



# Wisconsin Department of Natural Resources Municipal Waterworks Operator Certification

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## Groundwater Study Guide

December 2006 Edition (Revised February 2016)

Subclass G

Wisconsin Department of Natural Resources  
Bureau of Science Services  
Operator Certification Program  
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## Preface

This operator's study guide represents the results of an ambitious program. Operators of water supply facilities, regulators, educators and local officials, jointly prepared the objectives and exam questions for this subclass.

February 2016: Objective 3.1.9 was updated to reflect the revised total coliform rule that takes effect April 1, 2016.

February 2015: Objectives 2.1.9 and 2.2.7 now reference the Administrative Rule. The reference list was also updated.

August 2014: Objective 3.1.6 was updated to improve clarity.

July 2014: Objective 2.2.7 was updated to reflect requirement in NR 810.13(1)(d).

January 2013 Revisions: The December 2006 edition of this study guide has been updated to reflect recent changes in bacteriological sampling requirements, fluoride concentration targets, and the disinfection by-products stage 2 rule. The following objectives have been updated: 1.1.8, 3.1.6, 3.1.7, 3.1.9, 3.1.18, 3.1.24.

### How to Use This Study Guide with References

In preparation for the exam you should:

1. Read all the objectives and write down the answers to the objectives that readily come to mind.
2. Use the resources at the end of the study guide to look up those answers you are not sure of.
3. Write down the answers found in the resources to those objectives you could not answer from memory.
4. Review all answered objectives until you can answer each from memory.

It is advisable that the operator take classroom or online training in this process before attempting the certification exam.

### Choosing a Test Date

Before you choose a test date, consider the training opportunities available in your area. A listing of training opportunities and exam dates is available on the internet at <http://dnr.wi.gov>, keyword search "operator certification".

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## **Chapter 1 - Principle, Structure and Function**

### **Section 1.1 - Principles of Groundwater**

- 1.1.1 Describe the movement of water through the hydrologic cycle.
- 1.1.2 Sketch a diagram of the hydrologic cycle and label the parts.
- 1.1.3 Define the following terms:
- A. Water Table.
  - B. Permeability.
  - C. Infiltration.
  - D. Aquifer.
  - E. Impervious Layer.
  - F. Artesian Well.
  - G. Recharge Area.
  - H. Discharge Area.
- 1.1.4 State characteristics of a good aquifer and identify different types of formations which would serve as good aquifers.
- 1.1.5 List the factors which affect the depth at which groundwater is located.
- 1.1.6 Explain how water table levels are affected by seasonal changes.

- 1.1.7 List factors which affect the chemical and biological quality of groundwater.
- 1.1.8 Describe the health or aesthetic significance of the following elements and compounds:
- A. Iron
  - B. Manganese
  - C. Hydrogen Sulfide
  - D. Nitrate
  - E. Fluoride
  - F. Calcium
  - G. Magnesium
  - H. Dissolved Oxygen and Dissolved Air
  - I. Sodium
  - J. Natural Organic Matter (NOM)
  - K. Bromide
- 1.1.9 State the principal purpose for the chlorination of water.
- 1.1.10 Explain why the disinfection by-products trihalomethanes (TTHMs) and haloacetic acids (HAA5s) are a problem in drinking water.
- 1.1.11 Describe how trihalomethanes (TTHMs) and haloacetic acids (HAA5s) are formed.

## **Section 1.2 - Structure and Function**

- 1.2.1 List the six common types of wells and identify which are suitable for municipal use.

- 1.2.2 Discuss sanitary hazards that should not be near a well.
  
- 1.2.3 Sketch a typical well and identify each part: the air line, pressure gauge, air vent, static water level, pumping water level, drawdown, and the cone of depression.
  
- 1.2.4 Describe the purpose of a well casing.
  
- 1.2.5 Explain why wells are grouted.
  
- 1.2.6 Explain the purpose of a well screen.
  
- 1.2.7 Sketch and label a diagram of the various features in a typical pumphouse.
  
- 1.2.8 Sketch a diagram of a vertical turbine pump and label the parts.

- 1.2.9 Describe the functions of the following parts of a vertical turbine pump:
- A. Motor
  - B. Pump Head
  - C. Impeller
  - D. Bowl Assembly
  - E. Packing
  - F. Shaft
  - G. Thrust Bearing
  - H. Strainer
  - I. Spider
- 1.2.10 Describe how a vertical turbine pump works.
- 1.2.11 Sketch and label the components of a direct acid (fluoride) feed system.
- 1.2.12 Discuss when a diluted acid (fluoride) feed system is used, and what additional equipment is needed for this type system.
- 1.2.13 Sketch and identify a hypochlorination system and state the functions of the following components:
- A. Hypochlorite Solution Container
  - B. Suction Line, with Strainer
  - C. Diaphragm Type Positive Displacement Pump
  - D. Discharge Line
  - E. Anti-Siphon Device
  - F. Water Main Connection and Shut-Off Valve

- 1.2.14 Sketch and identify a solution feed gas chlorination system, then state the function of the following components:
- A. Chlorine Gas Cylinder
  - B. Yoke Unit
  - C. Control Unit (Chlorinator)
  - D. Gas Vacuum Line
  - E. Booster Pump and Piping
  - F. Ejector
  - G. Exhaust Fan
- 1.2.15 Describe the operation of a solution-feed vacuum type gas chlorination system.

## **Chapter 2 - Operation and Maintenance**

### **Section 2.1 - Operation**

- 2.1.1 Explain what a wellhead protection plan is, why it is important, and when it is required.
- 2.1.2 List the negative side effects of excessive groundwater use.
- 2.1.3 Cite remedies that help eliminate undesirable side effects of excessive groundwater use.
- 2.1.4 Discuss the problems hard water can create for utilities.



- 2.1.5 Explain why adjacent wells may have different water qualities.
- 2.1.6 Explain the effect well pumping can have on adjacent wells.
- 2.1.7 List the reasons for a rise or drop in the following:
- A. Static Water Level
  - B. Pumping Water Level
  - C. Specific Capacity
- 2.1.8 Describe the methods available to determine water levels in wells.
- 2.1.9 Per Wisconsin Administrative Code NR810.07, state how often water levels should be determined.
- 2.1.10 Identify two forms of incrustations found on well screens.
- 2.1.11 Identify considerations to be taken before starting a vertical turbine pump.

2.1.12 Identify suitable injection points for the following chemicals:

- A. Sodium Hypochlorite
- B. Calcium Hypochlorite
- C. Gaseous Chlorine
- D. Hydrofluosilicic Acid
- E. Polyphosphate
- F. Sodium Hydroxide

2.1.13 Describe how a chemical feed pump capacity can be controlled by:

- A. Length of Stroke
- B. Number of Strokes

2.1.14 Define the following terms:

- A. Dosage
- B. Chlorine Demand
- C. Free Chlorine Residual
- D. Combined Chlorine Residual
- E. Total Chlorine Residual
- F. Maximum Residual Disinfectant Level

2.1.15 Identify the various forms in which chlorine is available and the approximate percent available chlorine for each form.

- 2.1.16 Describe the physical properties (color, density, odor, etc.) of the following forms of chlorine:
- A. Gas
  - B. Solid (Calcium Hypochlorite)
  - C. Liquid (Sodium Hypochlorite)
- 2.1.17 Discuss the effect drinking water, containing the proper amount of fluoride, has on teeth during the years of tooth development.
- 2.1.18 Describe the effect on teeth of drinking water, containing fluoride greater than the maximum contaminant level (MCL), during the years of tooth development.
- 2.1.19 Discuss the purposes for adding polyphosphates to water.
- 2.1.20 Discuss problems with the use of polyphosphates.
- 2.1.21 Explain the purposes for adding sodium hydroxide.
- 2.1.22 Identify control strategies for trihalomethanes (TTHMs) and haloacetic acids (HAA5s).

- 2.1.23 Discuss disinfection by-product precursors, precursor sources and how to control them.
  
- 2.1.24 Describe treatment process modifications capable of controlling trihalomethanes (TTHMs) and haloacetic acids (HAA5s).
  
- 2.1.25 Describe the disinfection by-product bromate, its precursor, how it forms, and how it can be controlled.

## **Section 2.2 - Maintenance**

- 2.2.1 Describe good pump operational and maintenance procedures in relation to the following:
  - A. Priming
  - B. Packing
  - C. Bearings
  - D. Alignment
  
- 2.2.2 Outline a preventive maintenance program for a positive displacement pump feeding hypochlorite.
  
- 2.2.3 Explain why lead or asbestos washers should never be reused.
  
- 2.2.4 Discuss the symptoms of old packing and cavitation in pumps.

- 2.2.5 Describe the methods of well rehabilitation.
  
- 2.2.6 Explain the types and importance of stand-by power availability at a treatment plant.
  
- 2.2.7 Per Wisconsin Administrative Code NR810.13, describe the requirements for exercising emergency power generators and engines and keeping records of these activities.

## **Chapter 3 - Monitoring and Troubleshooting**

### **Section 3.1 - Monitoring**

- 3.1.1 Differentiate between "primary" and "secondary" drinking water standards.
  
- 3.1.2 Identify secondary standards for the following:
  - A. Iron
  - B. Manganese
  - C. Hydrogen Sulfide
  
- 3.1.3 State the monitoring requirements for the following:
  - A. Inorganic Chemicals (except Lead and Copper)
  - B. Lead and Copper
  - C. Synthetic Organic Chemicals
  - D. Disinfection/Disinfection By-Products
  - E. Volatile Organic Compounds
  - F. Radioactivity

- 3.1.4 Identify the maximum contaminant levels (MCLs) for fluoride and nitrate.
  
- 3.1.5 Describe a good bacteriological sampling program.
  
- 3.1.6 What is a raw water sample? For routine monitoring of coliform bacteria, how often should raw water be sampled from each well if the water system disinfects its water?
  
- 3.1.7 State the holding time for bacteriological samples.
  
- 3.1.8 Given hypothetical data, correctly complete a bacteriological report form.
  
- 3.1.9 Describe the procedure to follow when a bacteriological sample is positive.
  
- 3.1.10 Identify the laboratories where bacteriological samples may be analyzed.
  
- 3.1.11 List the circumstances where public notification is required.

- 3.1.12 State how often samples must be sent to the State Laboratory of Hygiene for fluoride analysis.
  
- 3.1.13 State how often an operator must test the chlorine residual in a groundwater-distribution system if chlorine is being added.
  
- 3.1.14 Define minimum chlorination residuals for water systems required to disinfect.
  
- 3.1.15 Explain the term maximum residual disinfectant level (MRDL) and list the MRDL for chlorine and chloramines.
  
- 3.1.16 Specify how often an operator must test for fluoride, if fluoride is being added to the water.
  
- 3.1.17 Identify the sample container requirements used in collecting fluoride samples.
  
- 3.1.18 Identify the range in which the fluoride concentration should be maintained for maximum health benefit. Identify the optimal target concentration for fluoride in public drinking water.
  
- 3.1.19 Define pH, and explain its importance to water supply operators.

- 3.1.20 List the acidic, neutral, and basic values for pH.
  
- 3.1.21 Identify methods to control corrosive water.
  
- 3.1.22 Discuss the various methods used to determine the stability of water with respect to calcium carbonate saturation.
  
- 3.1.23 Describe the calculations involved in using the Langelier Index and the Calcium Carbonate Solubility Curve in determining corrosive or depositing properties of a particular water.
  
- 3.1.24 Identify where samples are collected for analysis of the disinfection by-products (DPBs) trihalomethanes (THMs) and haloacetic acids (HAA5s) under the DBP Stage 2 rule, and list the MCLs.

## **Section 3.2 - Troubleshooting**

- 3.2.1 Explain remedial measures for drops in the static water level, pumping water level, and specific capacity.



3.2.2 List possible causes and remedies for the following pump symptoms:

- A. Short Bearing Life
- B. Cavitation
- C. Short Packing Life
- D. Vibrating Pump
- E. Pump Loses Prime
- F. Reduced Rate of Discharge
- G. Pumps Will Not Start

3.2.3 Describe the possible reasons for a well pump breaking suction.

## **Chapter 4 - Safety and Calculations**

### **Section 4.1 - Safety**

4.1.1 Describe the safety considerations when preparing a solution of hydrofluosilicic acid.

4.1.2 List the rules concerning chlorine storage.

4.1.3 Describe a method of detecting chlorine gas leaks.

### **Section 4.2 - Calculations**

4.2.1 Using a pressure gauge that reads in feet, determine the static water level, pumping water level, and drawdown in a well.

- 4.2.2 Given the static water level, pumping water level and pumping rate, calculate the specific capacity of a well.
  
- 4.2.3 Given water meter readings from the well house meter, estimate the daily pumpage or given pumping rate (calculate total gallons).
  
- 4.2.4 Given a graph of water pumpage versus volume of chemical used, determine the calculated dosages when volume of chemical and pumping rates are given.

## References and Resources

### **1. SMALL WATER SYSTEM OPERATION AND MAINTENANCE.**

5th Edition (2009). Kenneth D. Kerri. California State University, 6000 J Street, Sacramento, CA 95819-6025. Phone (916) 278-6142.

<http://www.owp.csus.edu/> or available through inter-library loan at  
<http://www.aqua.wisc.edu/Waterlibrary/>

### **2. WI ADMINISTRATIVE CODES NR 809, NR 810, and NR 811**

Chapter NR 809: Safe drinking water

Chapter NR 810: Requirements for the operation and maintenance of public water systems

Chapter NR 811: Requirements for the operation and design of community water systems

Wisconsin Legislative Reference Bureau (608) 266-0341

<http://docs.legis.wisconsin.gov/>

### **3. SAFE DRINKING WATER ACT**

US EPA. EPA 816-F-04-030, (June 2004).

<http://water.epa.gov/lawsregs/rulesregs/sdwa/>

### **4. GROUND WATER RULE**

US EPA (November 2006)

<http://water.epa.gov/lawsregs/rulesregs/sdwa/gwr/index.cfm>

### **5. STAGE 1 DISINFECTANT AND DISINFECTION BYPRODUCT RULE (December 1998 and January 2001)**

Complying with the Stage 1 Disinfectants and Disinfection Byproducts Rule: Basic Guide (March 2006) -- linked in the "Guidance" section

<http://water.epa.gov/lawsregs/rulesregs/sdwa/stage1/>

### **6. STAGE 2 DISINFECTANT AND DISINFECTION BYPRODUCT RULE (January 2006)**

<http://water.epa.gov/lawsregs/rulesregs/sdwa/stage2/index.cfm>

Complying with the Stage 2 Disinfectant and Disinfection Byproducts Rule: Small Entity Compliance Guide (February 2007) -- linked from the "Compliance Help" web site

<http://water.epa.gov/lawsregs/rulesregs/sdwa/stage2/compliance.cfm>

### **7. WELLHEAD PROTECTION: AN OUNCE OF PREVENTION.**

PUB-DG-039 99REV. Department of Natural Resources, Bureau of Drinking Water and Groundwater, PO Box 7921, Madison, WI 53707.

<http://dnr.wi.gov/topic/drinkingwater/wellheadprotection/>

**8. CROSS CONNECTION CONTROL MANUAL**

US EPA. EPA 816-R-03-002, (February 2003).

[http://water.epa.gov/infrastructure/drinkingwater/pws/crossconnectioncontrol/crossconnectioncontrol\\_manual.cfm](http://water.epa.gov/infrastructure/drinkingwater/pws/crossconnectioncontrol/crossconnectioncontrol_manual.cfm)

**9. WATER TREATMENT OPERATOR TRAINING HANDBOOK**

3rd edition, 2013: Nicholas G. Pizzi and William C. Lauer. Publisher: AWWA

<http://www.awwa.org> or available through inter-library loan at

<http://www.aqua.wisc.edu/Waterlibrary/>

**10. STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER.**

22nd Edition (2012). Joint Publication of: The American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF).

<http://www.standardmethods.org/> or available through most libraries

**11. WATER DISTRIBUTION SYSTEM MONITORING: A PRACTICAL APPROACH FOR EVALUATING DRINKING WATER QUALITY**

Cantor, Abigail E. 2009. CRC Press, Boca Raton. 203 pp.

**12. REVISED GUIDANCE MANUAL FOR SELECTING LEAD AND COPPER CONTROL STRATEGIES (March 2003)**

US EPA, EPA 816-R-03-001

Available from the Compliance Help section of EPA's web site on the Lead and Copper Rule

<http://water.epa.gov/lawsregs/rulesregs/sdwa/lcr/compliancehelp.cfm>

**13. WATER QUALITY AND TREATMENT: A HANDBOOK ON DRINKING WATER**

Edzwald, James K. Water Quality & Treatment: A Handbook on Drinking Water. 6th ed. New York: McGraw-Hill, 2011. Print.

<http://www.awwa.org>

**14. BASIC MANAGEMENT PRINCIPLES FOR SMALL WATER SYSTEMS.**

AWWA No. 20222 (1982). American Water Works Association, Member Service Department. 6666 W. Quincy Avenue, Denver, CO 80235. Phone (303) 794-7711.

[www.awwa.org](http://www.awwa.org)

**15. BEFORE THE WELL RUNS DRY - VOLUMES I AND II.**

VOLUME I, AWWA No. 20224 (1984). VOLUME II, AWWA No. 20225 (1984). American Water Works Association, Member Service Department. 6666 W. Quincy Avenue, Denver, CO 80235. Phone (303) 794-7711.

[www.awwa.org](http://www.awwa.org)

**16. IMPROVING WELL AND PUMP EFFICIENCY.**

Otto J. Helweg, Verne H. Scott, and Joseph C. Scalmanini. AWWA No. 20167 (1983). American Water Works Association, Member Service Department. 6666 W. Quincy Avenue, Denver, CO 80235. Phone (303) 794-7711.

[www.awwa.org](http://www.awwa.org)

**17. MAINTENANCE MANAGEMENT.**

James K. Jordan. AWWA No. 20252 (1990). American Water Works Association, Member Service Department. 6666 W. Quincy Avenue, Denver, CO 80235. Phone (303) 794-7711.

[www.awwa.org](http://www.awwa.org)

**18. NEW DIMENSIONS IN SAFE DRINKING WATER-SECOND EDITION.**

AWWA No. 20235 (1988). American Water Works Association, Member Service Department. 6666 W. Quincy Avenue, Denver, CO 80235. Phone (303) 794-7711.

[www.awwa.org](http://www.awwa.org)

**19. PLAIN TALK ABOUT DRINKING WATER.**

James M. Symons. AWWA No. 70076 (1991). American Water Works Association, Member Service Department. 6666 W. Quincy Avenue, Denver, CO 80235. Phone (303) 794-7711.

[www.awwa.org](http://www.awwa.org)

**20. PUBLIC INFORMATION - HOW TO BUILD A SUCCESSFUL PUBLIC INFORMATION/PUBLIC RELATIONS PROGRAM.**

AWWA No. 20242 (1989). American Water Works Association, Member Service Department. 6666 W. Quincy Avenue, Denver, CO 80235. Phone (303) 794-7711.

[www.awwa.org](http://www.awwa.org)

**21. TREATMENT TECHNIQUES FOR CONTROLLING TRIHALOMETHANE IN DRINKING WATER.**

AWWA No. 20221 (1982). American Water Works Association, Member Service Department. 6666 W. Quincy Avenue, Denver, CO 80235. Phone (303) 794-7711.

[www.awwa.org](http://www.awwa.org)