not greater than 1.65, specific gravity greater than 2.5 and an acid solubility less than 5 percent.

2. 'Anthracite.' Filter anthracite shall consist of clean, hard, and durable anthracite coal particles of various sizes. Non-anthracite material may not be blended. Anthracite used as the only media shall have an effective size from 0.45 mm to 0.55 mm and a uniformity coefficient not greater than 1.65. Anthracite used to cap sand filters shall have an effective size from 0.8 mm to 1.2 mm and a uniformity coefficient not greater than 1.7. Effective size of anthracite for iron and manganese removal from potable groundwater shall be a maximum of 0.8 mm. Effective sizes greater than 0.8 mm may be approved by the department based upon onsite pilot plant studies. Anthracite shall have a specific gravity greater than 1.4 and an acid solubility less than 5%.

3. 'Granular activated carbon (GAC).'

a. Granular activated carbon as a single media may be considered only after pilot or full scale testing and with prior approval of the department.

b. The media shall meet the basic specifications for filter media as provided in this paragraph except that larger size media may be allowed by the department where full scale tests have demonstrated that treatment goals can be met under all conditions.

c. There shall be provisions for a free chlorine residual and adequate contact time in the water following the filters and prior to distribution.

d. There shall be means for periodic treatment of filter material for control of bacterial and other growth.

e. Provisions shall be made for frequent replacement or regeneration of granular activated carbon if used for filtration.

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

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

b. Have an effective size of 0.2 to 0.3 mm.

c. Have a uniformity coefficient of not greater than 1.65.

d. Have an acid solubility less than 5%.

5. 'Other media.' Other media may be approved, but only on the basis of pilot tests and experience which demonstrate that the requirements of this chapter will be met.

6. 'Supporting media.' Torpedo sand and gravel shall be provided as supporting media except when proprietary filter bottoms are used. In that case, the department, on the basis of substantiating information provided by the owner, may allow elimination of certain layers of supporting media or a reduction in the depth of the layers. Otherwise, the following apply:

a. A 3-inch layer of torpedo sand shall be used as a supporting media for the filter sand. The torpedo sand shall have an effective size of 0.8 mm to 2.0 mm, and a uniformity coefficient not greater than 1.7.

b. Gravel, when used as the supporting media, shall consist of hard, rounded silica particles and may not include flat or elongated particles. The coarsest gravel shall be 2.5 inches in size when the gravel rests directly on the strainer system, and shall extend above the top of the perforated laterals or strainer nozzles. Not less than 4 layers of gravel shall be provided in accordance with the following size and depth distribution when used with perforated laterals or strainer nozzles. Reduction of gravel depths may be considered upon justification to the department when proprietary filter bottoms are specified.

Gravel Size	Gravel Depth
2 1/2 to 1 1/2 inches	5 to 8 inches
1 1/2 to 3/4 inches	3 to 5 inches
3/4 to 1/2 inches	3 to 5 inches
1/2 to 3/16 inches	2 to 3 inches
3/16 to 3/32 inches	2 to 3 inches

(g) *Filter bottoms and strainer systems.* Departures from these standards by using proprietary bottoms may be approved by the department on a case-by-case basis if the effectiveness of the method is demonstrated. Porous plate bottoms may not be used where iron or manganese may clog them or with waters softened by lime. The design of manifold type collection systems shall:

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 a ratio of the area of the final openings of the strainer systems to the area of the filter of about 0.003.

4. Provide a total cross-sectional area of the laterals about twice the total area of the final openings of the strainer system.

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

6. Lateral perforations without strainers shall be directed upwards.

(h) *Surface wash.* Surface wash facilities consisting of either fixed nozzles or a revolving mechanism are required unless air scour equipment is provided. All surface wash devices shall be designed with:

1. Water pressures of at least 45 psi.

2. Volume of flow of 2.0 gallons per minute per square foot of filter area with fixed nozzles and 0.5 gallons per minute per square foot with revolving arms.

3. A vacuum breaker installed above the high water elevation in the filter or other approved device to prevent back siphonage.

(i) *Air scouring.* Air scouring may be provided in place of surface wash. The following requirements apply:

1. Air flow for air scouring the filter shall be 2 to 5 standard cubic feet per minute per square foot of filter area when the air is introduced in the underdrain. Air scour distribution systems placed above the underdrains shall use the lower end of the range.

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

3. Air scouring shall be followed by a fluidization wash sufficient to restratify the media.

4. Air shall be free from contamination.

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

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

7. Air delivery piping may not pass down through the filter media nor may there be any arrangement in the filter design which would allow short circuiting between the applied unfiltered water and the filtered water except if all of the following criteria are met:

a. The vertical piping is double wall, welded at top and bottom, schedule 40 stainless steel for the internal pipe and schedule 5 stainless steel for the external pipe.

b. The annulus between the double-wall is pressurized on-site to 80 psi.

c. An air connection to the double-wall annulus shall be provided including piping with a pressure gauge, regulator, flow switch and ball valve along with an air reservoir and compressor.

d. The flow switch shall alarm and trigger filter shutdown if a pressure drop of over 10 psi is detected.

8. The backwash delivery system shall be capable of 15 gallons per minute per square foot of filter surface area; however, when air scour is provided, the backwash rate shall be variable and may not exceed 8 gallons per minute per square foot unless operating experience shows that a higher rate is necessary to remove scoured particles from filter surfaces.

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

10. Backwash facilities shall meet the requirements of par. (k).

(j) *Appurtenances.* The following shall be provided for every filter:

1. Sampling faucets on the influent and effluent lines.

2. Indicating loss-of-head gauge with appropriate cross-connection protection.

3. Indicating flow rate controls. A modified rate controller which limits the rate of filtration to a maximum rate may be used. However, equipment that simply maintains a constant water level on the filters will not be approved unless the rate of flow onto the filter is properly controlled. A pump in each filter effluent line may be used as the limiting factor for the rate of filtration only with approval from the department.

4. For surface water and groundwater under the direct influence of surface water, provisions for filtering to waste with appropriate measures for backflow prevention.

5. For surface water and groundwater under the direct influence of surface water, on-line continuous turbidimeters shall be installed on the effluent from each filter. All turbidimeters shall consistently determine and indicate the turbidity of the water in nephelometric turbidity units (NTUs). Each turbidimeter shall report to a recorder that is designed and operated to allow the operator to accurately determine the turbidity at least every 15 minutes. Turbidimeters on individual filters shall be designed to accurately measure low-range turbidities and trigger an alarm when the effluent level exceeds 0.3 NTU. Access to the filter interior through wall sleeves shall be provided in several locations to allow the installation of sampling lines, pressure sensors and other devices, at different depths in the filter media.

6. A 1 to 1.5-inch pressure hose and rack at the operating floor for washing the filter walls.

(k) *Backwash.* Backwashing facilities shall be designed to provide:

1. A minimum rate of 15 gallons per minute per square foot, consistent with water temperatures and specific gravity of the filter media. The department may approve a reduced rate of 10 gallons per minute per square foot for full depth anthracite or granular activated carbon filters, if justification is provided. A reduced rate of backwashing is acceptable when air scouring is provided that meets the requirements of par. (i).

Note: A rate of 20 gallons per minute per square foot or a rate necessary to provide for a 50% expansion of the filter bed is recommended.

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

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

4. Backwashing of not less than 15 minutes wash of one filter at the design rate of wash.

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

6. A rate-of-flow indicator and totalizer on the main washwater line, located for convenient reading by the operator during the washing process.

7. Backwashing by a method which prevents rapid changes in the backwash water flow.

8. Backwash shall be operator initiated. Backwash systems with automated sequencing shall be operator adjustable.

(L) *Miscellaneous.* Roof drains may not discharge into the filters and basins or the conduits preceding the filters.

(2) SLOW RATE GRAVITY FILTERS. The use of slow rate gravity filters is not allowed without prior engineering studies to demonstrate the adequacy and suitability of this method of filtration for the specific raw water supply. The following standards shall be applied:

(a) *Quality of raw water.* Slow rate gravity filtration shall be limited to waters having maximum turbidities of 50 nephelometric turbidity units (NTUs) and maximum color of 30 units; turbidity may not be attributable to colloidal clay. Raw water quality data shall include examinations for algae.

(b) *Structural details and hydraulics.* Slow rate gravity filters shall be designed to provide:

1. Not less than 2 filter units. If only 2 units are provided, each shall be capable of meeting the plant design capacity, normally the projected maximum daily demand, at the approved filtration rate. If more than 2 filter units are provided, the filters shall be capable of meeting the plant design capacity at the approved filtration rate with one filter removed from service.

2. A cover or superstructure.

3. Headroom to permit normal movement by operating personnel for scraping and sand removal operations.

4. Adequate manholes and access ports for handling of sand.

5. Filtration to waste and overflow at the maximum filter water level.

(c) *Rates of filtration.* The permissible rates of filtration shall be based on the quality of the raw water as determined from experimental data. Proposed rates shall be submitted to the department for approval. The design rate shall be 45 to 150 gallons per day per square foot of sand area. However, the department may approve design rates of 150 to 230 gallons per day per square foot if effectiveness is demonstrated to the satisfaction of the department.

(d) *Underdrains.* Each filter unit shall be equipped with a main drain and an adequate number of lateral underdrains to collect the filtered water. The underdrains shall be so spaced that the maximum velocity of the water flow in the lateral underdrain will not exceed 0.75 feet per second. The maximum spacing of the laterals may not exceed 3 feet if pipe laterals are used.

(e) *Filtering material.* A minimum depth of 30 inches of filter sand, clean and free of foreign matter, shall be placed on graded gravel layers. The effective size shall be between 0.30 and 0.45 mm, and the uniformity coefficient may not exceed 2.5.

(f) *Filter gravel.* The supporting gravel shall conform to the size and depth distribution requirements in sub. (1) provided for rapid rate gravity filters.

(g) *Depth of water on filter beds.* The design shall provide a depth of at least 3 feet of water over the sand. Influent water shall be distributed in a manner which will not scour the sand surfaces.

(h) *Control appurtenances.* Each filter shall be equipped with:

1. A loss-of-head gauge.

2. An orifice, Venturi meter or other suitable metering device installed on each filter to enable measurement of the rate of filtration.

3. An effluent pipe located at an elevation which will maintain the water level in the filter above the top of the sand.

NR 811.50 Filtration – Membrane. Membrane technologies have a wide range of applications from the use of lower pressure membranes for removal of surface water contaminants such as *Giardia Lamblia* and *Cryptosporidium* to the use of reverse osmosis for desalination, inorganic compound removal, and radionuclide removal. The following specific requirements shall be met:

(1) TREATMENT OBJECTIVES. The selection of the specific membrane process shall be matched to the desired treatment objectives. The department shall be contacted to determine inactivation/removal credits for the specific membrane and treatment objective membranes to be used in treatment of surface water or groundwater under the direct influence of surface water.

(2) WATER QUALITY CONSIDERATIONS. A review of historical source raw water quality data, including turbidity or particle counts or both, seasonal changes, organic loading, microbial activity, and temperature differentials as well as other inorganic and physical parameters shall be conducted. The data shall be used to determine feasibility and cost of the system and the degree of pre-treatment. Design considerations and membrane selection at this phase shall also address the issue of target removal efficiencies and system recovery versus acceptable transmembrane pressure differentials. On surface water supplies, pre-screening or cartridge filtration may be required. The source water temperature shall be considered when establishing the design flux of the membrane under consideration and the number of treatment units to be installed. Seasonal variation of design flow rates may be based on documented lower demand during colder weather.

(3) PILOT TESTING. Prior to initiating the design of a membrane treatment facility, pilot testing shall be conducted. The pilot plant study shall be designed to identify the best membrane to use, need for pre- treatment, type of post- treatment, cold and warm water flux, backwash optimization, chemical cleaning optimization, fouling potential, operating and transmembrane pressure, integrity testing procedures, bypass ratio, amount of reject water, system recovery, process efficiency, particulate or organism removal efficiencies, and other design and monitoring considerations, each where applicable. The duration of the pilot testing shall be 9 to 12 months for microfiltration and ultrafiltration on surface water supplies and 2 to 7 months for reverse osmosis and nanofiltration on groundwaters. The general protocol and sampling schedule shall follow the US EPA Membrane Filtration Guidance Manual, EPA 815-R-06-009, November 2005.

(4) CHALLENGE TESTING. Membranes treating surface waters or groundwater under the direct influence of a surface water shall be challenge tested to establish a product specific maximum *Cryptosporidium* and *Giardia Lamblia* log removal credit. Challenge testing shall meet the requirements of s. NR 810.45 (2).

(5) PRETREATMENT. Pretreatment shall be as follows:

(a) *Microfiltration and ultrafiltration.* Pretreatment shall be designed to remove suspended solids and large particulate matter. The pretreatment may consist of a screen or strainer with a 200 to 500 micron rating. Chemicals used for pretreatment shall be certified for compliance with ANSI/NSF Standard 60.

(b) *Reverse osmosis and nanofiltration.* Pretreatment shall be provided where appropriate for turbidity reduction, iron or manganese removal, stabilization of the water to prevent scale formation, microbial control, chlorine removal for certain membrane types, and pH adjustment. At a minimum, cartridge filters shall be provided for the protection of the reverse osmosis or nanofiltration membranes against particulate matter.

(6) MEMBRANE MATERIALS. Two types of membranes may be used for reverse osmosis and nanofiltration. These are cellulose acetate based and polyamide composites. Microfiltration and ultrafiltration membranes may be organic polymers such as: cellulose acetate, polysulfones, polyamides, polypropylene, polycarbonates or polyvinylidene. The physical configurations may include: hollow fiber, spiral wound or tubular. Membrane materials shall be compatible with any pre-oxidants.

(7) USEFUL LIFE OF MEMBRANES. The life expectancy of a particular membrane under consideration shall be evaluated during the pilot study or from other relevant available data.

(8) BACKWASHING. Automated periodic backwashing shall be provided for microfiltration and ultrafiltration on a timed basis or once a target transmembrane pressure differential or a high resistance have been reached. Back flushing volumes may range from 5% to 15% of the permeate flow depending upon the frequency of flushing or cleaning and the degree of fouling. The back flushing volumes shall be considered in the treatment system sizing and the capacity of the raw water source. For systems using pressurized air, the compressors shall utilize food grade oil and filters shall be provided to prevent oil from reaching the membranes. Chemically enhanced backwash systems shall be protected from cross connections and shall be followed by a regular backwash. Backwash wastes shall be disposed of in accordance with subch. XII.

(9) MEMBRANE CLEANING. A means shall be provided to allow for periodically cleaning the membrane. Cleaning shall include a soak type cleaning and may also include more frequent maintenance cleans. The cleaning process shall protect the raw and finished water from contamination. Cleaning chemicals, frequency and procedure should follow membrane manufacturer's guidelines. Some cleaning solutions require heated water. Cleaning chemicals shall be NSF/ANSI Standard 60 certified. Membrane cleaning shall be initiated by the operator. Waste streams from chemical cleaning shall be discharged to the sanitary sewer. Adequate space shall be provided for different or additional chemicals which may be required to adequately clean the membranes in the future.

(10) MEMBRANE INTEGRITY TESTING. A means shall be provided to conduct direct and indirect integrity testing to routinely evaluate membrane and housing integrity and overall filtration performance. Direct integrity testing may include pressure and vacuum decay tests for microfiltration and ultrafiltration and marker-based tests for nanofiltration and reverse osmosis. The direct testing method shall allow for conducting tests at least once per day and may be required three times per day. Indirect monitoring options may include particle counters or turbidity monitors or both and shall allow for testing continuously. The testing methodology shall be approved by the department during startup procedures.

(11) MONITORING. Equipment shall be provided to monitor water quality, flow rates, and water pressure.

(a) *Water quality.* Sampling taps shall be provided to allow monitoring of water quality from the source water, from the water after any pretreatment, from the filtrate of each membrane unit, from the combined filtrate of all membranes, from the backwash, and prior to the entry to any clearwell.

(b) *Flow monitoring.* Water meters shall be provided to allow flow measurement from the source water, from the filtrate of each unit, from the combined filtrate of all units, from the backwash source, from any recirculation line, and from any waste line.

(c) *Pressure monitoring.* Pressure gauges shall be provided prior to the membrane units, after each membrane unit, and on the combined effluent of all membrane units.

(d) *Additional monitoring.* Additional monitoring points shall be provided as necessary to satisfy integrity testing requirements and operational reporting requirements of sub. (10) and s. NR 810.07.

(12) CROSS CONNECTION CONTROL. Cross connection control considerations shall be incorporated into the system design, particularly with regard to chemical feeds and waste piping used for membrane cleaning, waste stream and concentrate. Protection may include block and bleed valves on the chemical cleaning lines and air gaps on the drain lines.

(13) REDUNDANCY OF CRITICAL COMPONENTS. Redundancy of critical control components including but not limited to pumps, valves, air supply, chemical feed equipment and computers shall be provided.

(14) POST TREATMENT. Post treatment of water treated using reverse osmosis or nanofiltration shall be provided. Post treatment may consist of degasification for carbon dioxide, if excessive, and hydrogen sulfide removal, if present, pH and hardness adjustment for corrosion control, and disinfection as a secondary pathogen control and for distribution system protection.

(15) BYPASS WATER. The design shall provide for a portion of the raw water to bypass the unit to maintain stable water within the distribution system and to improve process economics as long as the raw water does not contain unacceptable contaminants. Alternative filtration shall be provided for bypassed surface water or groundwater under the direct influence of surface water.

(16) REJECT WATER. Reject volumes shall be evaluated in terms of the source availability and from the waste treatment availabilities. The amount of reject water from a unit may be reduced to a limited extent by increasing the feed pressure to the unit. Waste disposal from reverse osmosis or nanofiltration reject water shall discharge to a municipal sewer system, to waste treatment facilities, or to an evaporation pond.

(17) TREATMENT EFFICIENCY. The design treatment efficiency shall be determined by pilot testing.

(18) POWER CONSUMPTION. The power consumption of a particular membrane under consideration shall be evaluated during the pilot study or from other relevant data.

(19) CONTROL SYSTEMS.

(a) *Back-up systems.* Automated monitoring and control systems shall be provided with back-up power and operational control systems consisting of the following:

1. Dual running programmable logic controllers (PLCs) with synchronized programs and memory, or spare PLCs loaded with the most current program.
2. Spare input/output (I/O) cards of each type.
3. A minimum of 2 human machine interfaces (HMI).
4. Backup power supply including uninterruptible power supply (UPS).

(b) *Remote or unmanned operational control.* Systems designed for remote or unmanned control shall be provided alarms, communication systems, and automatic shutdown processes. The department shall be contacted to determine the extent of operational control required. At a minimum the following alarms shall be provided:

1. High raw or filtrate turbidity.
2. Pump failure.
3. High pressure decay test.
4. High transmembrane pressure.
5. PLC failure.
6. Membrane unit shutdown.
7. Clearwell level high or low.
8. Equipment failure.
9. High or low chlorine residual.
10. Low chemical level.
11. Power failure.
12. Building intrusion
13. Building low temperature.

NR 811.51 Fluoridation. Sodium fluoride, sodium fluorosilicate and fluorosilicic acid shall conform to the applicable NSF/ANSI Standard 60 and AWWA standards B701, B702, and B703 in effect at the time of use. Other fluoride compounds which may be available shall be approved by the department. The following specific requirements shall be met:

(1) FLUORIDE CHEMICAL STORAGE. Fluoride chemicals shall be stored in accordance with the following requirements:

(a) Fluoride chemicals shall be isolated from other chemicals to prevent contamination.

(b) Fluoride chemicals shall be stored in covered or unopened shipping containers and stored inside a building.

(c) Unsealed storage units for fluorosilicic acid shall be vented to the atmosphere at a point outside the building. The vent piping shall terminate with a down-turned U-bend. The vent pipe opening shall be covered with a 24-mesh corrosion resistant screen.

(2) FLUORIDE ACID HOUSING. Equipment for feeding fluoride in the acid form and unsealed acid storage containers shall be housed in accordance with the following requirements:

(a) All chemical feed equipment, solution tanks, and acid containers shall be housed in a separate room within the pumphouse away from controls, electrical contacts and other equipment subject to damage.

(b) Unsealed acid storage units or solution tanks shall be vented to the outside in accordance with sub. (1).

(c) Ventilation shall be provided for the room.

(d) Entrance may be from inside the pumphouse but shall include a gasketed, sealed door to minimize the transfer of fumes outside the fluoride room.

(3) CHEMICAL FEED INSTALLATIONS. Chemical feed installations shall:

(a) Conform to the requirements of ss. NR 811.38 to 811.40.

(b) Provide scales, loss-of-weight recorders, liquid level indicators, or graduated feed drums for determining the amount of chemical applied. The method shall be accurate to within 5% of the average daily change in reading. A meter shall be provided on the water fill line to a fluoride saturator.

(c) Not allow fluoride addition before lime-soda softening or ion exchange softening.

(d) Provide feeders accurate to within 5% of any desired feed rate.

(e) Be such that the point of application of fluorosilicic acid, if into a horizontal pipe, shall be in the lower half of the pipe with the chemical injection nozzle projecting upward into the pipe as required by s. NR 811.39 (7) (f).

(f) Provide chemical feeder settings in accordance with s. NR 811.39 (2) (c).

(g) Provide adequate anti-siphon devices for all fluoride feed pumps or lines as required in s. NR 811.39 (2) (e).

(h) Provide soft water for fluoride saturator makeup water.

(4) SECONDARY CONTROLS. Secondary control systems for automatically controlled fluoride chemical feed devices shall be provided as a means of reducing the possibility for overfeed; these may include flow or pressure switches or other equivalent devices.

(5) DUST CONTROL. Dust control shall meet the following requirements:

(a) Provision shall be made for the transfer of dry fluoride compounds from shipping containers to storage bins or hoppers in such a way as to minimize the quantity of fluoride dust which may enter the room in which the equipment is installed. The enclosure shall be provided with an exhaust fan and dust filter which place the hopper under a negative pressure. Air exhausted from fluoride handling equipment shall discharge through a dust filter to the atmosphere outside of the building.

(b) Provision shall be made for disposing of empty bags, drums, or barrels in a manner which will minimize exposure to fluoride dust. A floor drain shall be provided to facilitate the hosing of floors.

(6) PROTECTIVE EQUIPMENT. Protective clothing, gloves, goggles or face shields and aspirator shall be provided.

(7) TESTING EQUIPMENT. Equipment shall be provided for measuring the quantity of fluoride in the water using the analytical methods as specified in s. NR 809.113 (1), Table A. When also feeding phosphates, the electrode method is required. The Alizarin Visual method may be approved only in special cases where the owner can allocate the extra time needed for testing.

(8) DILUTION EQUIPMENT. Where dilution of the chemical solution is necessary, a graduated container and transfer pump shall be provided.

NR 811.52 Iron and manganese control. Iron and manganese control 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 treatment processes shall meet specific local conditions as determined by engineering investigations, including chemical analyses of representative samples of water to be treated. The department may require the operation of a pilot plant in accordance with s NR 811.44 in order to gather all information pertinent to the design. Consideration shall be given to adjusting the pH of the raw water to optimize the chemical reaction. The following requirements for specified treatment processes shall be met:

(1) REMOVAL BY OXIDATION-DETENTION-FILTRATION OR OXIDATION-FILTRATION. (a) *Oxidation.* Oxidation may be by aeration, as indicated in s. NR 811.45, or by chemical oxidation with chlorine, potassium permanganate, sodium permanganate, hydrous manganese oxides, ozone or chlorine dioxide.

(b) *Detention or reaction.*

1. A detention period of 0.5 to 3 hours, as determined by pilot studies, shall be provided following oxidation by aeration in order to insure that the oxidation reactions are as complete as possible. The detention period may be omitted or reduced where a pilot plant study indicates no need for detention or that a detention period less than 30 minutes will be adequate and department approval is obtained.

2. The detention basin shall be designed as a holding tank with sufficient baffling to prevent short circuits. Sludge collection equipment is not required. The floor shall be sloped to facilitate cleaning. Detention basins shall meet all potable water reservoir standards as required by subch. IX.

(c) *Sedimentation.* Sedimentation basins shall be provided when treating water with high iron or manganese content or both and a significant volume of oxidized material will be created or where chemical coagulation is used to

reduce the load on the filters. Provisions for sludge removal shall be made. Sedimentation basins shall meet all potable water reservoir standards as required by subch. IX.

(d) *Rapid rate pressure filters.* Use of rapid rate pressure filters as well as gravity filters may be considered for iron and manganese removal. Use, however, is subject to the following conditions:

1. Minimum criteria relative to number, rate of filtration, structural details and hydraulics, filter media, etc., provided for rapid rate gravity filters in s. NR 811.49 also apply to pressure filters, where appropriate.

2. Generally, the design filtration rate shall be 3 gallons per minute per square foot of filter area. Higher or lower rates may be justified based on in-plant or pilot plant studies.

3. Filter design shall provide for:

a. Loss of head gauges with a suitable range in head on the inlet and outlet pipes of each filter.

b. An easily readable meter or flow indicator on each battery of filters.

Note: A flow indicator is recommended for each filtering unit.

c. Piping and shut-off valves so that each filter can be operated and backwashed individually.

d. Minimum side wall shell height of 5 feet. A corresponding reduction in side wall height may be approved where proprietary bottoms permit reduction of the gravel depth.

e. Wastewater collection a minimum of 18 inches above the surface of the media.

f. An underdrain system to efficiently collect the filtered water and distribute the backwash water.

g. Backwash and air relief valve discharge piping terminating with a free air break a minimum of 24 inches above the floor or wastewater collection pipe or sump.

h. Inlet and outlet sampling faucets for each filter.

(2) REMOVAL BY LIME PROCESSES. The removal of iron and manganese by lime processes shall meet the requirements in s. NR 811.57.

(3) REMOVAL BY MANGANESE GREENSAND TYPE FILTRATION. The removal of iron and manganese by greensand type filtration consisting of a continuous feed of potassium or sodium permanganate to the influent of a manganese greensand filter, is more applicable to the removal of iron plus manganese than to the removal of iron only because of economic considerations. As an alternate method, application of the potassium permanganate to the greensand on a "batch" basis may be installed when the department determines "batch" application is as effective as continuous feed. The following requirements apply:

(a) The permanganate shall 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) The normal filtration rate shall be 3 gallons per minute per square foot.

(d) The normal backwash rate shall be 8 to 10 gallons per minute per square foot for manganese greensand media and 15 to 20 gallons per minute per square foot for manganese coated media.

(e) Air washing may be provided.

(f) Sampling faucets shall be provided prior to application of permanganate, immediately ahead of filtration and at the filter outlet.

(4) REMOVAL BY ION EXCHANGE. The removal of iron and manganese by ion exchange may not be used unless pilot plant studies have demonstrated that satisfactory removal efficiencies can be continuously provided. There may be no oxidation of the iron or manganese prior to the process.

(5) TESTING EQUIPMENT. Testing equipment shall be provided for all plants. The equipment shall have the capacity to accurately measure the iron content to a minimum of 0.1 mg/l and the manganese content to a minimum of 0.05 mg/l.

NR 811.53 Organics removal.

(1) GENERAL REQUIREMENTS. Organic compounds may be removed by a variety of processes. All process designs shall be based on information from a pilot study conducted in accordance with s. NR 811.44 with the compounds to be removed unless the pilot study is waived by the department. Unless the department approves other requirements, the processes shall be designed to remove a minimum of 99% of the contaminant in question.

(2) PACKED TOWER AERATION. Packed tower aeration units shall meet the following requirements:

(a) *General.* Packed tower aeration, which is also known as air stripping, may be used for the removal of volatile organic chemicals, trihalomethanes, carbon dioxide, and radon.

(b) *Process design.* The process design shall include determination of the Henry's Constant for each contaminant, the mass transfer coefficient, air pressure drop, and stripping factor. Justification shall be provided for the selected design parameters including the height and other dimensions of the unit, air to water ratio, packing specifications, packing depth, and surface loading rate.

1. Pilot testing considerations:

a. The pilot study shall evaluate a variety of loading rates and air to water ratios at the peak contaminant concentration. Special consideration shall be given to removal efficiencies when multiple contaminants occur.

b. If there is adequate past performance data on the contaminant to be treated, including at the peak contaminant concentration, the department may approve the process design based on the appropriate calculations without pilot testing.

2. The installation shall be designed to reduce contaminants to below the maximum contaminant level and to the lowest practical level.

3. The packing material shall be NSF/ANSI Standard 61 approved for use in potable water in accordance with s. NR 810.09 (5). The packing material shall be resistant to the aggressiveness of the water, dissolved gasses, any chemicals added to the water supply, and any cleaning materials.

4. The packing tower shall be constructed of materials compatible with potable water including stainless steel, reinforced concrete, aluminum, reinforced fiberglass, or plastic. The tower construction materials shall be resistant to the aggressiveness of the water, dissolved gasses, any chemicals added to the water supply, and any cleaning materials. Towers constructed of light weight materials shall be provided with adequate support to prevent damage from wind.

5. The ratio of the column diameter to the packing diameter shall be at least 7:1 for the pilot unit and at least 10:1 for the full scale tower. The type and size of the packing used in the full scale unit shall be the same as that used in the pilot unit.

6. The blower shall be adequately sized to provide sufficient air to achieve the desired removal rates. The minimum volumetric air to water ratio at the maximum water flow rate shall be 25:1. The maximum air to water ratio shall not exceed 80:1.

7. The design shall give consideration to potential fouling problems from calcium carbonate, iron and manganese precipitation, and from bacterial growth. Pretreatment shall be provided where necessary to prevent significant fouling. Disinfection capability shall be provided immediately before and after packed tower aeration.

8. The effects of temperature shall be considered in the process design as a drop in water temperature can result in a drop in contaminant removal efficiency.

(c) *Water flow system.*

1. Water shall be distributed uniformly at the top of the tower using spray nozzles or orifice-type distributor trays that prevent short circuiting. For multi-point injection, a minimum of one injection point for every 30 square inches of tower cross-sectional area shall be installed.

2. A mist eliminator shall be provided above the water distributor system.

3. A side wiper redistribution ring shall be provided at least every 10 feet in order to prevent water channeling along the tower wall and short circuiting.

4. Sample faucets shall be provided on the tower inlet and outlet piping.

5. An outlet sump, if provided, shall be accessible for cleaning purposes and be equipped with a drain valve. The drain shall not be directly connected to a storm or sanitary sewer.

6. A drain fitting shall be installed in the outlet piping to allow for the discharge of water and any chemicals used to clean the tower. The drain shall not be directly connected to a storm or sanitary sewer.

7. The design shall prevent freezing of the inlet riser, tower, and the outlet piping when the unit is not operating.

8. All buried piping shall be maintained under a positive pressure greater than the elevation of the ground surface.

9. The water flow to each tower shall be metered.

10. Consideration shall be given to installing a butterfly valve in the inlet piping to control the water flow rate and to minimize air entrainment.

11. A means shall be provided to prevent flooding of the air blower.

12. The inlet piping shall be supported separately from the tower's main structural support.

(d) *Air flow system.*

1. The air inlet shall be installed in a protected location.

2. The air inlet to the blower and the tower discharge vent shall be screened and provided with a downturned, hooded or mushroom cap that protects the screen from the entrance of extraneous matter including insects and birds, obnoxious fumes, all types of precipitation and condensation, and windborne debris or dust. The screens shall be constructed of 24-mesh corrosion resistant material and installed at a location least susceptible to vandalism or damage. The air inlet shall also be provided with a dust filter.

Note: It is recommended that a 4-mesh corrosion resistant screen be installed in front of the 24-mesh screen on the air inlet system.

3. The blower shall be provided with a weather-proof motor, a tight housing, and an adequate foundation.

4. An air flow meter or department approved alternative method for determining the air flow shall be installed on the air inlet piping.

5. A positive air flow sensing device and a pressure gauge shall be installed on the air inlet line to the tower. If positive air flow is not detected, the device shall automatically shut down the water flow.

6. A backup motor for the blower shall be readily available where the tower is used to maintain primary drinking water standards.

(e) *Other requirements.*

1. The tower shall be provided with a sufficient number of access ports with a minimum diameter of 24 inches to facilitate inspection, media replacement, media cleaning, and maintenance of the interior.

2. A means shall be provided for cleaning the packing material should it become fouled.

3. Any clearwell or reservoir constructed to receive water from a tower shall be constructed to meet the potable water reservoir requirements of s. NR 811.64.

4. The tower shall be designed and constructed so that it can be extended without major reconstruction.

5. A means of bypassing the tower shall be provided unless the requirement is waived by the department because the water system has access to other water sources that can provide an average day supply of water at minimum.

6. Disinfection application points shall be provided on the tower inlet and outlet piping.

7. Any water passed through the tower shall be continuously disinfected and provided with a minimum of 30 minutes of post aeration contact time.

8. The water supply pump or pumps, blower motor, disinfection equipment, and the positive air flow sensing device shall be electrically interconnected to operate in series.

9. Adequate packing support shall be provided to allow the free flow of water and to prevent packing deformation.

10. Adequate auxiliary power shall be provided to operate the air blower and disinfection equipment during power failures unless the requirement is waived by the department because the water system has access to other water sources that can provide an average day supply of water at minimum or operation of the tower is not mandatory to meet primary drinking water standards.

11. The tower shall be provided with an adequate foundation and lateral support to prevent overturning due to wind loading.

12. The equipment shall be located within a secure building or within a locked security fence to prevent vandalism.

13. An access ladder with safety cage shall be provided to allow access and inspection of all areas of the tower.

14. Exhaust air shall be discharged directly to the outside atmosphere and in a location that will be protective of public health. Air emissions controls shall be provided if necessary to meet air quality standards.

15. Noise control equipment shall be provided where systems are located in residential areas.

(3) GRANULAR ACTIVATED CARBON FILTERS. Granular activated carbon filter installations shall meet the following requirements:

(a) The maximum filtration rate for pressure filters shall be 6 gallons per minute per square foot of filter area. The maximum filtration rate for gravity filters shall be 3 gallons per minute per square foot of filter area. Higher rates may be justified based on pilot studies for removal of the contaminant in question.

(b) The water from the carbon filter shall be continuously disinfected.

(c) The filter design shall provide for:

1. Loss of head gauges on the inlet and outlet pipes of each filter.
2. A meter or flow indicator.
3. Adequate freeboard for backwashing based on the specific gravity of the media.
4. An underdrain system to effectively collect the filtered water and distribute the backwash water.
5. Backwash and air relief valves having discharges that terminate in a free air break at least 24 inches above the floor.
6. Smooth end sampling faucets on the inlet and outlet pipes of each filter.
7. The ability to conveniently inspect, replace, or regenerate the media.

(d) The carbon used shall be virgin carbon.

(e) Information supporting selection of the carbon for removal of the contaminants in question shall be provided to the department.

(f) A plan for the disposal of the spent carbon shall be included in the specifications. Disposal of spent granular activated carbon shall comply with s. NR 811.859.

(g) An assessment of the impacts of radon and its decay products on operation, operator safety, and waste disposal shall be provided to the department.

NR 811.54 Ozonation. Ozonation can be used for a variety of purposes including disinfection, oxidation, and microflocculation. When applied, all of these reactions may occur but typically only one is the primary purpose for its use. Ozonation can be used for the removal of color, taste and odors, organics, algae, cyanide, hydrogen sulfide, iron, manganese, and heavy metals. In addition to these treatment processes, ozone is an acceptable alternative to chlorine disinfectants. Given the sophisticated nature of the ozone process, consideration shall be given to the need for maintaining qualified operators to operate and maintain the equipment. The following requirements shall be met:

(1) GENERAL. The following general requirements shall be met:

(a) All process designs shall be based on bench or pilot scale studies of dosage requirements, application points, and detention times conducted in accordance with s. NR 811.44.

(b) When ozone is used as a disinfectant, ozonation and detention shall provide the required disinfection CT value. Additionally, application of a disinfectant which maintains a measurable residual in the distribution system shall be required.

(c) Where ozonation is approved by the department to be used for disinfection of a bacteriologically unsafe water supply, duplicate process streams shall be provided. This includes air supply, air preparation equipment, ozone generators, ozone contact chambers, ozone diffusers, power supply, and post disinfection equipment. This requirement may be waived by the department where other acceptable water sources having sufficient capacity are available.

(2) FEED GAS PREPARATION. Feed gas can be air, oxygen enriched air, or high purity oxygen. Sources of high purity oxygen include purchased liquid oxygen; on site generation using cryogenic air separation; or temperature, pressure or vacuum swing, adsorptive separation, technology. For high purity oxygen-feed systems, dryers typically are not required. Feed gas preparation shall meet the following requirements:

(a) *Air handling equipment.* Air handling equipment on conventional low pressure air-feed systems shall consist of an air compressor unless drawn by vacuum, water or air separator, refrigerant and desiccant dryers and particulate filters. For oxygen-feed systems, compressors, separators, and dryers may not be required by the department depending on the purity of the oxygen. In all cases the design shall ensure that the maximum dew point of -60°C (-76°F) will not be exceeded at any time.

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

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

3. Air feed for the compressor shall be drawn from a point protected from rain, snow, condensation, mist, and fog to minimize moisture content of the air supply. The air feed shall be protected from contaminated air sources. Outside air intakes shall consist of a downturned pipe elbow installed at a location least susceptible to vandalism and covered with a 24-mesh corrosion resistant screen.

4. A compressed air after-cooler or entrainment separator or both with automatic drain shall be provided prior to the dryers to reduce the water vapor.

(c) *Air drying.* 1. Dry, dust-free, and oil-free feed gas shall be provided to the ozone generator. Sufficient drying to a maximum dew point of -60°C (-76°F) shall be provided at the end of the drying cycle.

2. Drying for high pressure systems shall be accomplished using desiccant dryers. For low pressure systems, a refrigeration air dryer in series with desiccant dryers shall be used.

3. A refrigeration dryer capable of reducing the inlet air temperature to 4°C (40°F) shall be provided for low pressure air preparation systems. The dryer may be of the compressed refrigerant type or chilled water type.

4. The desiccant dryers shall be of the external heated or heatless type.

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

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

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

2. The filter before the compressor shall be of the coalescing type and be capable of removing all particles larger than 10 microns in diameter. The filter before the dryer shall be of the coalescing type and be capable of removing all particles larger than 5 microns in diameter. The filter after the dryer shall be of the particulate type and be capable of removing all particles larger than 0.5 microns in diameter or a size specified by the generator manufacturer.

(e) *Air preparation piping.* Piping in a compressed air preparation system shall be common grade steel, seamless copper, stainless steel, or galvanized steel. The piping shall be designed to withstand the maximum pressures in the air preparation system. PVC piping may be used in a vacuum air preparation system when located and supported to be protected from physical damage including from heat.

(3) OZONE GENERATORS. Ozone generators shall meet the following requirements:

(a) *Capacity.* The production rating of the ozone generators shall be provided in pounds per day and pounds per kilowatt-hour. The capacity of any ozone generators shall be determined by ozone demand tests including tests under critical conditions. Where ozone is approved for use by the department as a disinfectant, the generators shall be sized in conjunction with the detention basins to provide the required inactivation CT values for viruses, *Giardia lamblia*, and *Cryptosporidium* contained in ss. NR 810.59, NR 810.60, and NR 810.61.

1. The design shall ensure that the minimum concentration of ozone in the generator exit gas will be 1.0% by weight.

2. Generators shall be sized to have sufficient reserve capacity so that the system does not operate at peak capacity for extended periods of time. Low, medium, and high frequency systems which operate at lower peak voltages require less reserve capacity.

3. Generators with individual dielectrics shall have the capability of operating satisfactorily while individual dielectrics are out-of-service. This shall be accomplished through the use of individually fused dielectrics.

4. At least two generators, each with a capacity of supplying the normal ozone demand, shall be provided. If determined by the department to be not critical to maintaining production capacity, smaller installations employing ozone generators with multiple individually fused dielectrics may be able to employ a fewer number of generators each having excess ozone production capacity.

5. If there is to be a variation in the supply temperature of the generator cooling water throughout the year, then curves or other data shall be furnished to the department to show ozone production changes due to the varying temperature of the supplied cooling water. The design shall ensure that the generators can produce the required ozone at the maximum coolant temperature.

(b) *Electrical.* The generators may be low, medium, or high frequency type. The specifications shall require that the transformers and other electrical hardware be proven, high quality components designed for ozone service.

(c) *Cooling.* Adequate cooling shall be provided. Cooling water supplied to the ozone generators may not be corrosive or scale forming and shall be sufficiently free of microbiological and inorganic contaminants to prevent fouling of the water side of the tubes. If natural water quality does not meet this requirement, treatment shall be required. A closed loop cooling water system shall be used if proper cooling water conditions cannot be assured.

(d) *Materials.* To prevent corrosion, the ozone generator shell and tubes shall be constructed of type 304L or 316L stainless steel.

(4) OZONE CONTACTORS. The selection or design of the contactor and method of ozone application depends on the purpose for which the ozone is being used. Contactors can be of the diffused bubble, venturi, or aspirating turbine mixer type as approved by the department. Ozone contactors shall meet the following requirements:

(a) Where ozone is used as a disinfectant, a minimum of two contact chambers shall be provided with the chambers designed to prevent short-circuiting. Contactors shall be closed vessels.

(b) Contactors shall be separate vessels having no common walls with the remainder of the facility, unless common walls are approved by the department on a case-by-case basis. If common walls are used, the contactor shall be kept under negative pressure and sufficient ozone monitors shall be provided to protect worker safety. No normally inhabited structure may be constructed over an ozone contactor or reservoir containing ozone.

(c) Contact vessels shall be made of reinforced poured concrete. All reinforcement bars shall be covered with a minimum of 1.5 inches of concrete. Ozone resistant interior coatings shall be approved by the department in accordance with s. NR 810.09 (5). Smaller contact vessels may be made of stainless steel, fiberglass, or other material which will be stable in the presence of residual ozone and ozone in the gas phase above the water level.

(d) Contact chambers shall be of sufficient depth and size to allow for adequate contact time and freeboard for foaming where applicable. The depth of water in bubble diffuser contactors shall normally be a minimum of 18 feet unless a shallower depth can be justified to the department. A minimum freeboard of 3 feet shall be provided where foaming will be an issue.

(e) The contact time for disinfection shall be determined based on the required inactivation CT values for viruses, *Giardia lamblia,* and *Cryptosporidium* contained in ss. NR 810.59, NR 810.60, and NR 810.61. The minimum contact time shall be 10 minutes. A shorter contact time may be approved by the department if justified by appropriate design and CT considerations. Sufficient ozone capacity and contact chamber size shall be provided to achieve the desired CT value when injecting ozone into only one of the 2 contact chambers. The diffusion system shall normally work on a countercurrent basis such that the ozone shall enter through porous diffusers at the bottom of the vessel and water shall enter from the top of the vessel. Countercurrent flow shall be provided in all chambers of the vessels. Co-current diffusion systems shall only be approved by the department where adequate justification can be supplied.

(f) For ozone applications in which precipitates are formed, such as with iron and manganese removal, porous diffusers may not be used.

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

(h) A system shall be provided between the contactor and the off-gas destruct unit to remove foam from the air and return the froth to the contactor or other location acceptable to the department when foam will be an issue. A potable water spray system shall be placed in the contactor head space if foaming is expected to be excessive.

(i) All openings into the contactor for pipe connections, hatchways, etc., shall be properly sealed to prevent the escape of ozone using welds or ozone resistant gaskets such as Teflon or Hypalon.

(j) A pressure or vacuum relief valve shall be provided in the contactor as appropriate. Pressure or vacuum relief valve discharge piping shall be piped to a location where there will be no damage to the ozone destruction unit or an uncontrolled release of ozone.

(k) Sampling faucets and monitors shall be provided on the inlet and outlet of each contact chamber to monitor water quality and the ozone residual. If allowed by the department, a portable monitor or a comparable testing method may be used to analyze water collected from sample taps provided on the inlet and outlet of each contact chamber.

(L) A water meter shall be provided on the inlet to the contact chambers to measure water flow.

(m) If required by the department, contactors or reservoirs used as contactors shall be fitted with the improvements necessary to allow sampling of water from intermediate points for ozone residual.

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

(5) OZONE DESTRUCTION. Ozone destruction shall meet the following requirements:

(a) A method or combination of methods for destroying or recirculating the final off gas from the ozone contactors shall be provided to meet safety and air quality standards. Acceptable methods include:

1. Thermal destruction.
2. Catalytic destruction.
3. Thermal and catalytic destruction.
4. Recycling to some point in the treatment system in addition to the installation of destruction equipment.

(b) A detectable ozone residual may not carry over into the distribution system.

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

(d) At least two units shall be provided which are each capable of handling the entire gas flow unless the second unit is deemed unnecessary by the department.

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

(f) Catalysts shall be protected from foam, moisture and other impurities that may harm the catalyst.

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

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

(6) PIPING MATERIALS. Piping materials used in ozone service shall meet the following requirements:

(a) Only low carbon 304L and 316L stainless steel piping shall be used for ozone service. Alternative piping materials may be approved by the department on a case-by-case basis.

(b) Gasket materials shall be Teflon or Hypalon.

(c) Rubber components may not be used in contact with ozone.

(7) JOINTS AND CONNECTIONS.

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

(b) Connections with meters, valves, or other equipment are to be made with flanged joints with ozone resistant gaskets, such as Teflon or Hypalon. Screwed fittings and field-cut threaded connections may not be used.

(c) A positive closing plug or butterfly valve and a leak-proof backflow prevention check valve system shall be provided in the piping between the generator and the contactor for pressurized ozone generation systems.

(8) INSTRUMENTATION. Instrumentation shall meet the following requirements:

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

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

(c) Dew point monitors shall be provided for measuring the moisture of the feed gas from each desiccant dryer. Where there is potential for moisture entering the ozone generator from downstream of the unit or where moisture accumulation can occur in the generator during shutdown, post-generator dew point monitors shall be used.

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

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

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

(g) At a minimum, ozone monitors shall be installed and maintained to measure ozone concentrations in both the feed-gas and the off-gas from the contactor and the off-gas from the destruct unit. Monitors or a comparable testing method shall also be provided for measuring ozone residuals in water in accordance with subs. (4) and (5) (b). The number and location of ozone residual monitors shall be such that the amount of time that the water is in contact with the ozone residual can be determined.

(h) Ambient air ozone monitors shall be installed in rooms where exposure to ozone is possible.

(9) ALARMS. The installation of alarm and shutdown systems shall meet the following requirements:

(a) A dew point alarm and shutdown shall shut down the generator in the event the system dew point exceeds -60°C (-76°F).

(b) An ozone generator cooling water flow alarm and shutdown shall shut down the generator in the event that cooling water flows decrease to the point that generator damage could occur.

(c) An ozone power supply cooling water flow alarm and shutdown shall shut down the power supply in the event that cooling water flow decreases to the point that power supply damage could occur.

(d) An ozone generator cooling water temperature alarm and shutdown shall shut down the generator if either the inlet or outlet cooling water exceeds the designated preset temperature.

(e) An ozone power supply cooling water temperature alarm and shutdown shall shut down the power supply if either the inlet or outlet cooling water exceeds the designated preset temperature.

(f) An ozone generator inlet feed-gas temperature alarm and shutdown shall shut down the generator if the feed-gas temperature exceeds the designated preset value.

(g) An ambient air ozone concentration alarm and shutdown shall sound when the ozone level in the building ambient air exceeds 0.1 ppm or a lower value chosen by the water supplier. Ozone generator shutdown shall automatically occur when the building ambient air ozone level exceeds 0.3 ppm or a lower value chosen by the water supplier.

(h) An ozone destruct temperature alarm shall sound when the temperature exceeds the designated preset value.

(i) Audible alarms and warning lights shall be installed and maintained to insure operators are alerted to improper operating or hazardous conditions.

(10) SAFETY.

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

(b) Noise levels resulting from the operation of the ozonation system shall be controlled to within acceptable limits by special room construction and equipment isolation.

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

(d) An exhaust fan shall be provided in the ozone generation and contactor rooms to remove ozone gas if a leak occurs and shall meet all of the following requirements:

1. One complete air change per minute shall be provided when the room is occupied.

2. The exhaust fan suction shall be located near the floor with the point of discharge located to avoid contamination of air inlets to other rooms and structures, to outside breathable air, or being blocked by snow or other obstructions.

3. Air inlets shall be located near the ceiling and controlled to prevent adverse temperature variations.

4. An exhaust fan switch shall be located outside of the entrance to the room with a signal light indicating fan operation when the fan can be controlled from more than one point.

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

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

NR 811.55 Radionuclide removal. (1) RADIUM REMOVAL. Water treatment to remove radium shall meet the following requirements:

(a) *General.* Radium may be removed by using the water treatment processes of zeolite softening, lime-soda softening, reverse osmosis, hydrous manganese oxides, and adsorptive resins. Other processes may also be used to remove radium as approved by the department on a case-by-case basis. The process design shall address the fate of radium in the treatment process including waste disposal. Where applicable, disposal of treatment plant wastes containing radium shall normally be to a sanitary sewer or wastewater treatment plant.

Note: It is recommended that measures be taken to protect workers from gamma radiation exposure and radon gas inhalation where applicable.

(b) *Finished water quality.* Radium removal processes shall be designed to provide a finished water with a radium content as close to 0 picocuries per liter as practical while maintaining a finished water that is not corrosive. The department shall determine allowable plant outlet water quality, including radium concentrations, based on the raw water quality and the treatment process proposed. If corrosive water is produced during the radium removal process, a department approved method of corrosion control shall be provided.

(c) *Finished water sampling and reporting.* For the radium removal processes listed in par. (a), a minimum of 4 consecutive quarters of finished water sampling for radium shall be required after the plant becomes operational to demonstrate treatment effectiveness. For other proposed radium removal treatment methods, the required radium monitoring program shall be established by the department. The sampling shall be conducted under worst case conditions. Radium analyses shall be performed by a U.S. environmental protection agency approved laboratory. The laboratory shall forward a copy of the radiological analyses to the department in an electronic format. Water hardness monitoring equipment shall be provided to monitor for hardness breakthrough when softening is used for radium removal. Daily water hardness measurements shall be reported on the monthly operating report submitted to the department. Use of hardness monitoring to substitute for radium analyses shall only be allowed if demonstrated effective by simultaneous radium and hardness sampling conducted for one year.

(d) *Water softening.* Treatment for radium removal using standard water softening processes shall comply with the requirements of s. NR 811.57.

(e) *Hydrous manganese oxides.* Water treatment using hydrous manganese oxides for radium removal shall meet the following requirements:

1. Each installation shall be individually pilot tested on-site under a department approval unless the pilot testing requirement is waived by the department based upon documentation of successful similar treatment performance at wells with similar water quality.

2. Pre-mixed or on-site mixed hydrous manganese oxide chemicals shall conform to the applicable NSF/ANSI Standard 60 and AWWA standards as required by s. NR 810.09 (1) (c).

(f) *Adsorptive resins.* Water treatment using adsorptive resins for radium removal that will continuously accumulate radium on the resin shall meet the following requirements.

1. Each installation shall be individually pilot tested on-site under a department approval unless the pilot testing requirement is waived by the department based upon documentation of successful similar treatment performance at wells with similar water quality.

2. The radiation protection section of the department of health services shall be contacted to obtain a radioactive material license to operate pilot and full scale installations prior to constructing or operating the systems.

(g) *Other treatment.* Other radium removal treatment processes may be approved by the department on a case-by-case basis using information obtained from department approved on-site pilot studies conducted on the water to be treated.

(h) *Waste disposal.* Disposal of radium removal treatment plant waste shall comply with subch. XII.

(2) RADON GAS REMOVAL. Water treatment to remove radon gas shall meet the following requirements:

(a) Radon may be removed using aeration or pressurized granular activated carbon filters. The process design shall address the gamma radiation and disposal concerns associated with the use of granular activated carbon filters.

(b) The design of radon removal equipment shall be based on a department approved on-site pilot study conducted on the water to be treated. The department may approve manufactured radon removal equipment without pilot study on a case-by-case basis if adequate treatment effectiveness is demonstrated to the department.

(c) Aerators used for radon removal shall comply with ss. NR 811.45 and 811.53.

(d) Radon gas shall be vented to the atmosphere at an elevation and location to prevent elevated radon gas air concentrations in inhabitable areas.

(e) Granular activated carbon filters for radon removal shall comply with s. NR 811.53. Disposal of carbon filters used for radon removal shall comply with s. NR 811.859.

(f) A minimum of 4 consecutive quarters of finished water sampling for radon gas shall be required after the plant becomes operational to demonstrate treatment effectiveness. The sampling shall be conducted under worst case conditions. Radon gas analyses shall be performed by a U.S. environmental protection agency approved laboratory. The laboratory shall forward a copy of the radiological analyses to the department in an electronic format.

(3) URANIUM REMOVAL. Water treatment to remove uranium shall meet the following requirements:

(a) The designer of any proposed uranium removal equipment shall contact the department prior to the final design of the equipment to allow for department input on design requirements. The design shall be based on information obtained from department approved on-site pilot studies conducted on the water to be treated. The process design shall address the fate of uranium in the treatment process. Disposal of water treatment plant wastes containing uranium shall be in accordance with written department guidance. If applicable, disposal of treatment plant wastes containing uranium shall be to a sanitary sewer or wastewater treatment plant as approved by the department. The discharged water treatment plant wastes and spent media shall be analyzed for radionuclide content as required by the department. The disposal of spent media containing residual radionuclides shall be as approved by the department.

(b) A minimum of 4 consecutive quarters of finished water sampling for uranium shall be required after the plant becomes operational to demonstrate treatment effectiveness. The sampling shall be conducted under worst case conditions. Uranium analyses shall be performed by a U.S. environmental protection agency approved laboratory. The laboratory shall forward a copy of the radiological analyses to the department in an electronic format.

(c) Prior to constructing or operating the systems, the radiation protection section of the department of health services shall be contacted to obtain a radioactive material license to operate pilot and full scale installations when uranium will be concentrated on the resin or media to a level greater than 170 picocuries per gram at any time during use, including just prior to backwashing, regeneration, or disposal.

(d) Disposal of uranium removal treatment plant waste shall comply with subch. XII.

NR 811.56 Sequestration. (1) SEQUESTRATION BY POLYPHOSPHATES. Sequestration by polyphosphates is suitable when concentrations of iron, manganese, or a combination of both, are 1.0 mg/l, or less. Polyphosphate treatment may be less effective for sequestering manganese than for iron. The following requirements shall be met:

(a) Where phosphate treatment is used, chlorine residuals shall be maintained in the distribution system. In addition:

(b) Polyphosphates may not be applied ahead of iron and manganese removal treatment. The point of application shall be prior to any aeration or oxidation and as far upstream as practical from the chlorine or other oxidant application.

(c) Chemical feed installations shall conform to the requirements of subch.VI.

(d) Chemicals for new or existing installations shall meet the applicable NSF/ANSI Standard 60 requirements of s. NR 810.09 (1) (c).

(e) Stock phosphate solution shall be kept covered and disinfected by carrying an approximate 10 mg/l free chlorine residual unless the phosphate is not able to support bacterial growth, has a pH of 2 or less, and has not been diluted.

(f) The total phosphate applied may not exceed 10 mg/l as PO_4.

(g) If polyphosphate sequestration is practiced, appropriate orthophosphate testing equipment shall be provided.

(h) Possible adverse affects on corrosion shall be considered and addressed if necessary when phosphate addition is proposed for iron or manganese sequestering.

(2) SEQUESTRATION BY SODIUM SILICATES. Sodium silicate sequestration of iron and manganese is appropriate only for groundwater supplies prior to air contact. Sodium silicate addition is applicable to waters containing up to 2 mg/l of iron, manganese, or a combination of both. The following requirements shall be met:

(a) On-site pilot tests are required to determine the suitability of sodium silicate for the particular water and the minimum chemical feed rate needed.

(b) Chlorine residuals shall be maintained throughout the distribution system to prevent biological breakdown of the sequestered iron.

(c) Rapid oxidation of the metal ions such as by chlorine or chlorine dioxide shall accompany or closely precede the sodium silicate addition. Injection of sodium silicate more than 15 seconds after oxidation may cause detectable loss of chemical efficiency. Dilution of feed solutions much below 5% silica as SiO_2 shall also be avoided for the same reason.

(d) The amount of silicate added shall be limited to 20 mg/l as SiO_2. The combined amount of added and naturally occurring silicate may not exceed 60 mg/l as SiO_2.

(e) Chemical feed installations shall conform to the requirements of subch. VI.

(f) Sodium silicate may not be applied ahead of iron or manganese removal treatment.

(g) Liquid sodium silicate shall meet the applicable NSF/ANSI Standard 60 requirements of s. NR 810.09 (1) (c).

NR 811.57 Softening. The softening process selected shall be based upon the chemical qualities of the raw water, the desired finished water quality, the requirements for disposal of sludge or brine waste, the cost of plant and chemicals, and plant location. The applicability of the process chosen shall be demonstrated and discussed in detail in an engineering report. For very hard water, the sodium levels in cation exchange softened water shall be considered in selecting the treatment process. Following are requirements for specific processes:

(1) LIME-SODA PROCESS. The applicable design standards for lime-soda softening of groundwater are the same as those for conventional clarification-filtration surface water treatment plants, except that the minimum settling time may be reduced to 2 hours. Where softening is included in the surface water treatment process, the clarification criteria shall govern. In addition:

Note: See s. NR 811.47 for criteria pertaining to softening with solids contact units and s. NR 811.49 for filtration requirements.

(a) Mechanical sludge removal equipment shall be provided in the sedimentation basin.

(b) Determinations shall be made for the carbon dioxide content of the raw water.

Note: When concentrations exceed 10 mg/l, the economics of removal by aeration as opposed to removal with lime should be considered. See s. NR 811.45 for aeration requirements.

(c) Equipment for stabilization of water softened by the lime-soda process is required.

Note: See s. NR 811.58 for stabilization requirements.

(d) Provisions shall be included for proper disposal of softening sludges.

Note: See s. NR 811.858 for design requirements.

(e) The use of excess lime may not be substituted for chlorination or any other approved method of disinfection.

Note: See s. NR 811.48.

(2) ION EXCHANGE PROCESS. Iron, manganese or a combination of both in the oxidized state or unoxidized state may cause resin fouling in the ion exchange process. Pretreatment shall be required whenever the content of iron, manganese, or a combination of both is one milligram per liter or more. In specific instances, the department may also require pretreatment where lesser amounts exist. In addition:

(a) The units shall be of pressure or gravity type, of either an upflow or downflow design, using automatic or manual regeneration. Automatic regeneration is suggested for small plants. A manual override shall be provided for all automatic controls.

(b) The design capacity for hardness removal may not exceed 20,000 grains per cubic foot when resin is regenerated with 0.3 pounds of salt per kilograin of hardness removed.

(c) The depth of the exchange material may not be less than 3 feet.

(d) The rate of softening may not exceed 7 gallons per square foot per minute, and the backwash rate shall be 6 to 8 gallons per square foot per minute.

(e) The freeboard design shall be based upon the specific gravity of the media and the direction of water flow.

(f) The bottoms, strainer systems, and support for the exchange materials shall conform to criteria provided for rapid rate gravity filters in s. NR 811.49.

(g) Facilities shall be included for even distribution of the brine over the entire surface of both upflow or downflow units. Backwash, rinse, and air relief discharge pipes shall be installed in such a manner as to prevent back-siphonage.

(h) A bypass shall be provided around softening units to produce a blended water of desirable hardness. Meters shall be installed on the bypass line and on each softener unit. An automatic proportioning or regulating device and shut-off valve shall be provided on the bypass line. The department may require treatment of the bypassed water to obtain acceptable levels of iron or manganese in the finished water.

(i) Waters having 5 units or more of turbidity may not be applied directly to the cation exchange softener. Silica gel materials may not be used for waters having a pH above 8.4 or when iron is present. When the applied water contains a chlorine residual, the cation exchange material shall be a type that is not damaged by residual chlorine. Phenolic resin may not be used.

(j) Brine storage tanks shall conform to the following requirements:

1. The wet storage tank shall be designed to hold at least 1.5 times the volume of salt delivered to permit refill before the tank is completely empty. The volume of both salt and brine storage to be provided depends upon the size of the plant, the proximity and assuredness of the salt source, and the method of delivery.

2. It shall be isolated from possible sources of contamination.

3. It shall be properly covered and equipped with manholes having overlapping watertight covers to prevent entry of surface runoff.

4. Overflows and vents shall be designed in accordance with ss. NR 811.64 (4) and (8), respectively.

5. The water for filling the tank shall be distributed over the entire surface of the tank by pipes at least 2 pipe diameters above the maximum liquid level in the tank or be protected from back-siphonage.

6. The underdrain collection system shall be covered with a screen or perforated plate to allow brine but not salt to pass through.

7. A sampling tap shall be provided on the brine discharge line in order that the concentration of brine can be determined. A suitable means for measuring the volume of brine used for regeneration shall be provided.

Note: It is recommended that the interior concrete surfaces of brine storage tanks be painted with a salt-resistant sealing compound or paint meeting NSF/ANSI Standard 61 requirements, to prevent deterioration.

(k) The requirements for brine wastes are found in s. NR 811.854.

(L) Smooth-end 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. Testing equipment shall be provided to adequately control the treatment process at all plants.

(m) Water from ion exchange treatment plants shall be stabilized as required in s. NR 811.58 (4), except where it can be shown that the treated water will be non-corrosive.

NR 811.58 Stabilization. Water that is unstable to the extent of causing corrosion or deposition problems in the distribution system, whether a result of natural causes or water treatment processes, shall be stabilized. The following standards shall apply:

(1) CARBON DIOXIDE ADDITION. (a) Recarbonation chamber design shall provide:

1. A total detention time of 20 minutes or as approved by the department.

2. Two compartments, with a depth that will provide a diffuser submergence not less than 7.5 feet nor greater than recommended by the manufacturer and as follows:

a. A mixing compartment having a detention time of at least 3 minutes.

b. A reaction compartment.

(b) The design shall prevent carbon dioxide from entering the plant from the recarbonation and reaction chamber.

(c) Plants generating carbon dioxide from combustion shall have open top recarbonation tanks in order to dissipate carbon monoxide gas.

(d) Provisions shall be made for draining the recarbonation basin and removing sludge.

(e) Recarbonation tanks shall be located outside or sealed and vented to the outside.

(2) PHOSPHATES. Phosphates may be used for sequestering calcium in lime softened water, corrosion control and in conjunction with alkali feed following ion exchange softening. When used:

(a) Feed equipment shall conform to requirements in ss. NR 811.38 to NR 811.40.

(b) Phosphate chemicals shall meet the NSF/ANSI Standard 60 requirements.

(c) Stock phosphate solution shall be kept covered and disinfected by carrying an approximate 10 mg/l chlorine residual. The department may exempt phosphate solutions having a pH of 2.0 or less from this requirement.

(d) Facilities shall be designed to maintain satisfactory chlorine residuals as indicated in ss. NR 810.09 (2) and (3).

(e) The total phosphate applied may not exceed 10 mg/l as PO_4.

(3) SPLIT TREATMENT. If approved by the department, a lime-soda water treatment plant may be designed using 'split treatment' in which raw water is blended with lime-treated water to partially stabilize the water. Treatment plants designed to utilize 'split treatment' shall contain facilities for further stabilization by other methods.

(4) ALKALI FEED. An alkali feeder shall be provided for all ion exchange water softening plants to provide stable water unless the effluent water is shown to be non-corrosive. Other waters may also be corrosive and require pH adjustment. The chemical shall be adequately mixed and the point of application located such that any deposition in the piping is minimized. The piping shall be accessible for cleaning or replacement. Equipment for monitoring pH shall be provided.

(5) CARBON DIOXIDE REDUCTION BY AERATION. The carbon dioxide content of an aggressive water may be reduced by aeration. Aeration devices shall conform to s. NR 811.45.

(6) OTHER TREATMENT. Other treatment for controlling corrosive waters by the use of sodium silicate and sodium bicarbonate may be used where necessary. Any proprietary compound shall receive the specific approval of the department before use. Chemical feeders shall comply with the requirements in subch. VI.

(7) CONTROL. Laboratory equipment shall be provided for determining the effectiveness of stabilization treatment.

NR 811.59 Taste and odor control. Waterworks which are designed and constructed to provide taste and odor control shall comply with any requirements provided for the following applicable methods:

(1) CHLORINATION. Chlorination is effective for the removal of some objectionable odors. Adequate concentration and contact time shall be provided to complete the chemical reactions involved. Excessive potential trihalomethane or other disinfection by-product production through this process shall be investigated by bench-scale testing prior to design.

(2) CHLORINE DIOXIDE. Chlorine dioxide may be used in the treatment of any taste or odor which is treatable by an oxidizing compound. Provision shall be made for proper storage and handling of sodium chlorite to eliminate any danger of explosion.

(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 alternate points is recommended, in no case may carbon be added near the point of chlorine application.

(b) The carbon shall be added as a premixed slurry or by means of a dry-feed machine if the carbon is properly 'wetted'.

(c) Continuous agitation or resuspension equipment shall be provided to keep the carbon from depositing in the mixing chamber/slurry storage tank.

(d) Dust control shall be provided.

(e) The required dosage of carbon in a water treatment plant depends upon the tastes and odors involved. Provisions shall be made for adding sufficient amounts to meet peak demands.

(f) Powdered activated carbon shall be handled as a potentially combustible material. It shall be stored in a building or compartment as nearly fireproof as possible. Other chemicals may not be stored in the same compartment. A separate room shall be provided for carbon feed installations. Carbon feeder rooms shall be equipped with explosion-proof electrical outlets, lights, and motors.

(4) GRANULAR ACTIVATED CARBON. The requirements for granulated activated carbon are in s. NR 811.49.

(5) COPPER SULPHATE AND OTHER COPPER COMPOUNDS. Continuous or periodic treatment of water with copper compounds to kill algae or other growths shall be controlled to prevent a level in excess of 1.0 mg/l as copper in the plant effluent or distribution system. Provisions shall be made for uniform distribution of the chemical.

(6) AERATION. The requirements for aeration are in s. NR 811.45.

(7) POTASSIUM PERMANGANATE. The department may approve application of potassium permanganate if the treatment will be controlled to insure that no residual color will be present in the finished water.

(8) OZONE. Ozonation may be used as a means of taste and odor control. Adequate contact time shall be provided to complete the chemical reactions involved. Ozone is generally more desirable for treating water with high threshold odors. Requirements for ozonation are contained in s. NR 811.54.

(9) OTHER METHODS. Any other methods of taste and odor control may be allowed by the department only after laboratory or pilot plant tests or both.

(10) FLEXIBILITY. Plants treating water known to have taste and odor problems shall be provided with equipment and multiple chemical addition points to provide several alternative control processes.

Note: Refer to subch. VI, for requirements for the storage, handling and application of chemicals in treating surface waters.

NR 811.60 Ultraviolet (UV) Light. Ultraviolet (UV) light technology is a primary disinfectant typically used for *Cryptosporidium* and *Giardia lamblia* inactivation of both surface water and groundwater supplies. The USEPA Ultraviolet Light Disinfection Guidance Manual (USEPA UVDGM) shall be used as the basis for the validation, design and operation of all UV systems. Water systems which are designed to provide ultraviolet light disinfection shall comply with the following:

(1) TREATMENT OBJECTIVES. The target pathogen and the target log inactivation shall be used to identify the corresponding required UV dose.

(2) WATER QUALITY CONSIDERATIONS AND PRETREATMENT. In order to provide adequate disinfection treatment, some water sources may need treatment prior to ultraviolet light disinfection. UV disinfection of surface water sources shall follow filtration. Department approval for specific pretreatment requirements is required if any of the parameters in Table No. 3 are exceeded in the water to be treated by ultraviolet light.

Table No. 3	
Inlet Water Quality Parameters	
Parameter	Maximum or Range
UV 254 mm Absorption	0.155 cm-1
Dissolved Iron	0.3 mg/l
Dissolved Manganese	0.05 mg/l
Hardness	120 mg/l
Hydrogen Sulfide	Non-detectable odor
Fouling Microorganisms	None
pH	6.5 to 9.5
Suspended Solids	10 mg/l
Turbidity	1.0 NTU
Total Coliform	1,000/100 ML

(3) VALIDATION. Ultraviolet light treatment devices shall be validated by a third party entity in accordance with the USEPA Ultraviolet Light Disinfection Guidance Manual (USEPA UVDGM) or another validation standard as approved by the department.

(4) MATERIALS. The ultraviolet light housing shall be type 304 or type 316L stainless steel.

(5) DESIGN. (a) The ultraviolet treatment device shall be designed to provide a UV light dose of a minimum of 40 millijoules per square centimeter (mJ/cm^2) and shall also deliver the target dose as prescribed by s. NR 810.62 by operating within the validated operating conditions for that particular unit.

(b) The ultraviolet treatment assemblies shall be designed to allow visual observation, cleaning, and replacement of the lamp, lamp sleeves, and sensor window or lens.

(c) All ultraviolet lamps shall be housed in quartz sleeves.

(d) Where in-situ cleaning of the lamp sleeves is proposed, the design shall protect the potable water from cleaning solutions.

1. When off-line chemical cleaning systems are used, the UV enclosure shall be removed from service, drained, flushed with an NSF/ANSI Standard 60 certified solution, drained, and rinsed before being placed back in service.

2. On-line systems that use wipers or brushes may use chemical solutions provided they are NSF/ANSI Standard 60 certified.

(e) An automatic shutdown valve shall be installed in the water supply line prior to the ultraviolet treatment device. When power is not provided the valve shall be in the closed position.

(f) The inlet and outlet piping to the reactors shall assure that the UV dose delivery is equal to or greater than the UV dose delivered during validation.

(g) The flow to each reactor shall be equally distributed and metered.

(h) Valves shall be provided to allow isolating and removing from service each UV reactor.

(i) Reactors shall be provided with air relief and pressure control valves per manufacturer requirements.

(j) UV transmittance (UVT) analyzers shall be provided if UVT is part of the dose monitoring strategy.

(k) Sample taps shall be provided downstream of each reactor.

(6) CONTROLS. (a) A delay mechanism shall be installed to provide sufficient lamp warm-up prior to allowing water to flow from the ultraviolet treatment unit.

(b) An automatic shutdown shall be designed to activate the shutdown valve in cases where the ultraviolet light dose falls below the approved design dose or outside of the validated specifications.

(c) Where the UV is necessary to provide adequate disinfection, 99.9 per cent of the volume of water passing through the reactors shall receive UV light treatment within the validated specifications. This may require the use of a bleed line from the reactors during lamp warm up and cool down periods.

(7) BACK-UP. A sufficient number of parallel ultraviolet treatment devices shall be installed to insure that adequate disinfection is provided when one unit is out of service. The department may approve an alternate method that provides adequate disinfection.

(8) TREATMENT BYPASS. No bypass of the ultraviolet treatment process may be installed unless an alternate method of providing adequate disinfection is provided.

(9) MONITORING. Continuous monitoring of UV intensity as measured by a UV sensor, flow rate, and lamp status shall be provided for each ultraviolet treatment device to demonstrate that the device is operating within the range of conditions for which it was validated for the required UV dose. Each monitoring device shall be connected to the control system for the shutdown valve for the respective ultraviolet treatment device. The department may require additional monitoring devices and control systems if any of the water quality characteristics listed in Table No. 3 are representative of the water to be treated and may impair the effectiveness of the ultraviolet light treatment.

(10) CHLORINE ADDITION. Unless waived by the department, chlorine shall be added after UV for virus inactivation and to provide a residual in the distribution system.

(11) PILOT TESTING. Pilot testing is generally not required unless factors such as fouling or aging cannot be predicted by bench-scale testing.

SUBCHAPTER VIII, HYDRO-PNEUMATIC TANKS

NR 811.61 General. The department may approve the use of hydro-pneumatic, or pressure, tanks, as provided in s. NR 811.62 (2). All of the following requirements shall be met:

(1) The tanks shall be completely housed, or earth-mounded with one end projecting into an operating house, to prevent freezing. A tank may be installed below grade if one end is exposed in a basement, vault or manhole. If the tank is installed below grade, all electrical controls and air release valves and any other appurtenances which may permit contamination of the water supply shall be extended to at least 24 inches above grade. Air release piping extended above grade shall be terminated in a down-turned U-bend screened with a 24-mesh corrosion resistant screen. The basement, vault or manhole shall be constructed to prevent surface water from entering including sealing any annular spaces where pipes and appurtenances pass through a wall, floor or ceiling. The basement, vault or manhole shall be equipped with heating, ventilation and dehumidification equipment if necessary to prevent excessive corrosion of the pressure tank and associated piping or to prevent water from freezing. Access manholes shall terminate a minimum of 24 inches above grade with an overlapping, locking cover. Vent pipes shall be metal and terminate a minimum of 24 inches above grade in a downward facing U-bend screened with a 24-mesh corrosion resistant screen. Doors shall open outward and be provided with a lock.

(2) Each tank shall be provided with bypass piping and the necessary shut-off valves to permit operation of the system while the tank is being repaired or painted. For galvanized or bladder type pressure tanks, the individual connecting pipe to each tank shall be provided with a shut-off valve, pipe union and drain fitting. Threaded drain fittings shall be provided with a vacuum breaker.

(3) Each tank not equipped with a bladder or diaphragm to separate the air and water and with a gross volume of 500 gallons or more shall have a drain fitting with shut-off valve and control equipment consisting of a pressure gauge, a pressure relief valve, a water sight glass, an automatic air blow-off, and pressure or probe operated start-stop controls for the pumps.

(4) Each tank not equipped with a bladder or diaphragm to separate the air and water and with a gross volume of 500 gallons or more or that will be painted inside shall be provided with an access manhole. If the tank interior is to be painted it shall be painted with NSF/ANSI approved paints in accordance with s. NR 810.09 (5).

(5) Each tank not equipped with a bladder or diaphragm to separate the air and water and with a gross volume of 500 gallons or more shall be provided with an automatically controlled air compressor to add air to the tank. All compressors used to routinely add air to tanks shall be oil-less. Larger capacity compressors that are not oil-less may be used temporarily to fill a tank upon startup, repair or service but shall be fitted with one or more filters and any other appurtenances necessary to remove particulates and oil from the air prior to injection.

(6) Each tank equipped with a diaphragm or bladder shall be equipped with an air inlet for adding air manually, a pressure relief valve for each tank or bank of tanks sized to handle the maximum flow rate, and pressure-operated start up and shut down controls for the well pump.

(7) The gross volume, in gallons, of any tank or combination of tanks, shall be at least 10 times the capacity of the largest pump, rated in gallons per minute, unless the proposed pump motor or motors will be controlled by a variable output control device in a manner intended to reduce the volume of required pressure tank storage in accordance with s. NR 811.34 (6). For a standard installation, the required storage volume is intended to provide a minimum pump run time of 2 to 3 minutes.

(8) Each tank shall be identified by stamping or labeling showing the manufacturer's name, a serial number, the tank volume, the allowable working pressure, and the year fabricated.

(9) Each tank not equipped with a bladder or diaphragm to separate the air and water and with a gross volume of 500 gallons or more shall be constructed of steel and have a 0.25 inch minimum side wall and head wall thickness.

SUBCHAPTER IX, STORAGE FACILITIES

NR 811.62 Volume and pressure. (1) VOLUME REQUIREMENTS. A sufficient quantity of water, as determined from engineering studies, shall be maintained in elevated storage when only one pumping unit to the distribution system is available to serve the water system. This shall be at least an average-day supply under normal operating conditions. When more than one distribution pump is available, the storage shall be in accordance with standard engineering practice. Standard engineering practice is based upon an engineering review of existing and future water supply needs including: type of service and population served; average day, maximum day, peak hour and fire flow

demands and durations; water source quality, availability and treatment, pump capacities, auxiliary power, storage capacity, water distribution and costs.

(2) PRESSURE REQUIREMENTS. Storage facilities shall be designed to meet all the following requirements:

(a) *Minimum and maximum pressures.* The storage facilities shall be designed to meet the minimum and maximum pressure requirements specified in s. NR 811.66 (1).

(b) *Fire flows and residual pressures.* When fire protection is to be provided, the storage facilities shall be designed in conjunction with distribution system design to provide the minimum fire flows and residual pressures specified in s. NR 811.70 (6).

(c) *Alternative means for maintaining pressure.* A hydro-pneumatic tank, booster pumping facilities, or other reliable means shall be provided to maintain system pressure when a gravity storage reservoir or tank is not available.

(3) ELEVATED STORAGE REQUIREMENT WAIVED. The department may waive the requirement for elevated storage if the system is designed to serve less than 50 homes, if it is not economically feasible to provide elevated storage, if elevated storage facilities are proposed for a later development phase, or if service is proposed for domestic use only.

NR 811.63 Location. Storage facilities shall be located in accordance with all the following requirements:

(1) FLOODWAY AND FLOODPLAIN.

(a) *Floodway.* Storage facilities may not be located within a floodway, as defined in s. NR 116.03 (22).

(b) *Floodplain.* If it is necessary to locate a reservoir in a floodplain, as defined in s. NR 116.03 (16), outside of the floodway, the lowest elevation of the bottom floor, including sumps, shall be a minimum of 2 feet above the regional flood elevation as determined in s. NR 116.07 (4). All projects shall conform to the requirements of that chapter.

Note: Refer to ch. NR 116 for floodplain and floodway requirements.

(2) GRADING. The area surrounding structures shall be graded in a manner that will prevent surface water from standing within 50 feet of the structure.

(3) YEAR-ROUND ACCESS. Storage facilities shall be located in an area accessible during the entire year. If necessary, road improvements shall be installed to provide year-round dry land access. Storage facilities and access roads shall be located on property owned by the water supply owner or for which the owner has obtained easements.

(4) FLOOR ELEVATIONS. The department recommends that the lowest elevations of floors and sump floors of ground level reservoirs and standpipes should be placed at or above the normal ground surface. If the department allows the floor or sump to be below the normal ground surface, it shall be placed a minimum of 2 feet above the groundwater table. Borings shall be made to determine groundwater elevations if that information is not available.

(5) CONTAMINATION SOURCES.

(a) Sewers, drains, fuel storage tanks, standing water, and similar sources of contamination shall be kept a minimum of 50 feet from the reservoir.

(b) The department may approve gravity or force main sewers within 50 feet of a reservoir if the sewer or force main is constructed of water main class pipe meeting the requirements of s. NR 811.69 and is pressure tested in place to meet the requirements of s. NR 811.12 (5) (d) 2.

(6) ROOF SURFACE ABOVE GRADE.

(a) The top roof surface of a ground level reservoir may not be less than 2 feet above normal ground surface.

(b) The department shall require a higher exposed elevation if high groundwater, poor surface drainage, or tight soils are encountered that will deter subsurface drainage or if necessary to provide positive pressures for pump intake or discharge lines in accordance with s. NR 811.37.

Note: It is recommended that no more than one-half of the reservoir depth be constructed below grade.

(c) The department may except clearwells constructed under filters from the 2 foot requirement when the total design gives the same protection.

NR 811.64 Construction details. (1) MATERIALS. Materials used in the construction of storage facilities shall meet all the following requirements:

(a) *General requirements.* 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. Unless the design engineer can justify the use

of other materials, the department will approve only steel or concrete for use in a water storage facility. Porous materials, including wood and concrete block, may not be used.

(b) AWWA *standards.* Structures shall be constructed in accordance with the AWWA standards D100, D102, D103, D104, D110, D115, D120, and D130 concerning steel; concrete or fiberglass tanks, standpipes, reservoirs, and elevated tanks in effect at the time of construction wherever they are applicable.

(2) PROTECTION. Storage facilities shall be constructed and maintained to protect the water supply in accordance with the following requirements:

(a) *General requirements.* All water storage structures shall have watertight roofs or covers which exclude surface water, rain, snow, birds, animals, insects and dust.

(b) *Installation of ancillary equipment.* The installation of ancillary equipment, such as antennas, shall be done in a manner that ensures no damage to the tank, coatings, or water quality. Any damage that occurs to the tank during installation shall be corrected.

(c) *Adjacent compartments.* Finished water may not be stored or conveyed in a compartment adjacent to nonpotable water when the two compartments are only separated by a single wall. The department may waive this requirement for backwash water holding compartments meeting potable water reservoir construction on a case-by-case basis.

(d) *Security.* Locks on access manholes, fences and ladder cage bottoms and any other necessary measures shall be provided to prevent trespassing, vandalism and sabotage.

Note: The department recommends that intrusion alarms and/or motion sensors be installed as applicable and where feasible for elevated tank pedestal access doors and reservoir access hatches. The department recommends that high strength, cut resistant locks or lock covers be installed to prevent direct cutting of a lock.

(3) DRAINS. Drains for storage structures shall meet all the following requirements:

(a) *General drain discharge requirements.*

1. Piping used to drain water from a water storage structure shall discharge to the ground surface. The drain piping shall be brought down to within 12 to 24 inches of the ground surface and discharged with a free air break over a drainage inlet structure, splash pad or riprap.

2. Drains may not be directly connected to a storm sewer. The department may approve discharge with a free air break over a storm sewer manhole or through a valved connection to the overflow piping on a case-by-case basis.

3. Drains may not be directly connected to a sanitary sewer. Clear water from drains may not be discharged to a sanitary sewer. The department may approve the temporary discharge of drain wastewater containing sediment and/or chemicals used for cleaning or temporary treatment of a water storage structure to a sanitary sewer on a case-by-case basis.

(b) *Impacts to the environment prohibited.* Negative impacts to the environment from the discharge of drainage water shall be prevented.

(4) OVERFLOW. Each reservoir shall be provided with overflow piping meeting all the following requirements:

(a) *General overflow discharge requirements.*

1. 'Discharge.' The overflow pipe of a water storage structure shall be brought down to within 12 to 24 inches of the ground surface and shall discharge with a downward opening and a free air break over a drainage inlet structure, splash pad or riprap. The department may approve discharge with a 12 to 24 inch free air break over a storm sewer manhole on a case-by case basis. Overflows may not discharge to a sanitary sewer.

2. 'Pipe diameter.' The overflow pipe shall be of sufficient diameter to permit wasting water in excess of the maximum filling rate.

3. 'Pipe material.' The over flow pipe shall be constructed of ductile iron, steel or stainless steel.

4. 'Visibility.' All overflow pipes shall be located so that any discharge is visible.

5. 'Flapper or rubber duck bill valve.' If a metal flapper valve or a rubber duck bill valve is used, a screen shall be provided in accordance with pars. (c) and (d).

(b) *Impacts to the environment prohibited.* Negative impacts to the environment from the discharge of overflow water shall be prohibited.

(c) *Elevated tanks and standpipes.*

1. When an internal overflow pipe is used on elevated tanks, it shall be located in the access tube.

2. The overflow pipe shall be provided with a 4-mesh corrosion resistant screen installed within the pipe at a location least susceptible to damage by vandalism.

(d) *Ground level structures.*

1. Overflow pipes shall terminate a minimum of 12 to 24 inches above the final graded ground surface in a manner to prevent the backflow of water into the reservoir.

2. The overflow shall be screened with 24-mesh corrosion resistant screen installed within the pipe at a location least susceptible to damage by vandalism.

3. Each reservoir chamber that can be isolated from the rest of the reservoir so that it can remain in service while other chambers are out of service shall be provided with its own overflow pipe terminating outside the reservoir in accordance with the requirements of subds. 1. and 2.

(5) INLET-OUTLET PIPING. Inlet and outlet piping to a storage structure shall meet all the following requirements:

(a) *Pressure requirements.* Inlet and outlet piping from a storage structure shall be under positive pressure at all times wherever practical and in conformance with s. NR 811.37 (1). The department may approve inlet piping that is not under positive pressure at all times on a case-by-case basis where the piping is exposed and located above grade.

(b) *Pipe sizing.* Piping shall be sized to accommodate design fill and removal rates including considerations for future improvements.

(6) BYPASS PIPING.

(a) *Groundwater facilities.* If the water system design is such that all water passes through one ground reservoir, there shall be bypass piping from the well pumps to the high lift pumps to allow the reservoir to be taken out of service for cleaning and maintenance. The department may waive this requirement if the well pumps can provide sufficient volume and pressure directly to the distribution system, if the well pumps and high lift pumps are greatly different in capacity, or if the reservoir is divided into multiple cells which can be independently removed from service. If CT is required, the department will approve bypass piping around reservoirs only if the required minimum CT can be met with the reservoir chamber or chambers out of service.

(b) *Surface water facilities.* If the water treatment plant design is such that all water passes through one ground reservoir, bypass piping or multiple cells shall be installed to allow the reservoir to be totally or partially taken out of service for cleaning and maintenance. The design shall provide for maintaining the required minimum CT while the reservoir is totally or partially out of service.

(7) ACCESS. Water storage structures shall be designed with reasonably convenient access for cleaning and maintenance. Manholes installed above the waterline shall meet the following requirements:

(a) *Elevated storage structures and reservoirs covered by inhabitable structures.* Manholes on elevated tanks, standpipes and reservoirs covered by inhabitable structures shall be framed a minimum of 4 inches above the surface of the roof. Manhole openings shall be fitted with a solid watertight cover which overlaps the framed opening and extends down around the frame a minimum of 2 inches. A compressible gasket shall be attached to the bottom side of the cover so that when the cover is closed it will provide a water tight seal around the manhole opening.

(b) *Ground storage structures.* On ground level structures, manholes shall be elevated no less than 24 inches above the top or covering sod. Manhole openings shall be fitted with a solid watertight cover which overlaps the framed opening and extends down around the frame a minimum of 2 inches. A compressible gasket shall be attached to the bottom side of the cover so that when the cover is closed it will provide a water tight seal around the manhole opening.

(c) *Locks.* Overlapping interior and exterior manhole covers shall be locked at all times except when being used by authorized personnel.

(d) *Other openings.* All other manholes, openings, or access ways shall be provided with watertight, bolted, and gasketed covers.

(8) VENTS. Water storage structures shall be vented to the atmosphere. Vent installations shall meet the following requirements:

(a) *General requirements.*

1. The overflow pipe shall not be considered a vent.

2. Open construction between the sidewalls and the roof to act as a vent is not allowed.

(b) *Exclude contamination.* Vents shall be constructed to:

1. Prevent the entrance of surface water, rain and snow as applicable.
2. Exclude birds and animals.
3. Exclude insects and dust to the extent this can be done while providing effective venting.

(c) *Elevated tanks and standpipes.* Vents installed on elevated tanks and standpipes shall terminate in a U-bend or mushroom cap constructed with the opening at least 4 inches above the roof and covered with 4- to 24-mesh corrosion resistant screen installed within the pipe or cap at a location protected from the environment. Mushroom caps shall be provided with an automatically resetting pressure-vacuum relief "frost-proof" mechanism. The skirted sides of mushroom caps shall totally cover any screens when viewing the cap from the side.

(d) *Ground level structures.* Vents installed on ground level structures shall terminate in a U-bend or mushroom cap constructed with the opening 24 to 36 inches above the roof or sod and covered with 24-mesh corrosion resistant screen installed within the pipe or cap at a location least susceptible to vandalism. The skirted sides of mushroom caps shall totally cover any screens when viewing the cap from the side.

(e) *Size.* Vents shall be sized to allow an air flow consistent with maximum water inflow and outflow rates.

(f) *Materials of construction.*

1. Vent pipes shall be constructed of ductile iron, steel, or stainless steel pipe.
2. Mushroom caps shall be constructed of steel, stainless steel, or aluminum.
3. Screens shall be constructed of stainless steel or aluminum.

(9) SILT STOP. The discharge pipes from all water storage structures shall be located in a manner that will prevent the flow of sediment into the distribution system. Removable silt stops shall be required where feasible.

(10) ROOF AND SIDEWALLS. The roof and sidewalls of all storage structures shall be constructed to meet the following requirements:

(a) *Watertight construction.* The roof and sidewalls of all structures shall be watertight with no openings except properly constructed vents, manholes, overflows, risers, drains, pump mountings, control ports, or piping for inflow and outflow.

(b) *Sealed openings.* Any pipes running through the roof, floor or sidewall of a finished water storage structure shall be sealed watertight. Openings for metal tanks shall be welded or properly gasketed. Pipes running through openings in a concrete structure shall be connected to a standard wall pipe or run through a wall sleeve which were poured in place during the formation of the structure. These wall pipes and wall sleeves shall be metal and have seepage rings embedded in the concrete. Pipes running through a wall sleeve shall be provided with a department approved watertight seal installed between the pipe and the wall sleeve.

(c) *Roof curbing.* Openings in a storage structure roof or top, designed to accommodate control apparatus, pump columns and other equipment, shall be provided with minimum 4-inch high curbing and sleeved with proper additional flashing to prevent the access of surface or floor drainage water to the structure.

(d) *Installation of appurtenances.* Valves and controls shall be located outside the storage structure so that valve stems and similar projections do not pass through the roof or top of the reservoir unless the department determines that this requirement need not be met to fulfill the other requirements of this chapter. The department may allow floor drain piping carrying graywater or a trench drain carrying graywater, electrical conduits, water service piping, and chemical feed piping to be encased in a concrete reservoir roof. Other appurtenances, including drain piping carrying blackwater, shall not be encased in a concrete reservoir roof. Toilets shall not be located above the reservoir roof.

(e) *Earth cover over reservoirs.*

1. In addition to meeting the requirements of s. NR 811.63 (6), the top of any earth covered reservoir shall be covered with a flexible waterproof membrane. The minimum membrane thickness shall be 0.060 inches. Department approval of the specific membrane proposed is required. Protective boards shall be placed over the membrane before applying the earth cover when recommended by the membrane manufacturer.
2. Bentonite panel membranes may not be used to meet the waterproof membrane requirement.
3. Earth covering of reservoirs shall be avoided where possible.

(f) *Roof slope.* The top of any storage structure shall have a minimum slope of 0.015 feet per foot to facilitate drainage.

(g) *Drainage for roof or cover.* The roof or cover of the storage structure shall be well drained, but downspout pipes may not enter or pass through the reservoir. Where parapets or similar construction which would hold water and snow on the roof are constructed, adequate waterproofing and drainage shall be provided.

(h) *Exposed grouted precast concrete planked roofs.* Grouted precast concrete planked roofs exposed to the environment shall meet the following requirements:

1. A minimum 2 inch thick reinforced concrete topping shall be installed over the top surface of the grouted plank roof. Fiber mesh may be used to provide reinforcing.

2. A minimum 0.060 inch thick flexible waterproofing membrane shall be installed over the concrete topping. Department approval of the specific membrane proposed is required. The installation of stone ballast over the membrane is optional.

3. The roof planks, concrete topping, or any insulation boards installed over the topping shall be installed to provide the minimum slope of 0.015 feet per foot required in par. (f).

(i) *Exposed reinforced poured-in-place flat concrete roofs.* Reinforced poured-in-place flat concrete roofs exposed to the environment shall be provided with a minimum 0.060 inch thick flexible waterproofing membrane installed over the roof. Department approval of the specific membrane proposed is required. The installation of stone ballast over the membrane is optional.

(11) SAFETY. Worker safety shall be considered in the design of the storage structure. The following shall apply:

(a) Ladders, ladder cages or safety climbing devices, balcony railings, landing platforms, guardrails, and safe locations of entrance hatches shall be provided where applicable.

(b) On elevated tanks where persons transfer from the access tube to the water compartment railings, handholds and landing platforms shall be provided, where applicable.

(c) On elevated tanks with riser pipes over 8 inches in diameter, protective bars shall be installed over the riser openings inside the tank.

(d) A handrail system shall be installed on the roof of any elevated tank.

(e) Storage structures shall be constructed to meet applicable local, state, including applicable portions of ch. Comm 32, and federal OSHA codes for specific safety requirements.

(f) Confined space entry should be in accordance with the requirements of s. Comm 32.29 and federal OSHA codes.

(12) FREEZING. All of the following actions shall be taken to minimize the potential for freezing:

(a) All water storage structures and their appurtenances, especially riser pipes, overflows, and vents shall be designed to minimize freezing that would interfere with proper operation.

(b) Riser pipes shall be insulated where possible.

(c) Recirculation pumps and air bubbler systems may be used to minimize freezing.

(d) Equipment used for freeze protection that will come into contact with the potable water shall meet ANSI/NSF Standard 61 or be approved by the department.

(13) TURNOVER. Storage facilities shall be designed to facilitate turnover of water in order to prevent freezing and stagnant water conditions. Consideration shall be given to installing separate inlet and outlet pipes, diffusers, baffle walls, adjusting controls to temporarily reduce storage capacities, or other department approved means where necessary.

(14) INTERNAL CATWALK. Every catwalk over a storage structure containing finished water or water to become finished water shall have a solid floor with sealed raised edges to prevent shoe scrapings, dirt, and other contaminants from falling into the water.

(15) PAINTING AND CATHODIC PROTECTION. Interior paints, coatings, and cathodic protection systems shall be installed in accordance with all of the following requirements:

(a) Metal surfaces shall be protected by paints or other protective coatings. The paints or coatings may be accompanied by cathodic protection devices.

(b) Interior paint and coating systems and application procedures shall be consistent with AWWA standard D102 in effect at the time of application, have ANSI/NSF Standard 61 approval for use in potable water, and be approved by the department in accordance with s. NR 810.09 (5). Paint and coating systems shall be applied, cured, and used in a manner consistent with the ANSI/NSF approval. After curing, the paint or coating shall not transfer any substance to the water that will be toxic or cause taste or odor problems.

(c) Cathodic protection shall be designed and installed by competent technical personnel.

Note: A copy of the cited AWWA standards is available from the American Water Works Association, 6666 West Quincy Ave., Denver, Colorado 80235.

(16) MISCELLANEOUS APPURTENANCES. The following miscellaneous appurtenances shall be installed where feasible or applicable and in accordance with the following requirements:

(a) *Smooth end sampling faucet.* A smooth end sampling faucet shall be installed in the connecting main or riser pipes of elevated tanks, standpipes, and reservoirs, if design permits. The sampling faucet shall be installed in accordance with the requirements of s. NR 811.37 (5) (b) 3.

(b) *Chlorination tap.* A threaded tap for chlorination purposes shall be installed in the connecting main or riser pipes of elevated tanks, standpipes, and reservoirs.

(c) *Valve vaults and above grade enclosures.* Valve vaults and above grade enclosures installed at the base of storage facilities shall be protected against freezing and provided with floor drainage facilities discharging to the ground surface by gravity, if possible, or else by a floor sump with a sump pump permanently installed. If constructed outside of the storage facility, the entrance to the vault or enclosure shall be locked to prevent unauthorized access.

(17) DISINFECTION. Water storage structures shall be disinfected in accordance with all the following requirements:

(a) *Disinfection required.* Water storage structures shall be disinfected before being put into service or before being returned to service following maintenance or repair work to the water storage structure. Detailed procedures for disinfection, equivalent to those outlined in AWWA standard C652 in effect at the time of disinfection, shall be written into the specifications by the design engineer or contractor as applicable.

(b) *Bacteriological sampling.* Disinfection and bacteriological sampling requirements shall meet the requirements of s. NR 810.09 (4). Detailed procedures for bacteriological sampling shall be written into the specifications by the design engineer or contractor as applicable.

(c) *Allowable chlorine in wasted water.* The amount of chlorine in any water wasted from a storage structure to the environment shall be assessed to prevent harmful impacts. Dechlorination prior to discharge may be necessary in some cases to prevent harmful impacts. Water wasted to surface water may not contain any substances in concentrations that adversely affect the water as determined under chs. NR 105 and 106. For chlorine, no total residual chlorine may be measured in water being discharged to a surface water.

Note: A copy of the AWWA standards is available for inspection at the central office of the department of natural resources and may be obtained for personal use from the American Water Works Association, 6666 West Quincy Avenue, Denver, Colorado 80235.

NR 811.65 Plant storage. The applicable design standards of ss. NR 811.63 and 811.64 shall be followed for plant storage. In addition:

(1) FILTER WASHWATER TANKS. Filter washwater tanks shall be sized, in conjunction with available pump units and finished water storage, to provide the backwash water required by s. NR 811.49. The design shall address the possibility of having to backwash more than one filter at a time, or several filters in succession.

(2) CLEARWELL.

(a) Clearwell storage shall be sized, in conjunction with distribution system storage, to relieve the filters from the strain of fluctuations in water use or peak demands.

(b) When water storage is used to provide proper contact time for disinfection, documentation, including tracer testing, shall be provided to assure adequate detention time under all operating conditions. The department may require the installation of baffle walls or additional reservoir capacity if necessary to prevent short circuiting and to obtain adequate contact times.

(3) BASINS AND WET-WELLS. Receiving basins, pump cans, and pump wet-wells for finished water or water to become finished water shall be designed as finished water storage structures.

NR 811.66 Distribution system storage. The applicable design standards of ss. NR 811.63 and 811.64 shall be followed for distribution storage. In addition:

(1) PRESSURE VARIATION. Distribution system storage facilities shall meet all the following requirements:

(a) *Allowable head range.* The maximum variation between high and low levels in storage structures which float on a distribution system may not exceed 30 feet during normal usage.

(b) *Minimum and maximum pressures.* The minimum and maximum pressure in service areas shall be 35 and 100 psi respectively at ground level.

1. In areas where a minimum of 35 psi cannot be maintained, a high pressure zone shall be established in the distribution system by means of booster pumps and related facilities or pressure boosting systems on individual service lines as required in subch. XI. The use of individual service line booster pumps shall be limited to the extent possible.

2. In situations where static pressures exceed 100 psi, pressure reducing devices may be required on mains in distribution systems having documented system deficiencies or problems due to high pressure such as main breaks and service line breaks.

Note: Section Comm 82.40 (7) (d) 2. a. requires a pressure reducing device to be installed to protect individual services when the incoming pressure exceeds 80 psig.

(2) DRAINAGE. The design shall allow draining of storage facilities for cleaning or maintenance while maintaining adequate positive pressure in the distribution system. The drains shall discharge to the ground surface as required in s. NR 811.64 (3).

(3) LEVEL CONTROLS. Adequate controls shall be provided to maintain required levels in distribution system storage structures. Level indicating devices shall be provided at a central location. Combination indicating and recording devices are recommended.

SUBCHAPTER X, DISTRIBUTION SYSTEMS

NR 811.67 Applicability. This subchapter covers water distribution systems for community water systems which are to be located in street rights-of-way or easements. Other piping systems shall be constructed in accordance with the requirements of ch. Comm. 82.

NR 811.68 Ownership of municipal water distribution systems.

(1) MUNICIPAL OWNERSHIP. The distribution system of a municipal water system shall be owned and maintained by the waterworks owner.

(2) MUNICIPALLY OWNED MAINS ON PRIVATE PROPERTY. All water mains owned by a municipal water system on private property shall be installed in permanent easements.

Note: To assure the use of approved materials and proper installation and maintenance, the department recommends that fire hydrants and water mains to be constructed on private property be installed in permanent easements and owned and maintained by the waterworks owner.

(3) PRIVATELY OWNED LOOPED MAINS REQUIRING CHECK VALVES. Water mains to be connected to the publicly owned distribution system at more than one point may be privately owned and maintained provided that a check valve is installed on the water main at each point of connection to the distribution system to prevent water from flowing back into the distribution system. Each check valve shall be located in a manhole or vault and shall be immediately preceded and followed by a buried or exposed shut-off valve on the main. The water supplier shall have access to the manholes and valves for inspection purposes.

Note: A drain fitting may be added on the piping between the check valve and the gate valve on the public water system side of the check valve. The gate valve may be closed and the drain fitting opened to periodically check for leakage through the check valve. Refer to s. Comm. 82.40 for standards for the construction of private water mains.

NR 811.69 Materials. Water main materials shall meet the following requirements:

(1) ACCEPTABLE MATERIALS. All pipe used for water main installations shall be cast iron, ductile iron, steel, reinforced concrete, polyvinyl chloride, high density polyethylene, copper or materials specially approved by the department for restricted or experimental use. If a restricted or experimental use approval is issued, the department may require special precautions until a satisfactory use record has been established. For polyvinyl chloride pipe, only joints with elastomeric gaskets or butt fusion welds shall be used.

(2) STANDARDS. Pipes, joints, fittings, valves, and fire hydrants shall have been manufactured in conformity with the latest standards issued by the AWWA and may not be used unless approved by the department. All pipe shall be minimum AWWA pressure class 150 and shall be designed for a minimum 100 psi working pressure except as approved by the department for special low pressure applications. Specifications for water main pipe and joints for water mains having a diameter less than those contained in AWWA standards shall meet the requirements of s. Comm. 82.40.

Note: A copy of the AWWA standards is available for inspection at the central office of the department of natural resources and may be obtained for personal use from the American Water Works Association, 6666 West Quincy Avenue, Denver, Colorado 80235.

(3) LEAD FREE. Any pipe, pipe fittings, solder, or flux used in the installation or repair of any public water system shall be lead free. Lead free is defined, with respect to solders and flux, as containing not more than 0.2% lead and, with respect to pipes and pipe fittings, as containing not more than 8.0% lead. Repairs to lead joints shall be made using alternative methods, if possible. For ductile iron pipe, the use of lead tipped gaskets is prohibited.

(4) PROTECTION AGAINST CORROSION. Special attention shall be given to selecting pipe materials which will protect against internal and external corrosion. If soils, groundwater, or both, are aggressive, ductile iron water mains shall be provided with polyethylene encasement installed in conformity with the latest AWWA standards.

(5) PROTECTION AGAINST CONTAMINATION FROM ORGANIC COMPOUNDS IN SOIL AND GROUNDWATER. If possible, construction of water mains through or near areas of soil or groundwater contamination shall be avoided. Special attention shall be given to selecting pipe and gasket materials for construction in contaminated soil or groundwater which will protect against external corrosion and penetration of the pipe and gaskets by the contaminants. Water mains designed to pass through or near areas of contaminated soil or groundwater shall meet the following requirements:

(a) The department shall be contacted to obtain approval of the water main design requirements prior to the submittal to the department of the plans and specifications.

(b) Installations shall meet the following design criteria:

1. Minimum class 52 ductile iron water main piping with polyethylene encasement shall be used.
2. Hydrant drain ports shall be permanently plugged or hydrant barrels installed without drain ports.
3. Nitrile gaskets shall normally be used, except as provided in subd. 4.
4. The use of fluorocarbon gaskets shall be required if:
   a. Nitrile gaskets will not be compatible with the contaminants present.
   b. The soil or groundwater contamination exceeds primary drinking water standards.
   c. The contamination concentrations and locations are uncertain.
5. Pipe bedding shall meet the requirements of s. NR 811.73 (2) (a).

(6) REHABILITATION. All materials used for the interior rehabilitation of water mains shall meet ANSI/NSF standards and may not be used until specifically approved by the department.

NR 811.70 Water main design. The design of water mains and distribution systems shall meet the following requirements:

(1) GENERAL. Water mains and water distribution systems shall be designed to maintain point-of-entry water quality. Special consideration shall be given to distribution main sizing, providing multidirectional flow where possible, providing an adequate number of shut-off valves for distribution system control, providing an adequate number of fire hydrants where fire protection will be provided, and providing for adequate flushing throughout the system. Systems shall be designed to maximize turnover, to minimize the number of dead ends and to minimize residence times while delivering code complying pressures and flows.

(2) FLOODING. Any areas of the project which are located within the floodway, as defined in s. NR 116.03 (22), or floodplain as defined in s. NR 116.03 (16), shall be identified on the plans and shall conform to the requirements of that chapter.

Note: Refer to ch. NR 116 for floodway and floodplain requirements.

(3) WETLANDS. Any areas of the project which are to be located within a wetland, pass through a wetland or may impact a wetland shall be identified.

Note: Copies of the Wisconsin wetland inventory maps are available for inspection at the office of the department of natural resources and may be purchased through the department's internet web site.

(4) PRESSURE. All water mains, including those not designed to provide fire protection, shall be sized after a hydraulic analysis based on flow demands and pressure requirements. The minimum and maximum normal static pressure in the distribution system shall be 35 psi and 100 psi, respectively, at ground level. The system shall be designed and operated to maintain a minimum residual pressure of 20 psi at ground level at all points in the distribution system under all conditions of flow.

(5) DIAMETER. The minimum diameter of water mains to provide water for fire protection and to serve fire hydrants is 6 inches. Larger mains are required if necessary to allow the required fire flow while maintaining a minimum residual pressure of 20 psi at ground level at all points in the distribution system.

(6) FIRE PROTECTION. The minimum flow requirement for water mains serving fire hydrants is 500 gpm at 20 psi residual pressure at ground level at all points in the distribution system.

Note: It is recommended that the actual fire flow design be based on the capacity of any fire pumper which may be connected to the water main and the type of services or buildings to be protected. It is also recommended that the local fire department be consulted to discuss needed fire flows before constructing water system improvements.

(7) SMALL DIAMETER MAINS. Any departure from minimum requirements shall be justified by hydraulic analysis and future water use, and will be considered for approval by the department only in special circumstances. The main sizing for small diameter mains may be calculated based upon a fixture unit determination.

Note: See the requirements of ch. Comm. 82 for guidance in sizing mains according to fixture units to be served.

(8) DEAD ENDS. Dead ends shall be minimized by looping mains whenever possible. Where dead end mains occur, they shall terminate with a fire hydrant, if flow and pressure are sufficient, or with an approved flushing hydrant or blow-off for flushing purposes. Flushing devices shall be installed on the dead end of all water main stubs 20 feet or more in length unless a shut-off valve is installed near the point of connection and closed until the stub is placed in service in the future. Flushing devices shall be sized to provide a minimum velocity of 2.5 feet per second in the water main being flushed. Flushing devices on dead end mains shall be installed downstream of all services. No flushing device shall be directly connected to any sewer.

Note: Refer to AWWA standard C651 for required flows and openings to flush pipelines.

(9) VALVING. Sufficient valves shall be provided on water mains so that inconvenience or sanitary hazard to water users will be minimized during maintenance and construction. Valves shall be located at not more than 500-foot intervals in commercial districts and at not more than one block or 800-foot intervals in other districts.

(10) FRICTION COEFFICIENTS. Unless other values are specially approved by the department, the following maximum "C" values, using the Hazen-Williams formula, shall be used for checking the hydraulic characteristics of new water mains shown on plans and specifications submitted for review:

Non-cement lined iron	C = 100
Cement lined iron	C = 140
PVC	C = 140
HDPE	C = 150

The "C" value of existing water mains and for all water mains with a pipe diameter of 12 inches or less may be less than the maximum "C" value for new pipe and shall be considered in distribution system analysis. The actual interior diameter of the pipe being modeled shall also be considered in the distribution system analysis.

NR 811.71 Hydrants. (1) LOCATION. Fire hydrants shall be provided at each street intersection and at intermediate points between intersections. Generally, fire hydrant spacing may range from 350 to 600 feet depending on the type of area being served and the individual fire hose length and fire fighting practices utilized by each system.

(2) SIZE. Fire hydrants shall have a bottom valve size of at least 5 inches, one 4.5-inch pumper nozzle, and two 2.5-inch nozzles unless the waterworks has established other hydrant criteria which are in accordance with AWWA standards C502 and C503 in effect at the time of design and are approved by the department. The connecting main between the supply main and the hydrants shall be a minimum of 6 inches in diameter.

(3) RESTRICTIONS. Fire hydrants may not be installed on proposed water mains which will not have minimum flow and pressure as required in s. NR 811.70 (6). The department may approve the installation of hydrants if system improvements which will make at least 500 gpm available at 20 psi are planned for construction within one year following construction of the proposed improvements. If the department approves the installation of hydrants which do not meet the minimum flow and pressure requirements of s. NR 811.70 (6), the hydrants shall be color coded or tagged and the fire chief shall be notified in writing that fire department pumpers may not be connected to the hydrants until the necessary additional improvements are made and fire flow tests have shown that greater than the minimum required flow and pressure are available.

(4) DRAINS. Hydrant drains may not be connected to, or located within 8 feet of sanitary sewers, storm sewers, or storm sewer inlets. If groundwater rises above the drain port, hydrant drain ports shall be permanently plugged prior to installation or hydrants with no drain ports installed and hydrant barrels shall be pumped dry during freezing weather. If hydrant drain ports are not plugged, a gravel pocket or dry well shall be provided unless the department finds that the natural earth will provide adequate drainage.

(5) AUXILIARY VALVES ON HYDRANT LEADS. Auxiliary valves shall be installed in hydrant leads off transmission water mains, off water mains in commercial and industrial districts and off all water mains 12 inches and larger.

Note: The department recommends that auxiliary valves be installed in all hydrant leads. Also, hydrants of the type that remain closed when the barrels are broken off are recommended.

(6) SERVICE LATERALS ON HYDRANT LEADS PROHIBITED. Service laterals may not be installed on hydrant leads.

(7) FLUSHING HYDRANTS. Flushing hydrants or blow-off installations shall be installed at all dead ends and at intermediate locations as necessary in order to remove sediment and optimize water quality for all water systems that do not provide fire protection. Flushing hydrants shall be sized to provide a minimum velocity of 2.5 feet per second in the water main being flushed. Flushing hydrants shall allow frost-proof operation. If necessary, flushing hydrants shall be pumped out prior to freezing weather.

(8) SAMPLING HYDRANTS AND FAUCETS. All water systems shall be provided with a sufficient number of sampling faucets, hydrants, or stations to provide representative water quality sampling sites throughout the water distribution system including extremities and dead ends. An adequate number of sampling sites shall be provided as required under the department's monitoring plan requirements contained in ch. NR809 to meet all of the department's water quality sampling requirements. Sampling faucets, hydrants, and stations shall be protected from contamination and vandalism to the extent possible. Locks shall be provided for sampling station enclosures. Fire hydrants may not be considered as sampling hydrants. All sampling locations shall be pumped out prior to freezing weather if necessary. Sampling installations may not have drain-to-soil weep ports and shall not drain to any sanitary or storm sewer.

NR 811.72 Air-relief facilities and valve and meter chambers. (1) AIR-RELIEF FACILITIES. If possible, water mains shall be constructed to avoid high points at which air can accumulate. Permanent provisions shall be installed to remove the air by means of air relief valves, hydrants, or blow-offs when high points cannot be avoided. Automatic air-relief valves may not be used in situations where flooding of the manhole or chamber may occur. The open end of an air-relief pipe shall be extended to the top of a manhole or chamber and have a screened, downward facing elbow.

(2) CHAMBERS. Chambers, pits, and manholes containing valves, blow-offs, meters, or other such appurtenances constructed for use in the distribution system shall meet the following requirements:

(a) *Location not subject to flooding or high groundwater.* If possible, chambers, pits, and manholes containing valves, blow-offs, meters, or other such appurtenances to a distribution system shall not be located in areas subject to flooding or in areas of high groundwater. If location in areas not subject to flooding or in areas of high groundwater is not possible, any valve discharge or structure vent pipes shall terminate a minimum of 24 inches above the ground surface or the high water level, whichever is the higher elevation.

(b) *Means to allow drainage.* Chambers, pits, and manholes containing valves, blow-offs, meters, or other such appurtenances to a distribution system may not be connected directly to any storm drain or sanitary sewer, nor may any blow-offs or air-relief valves be connected directly to any sewer. Chambers shall be drained to absorption pits underground or to the ground surface where they are not subject to flooding by surface water or high groundwater. If electrical power is available, sumps with sump pumps discharging above grade with a down-turned metal pipe and a free air break over grade or over a storm sewer receptacle may also be approved by the department.

(c) *Installation requirements.* If not installed in the road right-of-way or if installed in the road right-of-way in areas with minimal risk from damage due to traffic and maintenance equipment, larger below grade facilities or below grade facilities housing pumps and other electrical equipment shall meet the applicable booster pumping station requirements of s. NR 811.84. In addition, if installed in vulnerable areas of the road right-of-way, the facilities may be constructed with a gasketed, watertight, bolt-down cover at grade if approved by the department. All structures shall be vented to the atmosphere.

NR 811.73 Installation of mains. (1) GENERAL REQUIREMENTS. Installation of mains shall be in accordance with AWWA standards in effect at the time of design, manufacturer's recommended installation procedures, and the requirements of this section.

Note: A copy of the AWWA standards is available for inspection at the central office of the department of natural resources and may be obtained for personal use from the American Water Works Association, 6666 West Quincy Avenue, Denver, Colorado 80235.

(2) INSTALLATION SPECIFICATIONS. The specifications for installation of mains shall include provisions for all of the following:

(a) *Bedding.* Continuous and uniform bedding shall be provided in the trench for all buried pipe. Backfill material shall be tamped in layers around the pipe and to a sufficient height above the pipe to adequately support and protect the pipe. Grossly contaminated soil shall be removed, properly disposed of according to chs. NR 500 to NR 520 requirements, and replaced with clean material. Clean clay cut-off walls shall be installed to minimize the movement of contaminants along the trench if required by the department.

(b) *Stone removal.* Stones found in the trench shall be removed for a depth of at least 6 inches below the bottom of the pipe.

(c) *Testing.* Pressure testing of the installed pipe, including measurement of leakage and testing for electrical conductivity shall be conducted, if appropriate. Pressure and leakage testing shall be in accordance with AWWA Standard C600 in effect at the time of testing.

(d) *Disinfection and sampling.* All new, cleaned or repaired water mains shall be disinfected and sampled in accordance with the following requirements:–

1. 'Disinfection required.' Water mains shall be disinfected before being put into service or before being returned to service following maintenance or repair work. Detailed procedures for disinfection, equivalent to those outlined in AWWA Standard C651 in effect at the time of disinfection, shall be written into the specifications by the design engineer.

2. 'Bacteriological sampling.' Disinfection and bacteriological sampling requirements shall meet the requirements of s. NR 810.09 (4). The design engineer shall include detailed procedures for bacteriological sampling in the specifications.

3. 'Allowable chlorine in wasted water.' Consideration shall be given to the amount of chlorine in any water wasted from a water main to the environment to prevent harmful impacts. Dechlorination prior to discharge may be necessary in some cases to prevent harmful impacts. Water wasted to surface water may not contain any substances in concentrations that adversely affect the water as determined under chs. NR 105 and NR 106. For chlorine, no total residual chlorine may be measured in water being discharged to surface water.

Note: A copy of the AWWA standards is available for inspection at the central office of the department of natural resources and may be obtained for personal use from the American Water Works Association, 6666 West Quincy Avenue, Denver, Colorado 80235.