Chapter 2
General Design Considerations

Acronyms used in this chapter:
AWWA: American Water Works Association
CMR: Code of Massachusetts Regulations
DPD: N,N-diethyl-p-phenylenediamine colorimetric method
EPA: US Environmental Protection Agency
MassDEP: MA Dept. of Environmental Protection
OSHA: Occupational Health and Safety Act
PWS: public water system
SCADA: Supervisor Control and Data Acquisition
VPN: Virtual private network
WLAN: wireless local area networks

Chapter 2 General Design Considerations

2.0 General

The design of a water supply system or treatment process encompasses a broad area. Application of this part is dependent upon the type of system or process involved. See other relative sections in this guideline document for specific requirements.

2.1 Design Basis

The system, including the water source and treatment facilities, shall be designed for maximum day demand at the design year. All service connections shall have a minimum residual water pressure at street level of at least 20 pounds per square inch under all design conditions of flow.

2.2 Plant Layout

The design shall, at a minimum, consider the following:

a. Functional aspects of the plant layout;

b. Provisions for future plant expansion;

c. Provisions for expansion of the plant waste treatment and disposal facilities;

d. Access roads;

e. Site grading;

f. Site drainage;

g. Walkways;

h. Driveways;

i. Chemical delivery;

j. Layout of sanitary waste lines to prevent contamination of water;

k. For groundwater sources treating for secondary standards, piping for the bypass of the treatment units is allowed, provided that adequate safeguards are taken with regard to cross connection control. Under no circumstances shall bypass piping be opened, unless the appropriate MassDEP Regional Office is contacted and grants approval. Disinfection of the unused section of piping between the bypass and the treated water piping may be required, along with flushing through external hydrants prior to opening.

l. For surface water and groundwater sources treating for primary standards, bypasses of the facility are prohibited unless approved in writing by MassDEP. The MassDEP will allow the installation of a bypass arrangement, provided that a physical separation is accomplished. Bypasses may be constructed to allow insertion of a spool piece during an emergency, but only after receiving written approval from the MassDEP. Bypass arrangements shall contain appropriate valving, metering, and disinfection capabilities, with safeguards taken to prevent entry by unauthorized personnel.

2.3 Building Layout

The design shall provide:

a. Adequate ventilation;

b. Adequate lighting;

c. Adequate heating;

d. Adequate drainage;

e. Dehumidification equipment, if necessary;

f. Accessibility of equipment for operation, servicing, and removal;

g. Flexibility of operation;

h. Operator safety;

i. Convenience of operation;

j. Chemical storage and feed equipment in a separate room to reduce hazards and dust problems;

k. Employee facilities per State Plumbing Code (248 CMR 10.10 Plumbing Fixtures).

2.4 Location of Structures

No structures shall be located that will impede normal or flood stream flow without specific written approval of the MassDEP. All siting shall be done in accordance with 310 CMR 22.04 (Massachusetts Drinking Water Regulations), and all other applicable federal, state, and local regulations.

2.5 Electrical Controls

Main switch gear electrical controls shall be located above grade in areas not subject to flooding. All electrical work shall conform to the requirements of the National Electrical Code or to relevant MA State Electrical Code (237 CMR 1.00 – 23.00) and/or local codes as required.

2.6 Standby Power

Standby power is required at all water treatment facilities and other facilities as may be required by MassDEP, unless it can be demonstrated that the facility has the ability to provide the maximum daily demand for up to 24 hours by other means. This may include the combined ability of other sources to provide the maximum daily demand through existing or new emergency power generation at those sources, from storage tanks, or through a viable interconnection with another public water supplier that is part of an emergency plan approved by MassDEP. Refer to Chapter 7.7, *Standby Power*.

2.7 Shop Space and Storage

Adequate facilities should be included for shop space and storage consistent with the designed facilities.

2.8 Laboratory Facilities

Laboratory equipment and facilities shall be compatible with the raw water source, intended use of the treatment plant and the complexity of the treatment process involved. Testing equipment and supplies provided shall be adequate for the purpose intended and recognized procedures must be used. Laboratory test kits which simplify procedures for making one or more tests may be acceptable.

An operator or chemist qualified to perform the necessary laboratory tests is essential. Analyses conducted to determine compliance with drinking water regulations must be performed in an appropriately certified laboratory in accordance with latest "Standard Methods for the Examination of Water and Wastewater" or approved alternative methods.

Methods for verifying adequate quality assurances and for routine calibration of equipment shall be provided.

2.8.1 Testing and Monitoring Equipment

Testing equipment shall be provided for all plants or arrangements made for testing by a Massachusetts or EPA certified lab as required by MassDEP. As a minimum, the following laboratory equipment shall be provided:

1. Surface water supplies shall have a portable nephelometric turbidimeter meeting the requirements of latest "Standard Methods for the Examination of Water and Wastewater."

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

3. Each ion-exchange softening plant, and lime-softening plant treating only groundwater, shall have portable pH meter and titration equipment for both hardness and alkalinity unless otherwise approved in writing by MassDEP.

4. Each iron and/or manganese removal plant shall have test equipment capable of accurately measuring iron to a minimum of 0.1 milligrams per liter, and/or test equipment capable of accurately measuring manganese to a minimum of 0.01 milligrams per liter unless otherwise approved in writing by MassDEP.

5. All systems that chlorinate shall have DPD (N,N-diethyl-p-phenylenediamine colorimetric method) type test equipment for determining both free and total chlorine residual by methods in latest "Standard Methods for the Examination of Water and Wastewater." Refer to Chapter 5.4.2 .2, *Testing Equipment*.

6. All systems that fluoridate shall have test equipment for determining fluoride by methods in latest "Standard Methods for the Examination of Water and Wastewater." Refer to Chapter 5.7.6, *Testing Equipment.*

7. All systems that feed poly- and/or orthophosphates shall have test equipment capable of accurately measuring phosphates from 0.1 to 10 milligrams per liter as approved or accepted by US EPA.

8. All systems adding critical chemicals shall be monitored by an appropriate analyzer. Refer to Chapter 6.1.3, *Chemical Safety Control Strategy for Critical Chemical Feed Systems.*

9. Additional testing and monitoring equipment as may be required by MassDEP.

2.8.2 Physical Facilities

Sufficient bench space, ventilation, lighting, storage room, laboratory sink, and auxiliary facilities shall be provided. Climate control may be necessary.

2.9 Sample Taps

1. Sample taps shall be provided so that water samples can be obtained from each water source and from appropriate locations in each unit operation of treatment. Sample taps must be labeled.

2. Sample taps shall be consistent with sampling needs and should not be of the petcock type. Taps used for obtaining samples for bacteriological analysis shall be of the smooth-nosed type without interior or exterior threads, shall not be of the mixing type, and shall not have a screen, aerator, or other such appurtenance.

3. Proper sampling procedures shall be strictly practiced so that representative samples may be collected.

4. MassDEP requires finished water sampling taps to be located at consumers' tap in the distribution system and at every entry point to the distribution system after any application of treatment. However, there may be some situations where a consumer tap cannot reasonably be located. With MassDEP approval in writing, a non-freezing-type, covered, and lockable stand-alone sampling station may be approved on a case-by-case basis for residual measurement to meet the compliance monitoring requirements of the Ground Water Rule for systems that provide 4-log treatment.

5. The facility water supply service line and the plant finished water sample tap shall be supplied from a source of finished water at a point where all chemicals have been thoroughly mixed. Generally, the facility can meet this requirement if the source of finished water is located at least 100 feet downstream from the last point of chemical injection; however, in choosing this location, consideration must be given to the flow rate and the pacing equipment used for chemical injection. In some cases involving larger pipe diameters and slower chemical injection pulses per minute, a further distance will be required depending on sampling results.

2.10 Wall Castings

Consideration shall be given to providing extra wall castings built into the structure to facilitate future uses whenever pipes pass through walls of concrete structures.

2.11 Meters

All systems shall have an acceptable means of measuring the total production from all sources, the washwater, the recycled water, and the finished water. Refer to Chapter 7.6.3, *Gauges and Meters for Pumping Facilities*. All meters should be calibrated at a frequency as recommended by the meter manufacturer.

2.12 Piping Color Code

To facilitate identification of piping and tubing in wells, plants and pumping stations, the following color scheme shall be used:

Water Lines

Raw or Recycle	Olive green
Settled or Clarified	Aqua
Finished or Potable	Dark blue

Chemical Lines

Alum or Primary Coagulant	Orange
Ammonia	White
Carbon Dioxide (Gas, Liquid, and Solution)	Light Red
Carbon Slurry	Black
Caustic Compounds (NaOH or KOH)	Yellow with Green Band
Chlorine Compounds (Gas and Solution)	Yellow
Chlorine Dioxide	Yellow with Violet Band
Ferric Chloride	Orange
Fluoride Compounds	Light Blue with Red Band
Lime Slurry	Light Green
Ozone	Yellow with Orange Band
Phosphate Compounds	Light Green with Red Band
Polymers or Coagulant Aids	Orange with Green Band
Potassium Permanganate	Violet
Soda Ash	Light Green with Orange Band
Sulfuric Acid	Yellow with Red Band
Sulfur Dioxide	Light Green with Yellow Band

Waste Lines

Backwash Waste	Light Brown
Sludge	Dark Brown
Sewer (sanitary or other)	Dark Gray

Other

Compressed Air	Dark Green
Gas	Red
Other Lines	Light Gray

For liquids and gases not listed above a unique color scheme will be recommended by MassDEP upon request. In situations where two colors do not have sufficient contrast to easily differentiate between

them, a 6-inch band of contrasting color should be painted or placed on one of the pipes or tubing at approximately 30-inch intervals. The name of the liquid or gas shall be painted or placed on the pipes or tubing as well as arrows indicating the direction of flow.

2.13 Disinfection

All new, modified, or repaired wells, pipes, tanks, and equipment which can convey or store potable water shall be disinfected in accordance with American Water Works Association (AWWA) procedures or other procedures approved by MassDEP. Plans and specifications shall outline the procedure and include the disinfectant dosage, contact time, proper disposal of chlorinated water, and method of testing the results of the procedure. After disinfection, one or more water samples shall be submitted to a Massachusetts or EPA laboratory certified for bacteriological analyses. Satisfactory results shall be reported to MassDEP prior to placing the well, pipe, tank, and/or other facility in service or after being taken out of service for inspection, repairing, painting, cleaning, or other activity that might lead to contamination of the water. When the repair is the result of an unexpected transmission main or storage failure, the PWS shall adhere to protocols established as part of a comprehensive emergency response plan (see Chapter 12.1, *Minimum Components of Emergency Response Plans*).

2.14 Operation and Maintenance Manual and Parts List

An operation and maintenance manual, including a parts list and parts order form, shall be supplied to the water works for all water-related equipment, including any propriety unit equipment installed in the facility. The operation and maintenance manual shall be available at the facility at the time of final inspection and at all times after the facility is approved to go on line by MassDEP, and shall conform to Policy 93-02, *Operation and Maintenance Manuals*. Refer to Chapter 5.1.6, *Final Requirements for the Treatment Facility,* for more information.

2.15 Operator Certification and Instruction

1. Provision shall be made to ensure:

    a. That the facility or PWS is under the direct supervision of an operator who holds a valid certification equal to or greater than the classification of the treatment facility and/or the distribution system;

    b. That the operator(s) in responsible charge must hold a valid certification equal to or greater than the classification of the PWS;

    c. That all operating personnel making process control/system integrity decisions about water quality or quantity that affect public health be certified;

    d. That a designated certified operator be available for each operating shift as prescribed by 310 CMR 22.11B.

2. Provision shall be made for operator training at the start-up of a plant or pump station.

2.16 Safety

Consideration must be given to the safety of water plant personnel and visitors. The design must comply with all applicable safety codes and regulations, which may include the Uniform Building Code, Uniform Fire Code, National Fire Protection Association Standards, Massachusetts Right to Know Law, and state and federal OSHA standards. Items to be considered include noise arresters, noise protection, confined space entry, protective equipment and clothing, gas masks, safety showers and eye washes, handrails and guards, warning signs, smoke detectors, toxic gas detectors and fire extinguishers.

Refer to Chapter 5, *Treatment*, Chapter 6.3, *Operator Safety*, and Chapter 8.1.14, *Safety*, for more specific information.

2.17 Security

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

Every water treatment facility shall incorporate into their water system's emergency response plan all details and procedures related to the operation of their facility, as described in Chapter 12, *Emergency Response Planning Requirements*.

The following concepts and items shall be required in the design and construction of new water system facilities and improvements to existing water systems:

1. The design shall identify and evaluate single points of failure that could render a system unable to meet its design basis. Redundancy and enhanced security features should be incorporated into the design to eliminate single points of failure when possible, or to protect them when they cannot reasonably be eliminated.

2. Computer-based control technologies such as SCADA shall be secured from unauthorized physical access and potential cyber-attacks. Computer systems, including SCADA, shall have firewalls, passwords and other defensive measures if remote access via the Internet is desired. Any computers used for SCADA systems shall not be used to access the Internet for general browsing. Wireless Local Area Networks (WLANs) used in SCADA networks should be designed with multiple layers of protection such as firewalls, Virtual Private Network (VPN), and authentication. Wireless network communications shall be encrypted as a deterrent to hijacking by unauthorized personnel. Secure computer access and virus protection should be built into SCADA networks and effective data backup and recovery hardware and software should be utilized on a regular basis.

3. Facilities and procedures for delivery, handling and storage of chemicals shall be designed to minimize risk that chemicals delivered to and used at the facility can be intentionally released, introduced or otherwise used to debilitate a water system, its personnel, or the public. Particular

attention shall be given to potentially harmful chemicals used in treatment processes (e.g., strong acids and bases, toxic gases and incompatible chemicals) and on maintenance chemicals that may be stored on-site (e.g., fuels, herbicides, paints, solvents).

2.18 Flood Protection

Other than surface water intakes, all water supply facilities and water treatment plant access roads shall be elevated and/or protected to a minimum of two feet above the 100-year flood elevation or highest recorded flood elevation, whichever is higher, unless otherwise approved by MassDEP in writing. MassDEP recommends the station and access roads be elevated a minimum of three feet above the 100-year flood elevation to address potential climate change conditions.

Refer to MassDEP regulations 310 CMR 22.04(2), Construction, Operation, and Maintenance of Public Water Systems.

2.19 Other Considerations

Consideration must be given to the design requirements of other federal, state, and local regulatory agencies for items such as safety requirements, special designs for the handicapped, plumbing, electrical codes, construction in the flood plain, and any other consideration as may be recommended or required by MassDEP in writing.