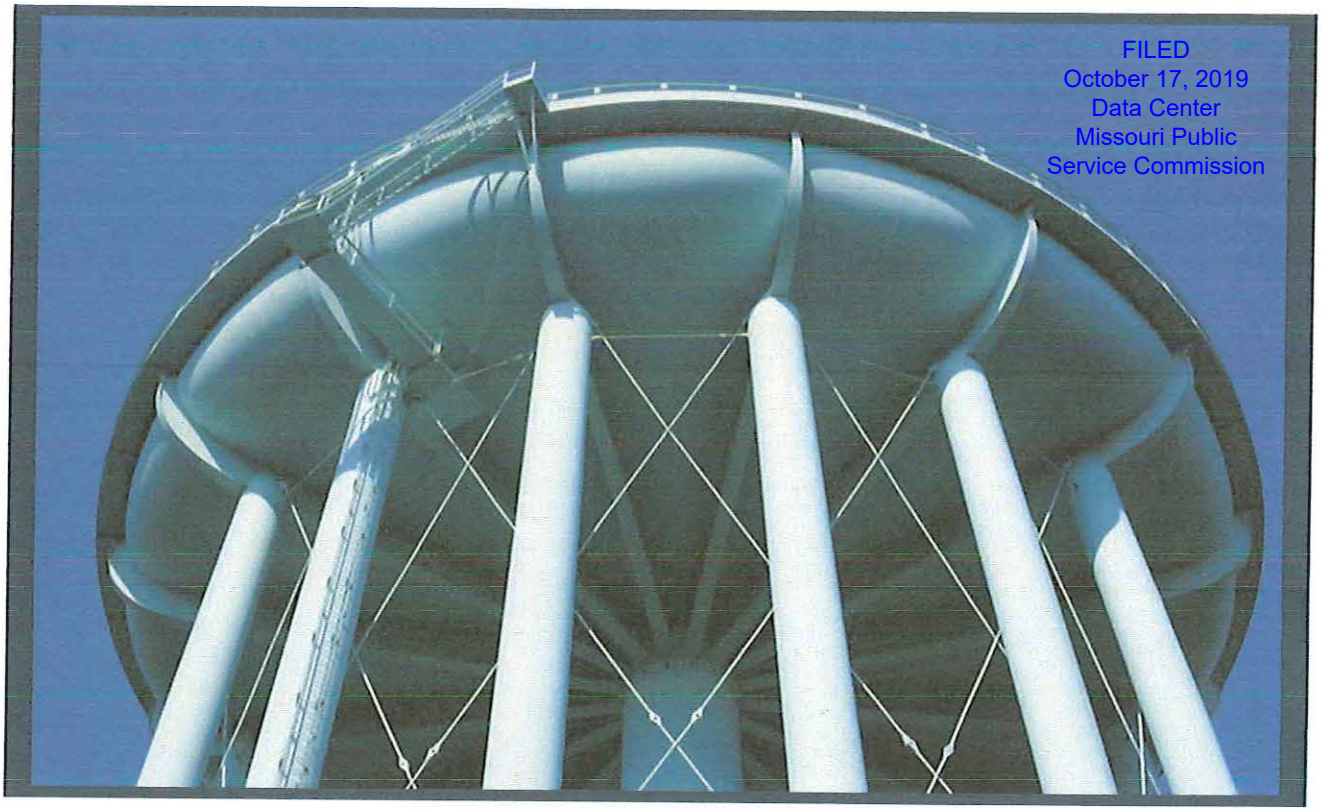

Minimum Design Standards for Missouri Community Water Systems

Effective Dec. 10, 2013

MISSOURI DEPARTMENT OF NATURAL RESOURCES

Division Of Environmental Quality Director Leanne Tippett Mosby
Public Drinking Water Branch
P.O. Box 176, Jefferson City, MO 65102-0176

PUB2489

Nothing in this document may be used to implement any enforcement action or levy any penalty unless promulgated by rule under Chapter 536, RSMo or authorized by statute.

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DEFINITION OF TERMS

The following is a list of terms used throughout this document and the definition of each.

7-day Q10 flow rate: The lowest average flow that occurs for seven consecutive days once every 10 years.

Alteration: Any change, removal or addition to an existing waterworks system, portion of the system, treatment process, and chemicals that affects any of the following:

1. Flow
2. Capacity
3. System service area
4. Source
5. Treatment
6. Reliability

This includes changes to location, materials, size, or function that differs from the original approved design and/or construction.

Community Water System: A public water system which serves at least 15 service connections and is operated on a year-round basis or regularly serves at least 25 residents on a year-round basis.

Comprehensive Performance Evaluation (CPE): A systematic review and analysis of a water treatment plant's performance without major capital improvements. It is the first part of a composite correction program.

Continuing Operating Authority: The permanent organization, entity or person identified on the permit to dispense water that is responsible for the management, operation, replacement, maintenance and modernization of the public water system in compliance with the Missouri Safe Drinking Water Law and Regulations (see 10 CSR 60-3.020).

Design Instantaneous Peak Flow: The flow rate measured at the instant the maximum demand is occurring in a water system. It is calculated by multiplying the cross-sectional area of the water pipe by the velocity of the water at any one instant.

Design Average Day Demand: The anticipated amount of water used in an average day. This is calculated by dividing the anticipated total annual water production by the number of days in the year.

Design Maximum Day's Demand: The anticipated amount of water needed to satisfy the day of highest water usage. Typically, this is 150 percent of the Average Day Demand.

Design Period: The span of time any proposed water system or water system component will be utilized.

Diurnal Flow Pattern: This is a plot of water demand versus time for a 24-hour period. The curve depicts a typical period of time and is used to simulate the daily operation of the network, especially the cycling of system storage.

Fire Protection: This is defined as the ability to provide water through a distribution system for fighting fires in addition to meeting the normal demands for water usage.

Historical Data: Actual records of past water production, consumption and other operational information.

Maximum Day Demand: The amount of water needed to satisfy the day of highest water usage. Typically, this is 150 percent of the Average Day Demand.

Maximum Flow: The greatest amount of water demanded within a specified time period.

Maximum Hour Demand: The amount of water needed to satisfy the highest flow rate in a water system occurring for one-hour duration.

Non-transient Non-community water system: A public water system that is not a community water system and that regularly serves at least 25 of the same persons over six months per year.
Normal Working Pressure: Design pressures that include all conditions of design flows excluding fire flow.
Peak Demand: The maximum momentary load, expressed as a rate, placed on a water treatment plant, distribution system, or pumping station. It is usually the maximum average load in one hour or less, but may be specified as instantaneous or for some other short time period.
Peak Flow: See: Maximum flow.
Period of Record: This is the time span covered by a particular set of data.
Permeate: As related to membrane filtration: the filtrate or the water filtered by the membrane filter
Public Water System: A system for the provision to the public water for human consumption through pipes or other constructed conveyances, if the system has at least 15 service connections or regularly serves an average of at least 25 individuals daily at least 60 days out of the year. The system includes any collection, treatment, storage, or distribution facilities used in connection with the system. A public water system is either a community water system or non-community water system.
Retentate: The filter residue: the water, chemicals and other elements withheld and not passed through by membrane filtration. Also known as reject water.
Secondary public water system: A public water system which obtains all of its water from an approved public water system(s), consists of a water distribution system, and resells the water or is a carrier which conveys passengers in interstate commerce. Parts of a primary public water system may be classified as being a secondary public water system if they meet this definition and are physically separated from those parts served by the source for the primary public water system.
Sorption: the taking in or holding of something, either by absorption or adsorption.
Transient non-community water system: A public water system that is not a community water system, which has at least 15 service connections or regularly serves an average of at least 25 individuals daily at least 60 days out of the year.

GLOSSARY

ANSI	American National Standards Institute
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
CFR	Code of Federal Regulations
COA	Continuing Operating Authority
CPE	Comprehensive Performance Evaluation
CSR	Code of State Regulations
FAA	Federal Aviation Administration
GAC	Granular Activated Carbon
HDPE	High Density Polyethylene
ISO	Insurance Services Office
NFPA	National Fire Protection Association
NIOSH	National Institute of Occupational Safety and Health
NPDES	National Pollutants Discharge Elimination System
NSF	National Sanitation Foundation
NSF	National Science Foundation
OSHA	Occupational Safety and Health Administration
PAC	Powdered Activated Carbon
PDWB	Public Drinking Water Branch
PPE	Personal Protective Equipment
PPI	Plastic Pipe Institute
PTA	Packed Tower Aeration
PVC	Polyvinylchloride
RSMo	Revised Statutes of Missouri
SCADA	Supervisory Control and Data Acquisition
SDR	Size Dimension Ratio
TOC	Total Organic Carbon
UL	Underwriters Laboratory
USC	United States Code
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UV	Ultraviolet Light

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PREAMBLE

What is the Purpose of This Document?

This publication reflects the minimum standards and guidelines of the Missouri Department of Natural Resources (the department) in regard to the preparation, submission, review, and approval of engineering reports, plans, and facilities for the construction or alteration of community public water systems. These standards are necessary for facilities to comply with the Missouri safe drinking water statutes and regulations.

These standards, consisting of proven technology, engineering principles, and sound water works practices, are intended to accomplish the following objectives: to serve as a reference for professional engineers in the design and preparation of engineering reports, plans, and specifications for community water systems; to suggest limiting values for items upon which evaluation of such engineering reports, plans, and specifications are evaluated by the department; and to ensure that a new or altered community water system facility will be capable of supplying adequate water in compliance with applicable regulations.

These standards draw heavily on the Recommended Standards for Water Works, commonly known as the "Ten State Standards." The Great Lakes-Upper Mississippi Board of Public Health and Environmental Managers created a Water Supply Committee in 1950 consisting of one associate from each state represented on the board (Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, New York, Ohio, Pennsylvania, and Wisconsin). In 1978, a representative of the Canadian province of Ontario was added. This committee was assigned the responsibility for reviewing existing water works practices, policies, and procedures, and reporting its findings to the board. The report of the Water Supply Committee was first published in 1953, and has been updated and revised several times since then. The "Ten State Standards" are widely accepted throughout the water works industry as minimum standards for construction of safe water supplies.

What Authority Is This Document Based On?

The primary authority for oversight of public water system design and construction is the Missouri Safe Drinking Water Law 640.115(2) which states "Construction, extension or alteration of a public water system shall be in accordance with the rules and regulations of the safe drinking water commission." The Missouri Safe Drinking Water Regulation 10 CSR 60-3.010(1) and (2) establishes the procedures for obtaining construction authorization, final construction approval and approval of a supervised construction program. The Missouri Safe Drinking Water Regulation 10 CSR 60-10.010 sets the requirements for submission, review and approval of engineering reports, plans and specifications for community water supply planning and construction. The Missouri Safe Drinking Water Regulation 10 CSR 60-10.020 establishes requirements for site approval of new or expanded water systems.

To Whom Do These Standards Apply?

These standards apply to new community public water systems designed during the effective dates of this document. These standards also apply to alterations made at existing community public water systems. Only the portion of the existing water system that is altered is subject to these standards. These standards are not an inspection tool to require facilities constructed with approvals issued under previous design standards to upgrade to newer standards. However, where deterioration of water quality, sanitation, safety, or performance requires corrective action, the alterations must meet or exceed minimum design standards.

What Does This Document Require?

Where the terms "shall" and "must" are used, mandatory requirements are indicated. These terms are used where practice is sufficiently standardized to permit specific delineation of requirements or where safeguarding public health justifies such definite action. Other terms, such as "should," "recommended," and "preferred," indicate desirable procedures or methods, and deviations are subject to individual consideration, but these terms in no way indicate a requirement.

Will Exceptions Be Considered?

Deviation from the mandatory "shall" or "must" requirements will be considered by the department on a case-by-case basis, based on the primary purpose of the proposed water works, the local conditions governing their functions, and operation.

In many instances in this document, exceptions are built-in. For example, general language is used where practical to account for a wide range of options (e.g., section 5.1.4.a. "positive displacement pumps"), or design alternatives are presented (e.g., section 1.1.2.d.) for meeting a requirement. Specific exceptions can be considered upon request to the department by submitting the appropriate form referenced in Chapter 9 of this document. In no case shall an exception be approved if granting such poses a proven public health risk. Reasons for a request for exception may include, but are not limited to, the following:

1. The proposal provides equivalent or superior proven performance;
2. New technology is available (See section 1.1.7.); or
3. Excessive cost of construction relating to the necessity for upgrading existing infrastructure that is within its design life.

An exception will be approved or denied based on the justification provided along with supporting documentation. Decisions may be subject to past experience, risk based analysis and prior history of compliance of the applicant.

This approach provides flexibility in meeting basic requirements that ensure the proposed new or modified water system provides safe quality and adequate quantities of drinking water. Approval of the use of "other criteria," where that option is offered, must, of necessity, be somewhat subjective and situation-specific. However, the department feels it is important to allow this extra degree of flexibility to the water system and its engineers.

Does This Document Guarantee Performance?

It is not possible for a publication of this type to address every situation that may be encountered. Future data, changes in water quality, and changing regulatory environment may also necessitate more thorough design and review than the standards covered by this document. In addition, the design standards contained within this document represent minimum acceptable standards for design and construction of public water systems in Missouri. Simply meeting minimum design standards does not guarantee acceptable performance, nor does it eliminate risk during the design life of a project. We highly recommend that design and construction account for unique situations and exceed minimum standards. We also highly recommend that managers and operators of drinking water facilities take a proactive approach to maintaining and operating facilities to maximize the effectiveness and life of your investment.

What Process Will the Department Use to Evaluate and Accept Alternative Designs?

See section 1.1.7

What Process is Available for Appealing the Department's Decision to Reject an Alternative Design?

See section 1.1.7

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Chapter 1 - Submission of Engineering Reports, Plans, and Specifications

1.0. General.

1.0.1. Preparation and Application Submittal

A minimum of one hard copy and one electronic copy of all engineering reports, final plans, and specifications should be submitted at least 30 working days prior to the date on which action by the department is desired. A completed and signed Department Form MO 780-0701 "Application for a Construction Permit" shall be submitted with all detailed plans and specifications to the Public Drinking Water Branch at the following address:

Missouri Department of Natural Resources
Public Drinking Water Branch
1101 Riverside Drive
P.O. Box 176
Jefferson City, Missouri 65102-0176
Attn: Permits and Engineering

Other federal, state, or local agencies may require permits for construction, waste discharges, stream crossings, etc. Preliminary plans and the engineer's report should be submitted for review prior to the preparation of final plans. No approval for construction shall be issued until final, complete, detailed plans and specifications have been submitted to the department and found to be satisfactory. Design-build projects will be considered on a case-by-case basis. Documents submitted for formal approval shall include but may not be limited to:

a. A summary of the basis of design, including hydraulic calculations sufficient to demonstrate the system will operate satisfactorily;
b. Identification of responsible party doing construction inspections along with their qualifications;
c. Applications for a construction permit;
d. Readily available cost estimates;
e. Specifications;
f. Detailed plans; and
g. General layout.

1.0.2. Appeals

Please refer to Chapter 9 for information on appealing decisions.

1.1. Engineering Report.

An engineering report is required for the development of a new water supply system, new water sources, and expansions or alterations to existing water systems that will result in changes to the treatment process, overall production or storage capacity, or any distribution changes that may significantly impact system hydraulics. The engineering report shall, where pertinent, present the information listed in this chapter.

1.1.1. General information

General information, including:

a. The name and mailing address of the water system's Continuing Operating Authority as defined in 10 CSR 60-3.020;
b. A description of the existing and proposed water system(s);
c. A description of the existing and proposed sewerage system and sewage treatment works as it affects the existing or proposed water system;
d. An identification of the water system, municipality (-ies) or area served with sufficient legible mapping so that the geographical area under concern is clearly understood and locatable; and
e. An imprint of professional engineer's seal or conformance with State of Missouri's engineering registration requirements.

1.1.2. Extent of the water system(s)

Extent of the water system(s), including the information in items a. through g. below:

a. A description of the nature and extent of the area to be served, including layout maps or drawings showing the legal boundaries of the water system(s).
b. Provisions for extending the water system to include additional areas.
c. Appraisal of the future requirements for service, including existing and potential residential, industrial, commercial, institutional, and other water supply needs.
d. Usage rates, water loss rates, unusual conditions, and population per service connection. This information shall be based on one or more of the alternatives listed in items 1- 4.
    1. Historical data from the public water system, if available. This data shall be representative of climatic conditions that affect demand and source.
    2. When such historical data from the public water system are not available, data from a comparable water system may be used if a rational basis for the choice of the comparison is provided and is sufficiently detailed to clearly demonstrate the applicability.
    3. If neither historical nor comparable water system data are available, the following information shall, as a minimum, be used for design purposes:
        i. Population per service connection. Unless satisfactory justification can be given for using lower per-unit occupancies, the numbers in Table 1 shall be used in determining the population for which to design the water works.

Table 1 – Per Unit Occupancies

Service Connection Type	Persons/Unit
Residences	3.7
Apartments or Condominiums	
1 Bedroom	2.0
2 Bedroom	3.0
3 Bedroom	3.7
Mobile Homes	3.0 – 3.7
Camper trailers without sewer hookup	2.5
Camper trailers with sewer hookup	3.0
Motels	3.0

ii. Domestic water usage for residential dwelling units excluding lawn/garden irrigation usage shall be an average of 80 gallons per person per calendar day, except that for rural water districts this may be an average of 60 gallons per person per day.

iii. A minimum of 10percent domestic usage per connection shall be added to account for unbilled and unaccounted for water (water loss and unbilled usage)

iv. Domestic water usage shall account for anticipated growth of the system for the expected design life of the proposed asset(s), but in no case less than 20 years.

4. Other usage criteria may be used in lieu of the criteria listed in the preceding item (1.1.2.d.3.) if the engineer provides adequate justification.

e. Lawn watering estimation may vary depending on the irrigation type, available flow, flow pressure, and area of coverage. Flow can be estimated from 0.75 – 3.0 GPM per sprinkler within a discharge pressure range of 35-100 PSIG. In lieu of the above estimation, total flow can be estimated at 12 GPM per household.

f. Peak flow (instantaneous, one hour, two hour, three hour, or four hour) shall be based on:

1. Historical data on the public water system, if available from the water system. These data shall be representative of climatic conditions that affect demand and source. If historical data is used, the entire distribution system hydraulics shall be calculated;
2. If such historical data from the public water system are not available, data from a comparable water system may be used; or
3. If neither historical nor comparable water system data are available, the following information shall be used for design purposes:
   Instantaneous Peak Flow = Domestic Peak Flow* + Lawn/Garden Irrigation Peak Flow + Commercial, Larger Users, Confined Feeding Operations
   *Domestic peak flow should be calculated as the greater of:
   i. One gallon per minute per connection, or

ii. Peak = $12(N)^{0.515}$

Where 'N' stands for number of connections

4. Other peak flow criteria may be used in lieu of the criteria listed in the preceding item (1.1.2.f.3.) if the engineer provides adequate justification; for example, rural water districts may calculate domestic peak flow as the greater of 0.75 gallons per minute per connection or Peak = 9(number of connections)$^{0.515}$.

g. Maximum day flow shall be based on:
   1. Historical data if these data are available from the public water system. This data shall be representative of climatic conditions that affect demand and source);
   2. If historical data are not available, data from a comparable system may be used; or
   3. If neither historical nor comparable data are available, the following information may be used for design purposes:
      Maximum Day Flow = 150 percent of Average Day Flow
   4. Other maximum day flow criteria may be used in lieu of the criteria in the preceding item (1.1.2.g.3.) if the engineer gives adequate justification.

1.1.3. Soil, ground water conditions, and foundation problems

The engineering report shall specifically address whether the native soils are suitable for main bedding and backfill and note the extent that crushed stone, gravel or other purchased bedding and backfill will be needed, along with estimated costs. The report shall also address the potential for rock excavation in the various soils encountered, along with estimated costs.

1.1.4. Flow requirements

Flow requirements, including:

a. Hydraulic analyses based on flow demands and pressure requirements (see Chapter 8 of this document); and
b. Refer to Chapter 7.1.1 for additional requirements when fire protection is provided.

1.1.5. Sources of water supply

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

1.1.5.1. Surface water sources

Including where pertinent:

a. Hydrological data, stream flow, and weather records;
b. Safe yield design as described in section 3.1. of this document;
c. The maximum flood flow and the safety features of the spillway and dam, shall be based on the design criteria of the Missouri Dam and Reservoir Safety Council, regardless of the height of the dam;
d. A description of the watershed, noting any existing or potential sources of contamination (such as highways, railroads, chemical facilities, farming

operations, etc.) which may affect water quality, a discussion of land use practices, and provisions for erosion and siltation control structures;

e. Summarized quality of the raw water, with special reference to fluctuations in quality, changing meteorological conditions, etc.; and
f. Source water protection issues or measures that need to be considered or implemented. (See 3.1.2)

1.1.5.2. Ground water sources

The department shall be consulted prior to design and construction regarding a proposed well location as it relates to required separation between existing and potential sources of contamination and groundwater development. The engineering report shall include:

a. A legal description of sites under consideration;
b. Advantages of the selected site;
c. Elevations with respect to surroundings;
d. Probable character of formations through which the source is to be developed;
e. Geologic conditions affecting the site; for example, any existing sinkholes, caves, test holes, abandoned wells, or anticipated interference between proposed and existing wells;
f. A summary of source exploration, test well depth, and method of construction, placement of liners or screen, test pumping rates and their duration, location, sieve analysis, water levels and specific yield, and water quality;
g. Existing wells within 300 feet radius of the proposed well site, giving their depths, protective casing depths, capacities, and location;
h. Sources of possible contamination within not less than 300 foot radius; such as sewers and sewerage facilities, highways, railroads, landfills, outcroppings of consolidated water bearing formations, chemical facilities, waste disposal wells, etc.; and
i. Wellhead protection measures being considered.

1.1.6. Alternate plans

Where two or more solutions exist for providing public water supply facilities, each of which is feasible and practicable, discuss the alternate plans. Give reasons for selecting the solution recommended, including financial considerations, and a comparison of the certification level of water system operator required.

1.1.7. New technology and unproven processes

The technologies provided in these design standards are generally based on standards of the American Water Works Association, Recommended Standards for Water Works (commonly called "Ten States Standards"), and other nationally recognized standards. These technologies have a long history of use and can be reasonably expected to perform satisfactorily. However, it is the policy of the department to encourage new technologies for the production, treatment, and distribution of drinking water while continuing to protect the public health. Any public water system proposing a new technology that is not addressed in these design standards shall provide and meet additional requirements outlined in this section.

1.1.7.1 Evaluation

a. It is not possible to cover recently developed processes and equipment in a publication of this type. However, it is the policy of the department to encourage rather than obstruct the development of new processes and equipment. Recent developments may be acceptable if they meet at least one of the following conditions:
   1. They have been thoroughly tested in full scale comparable installations under competent supervision;
   2. They have been thoroughly tested as a pilot plant operated for a sufficient time to indicate satisfactory performance; or
   3. A performance bond or other acceptable arrangements have been made so the owners or official custodians are adequately protected financially or in case of failure of the process or equipment.

b. General criteria for evaluating the merits of studies and pilot programs are as follows:
   1. Sufficient data to indicate comparable or superior performance under extreme operating conditions to existing proven technologies;
   2. Sufficient data to indicate comparable or superior reliability of service consistent with the operation and maintenance capabilities of the system for which the design is proposed; and
   3. Sufficient data to indicate comparable or superior costs of operation and maintenance to existing proven technologies.

1.1.7.2. Engineering report- Specific requirements for new technology

a. Complete description of the new technology including the scientific principles upon which the technology is based;
b. A statement indicating if the technology is currently protected by U.S. patents or is otherwise proprietary;
c. Results of full scale operations at other public water systems, with water similar to that of the public water system proposing the installation or pilot studies;
d. Pilot studies shall:
   1. Have protocols including proposed testing parameters approved by the department prior to initiating the pilot study;
   2. Be done in a manner that will assure an acceptable quality of finished water will be produced through all seasonal water quality variations of the source water;
   3. Include a research of historic data to determine the extremes of water quality that may be encountered and the research results submitted in the results of the pilot study submitted with the engineering report;
   4. Be conducted under the same operating parameters as the proposed full scale system;
   5. Include an assessment of the costs of operation, replacement, and maintenance to be included in the results of the pilot study submitted with the engineering report; and

6. Be done in a manner to show repeatability of performance under the same operating conditions and the effects of long term operation.

e. The expected design life of each equipment component used in the new technology and the present day replacement cost of each component including both material cost and labor cost;
f. A complete description of the training needed for public water system personnel to operate and maintain the new technology including the number of days of training and the cost of training. If initial training is provided with the purchase price, the cost of training additional operators or maintenance personnel must be identified to cover personnel turnover;
g. The estimated number of minutes or hours needed per day, week, month, quarter, or year (as appropriate) including any down time expected to operate and maintain the components of the new technology. Any expected maintenance or repairs that must be done by vendor or factory personnel must also be identified along with costs, frequency, and down time;
h. The estimated costs of operating and maintaining the new technology;
i. A complete description of standard technology including detailed cost estimates of material, labor, engineering, and contingency that would be needed to replace the new technology in the event the new technology is found to be ineffective; and
j. A complete list of operating records, maintenance records, cost records, and testing protocol needed to evaluate the performance of the new technology.

1.1.7.3. Specific requirements for financial certification

The public water system chief financial officer (or equivalent official if appropriate) shall provide written certification to the department that the system has financial resources that are adequate to operate and maintain the new technology and to replace the new technology with standard technology should the new technology be found to be ineffective. This certification shall include the nature of the financial resources, which may include but is not limited to:

a. Cash reserves in bank accounts;
b. U.S. Government securities;
c. Other investments (stocks, bonds, mutual funds, precious metals, etc.);
d. Local bonds passed for this project but left in reserve to cover this contingency;
e. Binding agreement with a government funding agency to provide the funding needed to replace the new technology if it proves ineffective;
f. A performance bond meeting the conditions noted in the Performance Contract; and
g. Projected annual operating fund surpluses.

1.1.7.4. Specific requirements for performance contract

The public water system shall enter into a contract with the department that includes the following elements: (A less stringent method would be a written certification instead of a contract)

a. The new technology shall be deemed ineffective if use of the technology results in a maximum contaminant level violation, action level violation, or treatment technique violation listed in 10 CSR 60 during any three months during a running 12-month period over the life of the performance period;
b. The new technology shall be deemed ineffective if use of the technology results in water outages or pressure reduction below 20 pounds per square inch gage (20 PSIG) during any three months during a running 12-month period over the life of the performance period;
c. The public water system shall maintain financial resources to replace the new technology with standard technology during the life of the contract. The reserve funds needed shall be initially based on the standard technology cost estimate from the engineering report and shall be increased annually for inflation using the federal consumer price index (or other suitable index);
d. The public water system will provide the operation and maintenance, including operator and maintenance personnel training, as outlined in the engineering report;
e. The public water system will collect and record all operation, maintenance, and cost records and perform all analysis outlined in the engineering report;
f. The public water system shall obtain the services of a professional engineer registered in Missouri to oversee data collection, record keeping, and provide a complete engineering analysis of the new technology after one year of operation, after the performance period is completed, and (if needed) following the department issuing a preliminary intent to declare the technology ineffective for this public water system. The professional engineer shall submit two copies of the engineering analysis to the department within six months of the end of the first year, within six months of the end of the performance period, and within six months of the department issuing a preliminary intent to declare the technology ineffective for this public water system. This engineering analysis shall evaluate the effectiveness of the new technology for its intended purpose and list all data and calculations supporting this evaluation, note any problems with operation or maintenance and including how, when, or if these problems were solved, note actual times spent operating and maintaining the new technology and compare these with those estimated in the engineering report, calculate costs of operating and maintaining the new technology and compare these with those estimated in the engineering report, complete a reassessment of the expected life of major components of the new technology, include the engineer's conclusion as to whether or not this technology was effective for this public water system and include the engineer's recommendation (with any reservations) as to whether or not this technology should be widely approved for similar application;
g. If the public water system has maximum contaminant level violations, action level violations, treatment technique violations, or low pressure violations at the frequency noted above in items a. and b., that, in the department's opinion, could be the result of use of the new technology, the department shall issue a preliminary intent to declare the new technology ineffective for this public

water system. The public water system shall then submit the engineering evaluation within the time frame noted above in item f.;

h. The department shall review the engineering evaluation and conduct other investigations as it deems necessary including, but not limited to, investigations by department employees or contractors, invitations to submit analysis from the vendor, manufacturer, and original project engineer (if different from the evaluation engineer). Within six months of submittal of the engineering evaluation by the public water system, the department shall make a formal determination of whether or not the new technology is ineffective for this public water system; and

i. If the department formally determines the new technology is ineffective for this public water system, the public water system shall:
   1. Within 180 calendar days, submit engineering plans and specifications prepared by a professional engineer registered in Missouri and a completed construction permit application to the department for replacing the new technology with the standard technology identified in the original engineering report;
   2. Within 30 calendar days of receipt of any request from the department for additional information or changes in the engineering plans and specifications, the public water system shall submit these alterations to the department;
   3. Within 180 calendar days of the department's approval to construct, the public water system shall construct the new facilities; and
   4. Within 21 calendar days of completion of construction, the public water system shall submit certification by the professional engineer stating that the project has been substantially completed in accordance with the approved plans and specifications to the department.

1.1.7.5. Performance period

The length of the performance period shall be the lesser of 60 months or the expected life of the major components of the new technology. The life of the contract shall be the performance period plus 12 months, which includes six months for the engineering analysis and six months for the department's final determination of effectiveness.

1.1.7.6. Performance follow-up

Initially, the department will approve only one project for a particular new technology statewide. After the department completes review of the one year engineering evaluation of this first project, the department may approve an additional nine projects for a particular new technology statewide. If any project is formally declared to be ineffective, all approvals shall cease until the department reassesses the new technology and determines if the failure was site specific or more general.

After the completion of ten successful projects for a particular new technology and department review of all engineering evaluations, the department may develop design standards allowing the new technology to become standard

technology or may allow additional projects to gather more information if needed. Ultimately, the department will either develop standards or will declare the new technology inappropriate for use in Missouri.

1.1.8. Project sites

The area and approximate geometry of the proposed site shall be identified and the adequacy for adding additional facilities on the site, and for providing adequate security. The proximity of residences, industries and other establishments shall be identified and their effect on the safety, security, operation and maintenance of facilities.

a. Projects located in areas that are subject to a significant risk from earthquakes, floods, fires, pollution or other disasters which could cause a breakdown of the public water system shall be designed to protect the facilities to the extent practical.
b. Systems shall not be located on sites with any potential sources of pollution or other factors that may influence the quality of the supply or interfere with effective operation of the water works system, such as sewage absorption systems, septic tanks, privies, cesspools, sinkholes, sanitary landfills, refuse and garbage dumps.

1.2. Plans.

Plans for water systems shall be legible and no larger than standard size 24 inches by 36 inches.

1.2.1. Plans shall include the following:

a. Suitable title identifying the project, and index;
b. The name of the Continuing Operating Authority responsible for the water supply;
c. The name of the public water system, or proposed public supply system;
d. The public water system's ID number;
e. Scale, in feet;
f. North point;
g. Latest U.S.G.S. datum and topographical elevations for new and existing tanks determined from surveys beginning at USGS or department elevation monuments;
h. Legible prints suitable for reproduction;
i. Date, name, and address of the designing engineer;
j. Imprint of professional engineer's seal in conformance with State of Missouri's engineering registration requirements;
k. Boundaries of municipality, water district, or area to be served;
l. Location and size of existing water mains;
m. Location and nature of existing water system structures and appurtenances affecting the proposed improvements, noted on one sheet;
n. Location and description of existing and proposed sewerage system;
o. Location of proposed water mains and water system structures, with size, length and identity;
p. Contour lines at suitable intervals; and
q. Names of streets and roads.

1.2.2. Detailed plans include:

a. Stream crossings, providing profiles with elevations of the streambed, general geology under the stream bed and the normal and extreme high and low water levels;
b. Profiles, where necessary, having a horizontal scale of not more than 100 feet to the inch and a vertical scale of not more than ten feet to the inch, with both scales clearly indicated. (Note: This does not apply to entire distribution systems.);
c. Location and size of the property to be used for the water works development with respect to known references such as roads, streams, section lines, or streets;
d. Topography and arrangement of present or planned wells or structures, with contour intervals not greater than two feet;
e. One hundred-year flood plain or elevations of the highest known flood level, floor of the structure, upper terminal of protective casings and outside surrounding grade, using U. S. Coast and Geodetic Survey, U. S. Geological Survey or equivalent elevations where applicable as reference;
f. Plat and profile drawings of well construction, showing the diameter and depth of drill holes and casings; liner diameters; grouting depths; elevations and designation of geological formations; water levels and other details to describe the proposed well completely;
g. Location of all existing and potential sources of pollution within not less than 300 -foot radius of the source, and within 300 feet of underground treated water storage facilities;
h. Size, length, and identity of sewers, drains, and water mains, and their locations relative to plant structures;
i. Schematic flow diagrams and hydraulic profiles showing the flow through various plant units;
j. All piping in sufficient detail to show dimensions, elevations, sectional views, and flow through the plant, including waste and chemical feed lines;
k. Locations of all chemical storage areas, feeding equipment, and points of chemical application;
l. All appurtenances, specific structures, equipment, water treatment plant waste disposal units, and points of discharge having any relationship to the plans for water mains and water system structures;
m. Locations of sanitary or other facilities, such as lavatories, showers, toilets, floor drains, etc.;
n. Locations, dimensions, and elevations of all proposed plant facilities;
o. Locations of all sampling taps;
p. Dimensional plans of elevation, sectional and detailed views of all process and storage tanks; and
q. Adequate description of any features not otherwise covered by the specifications.

1.3. Specifications.

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

a. A description of how existing water system facilities will continue in operation during renovation or construction of additional facilities to minimize interruption of service;
b. The specification of laboratory facilities and equipment;
c. The number and design of chemical feeding equipment;
d. A description of materials or proprietary equipment for sanitary or other facilities including necessary cross connection protection;
e. The specification of manufactured products such as pipe, valves, fittings, hydrants, steel, Portland cement, etc. by the appropriate national standard, sufficient to differentiate the exact product. Any stamp or marking required to identify the product as meeting the national standard and an affidavit from the manufacturer stating that the product meets the national standard. The standard names, number, effective date, publication date, name and address of the organization issuing the standard shall identify the national standard. Specifications for manufactured products may also include the complete detailed national standard at the discretion of the engineer;
f. All procedures, methods, testing requirements, and products except manufactured products noted in paragraph 1.3.e. above, specified by the appropriate national standard and all details of the national standard needed to properly construct the water system component shall be included in the specifications. The standard name, number, effective date, publication, name and address of the organization issuing the standard shall identify the national standard;
g. Where performance specifications are used, shop drawings must be provided;
h. Provisions for training of system operators to be provided by equipment manufacturers or suppliers concerning the operation and maintenance of the new facilities. The fulfillment of the training requirements will not be complete until system officials certify that adequate training has been provided;
i. Requirement for operation and maintenance manuals to be provided to the system by equipment manufacturers or suppliers on equipment and systems installed;
j. An executive summary describing the way a SCADA or other process instrument control system is intended to function; and
k. Requirements that coatings, sealants, additives, piping, fittings, appurtenances and materials in direct contact with the water shall meet National Science Foundation (NSF) Standard 61 to prevent imparting of harmful substances into the water. Untreated materials that are historically used in water treatment plant construction such as concrete, steel, iron, aluminum, stainless steel, redwood, cyprus, fiberglass, etc. are not required to have NSF approval.

1.4. Summary of Design Criteria.

A summary of complete design criteria shall be submitted for the proposed project, containing but not limited to the following:

a. Long term dependable yield of the source of supply;
b. Reservoir surface area, volume, and a volume versus depth curve;
c. Area of watershed;
d. Estimated average and maximum day water demands for the design period.
e. Number of proposed services;

f. Firefighting requirements;
g. Flash mix, flocculation and settling basin capacities;
h. Retention times;
i. Unit loadings;
j. Filter area and the proposed filtration rate;
k. Backwash rate; and
l. Chemical feeder capacities and ranges.

1.5. Additional Information Required.

The department may require additional information, which is not part of the construction drawings, such as head loss calculations, proprietary technical data, copies of deeds, copies of contracts, shop drawings, etc.

1.6. Revisions to Approved Plans.

a. Any deviation from approved plans or specifications affecting capacity, hydraulic conditions, operating units, the functioning of water treatment processes, or the quality of water to be delivered must be approved in writing before such changes are made.
b. Revised plans or specifications shall be submitted to the department for review and approval before any construction work affected by such changes is started.

1.7. Final Approval of Construction.

a. Final construction approval or a written interim approval to operate must be obtained from the department for all projects for which approval is required before that project is placed into service.
b. Upon completion of the construction, the engineer must:
    1. Notify the department and establish a mutually satisfactory time for making a final inspection, certify in writing that the construction is substantially completed in accordance with approved plans and specifications and change orders;
    2. Submit one hard copy, and one electronic copy of as-built plans to the department;
    3. Show that water quality is acceptable to the department;
    4. Submit the final cost of the project with all components of cost identified;
    5. Provide O&M manuals to system operators on systems and equipment installed; and
    6. Submit a statement of work completed.
c. In larger projects, an interim (partial) approval may be secured for the completed parts of the water system before they are placed in service.

1.8. Supervised Program.

a. A supplier of water may apply for an owner supervised program in lieu of submitting plans and specifications for expansion or alteration of an existing water distribution system.
b. A written request to the Department of Natural Resources for approval of a supervised program must include the following information:
    1. An engineer prepared report or a master plan showing the proposed waterlines over at least the next five years, along with engineering rationale, including hydraulic analyses, for sizing and locating the lines. The engineering report must discuss adequacy of present water system with regard to the source, storage and existing distribution piping,

discuss problems that need to be resolved (leaks, low pressures, etc.), discuss fire protection needs (if applicable). A priority listing of proposed improvements along with cost estimates should also be included in the engineering report;

2. A current layout map, or maps, of the distribution system (standard size 24" x 36"). The maps must show waterline sizes (existing and proposed), location of valves, fire hydrants and flushing devices, along with street names;
3. Adoption of a minimum pipe size for waterline replacements not otherwise shown on the master plan which will maintain a minimum pressure in accordance with Chapter 8 of this document;
4. Examples of permanent records and drawings of the distribution system including lines, valves, hydrants and cleanouts. Record plans must be large enough scale and provide sufficient detail to locate lines, valves and other appurtenances for excavation using only the plans;
5. Technical specifications prepared by an engineer covering construction materials, installation, and disinfection procedures in accordance with American Water Works Association standards;
6. Typical detail drawings by an engineer of special crossings, meter settings, valve settings, hydrant settings, cleanouts, thrust blockings, etc.;
7. A brief statement about qualifications of the person responsible for construction and inspection;
8. A description as to how permanent records and drawings will be provided. If permanent records and drawings are to be prepared by a consulting engineer, a copy of the agreement with the firm must be provided; and
9. Examples of inspection forms to be used to inspect water mains and appurtenances.

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 chapter depends on the type of system or process involved.

2.1. Design Basis.

The system shall be designed for maximum day demand at the design year.

2.2. Plant Layout.

Design of new treatment plants, well houses and pump stations shall consider:

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, driveways, walks, and fencing;
e. Site grading and drainage;
f. Chemical delivery and storage facilities;
g. Security of facilities; and
h. Provisions for safety

2.3. Building Layout.

Design shall provide for:

a. Adequate ventilation, lighting, emergency lighting, heating, and floor drainage;
b. Dehumidification equipment, if necessary;
c. Accessibility of equipment for operation, servicing, and removal;
d. Flexibility of operation, convenience of operation, and operator safety;
e. Chemical storage and feed equipment in separate rooms to reduce hazards and dust problems;
f. Adequate facilities should be included for shop space and storage, consistent with the designed facilities; and
g. Adequate number of emergency exits.

2.4. Site Selection Requirements.

a. Site must not be subject to a significant risk from floods, fires, pollution, or other disasters, which could cause a breakdown of the public water supply system or portion thereof.
b. Non-submersible intake pumping equipment and accessories must be located or protected to at least four feet above the 100-year flood elevation or the highest flood elevation on record.
c. The department must be consulted regarding any structure that may impede normal or flood stream flows.
d. In earthquake prone areas, structures should be designed to withstand earthquake effects.
e. The site will provide all-weather access road to all significant facilities.

2.5. Security and Safety Measures.

a. All water system facilities shall be designed to include measures to provide protection against vandalism, sabotage, terrorist acts, or access by unauthorized personnel. Protection measures may include, but is not limited to:
   1. Lockable doors and access ways;
   2. Secured outdoor electrical and control systems;
   3. Windows designed to deter human entrance;
   4. Exterior lighting sufficient to provide safe access and deter vandalism and sabotage; and
   5. Fencing around vulnerable areas of drinking water facilities such as treatment and storage facilities, pumping stations and wells with signs prohibiting unauthorized access.

b. Unless otherwise noted in this document, design and construction of all ladders, stairways, handrails, safety cages, fall protection and other safety appurtenances for water system facilities shall conform to the latest federal Occupation Safety and Health Administration (OSHA) Regulation 29 CFR, Part 1910, Subpart D, Occupational Safety and Health Standards, General Industry Standards. Safety appurtenances shall also conform to any applicable local ordinances, codes, standards or portion thereof that are more stringent than the OSHA standards.

2.6. Electrical Controls.

Main switch gear electrical controls shall be located above grade, and in areas not subject to flooding.

2.7. Standby Power.

For the system's own protection, standby power or an alternate power source should be provided for community water supplies that rely on their own treatment and pumping facilities to maintain their water system so that water may be treated and pumped to the distribution system during power outages to meet average day demand. Systems serving a population of 3,300 or greater shall have arrangements in place for standby or backup power and shall include these arrangements in their emergency operating plan.

2.8. Laboratory Equipment.

Each community water supply shall have its own equipment and facilities for routine laboratory testing necessary to ensure proper operation. Laboratory equipment selection shall be based on the characteristics of the raw water source and the complexity of the treatment process involved. Laboratory test kits that simplify procedures for making one or more tests may be acceptable. Analyses conducted to determine compliance with drinking water regulations must be performed in an appropriately certified laboratory in accordance with "Standard Methods for the Examination of Water and Wastewater," methods recommended by the USEPA in their list of approved methods or by methods approved by the department. Persons designing and equipping facilities for which laboratory certification by the department is desired shall confer with the department before beginning the preparation of plans or the purchase of equipment. Methods for verifying adequate quality assurance and for routine calibration of equipment shall be provided.

2.8.1. Testing equipment

a. Surface water supplies:
   1. Shall have a bench model Nephelometric turbidimeter;
   2. Shall have continuous Nephelometric turbidity monitoring and recording equipment on effluent lines located such that both filter effluent and filter-to-waste can be monitored;
   3. Shall have electrode pH meter;
   4. Shall have equipment necessary to perform jar test;
   5. Shall have titration equipment for both hardness and alkalinity; and
   6. Should provide the necessary facilities for microbiological testing of water from both the treatment plant and the distribution system.

b. Groundwater supplies, where pertinent:
   1. Shall have test equipment capable of accurately measuring iron and manganese to a minimum of 0.05 milligram per liter;
   2. Shall have electrode pH meter;
   3. Shall have titration equipment for both hardness and alkalinity; and
   4. With lime softening facilities, should have a Nephelometric turbidimeter.

c. Public water supplies that:
   1. Chlorinate shall have test equipment for determining both free and total chlorine residual by methods in "Standard Methods for the Examination of Water and Wastewater";
   2. Fluoridate shall have test equipment for determining fluoride by methods in "Standard Methods for the Examination of Water and Wastewater"; and
   3. Feed polyphosphates and orthophosphates shall have test equipment capable of accurately measuring phosphates from 0.1 to 20 mg/L.

2.8.2. Physical facilities

Sufficient bench space, adequate ventilation, adequate lighting, electrical receptacles, storage room, laboratory sink, and auxiliary facilities shall be provided. Air conditioning may be necessary.

2.9. Monitoring and Recording Equipment.

All water treatment plants with a capacity of 0.5 MGD or more should be provided with continuous monitoring and recording equipment to monitor water being discharged to the distribution system.

a. Plants treating surface water and plants using lime for softening:
   1. Should have the capability to monitor and record free or combined chlorine residual, temperature and pH;
   2. Shall have continuous monitoring of entry point disinfection residuals for systems with a service population greater than 3,300 people; and
   3. Should have monitoring of the parameters to evaluate adequate CT disinfection, such as residuals, pH and water temperature.

b. Plants treating ground water using iron removal or ion exchange softening should have the capability to monitor and record free chlorine residual.

2.10. Sample Taps.

a. 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.
b. Taps shall be consistent with sampling needs and shall not be of the petcock type.
c. Taps used for obtaining samples for bacteriological analysis shall be of material that resist flaming, 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 appurtenances.
d. The location of sample taps shall consider safety and ease of access for the operator, including the height above the floor, and the drainage of flushed water.
e. Ground water sources require at least one sample tap prior to any chemical treatment for compliance with the Ground Water Rule.
f. At least one sample tap after treatment and contact time is required for monitoring the treatment processes.

2.11. Facility Water Supply.

a. 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, and the required disinfectant contact time has been achieved.
b. There shall be no cross-connections between the facility water supply service line and any piping, troughs, tanks, or other treatment units containing wastewater, treatment chemicals, raw or partially treated water.

2.12. 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.

2.13. Meters.

All water supplies shall have an acceptable means of metering the raw water flow, finished water flow, flow through the treatment plant, and treatment plant service flow.

2.14. Piping Color Code.

To facilitate identification of piping in plants and pumping stations the color scheme in Table 2 is recommended. In situations where two colors do not have sufficient contrast to easily differentiate between them, a six-inch band of contrasting color should be on one of the pipes at approximately 30-inch intervals. The name of the liquid or gas should also be on the pipe. In some cases, it is also advantageous to provide arrows indicating the direction of flow.

Table 2 – Piping Color Code

TYPE OF PIPE	PIPE COLOR
WATER LINES	
Raw	Olive
Settled or Clarified	Aqua
Finished or Potable	Dark Blue
CHEMICAL LINES	
Alum or Primary Coagulant	Orange
Ammonia	White
Carbon Slurry	Black
Caustic	Yellow with Green Band
Chlorine (Gas and Solution)	Yellow
Fluoride	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
Residuals	Dark Brown
Sewer (Sanitary or Other)	Dark Gray
OTHER	
Compressed Air	Dark Green
Gas	Red
Other Lines	Light Gray

2.15. Disinfection.

All wells, pipes, tanks, and equipment which can convey or store potable water shall be disinfected in accordance with the current AWWA procedures. Plans or specifications shall outline the procedure and include the disinfectant dosage, contact time, and method of testing the results of the procedure.

2.16. Manuals and Parts List.

Provisions for supplying the water system with an operation and maintenance manual including a parts list, parts order form, and written instruction for start-up of the plant or station is required for approval of any proprietary unit installed in the facility.

2.17. 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 and electrical codes, construction in a flood plain, etc.

2.18. Automation.

The department encourages measures, including automation, which assist operators in improving plant operations and surveillance functions. Automation is not a substitute for qualified staffed operation and maintenance and all treatment plants must be staffed by qualified operators for what the department determines to be an appropriate part of each working day. Off-site automated operation of groundwater treatment facilities will be considered on a case by case basis. Automated, unstaffed, unsupervised operation of a surface water treatment facility does not adequately protect public health and is generally not acceptable. Automation of surface water treatment facilities to allow unattended operation with staffed off-site control presents a number of management and technological challenges that must be overcome before an approval can be considered. Automation of any type of treatment facility requires that each facet of the plant facilities and operations must be fully evaluated to determine what on-line monitoring is appropriate, what alarm capabilities must be incorporated into the design and what staffing is necessary. Consideration must be given to the consequences and operational response to treatment challenges, equipment failure and loss of communications or power.

The engineering report to be submitted to the department for review must cover all aspects of the treatment plant and automation system including the following information and criteria:

a. Identification of all critical features in the pumping and treatment facilities that will be electronically monitored, have alarms that directly contact a qualified operator, and can be operated automatically or off-site via the control system. Include a description of automatic plant shutdown controls with alarms and conditions that would trigger shutdowns. Dual or secondary alarms may be necessary for certain critical functions;
b. Provision for automated monitoring of all critical functions with major and minor alarm features. Automated plant shutdown is required on all major alarms. Automated remote startup of the plant is prohibited after shutdown due to a major alarm. The control system must have response and adjustment capability on all minor alarms. Built-in control system challenge test capability must be provided to verify operational status of major and minor alarms;
c. The plant control system that has the capability for manual operation of all treatment plant equipment and process functions;
d. A plant flow diagram that shows the location of all critical features, alarms and automated controls to be provided;
e. Description of off-site control stations that allow observation of plant operations, receiving alarms and having the ability to adjust and control operation of equipment and the treatment process;
f. Description of optimal staffing for the plant design, including meeting requirements in 10 CSR 60-14.010 for certified operators; an on-site check at least once per day by a certified operator to verify proper operation and plant security; and sufficient appropriate staffing to carry out daily on-site evaluations, operational functions, and maintenance and calibration of all critical treatment components and monitoring equipment and weekly checks of the

communication and control system to ensure reliability of operations. Challenge testing of such equipment should be part of normal maintenance routines;

g. Description of operator training planned or completed in both process control and the automated system;
h. Operations manual, which gives operators step-by-step procedures for understanding and using the automated, control system under all water quality conditions. Emergency operations during power or communications failures or other emergencies must be included;
i. A plan for a 6-month or more demonstration period to prove the reliability of procedures, equipment and surveillance system. A certified operator must be on duty during the demonstration period. The final plan must identify and address any problems and alarms that occurred during the demonstration period. Challenge testing of each critical component of the overall system must be included as part of the demonstration project;
j. A schedule for maintenance of equipment and critical parts replacement;
k. Provision for sufficient finished water storage to meet system demands and CT requirements whenever normal treatment production is interrupted as the result of automation system failure or plant shutdown; and
l. Provision for ensuring security of the treatment facilities at all times. Incorporation of appropriate intrusion alarms must be provided which are effectively communicated to the operator in charge. See section 2.5 Security Measures.

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Chapter 3 - Source Development

3.0. General.

In selecting the source of water to be developed, the design engineer must prove that an adequate quantity of water will be available. The proposed groundwater or surface water source must be adequate for future water demands during the design period. Water that is to be delivered to the consumers will meet the current requirements of the department with respect to microbiological, physical, chemical and radiological qualities. Each public water system should take its raw water from the highest quality and sustainable source that is economically reasonable and technologically possible.

3.1. Surface Water.

A surface water source includes all tributary streams and drainage basins, natural lakes, and artificial reservoirs above the point of water supply intake. A source water protection plan enacted for continued protection of the watershed from potential sources of contamination should be developed by the Continuing Operating Authority for all new surface water sources.

3.1.1. Quantity

a. Reservoir storage volume shall provide a reasonable surplus for reserve storage. A reasonable amount of surplus reserve storage should be considered in order to maintain public confidence in the reliability of supply at predicted depletion levels during a prolonged severe drought. A minimum of 120 days surplus reserve storage should be considered.
b. Reservoir storage volume shall provide for anticipated growth for a period of at least 20 years.
c. Reservoir storage volume shall be adequate to compensate for all losses such as silting, evaporation, seepage, stagnation, and required discharges to maintain downstream flows.
d. When multiple water sources are provided, the amount of water needed from the proposed reservoir shall be stated and that amount plus water losses due to sediment, evaporation, seepage, and stagnation shall be used to design the reservoir capacity.
e. The capacity of a water supply reservoir shall be determined by using a reservoir operations model such as the USDA Natural Resource Conservation Service's Procedures for Determining Runoff and Reservoir Operation Study. A reservoir study shall be conducted for the drought of record using future design period demand for the water system. The design draft shall include water losses due to sediment, evaporation, seepage, and stagnation as well as the predicted water system demand. Losses due to sediment shall be the accumulated loss predicted at the end of the design period of the reservoir. Climatic data such as precipitation and evaporation used shall be as specific to the proposed reservoir site as is possible. The usable quantity of water in a reservoir shall be sufficient to provide carryover storage at all design future demands and shall include a sufficient reserve to maintain public confidence in the reliability of supply at