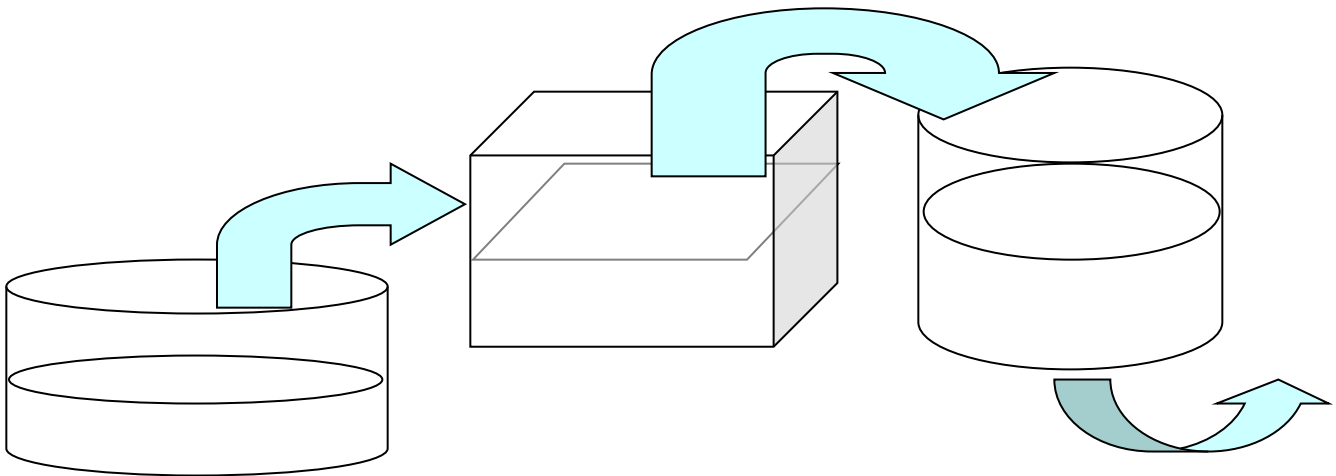


# STUDY GUIDE

## CLASS 4E

### ON-SITE WASTEWATER SYSTEM OPERATORS

**Class 4E– On-site septic tank primary treatment systems with complex or pumped sub-surface disposal. Includes pressure-dosed drainfields, siphon-dosed drainfields, elevated sand mound systems. Onsite septic tank primary treatment systems with simple sub-surface disposal by gravity drainfield.. Must be a public sewage system and flow to the facility will generally be greater 5000 gpd.**



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**MONTANA DEPARTMENT OF ENVIRONMENTAL QUALITY (DEQ)  
PERMITTING AND COMPLIANCE DIVISION**

**Class 4E On-Site Wastewater Certification Exam  
Study Guide**

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## STUDY GUIDE FOR CLASS 4E ON-SITE EXAMS

**Congratulations!** You are starting the process to become an operator in an exciting field of work as the protector of water quality and public health in your community. This study guide will help to ensure that you are properly trained, not only to pass the required examination to be certified, but also to competently operate your system. The guide is also a good indicator of the extent of knowledge needed to become a certified operator.

### I. CERTIFIED OPERATOR RESPONSIBILITIES

In 1967, Montana's Legislature first passed a law to require certified operators for water supply systems and wastewater treatment plants. The purpose of the law, as conveyed through Montana Codes Annotated 37-42-101, is as follows:

*"It is declared that the health and welfare of Montana citizens are jeopardized by persons not properly qualified to operate the water supply systems and that Montana's state waters are endangered by persons not properly qualified to operate the wastewater treatment plants. It is declared that the public policy of this state is to protect the public health and safety by certifying persons working in these occupations."*

### II. MONTANA OPERATOR CODE OF ETHICS

The Code of Ethics provides a good general description of the important aspects of your job, described as follows:

*"Using my best judgement and operating skills, I will always work, to protect public health, to ensure good service, to protect public property and the environment, by applying my skills in operating water and wastewater system equipment, by properly and accurately completing required records, following and complying with state and federal rules and regulations, continuing my education in my field, and working with management to establish distinct and safe operating policies for the public utilities for which I am entrusted."*

### III. RECOMMENDED STUDY MANUALS AND REFERENCES:

This study guide is intended to direct you to the information you need to obtain to study for the Class 4E exam and provide helpful ideas in preparing for the exam. There are three unique Study Guides developed for each level of operator classification and you should use the Study Guide specific to the exam that you will take. **It is your responsibility to find the appropriate reference materials and spend the necessary time to prepare for the exam.** Information needed for the Class 4E exam includes the following:

## Design and Operation:

- Basic On-Site Wastewater Treatment Training Manual prepared by Anderson-Montgomery Consulting Engineers, November 2011.
- “Circular DEQ-2, Design Standards for Wastewater Facilities, Montana DEQ (design requirements for on-site system components as referenced by Circular DEQ-4). Visit <http://www.deq.mt.gov/wqinfo/circulars.mcpX>
- “Circular DEQ-4, Montana Standards for Subsurface Wastewater Treatment Systems”, Montana DEQ (on-site system design requirements). Visit <http://www.deq.mt.gov/wqinfo/circulars.mcpX>
- “Onsite Wastewater Treatment Systems Manual”, U.S. EPA 2002, EPA/625/R-00/008 (principles and practices of on-site wastewater treatment). Visit <http://www.epa.gov/nrmrl/pubs/625r00008/html/625R00008.htm>
- “*Small Wastewater System O&M, Volumes I and II*”, California State University (Ken Kerri Manuals). For operators of all on-site systems. <http://www.owp.csus.edu/courses/wastewater/small-wastewater-system-operation-and-maintenance-vol-i.php> (Volume 1) and <http://www.owp.csus.edu/courses/wastewater/small-wastewater-system-operation-and-maintenance-vol-ii.php> (Volume II).
- “Wastewater Math, The Basics”, by Skeet Arasmith, ACRP Publications. For operators of all on-site systems.

## Rules:

- Administrative Rules of Montana (ARM) 17.30.501-518: “Mixing Zones in Surface and Ground Water “. Visit <http://www.deq.mt.gov/dir/legal/Chapters/Ch30-toc.mcpX>
- ARM 17.30.701-718: “Nondegradation of Water Quality”. Visit <http://www.deq.mt.gov/dir/legal/Chapters/Ch30-toc.mcpX>
- ARM 17.30.1001-1045: “Montana Groundwater Pollution Control System”. Visit <http://www.deq.mt.gov/dir/legal/Chapters/Ch30-toc.mcpX>
- ARM 17.36.301-345: “Subdivision Requirements”. Visit <http://www.deq.mt.gov/dir/legal/Chapters/CH36-toc.mcpX>
- ARM 17.36.901-924: “On-site Subsurface Wastewater Treatment Systems”. Visit <http://www.deq.mt.gov/dir/legal/Chapters/CH36-toc.mcpX>
- Environmental Protection Agency Part 503 Sludge Regulations: “Standards for the Use or Disposal of Sewage Sludge”. Visit [http://water.epa.gov/scitech/wastetech/biosolids/503pe\\_index.cfm](http://water.epa.gov/scitech/wastetech/biosolids/503pe_index.cfm)

#### **IV. EXAM FORMAT**

In 2001, the DEQ Certification Program developed a new format for the Wastewater Certification Exams, based on a Montana-specific listing of what operators “need to know” and exam questions prepared by the Association of Boards of Certification (ABC). A group of individuals comprised of knowledgeable Montana system operators, DEQ regulatory officials, the Water and Wastewater Operators Advisory Council, Montana Rural Water Systems and Anderson-Montgomery Consulting Engineers worked together to develop a list of skills and subject areas that they believe Montana operators need-to-know to properly operate a wastewater facility. The need-to-know lists were developed for the four different classes of operator certification exams and are subject areas that pertain, in general, to the type of system that you will be operating. In 2011, exam questions, need-to-know information and study guides were developed for three additional classes of exams designed for wastewater systems which dispose treated effluent “On-site”; Classes 2E, 3E and 4E. These exams were prepared in a format similar to that used in the existing water and wastewater certification exams.

Each exam will have 100 multiple-choice questions with one right answer and three wrong answers. Essay or true and false questions will not be used. A separate sheet for answering the questions will be provided, using a “fill in the dot” format. The results should be available in a timely manner. Information can be provided on how well you performed on the exam and what areas you might need to focus on in terms of needing more study. This will be particularly important if you did not pass the exam and desire to study more effectively to retake the test.

#### **V. WHAT A CLASS 4E WASTEWATER SYSTEM OPERATOR NEEDS TO KNOW**

##### **What do You Need-to-Know?**

As part of the revision in the examination process, the DEQ has developed a comprehensive listing of what operators need-to-know to properly operate an on-site septic tank primary treatment system with complex or pumped sub-surface disposal including pressure-dosed drainfields, siphon-dosed drainfields, elevated sand mound systems and gravity drainfields. Flow will generally be greater than 5000 gpd.

This needs-to-know list addresses aspects of wastewater treatment, public health protection, regulatory compliance and safety deemed essential for responsible operation of an onsite system. The list is extensive and you cannot anticipate a question on the exam for every subject shown under the Need-to-Know Summary. The summary will provide the general basis for any question given on the exam.

The following summary list should be used as a guide to direct further study of the identified items. The references identified previously in this Study Guide are good sources of information regarding the need-to-know subject materials.

**MONTANA ON-SITE SYSTEM OPERATORS**  
**Treatment with Septic Systems Prior to Groundwater Discharge**  
**NEEDS TO KNOW SUMMARY**

**Physical Characteristics of Waste**

Color  
 Flow  
 Foam  
 Odor  
 Solids concentration  
 Volume

**Perform Administrative Duties**

Write reports (internal, state, federal)  
 Respond to complaints  
 Set up facility operation record keeping  
 Set up maintenance record keeping

Record facility operation information  
 Record laboratory information  
 Record maintenance information

**Evaluate Operation/Equipment**

Inspect equipment for abnormal conditions  
 Read charts

Read meters  
 Read pressure gauges  
 Check speed of equipment  
 Measure temperature of equipment

**Operate Equipment**

Grounds maintenance equipment  
 Hand tools  
 Power tools  
 Chemical feeders  
 Flow measurement devices  
 Fittings  
 Gates  
 Hydraulic equipment

Measuring and control systems  
 Motors  
 Pneumatic equipment  
 Pumps  
 Traps and drains  
 Valves

**Establish Emergency Plans**

Facility upset  
 Hazardous Waste  
 Natural Disasters  
 Power disruption  
 Spill response

**Respond to Emergencies**

Facility upset  
 Hazardous Waste  
 Natural Disasters  
 Power disruption  
 Spill response

**Perform Lab Analyses**

Chlorine residual  
 Physical Characteristics of Waste

Settleable solids

Temperature

**Interpret Laboratory**

**Analyses**

5-day BOD  
 Ammonia  
 Chlorine residual  
 E. coli

Conductivity  
 Dissolved oxygen  
 Dissolved solids  
 TKN, Nitrate, Nitrite  
 Phosphorous  
 pH  
 Temperature  
 Total suspended solids

**Perform Preventive**

**Maintenance**

Fittings  
 Gates  
 Hydraulic equipment  
 Motors  
 Pipes  
 Pneumatic equipment  
 Pumps  
 Traps and drains  
 Valves

**Apply Safety Procedures**

Blood borne pathogens  
 Confined space entry  
 Electrical grounding  
 First aid  
 General safety and health  
 Lifting  
 Lock-out/tag-out  
 Personal hygiene  
 Personal protective equipment  
 Respiratory protection  
 Slips, trips, and falls

**Monitor, Evaluate and Adjust Treatment Processes**

Plant pumping of main flow  
 Grease removal  
 Screening

Clarification/sedimentation

Coagulation/flocculation  
 pH adjustment

Fixed growth treatment processes  
 Sand filtration  
 Chlorine disinfection  
 Ultraviolet disinfection  
 Monitoring requirements  
 Normal characteristics wastewater  
 Normal chemical range  
 Personal protective equipment  
 Physical science  
 Plumbing  
 Pneumatics  
 Primary treatment processes  
 Principles of measurement  
 Proper application of chemicals

Proper chemical handling, storage  
 Proper lifting procedures  
 Proper safety procedures  
 Proper sampling procedures  
 Record keeping policies  
 Regulations  
 Reporting requirements  
 Basic wastewater treatment concepts  
 Land disposal-evaporation  
 Subsurface disposal

## **NEEDS TO KNOW SUMMARY CONTINUED**

### **Ability to**

Adjust chemical feed rates  
Adjust equipment  
Assess likelihood of disaster occurring  
Calculate dosage rates  
Communicate in writing  
Communicate verbally  
Confirm chemical strength  
Demonstrate safe work habits  
Determine what info to record  
Differentiate/prevent & correct main.  
Discriminate/normal & abnormal cond.  
Evaluate facility performance  
Evaluate operation of equipment  
Evaluate and adjust process units  
Follow written procedures  
Identify potential safety hazards  
Interpret data  
Interpret Material Safety Data Sheets  
Maintain processes in norm condition  
Measure chemicals  
Monitor electrical equipment  
Operate safety equipment  
Order necessary spare parts  
Organize information  
Perform basic math  
Perform general maintenance  
Perform general repairs  
Perform laboratory calculations  
Perform physical measurements  
Prepare and measure chemicals  
Recognize abnormal analytical results  
Recognize unsafe work conditions  
Record information  
Report findings  
Review reports  
Select and operate safety equipment  
Transcribe data  
Use hand tools

### **Knowledge of**

Basic laboratory techniques  
Biological science  
Chemical properties  
Emergency plans  
Facility operation and maintenance  
Function of record keeping system  
Function of tools  
General chemistry  
General electrical principles  
Filtration  
Hydraulic principles  
Sample collection procedures  
Laboratory equipment  
Local codes and ordinances  
Lubricant and fluid characteristics  
Basic soil science  
Nitrogen cycle in waste treatment systems  
Aerobic-anaerobic conditions

### **Montana-Specific Needs to Know**

E.coli Test  
Interpret N&P Tests  
UV Maintenance, Adjustment, Safety  
Knowledge of Flow Measurement Equip.  
Cold Weather Operation  
Basic Electricity  
Montana Non-Degradation Law  
Septage Handling  
Certification Laws of Montana  
Operator Testing, CEC Requirements  
Understanding of MGWPCS Permit

## General Areas of Study

This need-to-know list is a lot of information to digest and it may not be practical to study each and every item on the list. The following information, extracted from previous DEQ Study Guides, provides a more general listing of subjects or skills that you should be familiar with:

### 1. Basic & Applied Math

Using a calculator and formula sheet, be capable of doing the following math calculations:

- Calculation of percent, volume, area, dosage, concentration and concentration time
- Unit conversions -- English system to metrics system
- Conversion between units of measure; e.g., cfs and gpm, gpm and MGD
- Interpretation & preparation of graphs, tables and charts
- Addition, subtraction, multiplication and division of whole numbers, fractions and decimals
- Percent removal and efficiency
- Surface-loading rate
- Soil hydraulic loading
- Drawdown rates
- Groundwater discharge impacts, dilution calculations
- Chlorine dose, residual, and demand
- Per capita BOD<sub>5</sub> loading

### 2. Basic Wastewater Characteristics

Be able to identify the source and the effect on public health and water quality of the following:

- Physical characteristics
  - Turbidity, temperature, odors, hardness, alkalinity
  - pH, hydrogen sulfide
- Water chemistry
  - Inorganic and organic substances in raw wastewater
- Biological characteristics
  - Bacteria, protozoa, viruses, insects, algae
- Sampling technique, preservation, interpretation of results

### 3. Hydraulic Concepts

Be able to define and perform calculations for the following:

- Detention, flow rate, velocity



- Force, pressure, head
- Flow measuring equipment

#### **4. Safety**

Be able to do the following:

- Describe the objectives of a safety program
- Describe the right-to-know laws
- Identify safety hazards for chemical feed, storage and electrical equipment
- Describe the hazards of and protection programs for confined spaces, traffic control at work areas, trenching and excavation projects
- Describe personal protective equipment for handling hazardous chemicals such as chlorine gas and calcium hypochlorite
- Describe proper handling & lifting procedures for heavy equipment and supplies
- Identify preventive measures to protect against slips & falls

#### **5. Regulatory Authority**

Be able to describe or understand the following:

- The purpose of the operator certification law and rules and the role of the certified operator in public health and environmental protection
- Use of a Professional Engineer when modifying a public water or sewer system
- Non-degradation provisions of the Montana Water Quality Act
- Requirements under the MGWPCS discharge permit program
- Septage disposal requirements
- Local sewer use ordinances

#### **6. Sources and Treatment**

Understand the following subject areas including the evaluation and operational characteristics associated with the wastewater unit processes listed below:

-Sources and characteristics of wastewater: domestic, commercial, industrial, storm sewers, toxics

-Odor control technologies

-Pretreatment

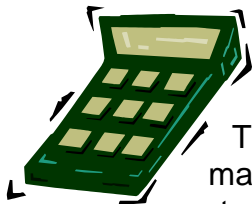
- Screening
- Aeration or freshening of septic wastewater or chlorination

-Primary treatment

- Sedimentation
- Septic tank design
- Dosing chambers

- Pumping systems
- Soil Disposal Systems
  - Standard drainfields
  - Pressure dosed drainfields
  - Sand filters
- Residuals or biosolids management
  - Land application
  - Composting
  - Landfilling
- Compliance testing and interpretation of data
- Corrosion control
- Conveyance systems
  - Trenching practices
  - Repairs
  - Materials Use
  - Testing
- Cross connections & backflow
- Maintenance records
- Pumps – Types, maintenance, troubleshooting, lift station components

## VI. USE OF CALCULATORS FOR CERTIFICATION EXAMS



The Water and Wastewater Operator Advisory Council has determined that calculators may be used during examinations. A calculator is defined by the Council as a piece of equipment used to assist in calculations only. Therefore, the equipment should only have the capability for mathematical manipulation. In other words, the only calculators that can be used during water and wastewater examinations are ones that **do not** have the full alphabet on the keyboard.

The calculator can be a very helpful tool in helping you answer test problems that require math calculations. It can help you answer questions quicker and more accurately than doing the math by hand calculation. A calculator is a good tool to utilize when you are performing your duties as an operator. It is important that you are familiar with the calculator you will be using for the exam. The test is no time to learn how to operate the calculator. Use the calculator when you are studying and use the same calculator you have become familiar with when taking the certification exam.

The calculator should be large enough that you can operate it easily with your fingers rather than a pencil. You should know how to store and recall numbers as well as perform multiple or chain operations such as adding numbers then dividing the sum and multiplying the result. You should make sure that your batteries last during your exam and have extra batteries or a second instrument if you suspect a problem.

## **VII. STUDY STRATEGY**

### **Study Habits**



The following tips are designed to help you study appropriately for the exam and be successful when you take the test:

1. The “*Small Wastewater System O&M, Volumes I and II*”, California State University (Ken Kerri Manuals), the “*Onsite Wastewater Treatment Systems Manual*”, U.S. EPA 2002, EPA/625/R-00/008, *the Basic On-Site Wastewater Treatment Training Manual* plus the formula sheet and definitions contains most, if not all, of the information that you need to know. If you know and understand the information in the reference information mentioned on Page 3 of this guide, you should do well on the test.
2. The Need-to-Know Summary provided earlier in Section V of this Study Guide provides you with a general listing of all of the study areas in which you may be tested.
3. Develop Good Study Habits
  - Study regularly in a quiet, uninterrupted setting for at least a half hour each day. Start studying well before the examination date.
  - Regardless of your education and background, do not assume that the test will be easy to pass. Studying is required.
  - When studying, highlight or underline important information. Take notes and refer back to them.
  - Focus on study areas that you may not be familiar with or have difficulty understanding.
  - Make a set of flash cards as study aids.
  - Review the definitions and formula sheets and make sure you understand what the terms mean and how to apply the formulas to problems.

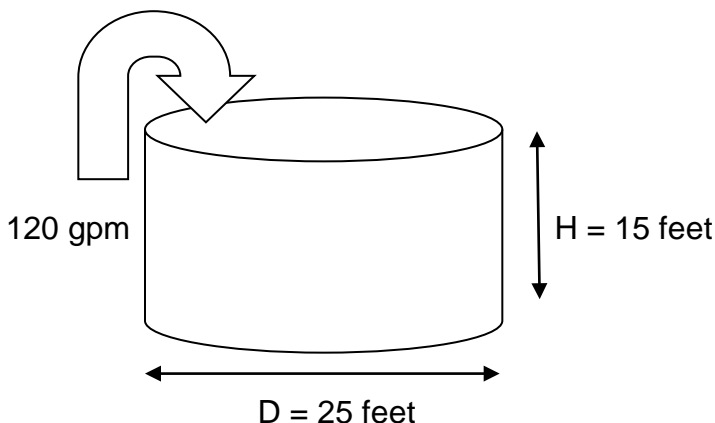
4. Visit an onsite system and talk with the operator in charge of the system. See what things look like in the real world and relate what you see to the exam.
5. Be familiar with lift station operation and disinfection equipment also as it will be included on the exam.
6. Attend pre-exam training classes held by the Montana Environmental Training Center, Montana Rural Water Systems and the Montana Department of Environmental Quality. The Fall Water School in Bozeman is a good opportunity for operators taking the exam to get quality training and help sessions in specific subject areas.
7. Work on your math skills! While the test is multiple-choice, it will contain math questions and you should be capable of solving mathematical calculations. Become familiar with the formula sheet provided with your study materials and use it when solving the math questions. The same formula sheet will be provided with the exam.
8. Study with someone else that is taking the exam. Test each other.

### Deciphering a Math Problem

A systematic approach towards a math problem will help you to successfully answer the question. Consider the following approach:

1. Read the question.
2. Determine what is being asked and identify the units given and the units required in the answer. Formulas and conversion factors often must be used to convert units to obtain the correct result.
3. Draw a picture or a diagram and label the drawing with known information.

**Example:** A pump is discharging 120 gallons per minute into a storage tank which is 15 feet high and 25 feet in diameter. The overflow is 1 foot from the top. How long can you pump into the tank if it is empty initially and you do not want to waste any water?



**Given:** Flow Rate = 120 gpm  
 Tank Volume based on  
 $V = (\pi/4) \times d^2 \times h$   
 $h = 14'$ , height of overflow

**Solution:** The answer is asking “how long” meaning what amount of time is needed to fill the tank. The units of the given information are mixed so they must be converted to make sure that the units are in agreement.

Use conversion factor from Formula Sheet

120 gallons/minute ÷ 7.48 gallons/ cubic feet = a pumping rate of 16 cubic feet/minute

$$\begin{aligned} \text{Tank Volume} &= (\pi/4) \times d^2 \times h \\ &= 0.785 \times 25^2 \times h \\ &= 6,868 \text{ cubic feet} \end{aligned}$$

same units of volume

The formula to use is: Time = Volume ÷ Pumping Rate

$$\begin{aligned} \text{Time} &= 6,868 \text{ ft}^3 \div 16 \text{ ft}^3/\text{min} \\ \text{Time} &= \underline{\underline{429 \text{ minutes or } 7.2 \text{ hours}}} \end{aligned}$$

Is the answer reasonable? – Yes, 7.2 hours with a relatively small pump seems to be reasonable

4. Divide the problems into steps to simplify solving.
5. Solve the equations; check your units and your arithmetic.
6. Is your answer reasonable? If not, it is probably wrong.
7. Reread the question to make sure that you solved the problems for what was asked.

### Multiple Choice Tactics

All questions on the exam are multiple-choice. The following information provides some helpful hints in solving these types of questions.

1. Read the question thoroughly and identify, in your own words, what is being asked.
2. Read all answers to the question. Care has been taken in formulating questions to ensure that clear and correct answers are provided in the list of choices.
3. Look for key words or phrases that may indicate correct or incorrect answers. Absolutes used in an answer such as *always* or *never* should be suspected as a poor choice.
4. Use the process of elimination and reject answers that you know are not right.

5. Trust your first time reaction or intuitive answer to a question. These often are the right answer!
6. Use your time wisely. If you struggle with a question, move on to the next one. Mark the question you didn't answer and come back to it. Answer all questions!
7. Try to make an educated guess on questions that you cannot answer. Look for clues within the question that may be linked to the correct answer. Focus on the answers that are possible and eliminate those that are obviously not correct.

## **VIII. PRACTICE EXAM**

The following practice exam contains 25 multiple-choice questions, written in a format which is similar to that to be used on the examination. We suggest that you take the practice exam in a manner similar to what you can expect when taking the real exam. You will have 4 hours to answer 100 questions on the real exam so allow yourself 1 hour to take the practice exam, to give an idea on how quickly you must answer questions. After taking the practice exam, review the solutions for those problems you may have had trouble with and evaluate the step-by-step process in solving math problems.

## Class 4E Practice Exam

1. What is the static pressure in pounds per square inch (psi) at the base of a tank if the water level in the tank is 50 feet?
  - A. 22 psi
  - B. 220 psi
  - C. 50 psi
  - D. 2.2 psi
  
2. A pressure-dosed drainfield consists of twenty (20) laterals, each 50-feet long. Each lateral trench is three (3) feet wide. The average flow is 1.5 gallon per minute. What is the drainfield trench loading rate in gpd/ft<sup>2</sup>?
  - A. 1.6 gpd/ft<sup>2</sup>
  - B. 3.0 gpd/ft<sup>2</sup>
  - C. 13 gpd/ft<sup>2</sup>
  - D. 0.7 gpd/ft<sup>2</sup>
  
3. The BOD removal at the sewage treatment plant averages 200 ppm for an average flow of 1.5 million gallons per day (MGD). How many pounds of BOD are removed each day?
  - A. 1500 lbs/day removed
  - B. 2500 lbs/day removed
  - C. 150 lbs/day removed
  - D. 250 lbs/day removed
  
4. What is the primary function of the drainfield system following a septic tank?
  - A. Providing moisture for the soil cover crops
  - B. Disperse nutrients over a wider area
  - C. Allow for further waste treatment prior to disposal
  - D. Recharging local groundwaters
  
5. Uniform distribution and dosing of wastewater is important because it:
  - A. Reduces hydraulic overloading of the infiltrative surface
  - B. Allows for improved aeration of the surrounding soil
  - C. Reduces soil oxygen
  - D. Both a and b
  
6. Which of the following will cause cavitation in a pump?
  - A. Excessive head on the suction side of the pump
  - B. Inadequate lubrication
  - C. Improperly adjusted wear rings
  - D. Excessive suction lift on the inlet side of the pump

7. What is the velocity in feet per second in a 12-inch diameter pipe when the flow rate is 1200 gpm?
- A. 6.0 feet/sec
  - B. 2.0 feet/sec
  - C. 3.4 feet/sec
  - D. 4.5 feet/sec
8. Which of the following pumps can be considered a positive displacement pump?
- A. Turbine
  - B. Diaphragm
  - C. Jet
  - D. Centrifugal
9. The process in a typical drainfield where ammonia compounds from the septic tank are oxidized under aerobic conditions to form nitrates is called:
- A. Mineralization
  - B. Stratification
  - C. Nitrification
  - D. Precipitation
10. You must install a new pipeline in your community and it will require a trench 4 feet wide, 6 feet deep and 250 feet long. You must bed the pipe with 1 foot of pea gravel. How much gravel is needed for bedding in cubic yards?
- A. 50 cubic yards
  - B. 3.7 cubic yards
  - C. 220 cubic yards
  - D. 37 cubic yards
11. Locations that may be hazardous due to an oxygen-deficient atmosphere or the presence of toxic or explosive gases include:
- A. Sewers
  - B. Manholes
  - C. Septic tanks
  - D. All of the above



12. The purpose of a septic tank is to:
- A. Allow for the separation and anaerobic decomposition of water solids
  - B. Distribute wastewater evenly throughout the granular media
  - C. Allow for settling and aerobic decomposition of wastewater solids.
  - D. Reduce the rate of flow to the low pressure disposal field
13. What pH indicates an acidic condition?
- A. 7.0
  - B. 4.2
  - C. 8.5
  - D. 10.0
14. What is one advantage that a gravity drainfield has over a dosed drainfield system?
- A. Better wintertime operation
  - B. Less complicated system
  - C. Better distribution
  - D. More operational flexibility
15. What problems can develop if too much grease is used in lubricating motor bearings?
- A. No problems will develop
  - B. It may cause bearing seal failure
  - C. It may result in high temperatures
  - D. Both B and C
16. Your MGWPCS discharge permit requires monthly monitoring frequency but you are closed from November through May. What are your reporting requirements during the period when you are closed?
- A. Only report during the month that you discharge in
  - B. Submit monthly reports and indicate "no discharge" when you do not discharge
  - C. Average the BOD<sub>5</sub> using 0 mg/l when you do not discharge
  - D. Contact the DEQ
17. What is the primary purpose of a check valve used on a pump station?
- A. Allow isolation of the pump for removal
  - B. To reduce water hammer
  - C. To prevent reverse flow
  - D. To allow monitoring of the force main

18. A single-pass intermittent sand filter is 30 ft. by 30 ft. by 24 inches deep. The average flow is 0.80 gallon per minute. The BOD<sub>5</sub> of the flow being treated is 190 mg/l. What is the organic loading rate in lbs BOD<sub>5</sub> / 1000ft<sup>2</sup> / day?  
(Round to nearest whole number.)
- A. 4
  - B. 10
  - C. 2
  - D. 1
19. The different levels of On-site wastewater operator certification (2E, 3E, 4E) are based on:
- A. Type of system being operated
  - B. Years of operator experience
  - C. Quality of the receiving stream
  - D. Number of employees working in the facility
20. The neutral wire in a building electrical system is usually what color?
- A. Green
  - B. Black
  - C. White
  - D. Bare copper
21. Detention time in a wastewater tank generally refers to:
- A. The theoretical time that a unit of wastewater stays in the basin before being discharged
  - B. Holding time needed to meet effluent standards
  - C. The flow rate divided by the sludge age
  - D. Volume between the basin bottom and water surface
22. Under Montana law, a professional engineer must be utilized for which of the following situations?
- A. Specifying a replacement pump
  - B. Modifying the sewer user charge rate structure
  - C. Rewiring a pump control panel
  - D. Extending a sewer main into a new subdivision

23. When operating a dosing tank with two identical pumps, how should the controls be adjusted so that both pumps remain in operating condition?
- The pumps should alternate in operation
  - The pumps should turn on together
  - One pump should do all of the work while the second one is held in reserve until the first one is worn out
  - The pumps should operate only when the wastewater has reached a level at which it would overflow to the bypass
24. Flow measurements are important because they are used to:
- Determine loadings on treatment units
  - Determine pathogen treatment efficiency
  - Determine dissolved oxygen concentration
  - Determine suspended solids removal efficiency
25. A worn impeller on a centrifugal pump could cause the following problem:
- High system pressure
  - Excessive temperatures
  - Reduced pump output
  - Rattling noise coming from the pump

### **Class 4E Study Guide Practice Problems - Solutions and Answers**

1. Formula:

1 psi = 2.31 ft (pressure head)

A column of water 2.31 feet high exerts a pressure of 1.0 psi at its base

$$\text{Pressure (psi)} = \frac{\text{Elevation (ft)}}{2.31 \text{ (ft/psi)}}$$

Solution:

$$\text{Pressure (psi)} = \frac{50 \text{ (ft)}}{2.31 \text{ (ft/psi)}}$$

**A - Pressure (psi) at Base of Tank = 21.6 psi**

2. Solution:

Drainfield surface area = 20 laterals x 50' x 3.0' = 3000 square feet of area

Flow to drainfield = 1.5 gpm x 60 minutes x 24 hours = 2,160 gpd

Drainfield Loading = 2,160 gpd/3000 square feet = 0.72 gpd/ft<sup>2</sup>

**D is the correct answer**

3. Formula:  
dosage (lb) = concentration (mg/L) x volume (MGD) x 8.34 lb/gal  
ppm = mg/L

Solution:  
BOD Removed (lb) = 200 mg/L x 1.5 MGD x 8.34 lb/gal

**B - BOD Removed (lb) = 2502 lb/day**

4. **C**

5. **D**

6. **D**

7. Solution:  
Velocity in pipes is expressed in ft/sec  
Formula:  $Q = VA$  where Q is flow, V is velocity and A is area  
therefore  $V = Q/A$

$$Q = 1200 \text{ gpm} - \text{ must be converted to CFS } 1 \\ = 1200 \times .002228 = 2.67 \text{ cfs} \quad (.002228 \text{ is a conversion factor})$$

$$A = \text{area of 12" pipe} = \pi R^2 = 3.14 \times (1.0/2)^2 = 0.785 \text{ ft}^2$$

$$V = Q/A = 2.67 \text{ cfs} / 0.785 \text{ ft}^2 = 3.401$$

**C is the correct answer**

8. **B**

9. **C**

10. Formulas:  
Volume = length x width x height  
1 Cubic Yard = 27 ft<sup>3</sup>

Solution:  
Volume of pea gravel = 250 ft x 4 ft x 1 ft  
Volume of pea gravel = 1000 ft<sup>3</sup>

$$\text{Volume of pea gravel} = \frac{1000 \text{ ft}^3}{27 \text{ ft}^3}$$

**D - Volume of Pea Gravel = 37 cubic yards**

- 11. **D**
- 12. **A**
- 13. **B**
- 14. **B**
- 15. **D**
- 16. **B**
- 17. **C**

18. Formulas:

dosage (lb)/day = concentration (mg/L) x volume (MGD) x 8.34 lb/gal

ppm = mg/L

application rate = dosage/1000 ft<sup>2</sup> filter area

Solution:

dosage (lb) = 190 mg/L x [(0.8gpm x 1440 min/day) ÷ 1,000,000 gal/MGD] MGD x 8.34 lb/gal = 1.83 lb

application rate = 1.83 lb/day ÷ [(30' x 30') ÷ 1000] = 2.03 lb per day/1000 ft<sup>2</sup>

**C is the correct answer**

- 19. **A**
- 20. **C**
- 21. **A**
- 22. **D**
- 23. **A**
- 24. **A**
- 25. **C**

## **XI. GLOSSARY OF WASTEWATER WORDS**

**ACID**: A substance that: tends to lose a proton, dissolves in water with the formation of hydrogen ions (H<sup>+</sup>), contains hydrogen which may be replaced by metals to form salts. Highly corrosive.

**ACRE FOOT**: A volume of water one (1) foot deep and one (1) acre in area, or 43,560 cubic feet.

**AERATION**: The process of adding air to wastewater to provide dissolved oxygen for aerobic bacterial treatment, to freshen wastewater and to keep solids in suspension.

**AEROBIC**: The condition in which free oxygen is dissolved in the water. Aerobic bacteria need free oxygen to live and multiply.

**ALGAE**: A class of microscopic plant life that contain chlorophyll, live floating (suspended) in water or are attached to rocks, walls and other surfaces, and grow and multiply through photosynthesis. Algae produce oxygen during sunlight hours, use oxygen during darkness and affect the pH and DO levels in water.

**ALGAL BLOOM**: Sudden, massive growths of algae that develop in lagoons, lakes and reservoirs.

**ALKALINITY**: The capacity of water to neutralize acids; the buffering capacity of water to resist changes in pH, especially with regard to acids, the effects of chlorine addition and the **DENITRIFICATION** process.

**ANAEROBIC**: The condition in which there is no, or very little, free dissolved oxygen in the water. **Anaerobic bacteria** live in the absence of free oxygen but they are able to obtain their oxygen from combined oxygen that exists in chemical compounds. Some treatment lagoons are purposely operated in an anaerobic state. Odors are often associated with anaerobic (septic) conditions due to formation of hazardous hydrogen sulfide gas.

**ANAEROBIC DIGESTION**: Anaerobic bacteria (saprophytic and methane fermenters) decompose wastewater solids (complex organic material) in two steps into: 1) volatile acids, and 2) methane gas, carbon dioxide and water in the absence of dissolved oxygen. Specially designed basins, digesters, are used to carry out the digestion processes, prevent air from entering and to capture the methane gas. The **sludge layer** at the bottom of lagoons provides for similar solids stabilization processes.

**AQUIFER**: A natural underground layer of porous materials usually capable of yielding a supply of water.

**AVAILABLE CHLORINE**: The amount of chlorine available in compound chlorine sources compared with that of elemental (liquid or gaseous) chlorine.

**BOD**: (Pronounce letters separately.) The **BIOCHEMICAL OXYGEN DEMAND** test measures the rate at which microorganisms use oxygen while decomposing organic matter under aerobic conditions. BOD is used as a measure the organic strength of wastewater.

**BACKFLOW:** A reverse flow condition, created by a difference in water pressures, which causes water to flow back into the distribution pipes of a potable water supply from any source or sources other than an intended source. Also see BACKSIPHONAGE.

**BACKSIPHONAGE:** A form of backflow caused by a negative or below atmospheric pressure within a water system. Also see BACKFLOW.

**BACTERIA:** Bacteria are single-celled, living, microscopic organisms which use organic matter for food and produce waste products. The three main types are: aerobic, anaerobic and facultative.

**BASE:** A substance that takes up or accepts protons, dissociates in water to produce hydroxyl (OH<sup>-</sup>) ions, reacts with metals and is corrosive.

**BERM:** The earthen dike that surrounds ponds, lagoons and containment areas for hazardous material.

**BIOMASS:** Amass or clump of living organisms feeding on wastes in wastewater, dead organisms and other debris. The mass may protect the organisms, as well as store food supplies. Also called ZOOGLEAL MASS.

**BLUE-GREEN ALGAE:** Varieties of algae characterized by their bluish-green color. The appearance of blue-green algae indicates unhealthy conditions in lagoon cells, often associated with organic overloading and lack of adequate dissolved oxygen.

**CAVITATION:** The formation and collapse of a gas pocket or bubble on the blade of an impeller or gate of a valve. The collapse of the bubble drives water into the impeller or gate with a terrific force that can cause pitting of the surface. Cavitation is indicated by loud hammering noises.

**CARBON DIOXIDE:** A common gas, CO<sub>2</sub>, found abundantly in air, is a product of bacterial respiration and used by algae in photosynthesis. The concentration of carbon dioxide in the lagoon water governs the pH of the lagoon.

**CARCINOGEN:** Any substance that tends to produce cancer in an organism.

**CHLORINATION:** The application of chlorine to water for disinfection or oxidation of undesirable compounds. Chlorine compounds are gas and liquid or solid (hypochlorites).

**CHLORINATOR:** A metering device which is used to add chlorine to water.

**CHLORINE CONTACT UNIT:** A baffled basin that provides sufficient time for disinfection to occur.

**CHLORINE DEMAND:** The difference between the amount of chlorine added to water and the amount of chlorine residual remaining after a given contact time.

**CHLORINE RESIDUAL:** The amount of free chlorine remaining after meeting chlorine demand under given conditions and is necessary to complete disinfection.

**CHLORINE REQUIREMENT:** The amount of chlorine needed for a particular treatment.

**CLARIFICATION:** Any process or processes used to reduce the concentration of suspended matter in a liquid, such as quiescent settling or sedimentation. Lagoons provide clarification across the cells and in quiescent zones in aerated systems, allowing solids to settle into a sludge layer

**CLEAN WATER ACT:** Federal legislation passed in 1972 creating the Environmental Protection Agency, requiring a nationwide system for controlling pollutant discharges and providing for construction and regulation of publicly owned treatment works.

**COLIFORM:** The presence of coliform bacteria indicates that the water is polluted, may contain pathogenic organisms and indicate the possible presence of human or animal waste. Fecal coliform are specific to feces from warm-blooded animals, including humans. The *E.coli test* is a specific coliform test used to regulate and protect public health from WWTP discharges containing pathogens.

**COMBINED SEWER:** A sewer designed to carry both sanitary wastewater and storm- or surface-water runoff.

**COMPOSITE (PROPORTIONAL) SAMPLE:** A collection of individual samples obtained at regular intervals during a 24-hour period. Each individual sample is combined with the others in proportion to the rate of flow when the sample was collected. The resulting mixture, or composite, forms a representative sample and is analyzed to determine the average conditions during the sampling period.

**CONTAMINATION:** The introduction into water of microorganisms, chemicals, toxic substances, wastes, or wastewater in a concentration that makes the water unfit for its next intended use.

**CREST:** The bottom edge of a weir plate.

**CROSS-CONNECTION:** A connection between a drinking water system and an unapproved system.

**CRUSTACEANS:** A class of microscopic water animals that consume large quantities of bacteria and algae.

**DAPHNIA:** A crustacean commonly found in wastewater lagoons.

**DECHLORINATION:** The removal of chlorine from the effluent of a treatment plant.

**DENITRIFICATION:** An anaerobic process that occurs when nitrite and nitrate ions are reduced to nitrogen gas and bubbles are formed. These bubbles attach to sludge flocs, causing rising sludge that floats to the surface of secondary clarifiers.

**DETENTION TIME:** The theoretical time that water may stay in a basin such as lagoon. It is the total volume of the lagoon divided by the flow rate. Usually expressed in days of time or in hours.



**DISINFECTION:** The process designed to kill most microorganisms in water, including the destruction or inactivation of pathogenic bacteria. Disinfection differs from sterilization which destroys all living forms.

**DISSOLVED OXYGEN:** Molecular (atmospheric) oxygen dissolved in water or wastewater, usually abbreviated as DO.

**DISSOLVED SOLIDS:** The salts and other residues left after evaporation of water that has been passed through a laboratory filter. Dissolved solids cannot be filtered out. Some colloidal solids may not be in true solution, but if they pass through the standard membrane filter, they are considered dissolved solids. (See suspended solids)

**DIURNAL:** Having a daily cycle; usually a 24-hour period from 12:00am to 12:00pm.

**DUCKWEED:** A water plant with single small leaf that floats and accumulates on the surface of lagoons.

**EFFLUENT:** The treated water leaving the treatment plant.

**FACULTATIVE:** A combination of both aerobic and anaerobic conditions. Facultative cells have both aerobic and anaerobic zones. Facultative bacteria are able to exist in both aerobic and anaerobic conditions. A facultative pond is commonly used to treat wastewater flows in small communities, It has an upper aerobic zone, a lower anaerobic zone, and algae provide most of the oxygen for the bacteria.

**FERMENTATION:** A process of decomposition of organic solid materials by bacteria and other biological actions.

**FILAMENTOUS:** The property of growing in long strings, or filaments. Algae and bacteria have filamentous forms. Algae filaments can clog up equipment and be a nuisance in receiving waters. Bacterial filaments are a common cause of bulking in activated sludge.

**FLOC:** Clumps of bacteria and particulate impurities that have come together and formed a cluster.

**FREE AVAILABLE RESIDUAL CHLORINE:** That portion of the total available chlorine residual composed of dissolved chlorine gas ( $\text{Cl}_2$ ), hypochlorous acid ( $\text{HOCl}$ ), and/or hypochlorite ion ( $\text{OCl}^-$ ) remaining in water after chlorination.

**FREE OXYGEN:** Oxygen can be dissolved in water as the soluble gas  $\text{O}_2$  when it is called free oxygen and measured as dissolved oxygen.

**FREEBOARD:** The vertical distance from the normal water surface to the top of the confining wall.

**GRAB SAMPLE:** A single sample of water collected at a particular time and place which represents the composition of water only at that time and place.

GREEN ALGAE: The common forms of algae in an aerobic lagoon environment. Green algae are essential for lagoon treatment.

GRIT: Raw sewage carries a variable amount of solids such as sand, and other heavier settleable solids. These are generally classed as grit.

HARD WATER: Water having a high concentration of calcium and magnesium ions.

HEAD: The vertical distance (in feet) equal to the pressure (in psi) at a specific point. The pressure head is equal to the pressure in psi times 2.31 ft/psi.

HYDRAULIC LOADING: The flow of water per acre of surface area.

HYDROGEN SULFIDE: A very odorous and poisonous gas. Commonly known as rotten egg gas. It is a combined form of hydrogen and sulfur with the formula  $H_2S$ .

HYDROLOGIC CYCLE: The process of evaporation of water into the air and its return to earth by precipitation. (Also called the WATER CYCLE)

HYPOCHLORINATORS: Chlorine pumps, chemical feed pumps or devices used to dispense chlorine solutions made from hypochlorites into the water being treated.

INFILTRATION: The gradual flow of water into the soil; also, the flow of groundwater as seepage into a sewer system.

INFLOW: Water discharged into the sewer system from sources other than regular connections, including yard drains, foundation drains and around manhole covers.

INFLUENT: The flow coming into the system.

INORGANIC: Material such as sand, salt, iron, calcium salts and other mineral materials and other than of plant or animal origin or of carbon compounds (ORGANIC).

METHANE: A combustible gas produced during anaerobic fermentation of organic matter, such as by anaerobic digestion of wastewater solids.

MGWPCS PERMIT: Montana Groundwater Pollution Control System permit. This permit is issued to owners/operators of potential sources of pollution to state ground waters.

MICROORGANISMS: Microscopic living organisms.

MILLIGRAMS PER LITER, mg/L: A measure of the concentration by weight of a substance per unit volume. One thousandth of a gram in one liter. One mg/L is equal to one part per million (ppm).

MONITORING WELL: Wells used to collect groundwater samples for analysis to determine the amount, type, and spread of contaminants in groundwater. Specific design is often determined by the Water Protection Bureau at MT DEQ.

MPDES PERMIT: Montana Pollutant Discharge Elimination System permit. This permit lists the conditions that must be met before treatment plants can discharge an effluent into state

receiving waters.

NITRIFICATION: An aerobic process in which bacteria change ammonia and organic nitrogen into nitrite and nitrate forms of nitrogen.

NONPOTABLE: Water that is considered unsafe and/or unpalatable for drinking.

NONPOINT DISCHARGE: A source of wastewater that comes from a relatively large area and would have to be controlled by a management or conservation practice. Storm waters and most agricultural waters are nonpoint sources.

NPDES: National Pollutant Discharge Elimination System. Establishes national levels of treatment and conditions for discharges to receiving waters. (See MPDES)

NUTRIENTS: Substances required by living plants and organisms. Forms of nitrogen and phosphorous are nutrients that can cause problems in receiving waters.

ORGANIC: Substances from animal or plant sources. Organic substances contain carbon. (See INORGANIC)

ORGANIC ACIDS: Weak acids formed from organic compounds, such as acetic acid and citric acid. These acids form first in anaerobic digesters and then are converted to methane. The organic acids in wastewater lagoons are much more complex and generally weaker.

OXIDATION POND: A term often used interchangeably with lagoon. Oxidation ponds are used after other treatment processes.

pH: (Pronounce letters separately.) The intensity of the basic or acid condition of a liquid.

PALMER-BOWLUS FLUME: A flow measuring device consisting of a preformed flume.

PARSHALL FLUME: A flow measuring device consisting of a preformed flume with restrictive area called the throat. The head of water at a stilling well just upstream from the narrow part of the throat is measured and a chart is used to obtain flow rate.

PATHOGENIC ORGANISMS: Organisms capable of causing diseases in a host.

PERCOLATION: The movement or flow of water through soil or rocks. A discharge option for many wastewater treatment systems. In Montana, a Montana Ground Water Pollution Control System (MGWPCS) permit and sampling in groundwater monitoring wells are required for permitted systems.

PHOTOSYNTHESIS: A complex process in all green plants that contain chlorophyll. The process uses sunlight as energy to convert carbon dioxide into plant growth. As a by-product oxygen is released.

POLISHING POND: A final lagoon cell after other treatment which completes the treatment, or "polishes" the effluent.

POPULATION EQUIVALENT: An average BOD contribution by each person to a domestic sewage. The accepted population equivalent is 0.17 pounds of BOD per person per day.

POTABLE WATER: Water that is considered satisfactory for drinking.

PPM: Abbreviation for Parts Per Million. See MILLIGRAMS PER LITER (mg/L)

PRIMARY CELL: The first cell in a series, generally receiving raw wastewater.

RIP-RAP: Erosion control by placement of large rocks along an embankment.

ROTIFER: A form of microscopic animal that feeds on algae and bacteria. The free swimming protozoa are common in lagoons. Rotifers require aerobic conditions.

SATURATION: Oxygen saturation is the concentration of free dissolved oxygen in water that is in equilibrium with atmospheric oxygen. It is measured in milligrams per liter (mg/l). It varies with both temperature and atmospheric pressure.

SECONDARY: The second in a series of cells.

SECONDARY TREATMENT: A wastewater treatment process used to convert dissolved or suspended materials into a form more readily separated from wastewater. Usually follows primary sedimentation treatment and uses biological processes to convert wastes to solids that settle in secondary clarifiers. Also occurs in lagoon systems.

SEDIMENTATION: A process in which solid particles settle out of water.

SEPTIC: A condition that exists when there is no dissolved oxygen (see anaerobic). Anaerobic bacteria and other microorganisms continue to use parts of the waste for food, but produce foul odors and black colored water. The waste in the common septic tank is typical of this condition.

SHORT-CIRCUITING: A hydraulic condition in which water may find a short path between the inlet and outlet of a cell with subsequent shortened time of retention.

SLUDGE: The settleable solids separated from wastewater during treatment.

STABILIZATION: The conversion of biodegradable materials into more stable solids. Stabilization is the primary function of wastewater lagoons and treatment plants. Lagoons are often called stabilization ponds.

STRATIFICATION: The formation of indistinct layers of slightly variable density of waters. Often caused by warming of the surface with an absence of mixing.

SURFACE LOADING: Lagoon loading is rated organically in pounds of BOD per acre of surface area per day. Northern climates require lower loading rates than warmer areas, because cold weather slows down the stabilization processes of microorganisms. Treatment plants clarifiers are rated hydraulically in flow (gpd) per surface area (sq ft).

SUSPENDED SOLIDS: Solid material so finely divided or light in weight that it does not settle, but can be filtered in a lab test and weighed. Also referred to as Total Suspended Solids (TSS).

TSS: Abbreviation for TOTAL SUSPENDED SOLIDS, a test measuring the amount of filterable solids in wastewater.

TOXIC: A substance that is poisonous to an organism.

TURBIDITY: The cloudy appearance of water caused by the presence of suspended and colloidal matter. A turbidity measurement is used to indicate the clarity of water.

UV: Ultraviolet light. UV is useful as a method of disinfection. It leaves no residual and is often used where no chlorine residual (or a very low residual) is allowed to be discharged.

WATER QUALITY ACT: Montana's primary water pollution control legislation that parallels the federal CLEAN WATER ACT. It establishes the public policy for Montana to: 1) conserve water resources by protecting, maintaining and improving water quality for all its beneficial uses, and 2) provides a comprehensive program for the prevention, abatement and control of water pollution.

WEIR: (1) A wall or plate placed in an open channel and used to measure the flow of water. The depth of the flow over the weir can be used to calculate the flow rate, or a chart or conversion table may be used. (2) A wall or obstruction used to control flow (from settling tanks and clarifiers) to assure uniform flow rate and avoid short-circuiting.