

Illinois Environmental Protection Agency
Bureau of Water
Class 4 Study Guide
Wastewater Operator Certification

The purpose of this study guide is to explain the testing process and to help you prepare for the Class 4 wastewater operator certification examination.

If this is your first exam attempt, a short history of the current exam development should be of interest. The exam questions were developed by experts in the wastewater field. Each question has been validated through a process of panel review. The panel is comprised of 8 experts who have worked for many years in the wastewater field. Every question with each of the four answer selections has been examined for content, readability, accuracy and relation to the Task Analysis.

The process of validation has taken several years. It is an on-going process with new questions being developed and reviewed each year. You might say the job is never finished since existing validated questions must also prove reliable; that is they must test what they are supposed to test. Reliability can only be established from statistical evidence, which takes a minimum question repetition of 100 times. If statistics show a question to be unreliable, it is removed from the question bank. Unreliable questions are sent back to the review panel for restructuring.

Each exam question is related back to a major subject category; Class 4 subject categories are:

- | | |
|------------------------------|---------------------------|
| 1. Collection Systems | 9. Maintenance |
| 2. Disinfection | 10. Management |
| 3. Electrical | 11. Math |
| 4. Flow Measurement | 12. Motors |
| 5. General Information | 13. Pumps and Pumping |
| 6. Intermittent Sand Filters | 14. Recordkeeping |
| 7. Laboratory | 15. Rules and Regulations |
| 8. Lagoons | 16. Safety and Health |

Each Class 4 exam version has 100 multiple-choice questions taken from any combination of the sixteen categories.

When you take the Class 4 exam, you are given one exam booklet containing questions, formulas and conversion factors; one answer sheet; two sheets of scratch paper; and two pencils. The only item you may bring to the exam site is your calculator, which must be non-programmable and incapable of storing alpha-numeric data. You are allowed a maximum of three hours to complete the exam. A copy of the conversion factors and formulas are provided at the back of this study guide. If you familiarize yourself with the format, it should cut down your referencing time during the examination.

Usually within two weeks of exam completion, your results are sent to your home. Whether or not you passed the exam, you receive a detailed breakdown of your performance as shown below:

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CATEGORY	NUMBER OF QUESTIONS	NUMBER CORRECT	NUMBER INCORRECT	% CORRECT IN CATEGORY
PUMPS AND PUMPING	2	1	1	50%
MATH	10	5	5	50%
LAGOONS	25	13	12	52%
LABORATORY	10	6	4	60%
GENERAL INFORMATION	10	8	2	80%
COLLECTION SYSTEMS	10	8	2	80%
DISINFECTION	8	7	1	88%
INTERMITTENT S.F	10	9	1	90%
FLOW MEASUREMENT	2	2	0	100%
SAFETY	10	10	0	100%
ELECTRICAL	2	2	0	100%
MAINTENANCE	1	1	0	100%

TOTAL	100	72	28	72%

Should you fail to achieve a score of 70%, you can use these results to determine the areas to study. In the above example, this examinee scored the lowest percent correct on Pumps and Pumping (50%) and Math (50%) but lost the most points on Lagoons (12 points). It would be wise to review all three subject categories. Notice how the category list progresses from lowest percent correct (Pumps and Pumping 50%) to highest percent correct (Maintenance 100%). This category list would appear in different orders for various examinees, depending on each examinee's area(s) of weakness.

If you score less than 70%, you may reschedule the Class 4 exam, without submitting another application, by completing and returning the exam scheduling form provided with your results. When you do retest, the number of questions per category or the categories themselves may differ on the exam you are given. If you find a need for additional technical information, there is a list of suggested reading on page 9 of this study guide.

The following is a list of the main subject areas that may be covered on the Class 4 examination. The questions are provided to show you the type of questions that one might expect to see on the examination; however, these exact questions do not appear on the examination.

- I. General Information
 - A. Characteristics of wastewater
 - B. Why treat wastewater
 - C. Basic steps of treatment
 - D. Basic wastewater terminology

Example Question:

Which of the following characteristics represents the composition of domestic wastewater?

- a) 99.9% water and 0.1% solids
- b) 85.5% wastewater and 14.5% pure water
- c) 79.9% water, 10.1% minerals, and 10% solids
- d) 75% water, 20% solids, and 5% floating material

II. Collection Systems

- A. Purposes and types of collection systems
- B. Collection system components
- C. Routine operation and maintenance procedures
- D. Sewer installation inspections
- E. Troubleshooting collection systems

Example Question:

A 48-inch interceptor that has a wastewater flow which is 10% of design flow may:

- a) be difficult to inspect
- b) provide sufficient scouring velocities
- c) allow the excessive production of hydrogen sulfide gas
- d) indicate excessive inflow and/or infiltration is occurring

III. Pumps and Pumping

- A. Types of pumps and motors and their application
- B. Operation and maintenance of pumps
- C. Operation and maintenance of pump motors
- D. Operation and maintenance of pump controls

Example Question:

In shutting down a centrifugal pump for an extended period of time an operator should:

- a) close the discharge line and open the suction line so that seals are not allowed to dry out
- b) close the suction line and open the discharge line so gases that might build up in the pump won't break the casing
- c) close the discharge line and suction line, open the air vent line and drain the pump
- d) open the discharge, suction and air vent lines so that the pump remains full of water and is vented to prevent gas build up

IV. Flow Measurement

- A. Instruments
- B. Process controls

Example Question:

Flow measurement at a lagoon is useful for an operator to determine all of the following except:

- a) extent of infiltration
- b) hydraulic loading
- c) mode of operation
- d) depth of lagoon

V. Preliminary Treatment

- A. Purpose of preliminary treatment
- B. Operation and maintenance of bar screens and comminutors
- C. Operation and maintenance of grit chambers

Example Question:

Bar screens are particularly useful for the removal of _____ from the wastewater:

- a) organic material
- b) grit and large rocks
- c) suspended solids
- d) large solids and trash

VI. Lagoons

- A. Purpose of lagoons
- B. Description of lagoons
 - 1. Aerobic lagoons
 - 2. Anaerobic lagoons
 - 3. Facultative lagoons
- C. Operation of lagoons
- D. Troubleshooting of lagoons

Example Question:

From an operational viewpoint, primary lagoons operated in series normally will provide better treatment than primary lagoons operated in parallel if:

- a) it is the winter season
- b) the loading to the lagoons is above the design loading
- c) blue-green algae are not present
- d) none of the above

VII. Tertiary Filtration

A. Purpose of filtration

B. Description and operation of filtration process

- 1. Intermittent sand filters
- 2. Submerged sand filters
- 3. Rock filters

Example Question:

Intermittent sand filters have which of the following advantages over submerged sand filters?

- a) reduced manpower requirements
- b) less likely to become anaerobic
- c) less subject to freezing problems
- d) wastewater can be continuously applied at greater depths

VIII. Disinfection

A. Purpose of disinfection

B. Operation and maintenance of chlorination systems

- 1. Hypochlorite systems
- 2. Gas chlorine systems

Example Question:

Chlorine is:

- a) colorless
- b) explosive
- c) toxic
- d) all of the above

IX. Laboratory Testing

- A. Purpose of testing
- B. Testing procedures
 - 1. BOD
 - 2. TSS
 - 3. pH
 - 4. DO
 - 5. Chlorine residual
 - 6. Fecal coliform

Example Question:

For what purpose is sodium thiosulfate or sodium bisulfite added to chlorinated effluent?

- a) to dechlorinate
- b) to disinfect
- c) to precipitate colloids
- d) to increase the effectiveness of chlorine

X. Safety and Health

- A. Apparel and clothing
- B. Machinery
- C. Chemical handling including chlorine
- D. Laboratory
- E. Collection systems

Example Question:

Which of the following is not a characteristic of hydrogen sulfide:

- a) rotten egg odor at low concentrations
- b) odor not evident at high concentrations
- c) colorless
- d) non-flammable

XI. Recordkeeping

- A. Plant operations
- B. Laboratory data
- C. Financial data
- D. Maintenance data

Example Question:

A daily operating log should be maintained and includes information such as:

- a) routine operational duties
- b) unusual conditions
- c) accidents to plant personnel
- d) all of the above

XII. Rules and Regulations

- A. 35 Ill. Adm. Code, Subtitle C: Water Pollution
- B. NPDES requirements
- C. Local sewer use ordinance

Example Question:

Which of the following is not a requirement of all NPDES permits:

- a) number of personnel for a particular facility
- b) self-monitoring activities
- c) access to records by Agency personnel
- d) submittal of application for renewal 180 days prior to expiration

XIII. Mathematics

- A. General math
- B. Process control math
- C. Laboratory math

Example Question:

Calculate the detention time of a 9-acre lagoon, which is 4 feet deep and receives a flow of 210,000 gpd with an influent BOD of 232 mg/l and suspended solids concentration of 180 mg/l.

- a) 28 days
- b) 42 days
- c) 56 days
- d) 74 days

LIST OF SUGGESTED READING

1. MOP 1 Safety and Health in Wastewater Systems
2. MOP 11 Operation of Wastewater Treatment Plants
3. Standard Methods for the Examination of Water and Wastewater - Latest Edition

The preceding three publications are available through:

Water Environment Federation
Publications Order Department
601 Wythe Street
Alexandria, VA 22314-1994
(800) 666-0206
Website: www.wef.org

4. Manual of Wastewater Treatment

Available through:

Texas Water Utilities Association
1106 Clayton Lane, Suite 101-E
Austin, TX 78723-1033

5. Operation of Wastewater Treatment Plants, a Field Study Training Program
 - a. Volume I
 - b. Volume II
6. Operation and Maintenance of Wastewater Collection Systems, a Field Study Training Program

The correspondence courses and/or texts for items 5 and 6 are available through:

Office of Water Programs
California State University, Sacramento
6000 J Street
Sacramento, CA 95819-6025
(916) 278-6142
Website: www.owp.csus.edu

and

Correspondence Course Coordinator
Environmental Resources Training Center
Campus Box 1075 - Southern Illinois Univ.
Edwardsville, IL 62026-1075
(618) 650-2030

7. Stabilization Ponds Operations Manual USEPA 430/9-77-012

Available through:

ORD Publications
P.O. Box 19962
Cincinnati, OH 45219
(513) 569-7562

or

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161

8. Math Review for Wastewater Certification

9. Stabilization Pond Filtration

The preceding items 8 and 9 are available through:

Environmental Resources Training Center
Campus Box 1075 - Southern Illinois Univ.
Edwardsville, IL 62026-1075
(618) 650-2030

10. WEF/ABC Study Guide for Wastewater Treatment and Collection Systems Personnel (Order No. E0376PC) by the Water Pollution Control Federation and the Association of Boards of Certification

Available through:

Water Environment Federation
Publications Order Department
601 Wythe Street
Alexandria, VA 22314-1994
(800) 666-0206
Website: www.wef.org

FORMULA SHEETS

CONVERSION FACTORS

$$\text{Pi } (\pi) = 3.14$$

$$1 \text{ gallon of water} = 8.34 \text{ pounds}$$

$$1 \text{ gallon of water} = 4 \text{ quarts} = 8 \text{ pints} = 3.785 \text{ liters}$$

$$1 \text{ Population Equivalent (PE)} = 0.17 \text{ pounds BOD/capita/day}$$

$$\text{"} = 0.20 \text{ pounds SS/capita/day}$$

$$\text{"} = 100 \text{ gallons water/capita/day}$$

$$1 \text{ day} = 24 \text{ hours} = 1440 \text{ minutes}$$

$$1 \text{ square foot (ft}^2\text{)} = 144 \text{ square inches (in}^2\text{)}$$

$$1 \text{ square yard (yd}^2\text{)} = 9 \text{ square feet (ft}^2\text{)}$$

$$1 \text{ cubic foot (ft}^3\text{)} = 7.5 \text{ gallons} = 1728 \text{ cubic inches (in}^3\text{)}$$

$$1 \text{ cubic yard (yd}^3\text{)} = 27 \text{ cubic feet (ft}^3\text{)}$$

$$1 \text{ acre} = 43,560 \text{ square feet (ft}^2\text{)}$$

$$1 \text{ horsepower (HP)} = 33,000 \text{ foot-pounds/minute (ft-lb/min)} = 746 \text{ watts} = 0.746 \text{ kilowatts (kw)}$$

$$1 \text{ foot of water} = 0.433 \text{ pounds/square inch (psi)}$$

$$1 \text{ pound/square inch (psi)} = 2.31 \text{ feet of water}$$

VOLUMES, AREAS, & PERIMETERS

GIVEN: V = Volume, L = Length, H = Height, W = Width, r = radius, d = diameter, π = Pi,
b = base, P = Perimeter, C = Circumference

VOLUMES

$$\text{Rectangular Solid: } V = L \times W \times H$$

$$\text{Cylinder: } V = \pi r^2 H = \frac{\pi d^2 H}{4} = 0.785 d^2 H$$

$$\text{Sphere: } V = \frac{4}{3} \pi r^3$$

$$\text{Cone: } V = \frac{1}{3} \pi r^2 H$$

$$\text{Pyramid: } V = \frac{1}{3} L \times W \times H$$

PERIMETER

$$\text{Polygon: } P = L_1 + L_2 + L_3 + \dots + L_n$$

$$\text{Circle: } C = \pi d$$

AREA

$$\text{Rectangle: } A = L \times W$$

$$\text{Triangle: } A = \frac{1}{2} b \times H$$

$$\text{Circle: } A = \pi r^2 = \frac{\pi d^2}{4} = 0.785 d^2$$

$$\text{Trapezoid: } A = \frac{1}{2} (b_1 + b_2) H$$

PROCESS FORMULAS

TEMPERATURE

$$^{\circ}\text{F} = 9/5 ^{\circ}\text{C} + 32$$

$$^{\circ}\text{C} = 5/9 (^{\circ}\text{F} - 32)$$

$$^{\circ}\text{K} = ^{\circ}\text{C} + 273$$

FLOW MEASUREMENT

$$90^\circ \text{ V-notch weir: } Q = 2.5H^{2.5}$$

$$\text{Sharp-crested weir: } Q = 3.33LH^{1.5}$$

$$\text{Cippolletti weir: } Q = 3.367LH^{1.5}$$

$$\text{Proportional weir: } Q = 7.57mH$$

$$\text{Parshall flume: } Q = 4WH^{1.52}W^{0.026}$$

ELECTRICITY

$$\text{Power} = \text{Current} \times \text{Voltage}$$

$$\text{Voltage} = \text{Current} \times \text{Resistance}$$

$$\text{Average Current} = \frac{\text{Line 1 Current} + \text{Line 2 Current} + \text{Line 3 Current}}{3}$$

$$\text{Current Imbalance} = \frac{\text{Average Current} - \text{Maximum Deviation}}{\text{Average Current}} \times 100$$

MISCELLANEOUS

$$\text{Efficiency} = \frac{\text{In} - \text{Out}}{\text{In}} \times 100\%$$

$$\text{Velocity} = \frac{\text{Distance}}{\text{Time}}$$

$$\text{Detention Time} = \frac{\text{Volume}}{\text{Flow Rate}}$$

$$\text{Application Rate} = \text{Concentration} \times \text{Flow} \times \text{Conversion Factor}$$

$$\text{Loading Rate} = \frac{\text{Concentration} \times \text{Flow} \times \text{Conversion Factor}}{\text{Area}}$$

LABORATORY

$$\text{BOD}_5 \text{ (mg/l)} = (\text{Initial DO} - \text{Final DO}) \times \frac{\text{Bottle Volume}}{\text{Sample Volume}}$$

$$\text{SS Concentration (mg/l)} = \frac{\text{Weight of Solids (g)}}{\text{Amount of Sample (ml)}} \times \text{Conversion Factor(s)}$$

$$\% \text{ Capture} = \frac{\text{Sludge SS} - \text{RAS SS}}{\text{Wet Sludge}} \times 100$$

$$\% \text{ Solids} = \frac{\text{Dry Sample}}{\text{Wet Sample}} \times 100$$

$$\% \text{ Moisture} = \frac{\text{Wet Sludge} - \text{Dry Solids}}{\text{Wet Sludge}} \times 100$$

$$\% \text{ Volatile Solids} = \frac{\text{Dry Sample} - \text{Ash}}{\text{Dry Sample}} \times 100$$

$$\% \text{ Reduction in Volatile Matter} = \frac{\text{In} - \text{Out}}{\text{In} - (\text{In} \times \text{Out})} \times 100$$

CLARIFIER

$$\text{Detention Time} = \frac{\text{Volume}}{\text{Flow Rate}}$$

$$\text{Weir Overflow Rate} = \frac{\text{Flow}}{\text{Length}}$$

$$\text{Surface Settling Rate} = \frac{\text{Flow}}{\text{Surface Area}}$$

PROCESS CONTROL

$$F/M = \frac{\text{lbs of BOD}}{\text{lbs of MLSS}}$$

$$(Q + RQ) \text{ MLSS} = RQ \times \text{RAS}$$

$$\text{MLSS (mg/l)} = \frac{\text{MLSS (lbs)}}{\text{Volume} \times \text{Conversion Factor(s)}}$$

$$\text{SDI} = \frac{\text{MLSS (mg/l)}}{\text{Settled Sludge Volume (ml) (30 minutes)} \times 10} \text{ or } \frac{100}{\text{SVI}}$$

$$\text{SVI} = \frac{\text{Settled Sludge Volume (ml) (30 minutes)} \times 1000}{\text{MLSS (mg/l)}}$$

$$\text{Gould's Sludge Age} = \frac{\text{lbs of MLSS [Aeration Tank(s)]}}{\text{lbs of TSS (Influent)}}$$

$$\text{MCRT} = \frac{\text{lbs of MLSS (Aeration Tank)} + \text{lbs of Solids (Clarifier)}}{[(\text{RAS(mg/l)} \times \text{WAS Flow}) + (\text{Effluent SS(mg/l)} \times \text{Flow})] \times \text{Conversion Factor}}$$

$$\text{Mixed Concentration} = \frac{(\text{Upstream Flow} \times \text{Upstream Concentration}) + (\text{Effluent Flow} \times \text{Effluent Concentration})}{\text{Downstream Flow}}$$

SLUDGE LAND APPLICATION

$$\text{lb/ton} = \text{mg/l} \times 0.002$$

$$1 \text{ mg/kg} = 0.002 \text{ lbs/ton}$$

$$\text{gal/acre} = \frac{\text{wet tons}}{\text{acre}} \times \frac{2000 \text{ lbs}}{\text{ton}} \times \frac{1 \text{ gal}}{8.34 \text{ lbs}}$$

$$\text{mg/l (dry)} = \text{mg/l (wet)} \times \frac{100}{\% \text{ Total Solids}}$$

$$\text{Dry Tons} = \text{Wet Tons} \times \frac{\% \text{ Total Solids}}{100}$$

$$\text{Plant Available Nitrogen(PAN)(mg/kg)} = \text{Ammonia Nitrogen(mg/kg)} + \text{Organic Nitrogen(mg/kg)}$$

$$\text{Organic Nitrogen(mg/kg)} = \text{Total Kjeldahl Nitrogen(TKN)(mg/kg)} - \text{Ammonia Nitrogen(mg/kg)}$$

WEST PROCESS CONTROL METHOD FOR ACTIVATED SLUDGE

$$F = 31.2 \text{ lbs/ft}^3 \times H^2 \times L$$

$$R_Q = \frac{\frac{MLSS \times Q}{RAS}}{1 - \frac{MLSS}{RAS}}$$

$$CFP = \frac{ATC - FEC}{RSC - ATC}$$

$$R_Q = \frac{Q \times M}{\frac{1,000,000}{SVI} - M}$$

$$ATC = \frac{(CFP \times RSC) + FEC}{CFP + 1.0}$$

$$WCR = \frac{MLTSS}{ATC}$$

$$RSC = \frac{ATC + (ATC - FEC)}{CFP}$$

$$SLU = \frac{\text{Volume} \times \text{Centrifuged Concentration}}{100}$$

$$RSP = \frac{ATC - PEC}{RSC - ATC}$$

$$SSC = \frac{1000 \times ATC}{SSV}$$

$$ATC = \frac{(RSP \times RSC) + PEC}{RSP + 1.0}$$

$$CFP = \frac{ATC}{(RSC - ATC)}$$

$$RSC = \frac{ATC + (ATC - PEC)}{RSP}$$

$$ATC = \frac{CFP \times RSC}{CFP + 1.0}$$

$$CSU = \frac{BLV \times CSC}{100}$$

$$RSC = ATC + \frac{(ATC)}{CFP}$$

$$CDT = \frac{CV \times 24}{CFI}$$

$$ASU = \frac{AV \times ATC}{100}$$

$$CSDT = \frac{CSU}{CSUO}$$

$$RSU = \frac{RSF \times RSC}{100}$$

$$OFR = \frac{CFO}{CFA}$$

$$ADT @ AFI = \frac{AV \times 24}{AFI}$$

$$SAH = \frac{ADT \times 24}{ADT + CSDT}$$

$$ADT @ TFL = \frac{AV \times 24}{AFI + RSF}$$

$$AGE = \frac{ASU + CSU}{TXU/\text{day}}$$

$$CSFD = \frac{RSF \times (RSC - ATC)}{SSC - ATC}$$

$$AAG = \frac{AGE \times SAH}{24}$$

$$SCR = \frac{SSC60}{RSC}$$

AAG	- Aeration Age	OFR	- Final Clarifier Surface Overflow Rate
ADT	- Aeration Tank Detention Time	PEC	- Primary Effluent Concentration
AFI	- Aeration Tank Wastewater Flow (In)	RAS	- Return Activated Sludge
AGE	- Sludge Age	RSC	- Return Sludge Concentration
ASU	- Aeration Tank Sludge Units	RSF	- Return Sludge Flow
ATC	- Aeration Tank Concentration	RSP	- Return Sludge Percentage
AV	- Aeration Tank Volume	RSU	- Return Sludge Units
BLV	- Sludge Blanket Volume	SAH	- Sludge Aeration Hours
CDT	- Final Clarifier Detention Time	SCR	- Sludge Concentration Ratio
CFA	- Final Clarifier Area	SLU	- Sludge Units
CFI	- Final Clarifier Flow(In)	SSC	- Settled Sludge Concentration
CFO	- Final Clarifier Flow(Out)	SSV	- Settled Sludge Volume
CFP	- Final Clarifier Sludge Flow Percentage	SVI	- Sludge Volume Index
CSC	- Final Clarifier Sludge Concentration	TFL	- Total Flow
CSDT	- Final Clarifier Sludge Detention Time	TXU	- Total Excess Sludge Units to Waste
CSF	- Final Clarifier Sludge Flow	VSS	- Volatile Suspended Solids
CSFD	- Final Clarifier Sludge Flow Demand	WAS	- Waste Activated Sludge
CSU	- Final Clarifier Sludge Units	WCR	- Sludge Weight to Concentration Ratio
CSUO	- Final Clarifier Sludge Units Out of Clarifier	XFP	- Excess Sludge Flow
CV	- Final Clarifier Volume	XSC	- Excess Sludge Concentration
FEC	- Final Effluent Solids Concentration	XSF	- Excess Sludge Flow to Waste
MCRT	- Mean Cell Residence Time	XSU	- Total Excess Sludge Units to Waste
MLSS	- Mixed Liquor Suspended Solids		
MLTSS	- Mixed Liquor Total Suspended Solids		
MLVSS	- Mixed Liquor Volatile Suspended Solids		