Laboratory Analyst
Grade I
2nd Edition

Certification Examination
Study Guide

- ✓ Revised for tests starting April 2016!
- ✓ New KSA descriptions including KSA weighting.
- ✓ Expanded practice test and solutions.
- ✓ Searchable text optimized for electronic reading.

California Water Environment Association

Laboratory Analyst Grade I
Study Guide, 2nd Edition
Version 2.0, Updated January 30, 2016

Appendix A: You and Wastewater Math

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Important Notice: CWEA is pleased that you have purchased this book. We want to remind you that this book is one of many resources available to assist you and encourage you to identify and utilize the other resources in preparing for your next test.

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Section 1

Introduction

What to Expect From This Study Guide

The purpose of this study guide is to help certificate candidates understand what is expected of them on the certification test and to help them identify resources to assist in preparation for the test. It is not a comprehensive text on the wide variety of topics covered on the certification test. Successful candidates should expect to spend significant time reading and reviewing additional materials listed in this study guide along with any other materials available that can help them understand the subject matter of the test. In addition, successful preparation strategies include attending study sessions, participating in study groups, and completing relevant vocational and college courses. Ultimately, the amount of preparation required to pass the test depends on a candidate's education, training, and work experience. After reviewing this study guide, you should be able to determine what you need to do to prepare for the test and how much time you will need (months are often required).

About the CWEA Certification Program

The California Water Environment Association (CWEA) Technical Certification Program (TCP) is either required or encouraged by many wastewater employers. Its purpose is to set a standard of the essential requirements for an individual to perform a given job safely and effectively, and to provide a measure of competency through certification testing. The certification test focuses on the Knowledge, Skills, and Abilities (KSAs) an individual must master to perform their job safely and effectively.

CWEA certifies personnel in six vocations:

- Plant Maintenance Technologist (with two parallel specialties of Electrical/ Instrumentation, and Mechanical Technologist)
- Laboratory Analyst
- Collection System Maintenance Technologist
- Environmental Compliance Inspector
- Industrial Waste Treatment Plant Operator
- Biosolids Land Application Management

Upon qualifying and successfully completing the certification test, an individual becomes certified in that specialty at that grade level. Grade levels within a vocation designate technical knowledge for the entry-level, apprentice, journey, and management levels. More information about minimum qualifications can be found in the Candidate Handbook for your vocation available at www.cwea.org/cert or calling (510) 382-7800.

Much of the CWEA mission is dedicated to providing education and training in all aspects of the wastewater industry including the KSAs of each certification vocation. CWEA is careful to separate its education and training activities from its certification activities to ensure that the educational focus is on the KSAs wastewater professionals need to know to perform their jobs rather than being narrowly focused on just passing the certification test.

Certification Program and Polices

CWEA's mission is to enhance the education and effectiveness of California wastewater professionals through training, certification, dissemination of technical information, and promotion of sound policies to benefit society through protection and enhancement of the water environment.
CWEA is a California Nonprofit Corporation, a Member Association of the Water Environment Federation (WEF), and a member of the Institute of Credentialing Excellence (ICE).

Technical Certification Program History

TCP was created to offer multilevel technical certification for individuals employed in the water quality field. Tests are written by vocational specialists and administered year round in six different vocations: Collection System Maintenance, Environmental Compliance Inspection, Laboratory Analysis, Plant Maintenance (Electrical/Instrumentation and Mechanical Technologist), Industrial Waste Treatment Plant Operation, and Biosolids Land Application Management.

CWEA first offered a certification program for wastewater treatment plant operators in 1937. The program was administered by CWEA until 1973 when the State of California assumed responsibility. During those 36 years, CWEA awarded 3,915 operator certificates.

CWEA established its Line Maintenance certification program in 1964. Eventually that would become the Collection System Maintenance certification program. In 1974 the first committees were formed to establish a voluntary certification program for water quality professionals specializing in disciplines other than plant operation. The following year the State Water Resources Control Board suggested that CWEA implement an industrial waste pretreatment certification program. TCP, then known as the Voluntary Certification Program or VCP, emerged in 1976 with specialized certificate programs for Plant Maintenance, Environmental Compliance Inspection, and Laboratory Analysis with certifications first issued in April 1976. In the 1980s, two more disciplines were added: Electrical/Instrumentation and Industrial Waste Treatment Plant Operator.

Today, CWEA offers certification in vocational programs with a total of 23 individual certifications. About 2,000 applications are processed annually and currently over 5,500 certificates are held by individuals primarily in California. CWEA also partners with other WEF Member Associations to offer certification in Michigan, Hawaii, and Missouri.

Certification Process

To become certified, all applicants must complete the Application for Technical Certification, pay the application fee, meet minimum qualifications regarding professional experience and education, and pass the computer-based test. Application instructions and fee schedules are listed on the application. After applications are received at the CWEA office, applicant information is compiled in a database, and reviewed by CWEA staff and experts in the field. If timing permits, staff will work with the applicant to resolve any incomplete applications. When approved, the applicant will receive an acceptance letter and test registration and scheduling instructions.

Immediately after completion of the computer-based test, a preliminary score and result will be given at the testing center. Occasionally, the official results may be adjusted from the preliminary results to resolve scoring issues. Official results are mailed to candidates. Those who pass the test are mailed certificates and blue wallet cards (also known simply as "blue cards").

Test Administration

Test Dates and Sites

Tests are given throughout the year within four quarterly windows (see Application for Technical Certification for test schedule). Applicants who are eligible to take the test are mailed an acceptance letter with instructions on how to schedule their exam.

Test Site Admission

Certificate candidates are required to show at least one valid government issued photo identification (state driver's license or identification, or passport). Only after the testing proctor has made positive identification can a candidate be allowed to take a CWEA cert test. Be sure the name on your acceptance letter matches your identification or you could be turned away at the test center. If your name does not match, contact the CWEA office immediately. Candidates are not required to show their eligibility letters to enter the test site.

Test Security

All tests are computer-based. No reference material, laptop computers, cameras or other personal items are allowed in the test site (see the test site policy at www.cwea.org/cbt). Candidates will have access to an on-screen calculator. However, candidates are welcome to bring their own calculator as long as it is on the list of approved calculators (visit www.cwea.org/cbt). Candidates are not permitted to take any notes from the test site. Candidates who violate test site rules will be asked to leave the site and may be disqualified from that test. All violations of test security will be investigated by CWEA and appropriate action will be taken.

Test Rescheduling and Cancellation

To reschedule your application, you must submit a written request stating that you wish to postpone to the adjacent testing window. You may only reschedule your application to the adjacent window once without a fee. Additional postponement will require a reschedule fee. There are no exceptions to this policy.

To cancel your application you must submit a request to CWEA. The request must be received at the CWEA office no later than 2 weeks after the approved test window begins. Full refunds, less the administrative fee, will be made within 4 weeks after the scheduled test date. There are no exceptions to this policy.

If you already have a scheduled exam with our testing partner, Pearson VUE, and need to cancel your appointment, you must contact them two business days in advance to avoid losing your exam fee.

Test Result Notification

Official test results are routinely mailed to certificate candidates approximately two weeks after the test date. Results are never given over the phone, via fax or email. All results are confidential and are only released to the certificate candidate.

Issue of Certificate / Blue Wallet Card

Certificates and blue wallet cards are issued to all candidates who pass the test. Certificates and blue wallet cards are mailed within three weeks after result notifications are mailed.

Certificate Renewal

All certificates are renewable annually. The first renewal is due one year from the last day of the month in which the certification test was held. Certificate renewals less than one year past due are subject to the renewal fee plus $25 late fee. Certificates more than two years past due are only renewable through retesting. Renewal notices are mailed to certificate holders two months before the due date. It is the responsibility of certificate holders to ensure the certificate(s) remains valid.
Every other year, certificates holders are required to submit 12 contact hours of education or training relevant to the certificate held. Continuing Education is required to help ensure that individuals certified by CWEA continue to be knowledgeable of technological advancements and regulatory requirements in the wastewater fields. Continuing education enhances the operation, maintenance and management skills of the certificate holders, and ensures the quality of wastewater treatment. This ultimately increases the ability and confidence of certificate holders and the credibility of the wastewater professions certified by CWEA.

Accommodations for Physical or Learning Disabilities

In compliance with the Americans with Disabilities Act, special accommodations will be provided for those individuals who provide CWEA with a physician's certificate, or its equivalent, documenting a physical or psychological disability that may affect an individual's ability to successfully complete the certification test. Written requests for special accommodations must be made with the test application along with all supporting documents of disability. Applicants requesting accommodations are encouraged to apply as early as possible to ensure sufficient time to process the request.

Test Design and Format

Test Design

All certification tests are designed to test knowledge and abilities required to perform the KSAs listed at the end of the section with minimal acceptable competence.

The KSAs were determined by a job analysis and meta-analysis of job specifications by experts in the filed under the guidance of test development specialists. The studies gathered data from on-site visits of over 31 water and wastewater agencies, interviews with 110 water and wastewater professionals, and analysis of more than 300 job specifications. All research was conducted under the guidance of the TCP Committee, vocational subcommittees, and CWEA staff. All test questions are designed to measure at least one area of knowledge or ability that is required to perform an essential duty.

Test Delivery Mechanism

All tests are computer-based format and are available in the English language only. Tests are delivered at Pearson VUE testing centers.

Test Format

All TCP tests are in multiple-choice format (see the sample test questions in this booklet for an example). The multiple-choice format is considered the most effective for use in standardized tests. This objective format allows a greater content coverage for a given amount of testing time and improves competency measurement reliability. Multiple choice questions range in complexity from simple recall of knowledge to the synthesis and evaluation of the subject matter.

Test Pass Point

The minimum score required to pass varies depending on the test and possible total points. The score may be adjusted downward depending on test complexity. It should be assumed that if the passing score is 75 percent candidates should try to score as high as possible on their test (in other words, always try for 100 percent). The pass point for each vocation and grade level is set independently. Also, each version, or form of a test will have its own pass point. Different versions are given each time the certification test is administered.

How Pass Points are Set

A modified Angoff Method is used to determine the pass point for each version of each test. The modified Angoff Method uses expert judgments to determine the test difficulty. The easier the test, the higher the pass point; similarly the more difficult the test, the lower the pass point.

The following is an outline of the modified Angoff Method (some details have been omitted):

1. A group of Subject Matter Experts (SMEs) independently rate each test question within a given test. The ratings are defined as the probability that an acceptably (minimally) competent person with the requisite education and experience will answer the question correctly. An acceptably (minimally) competent person is defined as someone who safely and adequately performs all job functions and requires no further training to do so.
2. The SMEs review each test question as a group. A consensus is reached for the rating of each test question. The SMEs also review comments submitted in writing by test-takers. Any test question that is judged to be ambiguous, has more than one correct answer, or has no correct answers is eliminated from the scoring process for that test. These test questions are then revised for future use, reclassified, or deleted from the test item bank.
3. After the data are refined, the final step is to calculate the mean, or average, of all the test question ratings. This becomes the overall pass point estimation.

Why Use Modified Angoff?

Each version of a given certification test uses questions from a test item bank. Each of these questions varies in difficulty. Because a different mix of questions is used in each test, the overall difficulty level is not fixed. Thus, it is important to make sure that the varying difficulty level is reflected in the pass point of each test to ensure that test results are reliable. Test reliability is concerned with the reproducibility of results for each version of a given test. In other words, for a test to be reliable it must yield the same result (pass or fail) for the same individual under very similar circumstances. For example, imagine taking a certain grade level test and passing it. Immediately after completing this test, a different version of the same grade level test is taken.

If the test is reliable, the same result will be achieved: pass. If a passing grade is not achieved, it is likely that the test is not a reliable measure of acceptable (minimal) competency.

By taking into consideration the difficulty of the test, the modified Angoff Method significantly increases the reliability of the test. Also, since each test is adjusted for difficulty level, each test version has the same standard for passing. Thus, test-takers are treated equitably and fairly, even if a different version of the test is taken.

There are other methods for setting pass points. However, for the type of tests administered by CWEA, the modified Angoff Method is the best and most widely used.

Test Scoring

All tests are electronically scored by Pearson VUE pending approval by CWEA. Most test items are valued at one point. After tests are scored, total points are compiled and an overall score is calculated as the sum of all points earned on the test. If the overall score is equal to, or greater than the established pass point, the candidate has passed the test. Total points possible for each test varies, but the average is 100 points plus or minus 25.

Item Appeals

Candidates who wish to appeal a specific test item must do so during the test by completing the Candidate Comment Review Section during the exam. Item appeals will be evaluated and appropriate adjustments will be made to the test content. Candidates submitting comments will not be contacted in regards to the appeal.

Section 3

Knowledge, Skills, and Abilities (KSAs)

Understanding The KSAs

The key to success on the CWEA certification test is understanding the KSAs and having adequate training, education, and experience in those KSAs. Each KSA describes the competencies required of an individual to successfully perform the essential duties of the job at grade level. Although the KSAs do not correspond precisely to every individual Grade I position description, they do reflect the core competencies and essential duties required of any Grade I Laboratory Analyst. The KSAs are developed from a job analysis that includes research of the essential duties at a representative cross-section of systems and facilities throughout California and other participating states.

This section outlines each KSA and includes descriptions of the general competencies, math competencies, and suggested reading for that KSA. Candidates are expected to understand the competencies described in this section and seek further educational opportunities to address those KSAs that have not been mastered. Although each candidate is encouraged to find educational opportunities that suit his or her needs best, typical educational opportunities include:

- On the job training
- Print or online training materials
- Manuals of practice, technical documents, regulations, etc.
- Mentoring
- Trade, vocational, or college courses
- Professional education sessions and seminar

Candidates seeking Laboratory Analyst Grade 1 certification should review the KSAs presented in this section and seek to understand how they apply to everyday duties and responsibilities.

KSA Weight

KSA Weight is the approximate percent of the test content covered by a KSA. For example, a KSA with a weighting of 7% will have about 7% of all questions (or points) dedicated to that KSA, or 7% of the test is about that KSA. The KSA weight is approximate and shows the relative importance of a KSA compared to the other KSAs. The KSA weight on the actual certification test may vary slightly.

General Competencies and Math Competencies

Each KSA includes an expanded description of the competencies, tasks, and duties expected of certificate holders. Math Competencies describe the math, analytical, or calculation knowledge and skills that are expected of certificate holders. There are no specific “math” questions on the test, but questions in some KSAs require computational skills to complete. Like all other questions on the test, questions requiring math or computational skills are randomly distributed throughout the test.

Suggested Reading

The Suggested Reading lists some materials that are representative of each KSA. Each reference includes chapters, sections, or pages that are representative of the KSA. This is not an exhaustive list of sources relevant to the KSA and candidates are strongly encouraged to seek additional material that covers each KSA especially in those KSAs where the candidate is not adequately prepared.

KSA 101 Weight: 13 %

Understands the basic physical properties of water and wastewater and analytical methods to determine:

- *Color*
- *Turbidity*
- *Odor*
- *Alkalinity*
- *Hardness*
- *Conductivity*
- *Solids*
- *Temperature*
- *pH*

KSA101 General Competencies

A Grade I Laboratory Analyst is expected to understand and competently perform relevant basic wet bench chemistry methods such as:

- Colorimetry using colorimetric comparators.
- Turbidimetry and Nephelometry using ion selective electrode equipment.
- Titrimetric tests.

These concepts are usually gained through a basic water chemistry class, entry level training or vocational school.

KSA101 Math Competencies

- Grade I analysts must be able to calculate alkalinity, hardness, and solids based on analytical testing results.
- Analysts should be able to perform unit conversions utilizing dimensional analysis.

KSA101 Suggested Reading

- *Standard Methods for Examination of Water and Wastewater*, Sections: 2120 A, B; 2130 A, B; 2150 A, B; 2320 A, B; 2340 A, B; 2510 A, B; 2550 A, B; 2540 A, B, C, D, E, F
- *Operation of Wastewater Treatment Plants*: Chapter 16

KSA 102 Weight: 10 %

Understands the basic chemical properties of water and wastewater and analytical methods to determine:

- *Dissolved oxygen*
- *Biochemical Oxygen Demand*
- *Chemical Oxygen Demand*
- *Chlorine residual (Total and Free)*
- *Sulfide*

KSA 102 General Competencies

- A Grade I Laboratory Analyst needs to demonstrate an understanding of the chemical properties and analytical methods in this KSA and how they relate to wastewater/water treatment.
- Determine dissolved oxygen using the Winkler method and a dissolved oxygen probe to determine biochemical oxygen demand.
- Determine chlorine residual using a colorimeter and titration.
- This knowledge is usually obtained through on the job training, vocational school, suggested reading, and basic water quality chemistry courses.

KSA 102 Math Competencies

- The Grade I lab analyst is expected to be able to calculate the results in this KSA from analytical results in using laboratory methods.
- Calculate results from above analytical methods.
- The analyst should be prepared to use dimensional analysis and unit conversions for calculations.
- The analyst should have basic algebraic skills to solve for an unknown.

KSA 102 Suggested Reading

- *Standard Methods for Examination of Water and Wastewater*, Sections: 4500-O A, C; 5210 A,B; 4500-CL A, B, D; 5220A, C,D; 4500-S2
- *Operation of Wastewater Treatment Plants*: Chapter16
- *Laboratory Procedures and Chemistry for Operators of Water Pollution Control Plants*: Lesson 4, Section 16.41, 16.410, 16.411

KSA 103 Weight: 8 %

Understands the microbiological properties and methods for analysis of water and wastewater such as:

- *Coliform by Multiple Tube Fermentation*
- *Coliform by Enzyme Substrate Test*
- *Heterotrophic Plate Count (HPC)*

KSA 103 General Competencies

- A Grade I laboratory analyst should understand the general bacteriological concepts (sterilization, media preparation and different types of bacteria).
- This knowledge is usually obtained through hands on experience, suggested reading, microbiology college course work, and vocational school.

KSA 103 Math Competencies

- Laboratory analysts should be comfortable calculating concentrations from a dilution series.
- This requires familiarity with scientific notation, dimensional analysis, unit conversions and solving for an unknown using algebra.

KSA 103 Suggested Reading

- *Standard Methods for Examination of Water and Wastewater*, Sections: 9050 A, C; 9215 A, B, C; 9221 A, B, C, E; 9223 A, B
- *Microbiological Methods for Monitoring the Environment*: *Part II*: A.1, 3,6, B. 1,2,3,4, 5, 6; Part III: A, B, C; Part IV: A; Part V: C
- *Laboratory Procedures and Chemistry for Operators of Water Pollution Control Plants*: Chapter 16, Lesson 7

KSA 104 Weight: 13 %

Collection of samples of wastewater, sludge, receiving water and industrial waste in accordance with established lab procedures.

- *Chain of custody*
- *Sample type (grab and composite)*
- *Container type and preparation*
- *Preservation*
- *Hold time*
- *Sampling techniques*
- *Proper labeling*
- *Storage condition*

KSA 104 General Competencies

- Accurate and clear documentation and legal/regulatory requirements for record keeping.
- Understanding of 24-hour sampling and operation of an autosampler.
- Knowledge of preservation and use of glass and plastic containers.

KSA 104 Math Competencies

- No known math competencies needed for this KSA.

KSA 104 Suggested Reading

- *Standard Methods for Examination of Water and Wastewater*, Section 1060: A, B, C, Table 1060:I; 1080, Table 1080:I; 9030, B. 18, 9060 A, B
- *Operation of Wastewater Plants*: Chapter 14, 16
- *Laboratory Procedures and Chemistry for Operators of Water Pollution Control Plants*: Chapter 16.3

KSA 105 Weight: 7 %

Utilizes techniques and equipment used in laboratory analysis.Gravimetric (balance weighing)

- *Titrimetric/volumetric (burette, pipette, graduated cylinder)*
- *Sterilization (autoclave, Bunsen burner, oven)*
- *Colorimetric (visual observation, spectrophotometer/colorimeter)*
- *Electrometric (meters, probes/electrodes)*
- *Turbidimetric (Nephelometer)*
- *Thermometers (ranges and max temp)*

KSA 105 General Competencies

- A Grade I Laboratory Experience with calibration and use of the above instruments and equipment.
- Ability to use these techniques and instruments to analyze physical properties listed in KSA 101 such as alkalinity, turbidity, color, etc.
- This knowledge is obtained through hands on experience, college level chemistry coursework, suggested reading, and vocational school.

KSA 105 Math Competencies

- Analyst should know how to complete unit conversions such as converting from PPM to mg/L, temperatures in Celsius and Fahrenheit.
- Ability to convert units using dimensional analysis.

KSA 105 Suggested Reading

- *Standard Methods for Examination of Water and Wastewater*, Sections: 1050; 2130 A, B; 4500-H+; 9040,9030,9020
- *Laboratory Procedures and Chemistry for Operators of Water Pollution Control Plants*: Chapter 16.1-16.2

KSA 106 Weight: 8 %

Operates, maintains and routinely calibrates basic test equipment such as:

- *Turbidimeters*
- *Dissolved oxygen meters*
- *pH meters*
- *Balances (analytical and top-loading)*
- *Conductivity meters*

KSA 106 General Competencies

- Experience calibrating and using the above equipment in the field and laboratory.
- Understand how to make a dilution series.
- Calibration of equipment based on direction from lead analyst.
- Experience is usually gained through on the job training, college level chemistry lab work, vocational school, and suggested reading.

KSA 106 Math Competencies

- Unit analysis
- Dimensional analysis
- Utilizing concepts such as molarity and normality.

KSA 106 Suggested Reading

- *Standard Methods for Examination of Water and Wastewater*, Sections: 2130 A, B; 2510 A, B; 4500-H+; 4500-O A, C, G

KSA 107 Weight: 10 %

Recognizes laboratory hazards and follows proper safety procedures with an understanding of

- *Chemical handling, storage, disposal, and spill response*
- *Personal Protective Equipment (PPE)*
- *Biological and chemical hygiene*
- *Engineering controls (fume hoods, etc.)*
- *Safety Data Sheet (SDS)*
- *Physical hazards (burns, sharps, compressed gas, electrical safety, fire, etc.)*
- *Good housekeeping*

KSA 107 General Competencies

- Knowledge of safety regarding handling and disposal of acids and bases, solvents.
- Safety regarding inhalation hazards.
- Familiarity with the purpose and use of Personal Protective Equipment (PPE) such as face shields, gloves, emergency showers.
- Understanding of each section of Safety Data Sheets and their relation to lab safety and the laboratory right-to-know law.
- Skills in this KSA are typically gained through hands on experience, suggested reading, college level chemistry lab coursework, and/or vocational school coursework.
- OSHA courses or safety training courses are useful in expanding knowledge in this KSA.

KSA 107 Math Competencies

- No specific math competencies needed for this KSA.

KSA 107 Suggested Reading

- *Standard Methods for Examination of Water and Wastewater*, Sections: 1090 A-J
- *Operation of Wastewater Treatment Plants*: Chapter 14
- *Laboratory Procedures and Chemistry for Operators of Water Pollution Control Plants*: Chapter 16, Section 16.2-16.23

KSA 108 Weight: 5 %

Prepares solutions and essential laboratory supplies

- *Dilution of concentrated solutions*
- *Preparation of filters and dishes for residue testing*
- *Preparation of bacteriological culture media*

KSA 108 General Competencies

- Knowledge of the safety concerns regarding the preparation of solutions and different types of measurement instruments/glassware.
- Glass fiber filters, crucibles.
- Sterilization.
- Buffering solutions.
- This knowledge and skills in this KSA are typically obtained through hands on experience, vocational training, water quality chemistry coursework and the suggested reading.

KSA 108 Math Competencies

- Ability to calculate concentrations from a dilution series.
- Familiarity with scientific notation, dimensional analysis, unit conversions and solving for an unknown using algebra.

KSA 108 Suggested Reading

- *Standard Methods for Examination of Water and Wastewater,* Sections: 2540 A, B, C, D, E, F; 9050 A, C; 9215 A. 6; 9221 B.1, 2, 3; 9221 E. 1

KSA 109 Weight: 5 %

Performs accurate calculations

- *Significant figures, proper rounding*
- *Unit conversion*
- *Basic algebraic and statistical calculations*
- *Solution preparation (dilution factors, normality, molarity)*
- *Sample dilution*
- *Scientific notation*

KSA 109 General Competencies

- The ability to apply these math skills in the performance of other relevant KSAs.
- These skills through coursework in algebra and chemistry through a vocational school or the suggested reading.
- While an analyst can learn some on the job, an entry level analyst should already have a firm grasp on these concepts.

KSA 109 Math Competencies

- It is important for calculating wastewater and water parameters to know: multiplication, division, algebraic concepts, dimensional analysis, and unit conversions.

KSA 109 Suggested Reading

- *Standard Methods for Examination of Water and Wastewater*, Sections: 1010; 1020 A, B; 1030 A, B, C; 1050 A, B

KSA 110 Weight: 4 %

Understands and practices proper laboratory ethics.

KSA 110 General Competencies

- Reporting ethics violations such as improper data manipulations, adjustments of instrument time clocks, and inappropriate changes in concentrations of standards.
- Direct chain of command
- Consequences of violations.
- Typically knowledge in this KSA is gained on the job through data integrity/ethics program training courses, a vocational or college level chemistry course.

KSA 110 Math Competencies

- None for this KSA.

KSA 110 Suggested Reading

- *NELAC Standard (2003) Section 5.5.2.7*

KSA 111 Weight: 10 %

Documents and maintains accurate and complete laboratory records.

- *Routine documentation, including worksheet/log sheet entries*
- *Sample documentation*
- *Chain-of-custody*
- *Record data accurately*
- *Report non-conforming data*
- *Awareness of LIMS (Laboratory Information Management Systems)*
- *Data integrity and legal defensibility*

KSA 111 General Competencies

- Baseline knowledge in order to analyze samples and keep legal documentation of samples from receiving to reporting.
- These skills can be obtained through on the job training, vocational school, college level chemistry course or suggested reading.

KSA 111 Math Competencies

- Understanding of standard deviations, mean, median, and mode.

KSA 111 Suggested Reading

- *Standard Methods for Examination of Water and Wastewater*, Sections: 1050; 1080, Table 1080:
- *Operation of Wastewater Treatment Plants*: Chapter 16.0, 16.1

KSA 112 Weight: 7 %

Understands basic concepts of Quality Assurance/Quality Control

- *Control charts*
- *Data quality*
- *Standard and reagent quality*
- *Reagent water quality*
- *DOC (Demonstration of Competency)*

KSA 112 General Competencies

- These skills can be obtained through on the job training, vocational school, water quality laboratory methods course or suggested reading.

KSA 112 Math Competencies

- Understand and apply standard deviations, mean, median, and mode.

KSA 112 Suggested Reading

- *Standard Methods for Examination of Water and Wastewater*, Sections: 1010; 1020 A, B; 1030 A, B, C; 1050 A, B

Section 4

Test Preparation

This section provides tips on how candidates should prepare for the test, information on questions that will be on the test, and solutions to math problems. Information included on the test, as well as a table of units and sample math problems are included.

Basic Study Strategy

To prepare adequately, candidates need to employ discipline and develop good study habits. Ample time to prepare for the test should be allowed. Candidates should establish and maintain a study schedule. One or two nights a week for one or two months should be sufficient in most cases. Spend one or more hours studying in quiet surroundings or in small groups of two or three serious candidates. Efforts should be directed to the test subject areas that are not being performed on a day-to-day basis.

While using this study guide, be sure to understand the KSAs and answers to all questions. Discuss test questions with others. Not only is this a good study technique, it is also an excellent way to learn.

Candidates should study at the certification level being sought after. There is no advantage to spending time studying material that will not be on the test. Refer to Section 3 for a description of the KSAs and reading assignments that cover the topics on the test.

It is not necessary, but certainly helpful, to memorize all formulas and conversion factors. A formula table is provided on the test to assist in this area. Tables 4-1 give the same formulas and conversion factors as those given on the test.

Candidates should obtain the primary reference and training material listed in Section 6. Any material not available at their workplace can be obtained from the sources listed in Section 6.

Multiple Choice Questions

All test questions are written in multiple-choice format. At first glance, the multiple-choice problem may seem easy to solve because so much information is given, but that is where the problem lies. The best answer must be chosen from the information provided. Here are some tips that may help solve multiple-choice questions.

1. Read the question completely and closely to determine what is being asked.

2. Read all the choices before selecting an answer.

3. Look for key words or phrases that often, but not always, tip off correct or incorrect answers:

Absolute Words
(Suspect as a wrong choice)

All	Never
Always	None
Totally	Completely

Limiting Words
(Often a correct choice)

Few	Occasionally
Some	Generally
Often	Usually
Many	Possible

4. Never make a choice based on the frequency of previous answers. If the last ten questions have not had a “b” answer, don’t arbitrarily select “b”. Instead use logic and reasoning to increase the chances of choosing the best answer.

5. Reject answers that are obviously incorrect and choose from the remaining answers. For example, in the multiple-choice question, “Why are gasoline and volatile solvents objectionable when present in a sewer?

   a. They produce an explosion hazard.
   b. They tend to cause solids to vaporize.
   c. They will coagulate floatables and cause stoppages.
   d. Because they float, the substances flow to plant headworks quicker.”

   In reviewing physical and chemical characteristics of gasoline and volatile solvents, the specific gravities of these substances are generally less than water and float to the surface. They are solvents for other similar industrial organic chemicals. Therefore, answer “b”, that proposes gasoline and volatile solvents cause solids such as sand, and grit to vaporize, is obviously an incorrect answer.

6. Make an educated guess. Never reconsider a choice that has already been eliminated. That means in the example above, answer “b” is out.

   Look for “key” phrases or words that give a clue to the right answer. For the example above, choices “c” and “d” discuss floatables and are potentially good answers. For answer “c”, chemical interaction of gasoline with floatables is not likely unless they are oil and grease. In such case, the solvent may disperse the oil and grease and reduce stoppages.

   Answer “a” and “d” remain and are both reasonable choices. However, the best answer must be selected. Answer “d” is true, but without knowing the explosive nature of gasoline and volatile solvents, the answer is only a fact. An explosive material in wastewater creates a condition that endangers the public, a potential loss of expensive facilities, and a hazard to operations and maintenance personnel. The best answer is “a”, they produce an explosion hazard.

7. Skip over questions that are troublesome. Mark these questions for later review.

8. When finished with the test, return to the questions skipped. Now think! Make inferences. With a little thought and the information given, the correct answer can be reasoned out.

9. Under no circumstances leave any question unanswered. There is no penalty for an incorrect answer. However, credit is given only for correct answers.

   NO ANSWER=WRONG ANSWER

10. Keep a steady pace. Check the time periodically.

11. Remember to read all questions carefully. They are not intended to be "trick questions"; however, the intent is to test candidates' knowledge of and ability to understand the written languages of this profession.

Math Problems

Math problems on the certification tests are meant to reflect the type of work encountered in Laboratories. Although there is no specific math section on the test, many questions will require some calculations such as area, volume, ratios, and conversion of units. Although math is important on the test, do not neglect other parts of the KSAs and focus too much time on the math. Completing the math problems will be greatly simplified by using a calculator and the approach suggested in the following paragraphs.

Calculators

Approved calculators may be used during the test. See the approved calculator list at www.cwea.org/cbt. A screen calculator will also be available on the test similar to the standard calculator found on computers running Windows. The most important factor in effectively using a calculator is the candidates' familiarity with its use prior to the time of the examination. Confidence in the calculator and a full understanding of how to properly operate it are a must. The best way to gain confidence is to obtain a calculator from the approved calculator list and use it frequently.

Completing the worksheets in this section as well as the sample problems at the various grade levels will improve proficiency. Additional use will also help. For example, calculate the gas mileage when filling a vehicle's tank each time. Check the sales tax calculation on each purchase. Balance a checkbook, or check a paycheck. The calculator chosen should have large enough keys so that the wrong keys are not accidentally punched. Be certain there are new batteries in the calculator, or use a solar powered calculator with battery back up.

Approach

The solution to any problem requires understanding of the information given, understanding of what is being requested, and proper application of the information along with the appropriate equations to obtain an answer. Any math problem can be organized as follows:

Given or Known. All information provided in the problem statement that will be used to get the correct answer.

Find. A description of the answer that is being requested.

Sketch. If possible, sketch the situation described in the problem statement showing size and shape (dimensions).

Equation. The equation or equations that will be used to generate the listed answers

Assumption(s). Stated assumptions of key information needed to answer a math problem with missing information. This occurs frequently on higher-grade tests.

Answer. This is where the answer is clearly identified.

Advantages to using this approach to organize math problems are that it helps to organize thoughts, breaks the problem solution into a series of smaller steps, reducing chances of making an error.

Solutions

Solutions to math problems are like driving routes from Los Angeles to San Francisco: there are many different routes that can be taken. Some routes are shorter or less complicated than others. Only certain routes end up in San Francisco.

Solutions to sample problems given in this study guide are the most common solutions. If a solution that is different, but arrives at the correct answer is found, then that solution can be used.

Equivalents/Formulas

A sample of the equivalents and formulas sheet from the examination is included in Table 4-1. Familiarity with each of the equivalents (conversion factors) and each of the formulas is important. Pay special attention to the units of measure that are used in the formulas. A correct answer will not be obtained unless the correct units of measure are used.

Check the units, arithmetic, and answer. So that:

1. The units agree.
2. The answer is the same when the arithmetic is repeated.
3. The answer is reasonable and makes sense.

Dimensional Analysis

When setting up an equation to solve a math problem, the trick is to have clearly in mind what units the answer should be in. Once the units have been determined, work backwards using the facts given and the conversion factors known or given. This is known as dimensional analysis, using conversion factors and units to derive the correct answer.

Remember, multiplying conversion factors can be likened to multiplying fractions. The denominator (the number on the bottom of the fraction) and the numerator (the number on the top of the fraction) cancel each other out if they are the same, leaving the units being sought after.

Example:

If a company runs a discharge pump rated at 50 gallons per minute all day, every day for a year, what is the discharge for the year in millions of gallons per year (MGY)?

$$\text{Given: pump rating } = 50\,\frac{\text{gal}}{\text{min}}$$

Find: discharge = __?__ MGY

Calculations: Convert gal/min to million gal/yr, convert gallons to million gallons, and minutes to years.

What is known about minutes and years? There are 60 minutes in an hour, 24 hours in a day, and 365 days in a year. Put that into an equation, and multiply each conversion factor so the unneeded units are cancelled out:

$$\frac{50\ \cancel{\text{gal}}}{\cancel{\text{min}}} \text{ x } 60\ \frac{\cancel{\text{min}}}{\cancel{\text{hr}}} \text{ x } 24\ \frac{\cancel{\text{hr}}}{\cancel{\text{day}}} \text{ x } 365\ \frac{\cancel{\text{days}}}{\text{yr}} \text{ x } 1\ \frac{\text{MG}}{1{,}000{,}000\cancel{\text{gal}}} = 26.28 \text{ mgy}$$

Sample Questions

The following sample math problems are intended to demonstrate unit conversion techniques. Although they are general wastewater problems, the questions may not be specific to any vocation.

1. How many gallons of water will it take to fill a 3 cubic foot container?

$$3\ \cancel{\text{cubic feet}} \text{ x } 7.48\ \frac{\text{gallons}}{\cancel{\text{cubic feet}}} = 22.4 \text{ gallons}$$

2. If a gallon of gasoline weighs 7.0 pounds, what would be the weight of a 350-gallon tank full of gasoline?

$$350\ \cancel{\text{gallons}} \text{ x } 7.0\frac{\text{pounds}}{\cancel{\text{gallon}}} = 2{,}450 \text{ pounds}$$

3. The rated capacity of a pump is 500 gallons per minute (GPM). Convert this capacity to million gallons per day (MGD).

$$500\ \cancel{\text{gpm}} \text{ x } 1\ \frac{\text{MGD}}{694\ \cancel{\text{gpm}}} = 0.72 \text{ MGD}$$

4. A chemical feed pump is calibrated to deliver 50 gallons per day (GPD). What is the calibrated chemical feed in gallons per minute (GPM)?

$$\frac{50 \text{ gal}}{\text{day}} \text{ x } \frac{1 \text{ day}}{24 \text{ hr}} \text{ x } \frac{1 \text{ hr}}{60 \text{ min}} = 0.035 \text{ GPM}$$

5. A chemical feed pump delivers 50 mL per minute (mL/min). Determine the chemical feed in gallons per day (gpd).

$$\frac{50\text{mL}}{\cancel{\text{min}}} \text{ x } \frac{1\cancel{\text{L}}}{1{,}000\cancel{\text{mL}}} \text{ x } \frac{1 \text{ gallon}}{3.785\cancel{\text{L}}} = \frac{60\ \cancel{\text{min}}}{\cancel{\text{hr}}} \text{ x } \frac{24\ \cancel{\text{hr}}}{\text{day}} = 19\frac{\text{gallon}}{\text{day}} = 19\text{gpd}$$

6. A cyanide destruction process is designed to treat 30 pounds of cyanide per 24-hour operational day. How many pounds of cyanide can be treated during an 8- hour shift?

$$\frac{30\text{lbs CN}}{\cancel{\text{day}}} \text{x} \frac{8\ \cancel{\text{hr}}}{24\ \cancel{\text{hr}}} \text{x} \frac{1\ \cancel{\text{day}}}{\text{shift}} = 10\text{lbs CN/shift}$$

Math Skills

Successful Grade I Lab Analyst candidates must be skilled in arithmetic, beginning statistics, and algebra. Candidates must be able to apply these skills to make calculations for work-related tasks in general chemistry, preparing standard solutions, reporting laboratory data, assisting plant operations, and any other job related math skill that may fall within the Skill Sets listed in Section 3.
General chemistry problems will require Lab Analysts to understand how to determine:

- Mass given concentration in mg/L (or ppm), flow converted to mgd and memorizing the formula: mg/L X mgd X 8.34 = lbs/day
- Mean, median, mode, and range given a set of numbers
- Correct number of significant digits
- Conversion of temperatures from Fahrenheit to Celsius and vice versa
- Gram molecular weight given a chemical formula and molecular weights of the elements
- Concentration of a diluted solution in mg/L or ppm given the initial percent concentration, the volumes used to dilute, and the volume of the final solution
- Normality of an acid or base given the three of the factors in the formula $N_1V_1 = N_2V_2$ (the formula must be memorized)
- Weight of dry reagent required to prepare a standard solution given the molecular formula of the reagent, molecular weights of the elements, and the final volume desired.

Problems using laboratory data will require Lab Analysts to memorize the formulas in *Standard Methods* for the analytical methods covered by a Grade I exam. These types of problems will require Lab Analysts to determine:

- Suspended solids, volatile solids, total solids, and dissolved solids given weights of the tared filter or dish and final weights of the filter with residue.
- BOD concentration given the initial and final DO concentrations. Lab Analysts must memorize the acceptance criteria for DO depletion in the blank and in the diluted samples, and the calculation differences when the sample is seeded or not seeded.
- Estimated sample volume required for the BOD test given the bottle volume, expected BOD results, and 50 percent depletion.
- Chloride, residual chlorine, hardness, COD and alkalinity from the formulas given in *Standard Methods.*

A thorough review of the types of mathematics required for the test is beyond the scope of this study guide. Consult an appropriate math text (see Section 6, References) if there is unfamiliarity with any of these specific math skills. Appendix A provides general strategies for approaching math problems, math anxiety, and resources for remedial study.

Arithmetic

Candidates should be able to perform and understand the following calculations either manually or with a calculator:

1. Addition and subtraction of whole numbers and fractions.

2. Multiplication and division of whole numbers and fractions.

Be prepared to apply these basic skills to work-related problems. The following example problem requires application of knowledge and application of basic arithmetic and the ability to convert units.

Example:
How many grams of silver nitrate ($AgNO_3$) are needed to prepare one liter of 1,000 mg/L Ag standard (Ag=108, N=14, O=16)?

First, determine the molecular weight of silver nitrate in g/gmole.

(108+14+3X16) = 170 g/gmole

Determine the unit weight (g) of silver nitrate per weight (g) of silver

$$= \frac{\text{gmole Ag}}{108\text{ g}} \text{x} \frac{1\text{ mole Ag NO}_3}{1\text{ gmole AG}} \text{x} \frac{170\text{ g AG NO}_3}{1\text{ gmole AG}} = 1.574\text{ g } \frac{\text{Ag NO}_3}{\text{g Ag}}$$

Multiply the unit-weight factor by the desired concentration to determine the weight of silver nitrate including the conversion factor of grams to milligrams

$$\frac{1{,}000\text{ mg}}{1\text{L std}} \text{x} \frac{\text{g}}{1{,}000\text{ mg}} \text{x} \frac{1.574\text{ g Ag NO}_3}{\text{gAg}}$$

Statistics

Candidates should be able to perform and understand the basic statistical calculations such as determining the mean, median, mode and range of numbers either manually or with a calculator.

Example

Find the mean, median, and range of the following numbers.

6, 7, 8, 6, 9, 8, 8, 9, 8

Use the definitions of each term to determine the value.

Mean or average is the sum of all the values divided by the number of values.

$$\text{mean} = \frac{\text{Sum of All Value}}{\text{Number of All Values}}$$

$$= \frac{6+7+8+6+9+8+8+9+8}{9} = 7.7$$

Median is the midpoint of the range of values, where one-half of the values are higher and one-half of the values are lower. Arrange the values from highest to lowest.

6, 6, 7, 8, 8, 8, 8, 9, 9

Median value = 8.

There are four values higher than this number and four values lower. If the total number of values is an even number, the two values closest to the mid-point are averaged to obtain the midpoint, or median value.

Range is simply the difference between the highest value and the lowest value.

Range = $V_H - V_L$ 9 – 6 = 3

Algebra
Candidates should be able to perform basic applied algebra for solving calculations such as solving for one unknown in one equation. Remember that when solving for the unknown that there are two basic rules that apply:

- The unknown must be in the numerator (on the top of the fraction, if one exists).
- The unknown must be by itself on one side of the equation with all knowns on the other side.

These two basic steps should be performed in the order that they appear above.

Example

A treatment plant removes 85% of the suspended solids in the secondary clarifier. If the effluent suspended solids are 22 mg/L, the secondary influent suspended solids are ____mg/L.

Solution
This problem can be done using ratios:

$$\frac{\%\text{ SS effluent}}{\%\text{ SS effluent}} = \frac{\text{mg/L SS influent}}{\text{mg/L SS influent}}$$

Given that influent represent 100 percent of the suspended solids and removal in the secondary clarifier is 85 percent, primary effluent percent suspended solids is calculated as follows:

% SS influent = (100% - 85%) = 15%

$$\frac{15\%}{100\%} = \frac{22\text{ mg/L}}{\text{SS influent}}$$

Solving for the unknown multiply both sides by SS influent.

$$\text{SS influent x}\frac{15\%}{100} = \frac{22\text{ mg/L}}{\cancel{\text{SS influent}}}\text{x }\cancel{\text{SS influent}}$$

Multiplying by inverse percentages

$$\text{SS influent}\,\frac{\cancel{15\%}}{\cancel{100\%}} = \frac{\cancel{100\%}}{\cancel{15\%}} = 22\ \text{mh/L}\ \text{x}\ \frac{100\%}{15\%}$$

$$\text{SS influent}\,\frac{22\ \text{mg}}{\text{L}} = \frac{100\%}{15\%} = 147\ \text{mg/L}$$

LABORATORY ANALYST CONVERSION FACTORS & FORMULAS
Grade 1-4

Element Name, Symbols and Standard Atomic Weights:*

Aluminum	Al	26.981
Arsenic	As	74.921
Calcium	Ca	40.078
Carbon	C	12.010
Chlorine	Cl	35.446
Chromium	Cr	51.996
Copper	Cu	63.546
Hydrogen	H	1.007
Iodine	I	126.904
Iron	Fe	55.845
Magnesium	Mg	24.305
Nickel	Ni	59.693
Nitrogen	N	14.006
Oxygen	O	15.999
Phosphorus	P	30.973
Potassium	K	39.098
Silver	Ag	107.868
Sodium	Na	22.989
Sulfur	S	32.059

Conversion Factors:

1 gal = 8.34 lbs
1 cu ft = 7.48 gal
1 lb = 454 grams

Abbreviations

AA = atomic absorption
AE = atomic emission
mL = milliliter
mg = milligram
L = liter
g = gram
GC = gas chromatography
M = molar
N = normal
MGD = million gallons per day

MPN Index (10 mL, 1.0 mL, 0.1 mL)

5 - 3 - 0	80 MPN/100mL
5 - 5 - 3	900 MPN/100mL
5 - 5 - 4	1600 MPN/100mL
5 - 5 - 5	> 1600 MPN/100mL

*Source: Standard Methods for the Examination of Water and Wastewater, 22nd Edition.

Section 5

Practice Test

This section provides a practice certification test to help certificate candidates become familiar with the test format and subject matter. The actual certification test is given on a computer at a secure testing site. The computer-based test (CBT) requires test takers to be able to use a computer mouse and some very basic keyboard functions. Candidates who have never taken a computerized test are strongly encouraged to try the online CBT demo to become familiar with the computerized test format before going to a test site. A CBT tutorial is also available to candidates just before they start their test. For more information about CBT and to try the CBT demo go to www.cwea.org/cbt.

The number of test questions on the actual certification test may range from about 90 to 130 questions (this practice test has over 50 questions). The time limit for the test is 3 hours. The computerized certification test can be paused for restroom breaks, but the 3-hour clock will not stop. A formula table very similar to Table 4-1 (Section 4) will be available as a window on the computer screen during the test. The format of the test questions on the computerized certification test is very similar to the multiple-choice questions given in this practice test. There are no fill-in or essay type questions given on the test. Most questions on the certification test are worth 1 point, however some can be worth up to 5 or more points depending on the level of difficulty or calculations required. No point values are given for questions on this practice test so the weighting will not precisely reflect that of the actual certification test. If answered correctly, candidates will earn the number of points given for a question. If a question is not answered correctly, then no points are awarded (there is no penalty for “guessing”). At the test site, calculators are limited to a list of approved calculators. A screen calculator, similar to the basic Windows computer calculator, is also available during the test and can be toggled between basic and scientific modes. For the list of allowable calculators see the Calculator Policy at www.cwea.org/cbt, or contact CWEA at 510-382-7800, or tcp@cwea.org.

The practice test includes a key after the end of the test. Some questions that require calculations include solutions that are given after the key. These are indicated on the key with “see solutions” to the right of the correct answer. Candidates are encouraged to find the solutions to all of the questions requiring calculations themselves.

Practice Test

1. Sexual harassment is not a workplace issue when the:
   a. harasser is a female.
   b. behavior occurs off the work site.
   c. behavior is welcome.
   d. subordinate is harassing a supervisor.

2. If you have been given written instructions that you do not understand:
   a. do what you think is best.
   b. ask a co-worker.
   c. ask your supervisor.
   d. ask the author.

3. The mercuric nitrate titration technique for measuring chloride is falling into disuse in the laboratory because the:
   a. results are not as reliable as those achieved by the silver nitrate titration technique.
   b. endpoint is difficult to determine.
   c. technique is lengthy and requires highly skilled instrument technicians to accurately analyze the samples.
   d. mercury creates a hazardous waste disposal problem.

4. Standard phenylarsine oxide solution (PAO):
   a. requires only routine lab safety considerations.
   b. should be handled with caution because it is highly corrosive.
   c. should be handled with caution because it is highly acidic.
   d. should be handled with caution because it is a severe poison.

5. Sampling protocol for chloride includes:
   a. glass or plastic container preserved with sodium thiosulfate.
   b. plastic container preserved with sulfuric acid.
   c. glass or plastic container with no preservative.
   d. glass or plastic container preserved at 4°C.

6. You have been directed to collect a 12-hour flow proportional sample. Using the following data, select the volume of sample to be collected at 12:00 p.m. if a total sample volume of one liter is required.

Time	Flow, MGD
6:00 a.m.	5.8
7:00 a.m.	6.4
8:00 a.m.	6.8
9:00 a.m.	7.2
10:00 a.m.	6.8
11:00 a.m.	7.2
12:00 p.m.	9.0
1:00 p.m.	9.6
2:00 p.m.	8.8
3:00 p.m.	8.2
4:00 p.m.	7.6
5:00 p.m.	6.8

a. 90 mL

b. 90.2 mL

c. 100 mL

d. 180 mL

7. The incubator for the BOD determination should be monitored and recorded daily. The incubator temperature should be:

a. 20° +/- 0.5° C.

b. 20° +/- 1° C.

c. 20° +/- 2° C.

d. 20° +/- 5° C.

8. Laboratory data mistakes may be corrected by:

a. covering the mistake with white correction fluid, writing over the fluid after it has dried with analyst's initials and date.

b. erasing the mistake and writing the correct answer again in pencil.

c. lining out the mistake with pen and writing the correct answer to the side of the first.

d. lining out the mistake with pen and writing the correct answer to the side of the first, with analyst's initials and date.

9. The Sample Receiving Log must record time and date sampled:
   a. time and date received at the laboratory, sample collector, nature of sample and sample recipient.
   b. sample collector, nature of sample, analyses to be performed, preservatives, condition of sample and sample recipient.
   c. time and date received at the laboratory, sample collector, nature of sample, analyses to be performed, preservatives.
   d. time and date received at the laboratory, sample collector, nature of sample, weather conditions during sampling, analyses to be performed, preservatives, condition of sample and sample recipient.

10. Hood flow should be monitored and documented at:
    a. 100 milligrams per liter.
    b. 100 parts per million.
    c. 100 linear feet per minute.
    d. 100 cubic feet per minute.

11. An analyst filters 50 mL of raw domestic wastewater through a tared glass fiber filter, dries the filter at 103 degrees to 105 degrees C and weighs it again. Given the following weights, what is the total suspended solids of the sample in mg/L?

    Tare weight: 0.4158 g

    Dry weight: 0.4285 g

    a. 0.25 mg/L
    b. 0.64 mg/L
    c. 250 mg/L
    d. 640 mg/L

12. Given the following data, calculate the COD for the sample.

    mL of FAS to titrate 10 mL of 0.25 N dichromate = 10.7

    mL of FAS to titrate reagent blank = 10.6

    mL of FAS to titrate sample = 7.5

    sample size = 20 mL

a. 32 mg/L COD
b. 230 mg/L COD
c. 290 mg/L COD
d. 975 mg/L COD

13. Given the following, find the percent solids and the percent volatile solids of the sample:

Dish tare weight = 1.38 g

Dish and wet sample weight = 32.40

Dish and dry sample weight = 1.86 g

Dish and ashed weight = 1.56 g

a. 0.96 percent solids and 62.5 percent volatile solids
b. 0.96 percent solids and 83.9 percent volatile solids
c. 1.55 percent solids and 62.5 percent volatile solids
d. 1.55 percent solids and 83.9 percent volatile solids

14. A treatment plant removes 41% of the suspended solids in the primary clarifiers. If the primary effluent suspended solids are 112 mg/L, the primary influent suspended solids are :

a. 52.7 mg/L influent SS.
b. 66.1 mg/L influent SS.
c. 190 mg/L influent SS.
d. 273 mg/L influent SS.

15. What is the normality of a sodium hydroxide solution if 25 mL of a 0.01 N sulfuric acid solution neutralizes 100 mL of the NaOH solution?

a. 0.0025 N
b. 0.064 N
c. 0.25 N
d. 6.4 N

16. A sample of ferrous chloride contained 30% ferrous chloride and had a density of 1.33 g/m. Calculate the total ferrous chloride in one liter of the solution.
    a. 39.9 grams per liter
    b. 226 grams per liter
    c. 399 grams per liter
    d. 4,430 grams per liter

17. Given the following data, calculate the BOD for the sample if the initial DO is 8.5 mg/L.

Sample size, mL	DO Final, mg/L
Blank	8.5
3.0	7.0
5.0	5.8
7.0	4.8
9.0	3.4
11	2.7
15	0.5

    a. 159 mg/L
    b. 159.7 mg/L
    c. 160 mg/L
    d. 162.2 mg/L

18. A standard solution is prepared from a 0.100% stock solution of a pure metal. Ten mL of the stock solution is diluted to one liter, and 5 mL of this solution is diluted to 100 mL to make the standard. The concentration of the standard solution is:
    a. 0.2 mg/L.
    b. 0.5 mg/L.
    c. 1.0 mg/L.
    d. 2.0 mg/L.

19. How many grams of chromium trioxide (CrO_3) are needed to prepare one liter of 1,000 mg/L Cr standard (Cr=52, O=16)?
    a. 0.520 g CrO_3
    b. 0.765 g CrO_3
    c. 1.308 g CrO_3
    d. 1.923 g CrO_3

20. Lauryl Sulfate Broth is sterilized before use for:
    a. 15 minutes at 121°C (15 lbs. pressure).
    b. 15 minutes at 118°C (12 lbs. pressure).
    c. 20 minutes at 115°C (10 lbs. pressure).
    d. 20 minutes at 121°C (15 lbs. pressure).

21. Agar medium is used for:
    a. escherichia coliform.
    b. fecal coliform.
    c. heterotrophic plate count.
    d. all bacterial analysis.

22. During an acid-base titration, the titrant is added to the sample with a:
    a. graduated cylinder.
    b. serological pipet.
    c. class A pipet.
    d. burette.

23. When preparing diluted calibration standards from a stock standard, use a combination of the following to get the most precise standard:
    a. graduated cylinder and class A volumetric pipet
    b. graduated cylinder and burette
    c. class A volumetric flask and class A volumetric pipet
    d. class A volumetric flask and burette

24. At a given temperature, the intensity of the acidic or basic character of a solution is indicated by:
    a. conductivity.
    b. pH or hydrogen ion activity.
    c. specific ion probe analysis.
    d. alkalinity.

25. A solution with a pH of 5 has a concentration of hydrogen ions that is how many times higher than a solution with a pH of 7?
    a. 2 times higher
    b. 10^{-5} times higher
    c. 10^{-2} times higher
    d. 100 times higher

26. A pH measurement requires the following:
    a. a voltmeter, glass pH electrode, reference electrode, and a temperature compensating device.
    b. a voltmeter, glass pH electrode, combination electrode, and a temperature compensating device.
    c. a voltmeter, combination electrode, reference electrode and a temperature compensating device.
    d. a voltmeter, glass pH electrode, reference electrode, and a combination electrode.

27. Conductance measurements are temperature compensated to:
    a. 20.0°C.
    b. 25.0°C.
    c. 30.0°C.
    d. 20.0° to 25.0° C.

28. The conductivity meter is calibrated with:
    a. 0.0100 N potassium chloride standard.

b. 0.0100 N silver chloride standard.

c. 0.0100 N sodium chloride standard.

d. 0.1000 N sodium chloride standard.

29. Alkalinity is reported as:

a. alkalinity, mg/L phenolphthalein.

b. alkalinity, mg $CaCO_3$/L.

c. alkalinity, mg/L.

d. alkalinity, mg/L acetic acid.

30. The hardness determination by EDTA titration measures:

a. calcium and magnesium.

b. calcium carbonate.

c. alkalinity, corrosivity and carbonates.

d. calmagite.

31. The indicator for the hardness determination is:

a. ethylenediaminetetracetic acid.

b. eriochrome Black T.

c. ethylenediaminetriacetic acid.

d. bromcresol green.

32. EPA acceptable primary standards for the turbidity determination include:

a. formazine and synthetic styrene-divinylbenzene.

b. formazine only.

c. synthetic styrene-divinylbenzene only.

d. formazine, and manufactured gel-filled vials.

33. The Biochemical Oxygen Demand (BOD) determination is an empirical test in which standardized laboratory procedures are used to:

a. determine the relative dissolved oxygen in wastewaters, effluents and polluted waters.

b. determine the relative oxygen requirements of wastewaters, effluents and polluted waters.

c. determine the relative chemical oxidizers in wastewaters, effluents and polluted waters.

d. determine the relative organic compounds of wastewaters, effluents and polluted waters.

34. Sample pretreatment for the BOD determination includes:

a. assuring that the samples are neutralized to a pH range between 6.5 and 7.5, and that any residual chlorine has been dechlorinated.

b. assuring that the samples are neutralized to a pH range between 5.5 and 8.5, and that any residual chlorine has been dechlorinated.

c. assuring that any residual chlorine has been dechlorinated.

d. assuring that the samples are neutralized to a pH range between 6.5 and 7.5.

35. The process designed to kill most microorganisms in wastewater, including essentially all pathogenic bacteria is called:

a. sterilization.

b. disinfection.

c. biodegradation.

d. chlorine demand.

36. Fecal coliform bacteria:

a. are pathogenic bacteria found in the intestinal tract of warm-blooded animals.

b. are the cause of cholera, a water-borne disease in humans.

c. are the cause of dysentery, a water-borne disease in humans.

d. are bacteria found in the feces of warm-blooded animals.

37. The definition for the total coliform group is:

a. all of the aerobic and facultative anaerobic, gram-negative, nonspore-forming, rod-shaped bacteria that ferment lactose in 24-48 hours at 35°C.

b. all of the aerobic and facultative anaerobic, gram-negative, spore-forming, rod-shaped bacteria that ferment lactose in 24-48 hours at 35°C.

c. all of the aerobic and facultative anaerobic, gram-positive, nonspore-forming, rod-shaped bacteria that ferment lactose in 24-48 hours at 35°C.

d. all of the aerobic and facultative anaerobic, gram-negative, nonspore-forming, rod-shaped bacteria that ferment alcohol in 24-48 hours at 35°C.

38. Laboratory test results for an individual environmental sample within an analytical batch may be rejected when:

a. extremely high or low concentrations of the analyte are achieved.
b. the recovery of the laboratory control standard falls outside of the control limits.
c. the relative standard deviation between the duplicates falls outside the control limits.
d. a known error has occurred.

39. Precision is measured by:
    a. analyzing replicate samples.
    b. analyzing matrix spiked samples.
    c. calculating standard error.
    d. calculating percent recovery.

40. Match the term with one of the four definitions listed below:

Term	Definition
a. Accuracy	1. Consistent deviation of measured values from the true value, caused by systematic errors in a procedure.
b. Bias	2. The deviation in any step in an analytical procedure that can be treated by standard statistical techniques.
c. Precision	3. The combination of bias and precision of an analytical procedure, which reflects the closeness of a measured value to a true value.
d. Random Error	4. Measures the degree of agreement among replicate analyses of a sample, usually expressed as the standard deviation.

41. Select the correct mean, median, mode and range from the following list:

    6.7, 8.6, 9.0, 8.9, 8.9, 9.0, 8.5, 8.4, 8.7, 6.6, 8.8, 7.2, 8.5, 9.3, 8.9

    a. Mean = 8.4, median = 8.7,
       mode = 8.9, range = 2.6
    b. Mean = 8.4, median = 8.7,
       mode = 8.9, range = 2.7
    c. Mean = 8.4, median = 8.8,
       mode = 8.9, range = 2.7
    d. Mean = 8.5, median = 8.6,
       mode = 8.4, range = 2.4

Test Answer Key

The following tables show the correct answers for the test questions included in this study guide. The tables show what section the answers are for, the correct answer, and the KSA the question refers to. If you marked a wrong answer to any of the diagnostic test questions, refer to the KSA and you will be able to find the reference material to study to help you correctly answer the question.

No.	**Answer**	**KSA**
1	c	110, 111
2	d	111, 111
3	d	107
4	d	107
5	c	104
6	c	104
7	b	102, 107, 111
8	d	102, 107, 111
9	b	102, 107, 111
10	c	102, 107, 111
11	c	101, 102, 109
12	c	101, 102, 109
13	c	101, 102, 109
14	c	101, 102, 109
15	a	102, 103, 108, 109
16	c	102, 103, 108, 109

17	c	102, 103, 108, 109
18	b	102, 103, 108, 109
19	d	102, 103, 108, 109
20	a	102, 103, 108, 109
21	c	102, 103, 108, 109
22	d	105
23	c	105
24	b	101
25	d	101
26	a	101
27	b	101
28	a	101
29	b	101, 102
30	a	101, 102
31	b	101, 102
32	b	101, 102
33	b	101, 102
34	a	101, 102
35	b	103, 108
36	d	103, 108
37	a	103, 108
38	d	112
39	a	112
40	A=3, B=1, C=4, D=2	112
41	b	112

Solutions:

6. You have been directed to collect a 12-hour flow proportional sample. Using the following data, select the volume of sample to be collected at 12:00 p.m. if a total sample volume of one liter is required.

Time	Flow, MGD
6:00 a.m.	5.8
7:00 a.m.	6.4
8:00 a.m.	6.8
9:00 a.m.	7.2
10:00 a.m.	6.8

11:00 a.m.	7.2
12:00 p.m.	9.0
1:00 p.m.	9.6
2:00 p.m.	8.8
3:00 p.m.	8.2
4:00 p.m.	7.6
5:00 p.m.	6.8

Solution:

$\frac{\text{mL, 12:00 p.m. sample}}{\text{mL, total sample}} = \frac{\text{mgd, flow at 12:00 p.m.}}{\text{mdg, total flow}}$

$\text{mL, 12:00 p.m. sample} = \frac{\text{mgd, flow at 12:00 p.m.}}{\text{mgd, total flow}}$

$\frac{9 \text{ mgd} \times 1{,}000 \text{ mL}}{90.2 \text{ mgd}} = 100 \text{ mL}$

11. An analyst filters 50 mL of raw domestic wastewater through a tared glass fiber filter, dries the filter at 103 degrees to 105 degrees C and weighs it again. Given the following weights, what is the total suspended solids of the sample in mg/L?

Tare weight:	0.4158 g
Dry weight:	0.4285 g

Solution:

0.4285g - 0.4158g = 0.0127g suspended solids per 50 mL wastewater

$\frac{0.0127 \text{ g}}{50 \text{ mL}} \times \frac{1{,}000 \text{ mL}}{1 \text{ L}} \times \frac{1{,}000 \text{ mg}}{1 \text{ g}} = \frac{254 \text{ mg}}{1\text{L}}$

= 250 mg/L

12. Given the following data, calculate the COD for the sample.

mL of FAS to titrate 10 mL of 0.25 N dichromate = 10.7

mL of FAS to titrate reagent blank = 10.6

mL of FAS to titrate sample = 7.5

sample size = 20 mL

Solution:

1. Determine the normality of FAS ($N_1V_1=N_2V_2$)

2. Determine the COD, mg/L

$N_{FAS} = \dfrac{\text{N dichromate x mLs dichromate}}{\text{mLs FAS}}$

$= \dfrac{0.25 \text{ N} \times 10 \text{ mL}}{10.7 \text{ mL}} = 0.23 \text{ N}$

mL FAS_{blank} = A   mL FAS_{Sample} = B

$COD = \dfrac{(A - B) \times 8{,}000 \times N_{FAS}}{\text{mL}}$

$\text{COD mg/L} = \dfrac{(10.6 \text{ mL} - 7.5 \text{ mL}) \times 0.23 \text{ N}}{20 \text{ mL}}$

= 290 mg/L COD

13. Given the following, find the percent solids and the percent volatile solids of the sample:

Dish tare weight = 1.38 g

Dish and wet sample weight = 32.40

Dish and dry sample weight = 1.86 g

Dish and ashed weight = 1.56 g

a. 0.96 percent solids and 62.5 percent volatile solids

b. 0.96 percent solids and 83.9 percent volatile solids

c. 1.55 percent solids and 62.5 percent volatile solids

d. 1.55 percent solids and 83.9 percent volatile solids

Solution:

Wet sample weight = 32.40 g - 1.38 g = 31.02 g

Dry sample weight = 1.86 g - 1.38 g = 0.48 g

Ash sample weight = 1.56 g - 1.38 g = 0.18 g

$\% \text{ solids} = \dfrac{\text{dry sample weight} \times 100}{\text{wet sample weight}}$

$= \dfrac{0.48 \text{ g} \times 100}{31.02 \text{ g}} = 1.55\% \text{ solids}$

$\% \text{ volatile solids} = \dfrac{(\text{dry wt.} - \text{ash wt.}) \times 100}{\text{dry wt.}}$

$= \dfrac{(0.48 \text{ g} - 0.18 \text{ g}) \times 100}{0.48 \text{ g}} = 62.5\% \text{ volatile}$

14. A treatment plant removes 41% of the suspended solids in the primary clarifiers. If the primary effluent suspended solids are 112 mg/L, the primary influent suspended solids are:

Solution:

The problem can be done using ratios:

$$\frac{\%\ \text{SS effluent}}{\%\ \text{SS influent}} = \frac{\text{mg/L SS effluent}}{\text{mg/L SS influent}}$$

Given that influent represent 100 percent of the suspended solids and removal in the primary clarifier is 41 percent, primary effluent percent suspended solids is calculated as follows:

$$\frac{59\%}{100\%} = \frac{112\ \text{mg/L}}{?}$$

Solving for the unknown:

$$112\ \text{mg/L} \times \frac{100\%}{59\%} = 190\ \text{mg/L influent SS}$$

15. What is the normality of a sodium hydroxide solution if 25 mL of a 0.01 N sulfuric acid solution neutralizes 100 mL of the NaOH solution?

Solution:

$$N_1V_1 = N_2V_2\ \frac{25\ \text{mL} \times 0.01\ \text{N}}{100\text{mL}} = 0.0025\ \text{N NaOH}$$

16. A sample of ferrous chloride contained 30% ferrous chloride and had a density of 1.33 g/mL. Calculate the total ferrous chloride in one liter of the solution.

Solution:

$$\frac{1{,}000\ \text{mL sample}}{1\ \text{L sample}} \times \frac{1.33\ \text{g sample}}{1\text{mL sample}} \times$$

$$\frac{30\ \text{g ferrous chloride}}{100\ \text{g sample}} = 399\ \text{grams/L}\ FeCl_3$$

17. Given the following data, calculate the BOD for the sample if the initial DO is 8.5 mg/L.

Sample size, mL	DO Final, mg/L
Blank	8.5
3.0	7.0
5.0	5.8
7.0	4.8

9.0	3.4
11	2.7
15	0.5

Solution:

Calculate the BOD for each sample, average the valid sample results, and round the results to proper significant digits.

$$BOD = \frac{(DO_{initial}\ mg/L - DO_{final}\ mg/L) \times 300\ mL}{sample\ size\ mL}$$

Average of 5, 7, 9 and 11 mL sample size is 162 mg/L. Round to 160 mg/L.

Solution

The problem can be done using ratios:

$$\frac{\%\ SS\ effluent}{\%\ SS\ influent} = \frac{mg/L\ SS\ effluent}{mg/L\ SS\ influent}$$

Given that influent represent 100 percent of the suspended solids and removal in the primary clarifier is 41 percent, primary effluent percent suspended solids is calculated as follows:

$$\frac{59\%}{100\%} = \frac{112\ mg/L}{?}$$

Solving for the unknown:

$$112\ mg/L \times \frac{100\%}{59\%} = 190\ mg/L\ influent\ SS$$

18. A standard solution is prepared from a 0.100% stock solution of a pure metal. Ten mL of the stock solution is diluted to one liter, and 5 mL of this solution is diluted to 100 mL to make the standard. The concentration of the standard solution is:

    Solution:

    This is a serial dilution problem. First convert the standard solution to concentration and then multiply by the dilutions.

    $$\frac{1{,}000{,}000\ mg/L}{100\%} \times 0.100\% = 1{,}000\ mg/L$$

    $$\frac{1{,}000\ mg\ \text{“X”}}{1{,}000\ mL\ \text{“A”}} \times \frac{10\ mL\ \text{“A”}}{1{,}000\ mL\ \text{“B”}} \times \frac{5\ mL\ \text{“B”}}{100\ mL\ \text{“C”}}$$

    $$\times \frac{1{,}000\ mL\ \text{“C”}}{1L\ \text{“C”}} = \frac{0.5\ mg\ \text{“X”}}{L\ \text{“C”}} = 0.5\ mg/L$$

19. How many grams of chromium trioxide (CrO_3) are needed to prepare one liter of 1,000 mg/L Cr standard (Cr=52, O=16)?

Solution:

Molecular weight of CrO_3

= (1 x 52 g/gmole) + 3 x 16 g/gmole)

= 100 g/gmole

$$\frac{1{,}000 \text{ mg Cr}}{\text{L standard}} \times \frac{1 \text{ g Cr}}{1{,}000 \text{ mg Cr}}$$

$$\times \frac{1 \text{ mole Cr}}{52 \text{ g Cr}} \times \frac{1 \text{ mole } CrO_3}{1 \text{ mole Cr}}$$

$$\times \frac{100 \text{ g CrO3}}{1 \text{ mole CrO3}} = 1.923 \text{ g } Cr0_3$$

41. Select the correct mean, median, mode and range from the following list.

6.7, 8.6, 9.0, 8.9, 8.9, 9.0, 8.5, 8.4, 8.7, 6.6, 8.8, 7.2, 8.5, 9.3, 8.9

Solution:

To do this problem, the candidate must know the definitions and formulas of the requested statistical parameters.

Mean = sum of numbers divided by the number of values (same as average)

Median = central number when listed in numerical order

Mode = most frequently occurring number, it may not be unique

Range = absolute difference between high and low

Mean: 126/15 = 8.4

Median: 6.6, 6.7, 7.2, 8.4, 8.5, 8.5, 8.6, 8.7, 8.8, 8.9, 8.9, 9.0, 9.0, 9.3

15/2 = 7.5, therefore the eighth value or 8.7

Mode: 8.5, 8.9, 9.0

Range: 9.3 – 6.6 = 2.7

Mean = 8.4, median = 8.7, mode = 8.9, range = 2.7

Section 6

Study Materials

The following section includes the titles and information of primary and secondary references for the Laboratory Analyst. Because these references contain the majority of the information needed for the CWEA certification test, it is recommended that these references be obtained for personal use. They may also be obtained at a university library or possibly an employer's library.

The Internet is also a valuable resource. However, when searching for material the source should be considered and your search information should be as targeted as possible to obtain the resource requested. If possible, you should target colleges, government agencies, public works agencies and similar trustworthy sources for your requests.

For the latest information on how to get the following references visit the TCP Resources web page at http://www.cwea.org/book_brcsg.shtml. Many publications are available for free download.

Study Materials Referenced in Section 3

Primary References

- *Operation of Wastewater Treatment Plants, A Field Study Training Program* Fourth Edition, Volume I and II. □Office of Water Programs□California State University Sacramento□6000 J Street □Sacramento, CA 95819-6025□916/ 278-6142□Fax 916/ 278-5959 □www.op.csus.edu

- *Handbook for Analytical Quality Control in Water and Wastewater Laboratories*□EPA: 600/4-79-019; NTIS: PB-297451□National Technical Information Service□5285 Port Royal Road□Springfield, VA 22161□800/553-NTIS www.ntis.gov□ go to http://www.cwea.org/book_brcsg.shtml for free download of this publication.

- *Standard Methods for the Examination of Water and Wastewater, APHA, AWWA, and WEF*□Water Environment Federation□601 Wythe Street□Alexandria, VA 22314-1994□800/666-0206 or 703/684-2452□Fax 703/686-2492□ www.wef.org□ go to http://www.cwea.org/book_brcsg.shtml about the edition currently being used and links to buy the book.

- *Water and Wastewater Laboratory Techniques*□Author: Smith, R. K.□NTIS: P15124WW□Water Environment Federation□601 Wythe Street□Alexandria, VA 22314-1994□800/666-0206 or 703/684-2452□Fax 703/686-2492□ www.wef.org

Secondary References

The information contained in the Primary Reference section above provides a solid base of knowledge for the Grade I Lab Analyst. Additional references that enhance the material provided in these references may be found at a university library, or in the case of chemistry textbooks, at a thrift store, often for less than one dollar. Many of these references can also be found on Amazon.com or other electronic book retailers. Visit www.cwea.org/tcp/resources for the latest information about how to get these books.

- *Laboratory Procedures and Chemistry for Operators of Water Pollution Control Plants* (Reprinted from Operation Wastewater Treatment Plants Volume II.)□CWEA□7677 Oakport St. Suite 600 □Oakland, CA 94621□510-382-7800□http://www.cwea.org/book_brcsg.shtml

- *Lectures on Wastewater Analysis and Interpretation* □Genium Publishing Corporation□Dept. EAM99A□One Genium Plaza□Schenectady, NY 12304-4690□800/ 243-6486. □Fax 518/ 377-1891□genium@genium.com □http://www.cwea.org/book_brcsg.shtml

- *Laboratory Safety Pocket Handbook*□Genium Publishing Corporation□Dept. EAM99A□One Genium Plaza□Schenectady, NY 12304-4690□800/ 243-6486. □Fax 518/ 377-1891□genium@genium.com□http://www.cwea.org/book_brcsg.shtml

- *Basic Science Concepts and Applications, Principles and Practices of Water Supply Operations* □American Water Works Association□6666 W. Quincy Ave.□Denver, CO 80235 303/ 794-7711□www.awwa.org

- *Microbiological Skills for Water and Wastewater Analysis*□Author: Douglas W. Clark□Report No. M16□New Mexico Water Resources Research Institute□New Mexico State University□Box 30001, MSC 3167□Las Cruces, NM 88003-8001□505/646-4337□505/646-6418 fax□
  www.wrri.nmsu.edu

Appendix A

You and Wastewater Math

By Cheryl Ooten, Santa Ana College   email: ooten-cheryl@rsccd.org

Example math problems found in Appendix A are representative of general wastewater math and are designed to illustrate a math problem solving strategy, not specific math skills. Examples given in this appendix may not be like the problems given on the test for your discipline. However, the problems are typical of types of problems you may encounter, including, but not limited to, basic algebra (solving one equation for one unknown), story problems, and geometry, (area and volume problems). For specific kinds of math skills and problems you may encounter on the Collection System Maintenance certification test, please review Sections 3, 4, and 5 of this study guide.

Section 1: Introduction

Now is the time for you to begin preparation for the math portion of your technical certification exam. This Appendix provides suggestions to take charge of:

- ❑ Your math skills
- ❑ Your attitudes toward math
- ❑ Your test-taking skills

By doing this, you can improve your performance in successfully completing the math questions on the certification exam.

Two Facts to Consider

First, since early childhood, you have used math mostly without giving it a second thought. Knowing your age, counting, comparing sizes and shapes, adding your money, and subtracting to get change are math skills.

You drive the streets judging distances, speeds, and times. You estimate if you can afford a vacation or a car and when you can retire. You compare volumes and areas as you build and do jobs around the work site. You even measure volume in putting toothpaste on your toothbrush. You use statistics as you watch sports and consider things like RBIs in baseball or field goal percentages in basketball. All of these are mathematical skills many people take for granted.

Second, if you think math is hard, please know that math becomes hard for everyone at some point. You are not alone. There are math problems that have been unsolved for hundreds of years even though they have been attempted by competent, well-informed mathematicians who may work at them for decades. Those are not the problems you need to work unless you are curious. When you work at your appropriate level, you find a combination of easy ideas and hard ideas.

You may get discouraged comparing your speed and understanding in math with others. Those people who appear to do math easily have, most likely, done those specific problems, or ones like them, many, many times.

You will want to study and progress at your "growing edge"—the skill level where you have a bit of discomfort with new material, but where you are not totally overwhelmed. You can expect challenges that trouble you, but that can be overcome. Instead of saying "I cannot do math," decide now to begin learning enough math to make work and test-taking easier.

Move Beyond the Math You Know

To move beyond your routine skill level in math, consider the following points:

You Have Skills. You already have many math skills and can build on that base. It is best and easiest to build on what you already know.

Basics are Important. Going back over the basics of what you know will build confidence and help you progress and add new math skills to your ability to solve math problems.

Math Progresses Logically. There are many different areas of math and each builds on itself as well as on the others. If you cannot do a particular problem, it may be because you have missed something basic to that one area along the way. Working your way up slowly and cumulatively in math is the fastest way to gain skills.

Words Count. Each and every word and symbol in math means something. You need to find out those meanings and then practice them. If you do not know what "mgd" or "psi" means, or which units measure "flow," it is harder to do problems involving them. It can seem like a foreign language.

Brains are Unique. Each individual brain is wired differently, causing each person to think and learn differently. The more you know about the way you as a specific individual learn, the more you will permit yourself to do what it takes to learn math. Some people need to do many written repetitions. Some need to walk or move around as they do math. Some need to talk out loud. Others need to draw pictures. Some need to work problems with other people. Some need to use words and some need to use symbols. In order to focus on how to move forward, think about what works for you or where learning has been difficult for you.

If you are an independent learner, you might find a basic math book at your library to work through on your own. You may be able to study with your own children to learn some math together or with your friends and colleagues. You may have an old math book you used a long time ago that could be helpful, and you may come to remember what you learned from it.

Assessment Helps. Assess your skill level honestly. Math placement tests are available at your local college and through private educational agencies to help you determine where your skills are and where you can best get help to make comfortable progress.

You are Not Alone. No one promises that math will always be easy or interesting for you. For most people, working on math is a challenge. Persevering and pushing personal limits allows you to experience the satisfaction of success.

Get help when you get discouraged or experience confusion. Remember this is just a momentary problem in a sequence of ideas that you are confronting. Do not buy into the myth that you have to do math alone. Do not believe it is demeaning for you to admit you do not understand. You can have fun if you lighten up as you progress. Working with others is an outstanding way to improve math skills.

Questions are Essential. Make a list of people with whom you feel comfortable discussing your math questions. They may be your colleagues, teachers, fellow students, friends, or family members—even your children. Do not ask just anybody; pick people who are helpful and positive or non-judgmental about your questions.

Mistakes Happen. Expect mistakes up front. As you learn anything new, you will make errors. Do not blame your mistakes on math itself! In any new endeavor you need to allow yourself to crawl before you can walk. Successful people in all fields know this. Trial and error is the basis of all learning.

You can learn more from your mistakes than from repeated successes. Making errors gives you feedback by showing you what you do not understand. Learn to value and accept those errors and use them to find out what areas of your learning need more work. Correct them and then move on with new knowledge.

Learning Math is Not a Competitive Game. Physicist Albert Einstein, politician Winston Churchill, and inventor Thomas Edison were all considered slow in school. Musical composer Ludwig Van Beethoven and scientist Louis Pasteur probably had learning disabilities. What all five certainly had was determination and patience to persevere. Only compete with yourself, pushing yourself forward, in learning math.

There is Hope for Those with Learning Disabilities. If you really have a hard time learning, you might ask your local college or a private learning specialist to assess you for a learning disability. Many colleges and universities do free testing and training for their students. You can also purchase this kind of assistance from private consultants. Much is now known about learning disabilities and how to help people who have them. Learning disabilities often become just learning differences as students learn to honor and use their own thinking and learning styles.

Math Success and Test-Taking Success are Not the Same. Many math students understand and can work math problems, but have difficulty in test-taking situations. It is possible to know math and still fail exams. These people may find Section 4 “Test-Taking Strategies” very helpful. Conscious practice of both math skills and test-taking skills can make a big difference in your score.

Resources are Available. Resources exist for all types of math. You will need to decide whether you will work on your math skills independently or with the help of some structure such as a math course or a tutor. Different strategies may work better at different stages in your progress.

Your local community college has inexpensive math courses. Some colleges even have math courses specifically for water and wastewater professionals. Professional organizations sponsor training conferences and seminars, which include math courses specific to the field. Many agencies can provide in-house training and many agencies will provide individual help with all aspects of test taking.

Community Colleges. Community colleges offer several types of services including:

- Math Placement Testing
- Math Courses
- Water Utility Science Courses
- Math Anxiety Reduction Courses
- Testing and Training for those with Learning Disabilities

Professional Organizations. Organizations such as the California Water Environment Association (CWEA), American Water Works Association, and American Public Works Association also provide opportunities to practice your math skills and network with others:

- CWEA local section study sessions
- Technical Certification Training Classes and Annual Conferences
- CWEA Northern Regional Training Conferences
- CWEA Study Manuals

At Work. Ask for help and suggestions from others who have taken math courses or are skilled in the work area similar to the one you are trying to prepare or improve. Ask your supervisor for advice on how to prepare and how much time on the job you can have to prepare. Ask your supervisor to provide training classes for the areas that you want to improve. Ask those managing other departments, agencies, or local professional organizations for help in the training you need.

Materials. Any basic math book or instructional manual that you can beg, borrow, or buy, including:

- Courses from Office of Waste Programs, California State University, Sacramento, 6000 J Street, Sacramento, CA 95819.
- Price, Joanne Kirkpatrick. Basic Math Concepts for Water and Wastewater Plant Operators. Lancaster, Pennsylvania: Technomic, 1991.
- Smith, Richard Manning. Mastering Mathematics: How to Be a Great Math Student, 3rd Ed. Pacific Grove, CA: Brooks/Cole, 1998.
- Zaslavsky, Claudia. Fear of Math. New Brunswick, NJ: Rutger University Press, 1994.

Section 2: Practice Problem Solving Strategies

Wastewater math deals with only a handful of basic types of problems that involve moving liquids and semi-solids from place to place, and manipulating, storing, and treating these substances along the way.

So basically, understanding area, volume, slope, rates, concentrations, costs, and time elements that occur in wastewater treatment 24 hours per day, 365 days per year, pretty much covers what you need to know.

Units and Arithmetic

All wastewater math problems can be solved by simple arithmetic—adding, subtracting, multiplying, and dividing. You can become proficient with wastewater math by paying careful attention to the units

in the problems as you write down your strategies, and then using a calculator to do the needed arithmetic. Make sure you use only a calculator that you can take into the test site (see www.cwea.org/cbt for a list of approved calculators).

Units. Units such as cubic feet, gallons, gpm, and mgd are important in wastewater math problems. Paying attention to the units will tell you whether to multiply or divide. Also, the units will often help you know what numbers to multiply or divide.

Notice in each example that doing math operations on the units produces the correct units in the answer. Many people do the math on the units first to figure out the correct procedure before they ever do the math on the numbers.

Multiplying. Multiplying is important. There are several symbols for multiplication. They are •, x, and ()().

For example,

$$2 + 3 = 2x3 = (2)(3) = 6$$

Dividing. Dividing is important to wastewater math because units often used such as mgd, cfs, ppm, gpm, psi, mg/L, gpd/sq.ft., and % are really division problems.

“Per” stands for “divided by”.

$$\text{mgd} = \frac{\text{million gallons}}{\text{day}}$$

$$\text{cfs} = \frac{\text{cubic feet}}{\text{second}}$$

$$\text{ppm} = \frac{\text{parts}}{\text{million}}$$

$$\text{gpm} = \frac{\text{gallons}}{\text{minute}}$$

$$\text{pso} = \frac{\text{pounds}}{\text{square inch}}$$

$$\text{mg/L} = \frac{\text{miligrams}}{\text{Liter}}$$

$$\text{gpd/square foot} = \frac{\text{gallons/day}}{\text{square foot}}$$

$$10\% = \text{ ten percent} = \frac{10}{100}$$

Example Problems

Example 1. Plant No. 1 measured a flow of 3.5 million gallons in half a day. If the peak flow (hydraulic) capacity of the plant is 8 mgd, is there need for concern?

Using the conversion factor:

$$\text{mgd} = \frac{\text{million gallons}}{\text{day}}$$

divide 3.5 million gallons by half a day.

$$\text{mgd} = \frac{3.5\ \text{million gallons}}{0.5\ \text{day}} = 7\text{mgd}$$

7 mgd is less than the peak flow capacity, 8 mgd. There is no need for concern yet.

Example 2.

a. Find the number of gallons in 10 cubic feet.

Since we can pour 7.48 gallons into a 1 cubic foot container, that means that 7.48 gallons = 1 cubic foot. We can use either factor:

$$\frac{7.48\ \text{gal}}{1\text{cu ft}} \text{or} \frac{1\ \text{cu ft}}{7.48\ \text{gal}}$$

to convert cubic feet units into gallons or vice versa

$$\frac{10\ \cancel{\text{cu ft}}}{1} \cdot \frac{7.48\ \text{gal}}{\cancel{1\ \text{cu ft}}} = \frac{(10\ \cancel{\text{cu ft}})(7.58\ \text{gal})}{1\ \cancel{\text{cu ft}}} = 74.8$$

Notice that using the first factor allows the unit “cu ft” to cancel out leaving the answer in gallons.

b. Find the number of cubic feet in 10 gallons. Notice that using the second factor allows the unit “gal” to cancel out leaving the answer in cubic feet.

$$\frac{10\ \cancel{\text{gal}}}{1} \cdot \frac{1\ \text{cu ft}}{7.48\ \cancel{\text{gal}}} = \frac{(10\ \cancel{\text{gal}})(1\ \text{cu ft})}{7.48\ \cancel{\text{gal}}} = 1.34\ \text{cu ft}$$

You will notice how important it was in these examples to consider the units in deciding whether to multiply or divide by 7.48.

Example 3.
a. Find the detention time for a basin with 675,460 gal if the flow is 1,000,000 gal/day.

Flow is always a rate which is division. Units like gpd or cfs are both division.

The formula for the basin detention time is

$$\mathrm{D}_1 \frac{\text{volume}}{\text{flow}}$$

$$\mathrm{D}_1 \frac{675{,}460\ \cancel{\text{gal}}}{1{,}000{,}000\ \cancel{\text{gal}}/\text{day}} = \frac{675{,}460\ \cancel{\text{gal}}}{1} \cdot \frac{\text{day}}{1{,}000{,}000\ \cancel{\text{gal}}} = 0.675\ \text{days}$$

b. Find the detention time for a 426 cubic foot basin if the flow is 1,000 cfs.

$$\mathrm{Dt} \frac{426\ \text{ft}^2}{1{,}000\ \text{cfs}} = \frac{426\ \cancel{\text{ft}^2}}{1{,}000 \frac{\cancel{\text{ft}^2}}{\text{sec}}} = \frac{426\cancel{\text{ft}^2}}{1} = \frac{\text{sec}}{1{,}000\ \cancel{\text{ft}^3}} = 0.426\ \text{sec}$$

Example 4.
Find the number of gallons of an 11% polymer needed to produce 100 gal of a 0.75% solution. Use the formula $C_1V_1 = C_2V_2$ where C = concentration or % and V = volume.

You can let the volume you are looking for (i.e. the number of gal of 11% polymer) be represented by V_1. Then C_1 = 11% or 0.11, C_2 = 0.75% or 0.0075, and V_2 = 100 gal.

Using the formula $C_1V_1 = C_2V_2$, you have $(0.11)(V_1) = (0.0075)(100)$

Notice to find V_1, you do the opposite of multiplying (i.e. dividing) by 0.11 on both sides. You then have

$$\frac{(\cancel{0.11})(V_1)}{\cancel{0.11}} = \frac{(0.0075)(100)}{0.11}$$

and using a calculator, V_1 = 6.82. So, the amount needed is 6.82 gal.

Example 5.
How many hours will it take to empty a 43,000 cubic foot tank if it empties at a rate of 2.7 cubic feet per second?

Notice that dividing 43,000 cubic feet by 2.7 cubic feet per second would make the cubic feet unit cancel out. This would give us the time in seconds. To convert seconds into hours, use the factors

$$\frac{1 \text{ min}}{60 \text{ sec}} \text{ and } \frac{1 \text{ hr}}{60 \text{ min}}$$

The work is given below.

Notice how the units cancel out leaving the answer in hours.

$$\text{Time} = \frac{43{,}000 \cancel{\text{cu ft}}}{2.7 \cancel{\text{cu ft/sec}}} \text{x} \frac{1 \cancel{\text{min}}}{60 \text{ sec}} \text{x} \frac{1 \text{ hr}}{60 \cancel{\text{min}}} = 4.42\text{hr}$$

Example 6.
Find the number of gallons of water in a rectangular basin 200 ft. long, 50 ft. wide, and 12 ft. deep.

First, find the volume of the rectangular basin by multiplying length by width by height. Volume = (200 ft.)(50 ft.)(12 ft.) = 120,000 cubic feet or cu ft. or ft^3.

You now have a problem similar to Example 2. How many gallons are there in 120,000 cubic feet?

Use the factor

$$\frac{7.48 \text{ gal}}{1 \text{ cu ft}}$$

to convert cubic feet into gallons.

$$\text{volume} = \frac{120{,}000 \text{ cu ft}}{1} \text{ x } \frac{7.48 \text{ gal}}{1 \text{ cu ft}} = 897{,}600 \text{ gal}$$

Example 7.
A cylindrical tank is full to 3 feet below the top at 10 a.m. and empty at 4 p.m. If the tank is 50 ft. tall with a diameter of 70 ft., find the volume (in gal) of the liquid at 10 a.m. and the rate of flow from the tank in gal per minute.

For a math problem with many words, I recommend always first writing down what you are trying to find:

a. First, find the number of gal of water in the tank at 10 a.m.

b. Second, find the rate of flow in gal/min.

Drawing a sketch helps some people understand the problem and helps to keep track of the data.

I also like to write down and interpret the details that are given to me like:

Full to 3 ft. below the top at 10 a.m.
Empty at 4 p.m.
Takes 6 hours to empty

The solution is presented in two parts.

a. First, to find the volume in gal at 10 a.m., use the formula for volume of a cylindrical tank which is V=(area of the base) times (height).

To find the area of the base of the tank, which is a circle, multiply 0.785 times the diameter squared.

So, the area of the base = $0.785(70^2)$ = 3,846.5 sq. ft.

The height at 10 a.m. is 47 ft. because the tank is filled to 3 ft. below the top.

Volume = (area of the base)(height) = (3846.5 ft^2)(47 ft.) = 180,785.5 $ft.^3$

However, you want the volume in gal so use the factor $\frac{7.48 \text{ gal}}{1 \text{ cu ft}}$ to convert.

Volume in gallons =$(180{,}785.5 \text{ ft}^3)\left(\frac{7.48 \text{ gal}}{1 \text{ ft}^3}\right) = 1{,}352{,}275.54 \text{ gal}$

b. Second, to determine the rate of flow in gallons per minute, divide the number of gallons by the number of minutes it took the tank to empty. It took 6 hours to empty. To convert 6 hours to minutes,

use 60 min = 1 hour or factors $\frac{60 \text{ min}}{1 \text{ hr}}$ or $\frac{1 \text{ hr}}{60 \text{ min}}$ to convert. You want the hour unit to cancel out, so

you will use the first factor. The time becomes: $\frac{6 \cancel{\text{hrs}}}{1} \text{ x } \frac{60 \text{ min}}{1 \cancel{\text{hr}}} = 360 \text{ min}$

Rate of flow in gal per minute = $\frac{1{,}352{,}275.54}{360 \text{ min}} = 3{,}756.32 \text{ gal per min}$

Section 3: Take Charge of Your Success

The key to progress with math is to consciously take charge of your thoughts and actions. Then, instead of letting math control you, you control math and you take charge of your success.

Recommendations

Ask Questions. Be active and assertive. Learning is not a spectator sport. You cannot learn well from the sidelines. Get involved. Work problems and keep asking questions until they become clear. In classes and seminars, ask questions on confusing procedures.

Take It Easy. When you get stuck working problems, hang in for a while and then take a break. Go back later, begin at the beginning with a clean sheet of paper and a different point of view. Just because you do not understand at first does not mean understanding will not come. Math learning requires time to settle into your brain. Being able to live with uncertainty for a while is a good math skill to have.

Keep a List. Write down your resources (books, tutors, people to answer questions, people who understand) so that you can consult them when you get discouraged. You are not alone. Find helpful people with whom you are comfortable. Form a network with others working toward the same goals as you.

Find Yourself. Discover your own unique ways of learning. Experiment with new ones. If a method does not work, find others. Ask different people how they learn math or do a problem. They will often feel honored and pleased that you asked them and you might get a breakthrough idea.

Be Positive. Listen to what you say to yourself inside your head. It is difficult to work well if you are saying, “I will never get this” or “I cannot do math.” Change those negative messages to neutral ones like “I have not learned this yet” or “I cannot do this particular problem yet.”

Reward Yourself. Acknowledge your progress—every little bit! Pat yourself on the back for each and every problem you work. Notice what you know now that is new that you did not know two weeks ago. Maybe even write it down to document your growth.

Learn From Mistakes. Remember that errors are part of the learning process. Pay attention to them and figure out where they happened and how to fix them.

Keep It Real. Be realistic with your expectations of yourself—your math level, your life commitments, and your time constraints. Do not beat yourself up for being a human being.

Use Technology. Learn to use a calculator and use it appropriately for calculations with large numbers and decimals. Be sure to use only an approved calculator for the test site (a list is available at www.cwea.org/cbt). Each brand of calculator is different so keep your manual for reference. Take spare batteries to exams.

Start Easy. Practice the easier math problems to warm up each time you begin your math study. This builds confidence and strengthens those math pathways in your brain.

Write Out Problems. You will be given a dry erase sheet to use at the test site. Practice math problems using scratch paper. Use this to think and do calculations.

Promote Emotional Well Being. Patience, self-care, and humor will make your math work so much easier. Your brain will work better too.

Be Healthy. You are making new connections in your brain as you practice math so sufficient sleep and healthy foods are important. Having fresh drinking water available and breathing fresh air also helps you think better.

Section 4: Test-Taking Strategies

There are many actions you can take before, during, and after exams that will improve your test-taking performance and outlook. Remember that math skills and test-taking skills are different from each other. This section will help you become conscious of your thoughts and actions regarding test preparation. Use these suggestions to take charge and approach your test confidently.

If you find yourself thinking negative thoughts about your coming exam, skip to the last section and read “Negative Thinking about Exams” first.

Before the Exam

Work Problems. Diligently prepare and practice. Repeat solving problems to gain speed and confidence. This takes work and time—sometimes many hours, even days. Going in to an exam with the knowledge that you have worked lots of problems boosts confidence. Prep time is invaluable.

Relax. Practice relaxation daily for about at least ten minutes using breathing. Sitting or lying comfortably, breathe slowly in through your nose counting to five and then out through your mouth counting to ten. If you feel dizzy, breathe normally for a while. Deep breathing activates chemicals in your body that help you relax and feel better. Any type of regular meditation, yoga, or slow stretching while breathing deeply can help facilitate your relaxation response. Practicing daily will help you control your adrenaline level during your exam. Using relaxation consciously during an exam frees up the thinking part of your brain. (Do not practice these deep breathing exercises while you are driving.)

Stay Active. Daily walks or biking or whatever aerobic exercise you use consistently prepares your body for your exam by relieving stress and keeping your state of mind positive. Your mind and your body are connected so tightly that they are nearly the same.

Rehearse. Do a dress rehearsal for your exam. Write or have someone assist you in writing a practice test with problems and questions that you think might be on the real exam. Take the practice test in this study guide in an environment as close to your testing situation and schedule as possible. Time it and then correct it to learn from your errors.

Plan Ahead. Plan ahead carefully so that you will get to the exam early—do not be in a rush. Know exactly how to get there and what you will wear so that you are comfortable. You might want to wear your “lucky” shirt or bring a photograph in your wallet of people who care about you and believe in you. WHATEVER you can do to increase your sense of comfort and security, do it. Ahead of time, pack a Testing-Taking Kit with sharp pencils, pens, a ruler, erasers, tissues or handkerchief, a bottle of water, extra calculator batteries, and anything else you think you might need that is allowed at the test.

Care For Your Body. Optimal food and rest are individual preferences. Plan these ahead of time. Some research has shown that a brisk walk before an exam has raised test results. Some research has shown that eating a few candies (not chocolate) right before an exam has raised test results. Protein appears to be essential for clear thinking. Be in charge of what happens to you before the exam. Do not let outside influences take charge of you for this little time before your test.

At the Exam

Do a Data Dump. Bring a short list of formulas or facts you find difficult to remember. Look at them before the test. Visualize them going into a holding tank in your brain. Practice making them subject to recall. You are not allowed to use notes on the exam, so be sure to put the list away so that your honesty is not questioned. When you start your test, quickly write these formulas or facts on your dry erase sheet. Now you do not have to expend any energy trying to recall them later when you need them.

Ignore Others. Ignore all of the other people at the test site—before, during, and maybe even after. Different people have different ways of dealing with their anxiety during tests (and remember, they are likely to be taking a completely different test than you). Some people get a little hyper and try to rub off their anxiety on everyone else. Do not take on someone else's anxiety. Your test is not a competition so what other people do will not affect your score. Often the first person to leave an exam gets a very low score, while the last person to leave gets a very high score. Take your time. Pay no attention to other people's behavior.

Breathe. When you feel stuck or tense, take a deep breath. Let it all go as you expel the air. (The more you have practiced relaxation and deep breathing before the exam, the more you will relax during the test.)

Take Time Out. Take short breaks during the exam to close your eyes, breathe deeply, and stretch your neck and arms. Massaging your temples, scalp, and the back of your neck will increase blood flow with oxygen to your brain to help you think better. A few isometric exercises can release tension too.

Use Your Subconscious Mind. If a problem makes no sense, read it and go on. Ideas will come to you as the problem sinks into your subconscious mind while you continue with the test.

Trust. Let each question reach into your mind for the answer. Remind yourself that you know everything you need to know for now.

Strategize. Do the easy problems and questions first. Make pencil marks by the questions to which you want to return.

Use Time Wisely. Do not work on one problem for a long time. Often a question further into the exam will act as a "key" to unlock a previous problem. Tell yourself that you have all of the time you need. Let go of the rest of your life during the exam. You can deal with all that later.

After the Exam, Let the Results Go. You have used a lot of energy and may be low and off balance. You may wish to pass up discussing the exam with others so you can take care of yourself. Going to the bathroom, drinking some water, and eating something can help you feel normal again. You may have set much of your life aside to prepare for this exam. Refresh yourself and get your life back. You can deal with the test results later when your priorities are in order again.

Negative Thinking About Exams

Here are negative thoughts math students often think before test-taking. Put a check mark by the examples familiar to you. Recognizing the distorted thinking in each example can help you change negative thoughts to neutral or positive ones. If you need more assistance with overwhelming negative thoughts, I recommend the book Feeling Good by David Burns (WholeCare, 1999).

"I Will Fail." Unless you have a crystal ball and can see into the future OR unless you have made a definite plan NOT to prepare for the test OR unless you plan to "freeze up" during the exam, you have no way of knowing whether you will fail or not. Worrying about the future only takes energy from today.

"I Will Panic During the Test." It is not uncommon to be excited. An exam is a process during which you will experience many thoughts, feelings, and body sensations. Actors get nervous, yet they still perform. If you do panic, let panic leave you. It will. No one dies from panicking during an exam.

Preparation by practicing problems, asking questions, and reviewing gives you confidence and skills that you need. Taking a dress rehearsal test and trying to panic can help you practice dealing with out-of-control feelings. Learning some relaxation techniques to use before and during the exam calms you and aids clear thinking. The more you prepare yourself ahead, the more you are in charge and feel relaxed.

"I Cannot Do Math." Math is a very broad subject involving many different skills. If you can recognize shapes, tell time, and know where the front and back of a classroom are, you can already do math. There are many more math skills that you have and many that you do not have YET. There are also many that you will never choose to acquire. Instead of thinking so absolutely about math, find areas where you can grow and learn new skills instead of paralyzing yourself with this broad generalization.

"I Am Stupid." Name calling is seldom productive. Occasionally you may feel stupid because you do not know something or you mess up. What really is happening is that you are being human and humans are not stupid. Educators recognize the need to change how everyone thinks about intelligence. They recognize that there are many different kinds of intelligence including:

- ❑ bodily/kinesthetic
- ❑ verbal/linguistic
- ❑ naturalist
- ❑ logical/mathematical
- ❑ visual/spatial
- ❑ interpersonal
- ❑ intrapersonal
- ❑ musical/rhythmic

This comes from the work of Howard Gardner [Gardner, Howard. *Multiple Intelligences: The Theory in Practice.* New York: Basic Books, 1993].

You are a wonderful combination of these talents—not just an IQ number. IQ Tests are limited because they only measure a few types of intelligence and ignore the rest. We are not all the same and cannot possibly know all there is to know in every situation. Between now and the exam, there are many questions you can get answered as well as many new skills you can practice and master if you use the skills and intelligence that you have.

"I Will Forget Everything." Forgetting does not mean something is gone from your mind forever. The right cue will often help you remember what you need to know. Your exam will be filled with cues—words and symbols—that will trigger formulas and ideas you have practiced.

Expecting to forget "everything" is foretelling the future and making a broad generalization. Even most people with amnesia caused by illness or injury do not forget "everything." If you are extremely worried about your memory, The Great Memory Book by Karen Markowitz and Eric Jensen (The Brain Store, 1999) can be of assistance to you.

"Math Tests Are Tricky." Math students who rely on memorizing the material rather than understanding it are usually the ones who think tests are tricky. You will use your memory to add to your understanding of how to do the math. Your math problems will contain many units such as mgd or ft^3 or psi. Learning how to skillfully convert back and forth between units of measure will take a lot of the trickiness away from your test problems. Practicing using your calculator will help too.

"There Is So Much I Do Not Know." This will always be the case the rest of your life. It is the human condition. Taking a deep breath and finding the level where you can begin to learn will improve your feelings and your confidence.

Glossary

Technical Terms

40 CFR 121-124: The federal storm water regulations for the permitting of municipalities and industries. Regulations define storm water terms, permitting, inspecting, and sampling requirements.

40 CFR 136: The regulations for sampling preservation and analyses of water, wastewater, and solid waste.

40 CFR 403: The federal regulations defining the elements of a pretreatment program, prohibited discharges, and the approval process for establishing a pretreatment program.

Acid: A compound which liberates hydrogen ions and has a pH below 7.

Alkalinity: The measurement of a sample's capacity to neutralize acid.

Approval Authority: The agency determining whether a pretreatment program contains the necessary elements to meet the intent of the Act.

Atomic Weight: The sum of the number of protons and the number of neutrons in the nucleus of an atom. Atomic weights of elements are found on periodic tables.

Base: A compound which liberates hydroxide ions and has a pH above 7.

Biochemical Oxygen Demand (BOD): The quantity of oxygen utilized in the biochemical oxidation of organic matter under standard laboratory procedures for five days at 20° Centigrade, usually expressed as a concentration (e.g., mg/L). BOD measurements are used to indicate the organic "strength" of wastewater.

Biological Treatment: A waste treatment process by which bacteria and other microorganisms break down complex organic or inorganic (e.g., ammonia) materials into simple, nontoxic, more stable compounds.

Categorical Industrial User (CIU): An industrial user (see IU definition below) that is conducting processes subject to a categorical standard promulgated by the U.S. EPA.

Centrifugal Pumps: Pumps using centrifugal force to convey liquid. Discharge will vary according to inlet and discharge pressure.

Chain-of-Custody: A legal record (which may be a series of records) of each person who had possession of an environmental sample, from the person releasing the sample, to the person who collected the sample, to the person who analyzed the sample in the laboratory, to the person who witnessed the disposal of the sample.

Chemical Oxygen Demand (COD): The amount of oxygen (expressed in mg/L) consumed from the oxidation of pollutants during a specific test. As such, COD is a measure of the oxygen-consuming capacity of the pollutants present in wastewater. The results of the COD test are not necessarily related to the BOD, because the chemical oxidant responsible for utilizing the oxygen may react with substances which bacteria do not stabilize.

Cipolletti Weir: A trapezoidal sharp-crested weir for measurement of liquid discharge in open channels.

Clean Water Act (CWA): Public law (PL 92-500) enacted in 1972, which sets the framework for the imposition of industrial wastewater control programs on municipalities and the regulation of industrial users. Sections 307(b) and (c) of the CWA set forth the authority for the U.S. EPA to establish pretreatment standards for existing and new sources discharging industrial wastewater to publicly owned treatment works (POTWs).

Composite Sample: A collection of individual samples obtained at regular intervals, based either on flow or time. The individual samples are combined proportionally.

Concentration Based Discharge Limits: Allowable concentration of a pollutant in wastewater discharges, usually expressed as a concentration (i.e., mg/L) in the discharge.

Confined Space: A space, which has limited openings for entry and exit, has unfavorable natural ventilation which could contain or produce dangerous air contaminants (or create an atmosphere of oxygen deprivation), and which is not intended for continuous employee occupation. A permit may be required under OSHA to enter a confined space.

Control Authority: The agency responsible for implementing a pretreatment program.

Conventional Pollutants: Those pollutants, which are usually found in domestic, commercial or industrial wastes (such as suspended solids or biochemical oxygen demand) that POTWs are designed to treat.

Density: The relationship between weight and volume, e.g., grams per cubic centimeter or pounds per gallon.

Detention Times: The residence time of wastewater undergoing treatment in a treatment unit such as a clarifier or tank. Minimum detention times are required for settling, chemical treatment, and biological treatment.

Doppler Flow Meter: A device that measures the velocity of a liquid by measuring the change in frequency between a wave source and the meter.

Electroplating: The process of applying a thin metal coating to the surface of a substrate by electrodeposition of dissolved metal in a plating solution.

Flow Equalization: Temporary storage of wastewater flow to provide more uniform flow or waste characteristics for treatment or discharge.

Flume: A specially shaped open channel flow section with an area and/or slope that is different from that of the channel.

Grab Sample: A sample, which is taken from a wastestream without regard to the flow in the wastestream, and over a period of time not to exceed 15 minutes.

Holding Time: The maximum time allowed between when a sample is taken and when it must be analyzed in the laboratory, in accordance with standard preservation, storage, and analytical procedures.

Dissolved Sulfide (H2S): Produced by the biological reduction of sulfate and organic matter under anaerobic (oxygen-free) conditions. Dissolved sulfide can combine with hydrogen to form hydrogen sulfide gas. H2S gas is potentially hazardous to sewer maintenance workers.

Industrial User (IU): Any non-domestic source, which introduces pollutants into a POTW.

Industrial Wastewater: Any non-domestic wastewater (excluding storm water).

Magnetic Flowmeter: A flowmeter that creates a magnetic field across a pipe flowing full, in which the liquid acts as a conductor to measure the velocity and flow in the pipe.

Mass Based Limits: Discharge limits based on allowable dry weight of pollutant, usually expressed in pounds per day (lbs/day).

Mass Emission Rate: The rate of discharge of the dry weight of a pollutant in wastewater or air, expressed in lbs/day or kilograms per day (kg/day).

Material Safety Data Sheets (MSDS): Sheets providing information about manufactured chemicals, as required by the Hazard Communication Rule.

Molarity: Moles per liter; a measure of concentration.

Mole: An Avogadro's number of something.

Molecular Weight: The sum of the atomic weights of all atoms making up a molecule.

National Pollutant Discharge Elimination System (NPDES): The federal permitting program designed to control all discharges of pollutants from point sources into U.S. waterways, as required under the CWA.

National Prohibited Discharge Standards: Prohibitions, applicable to all nondomestic dischargers, regarding the introduction of pollutants into POTWs as set forth in 40 CFR 403.5.

Neutralization: Addition of an acid or alkali (base) to a liquid to cause the pH of the liquid to move toward a neutral pH of 7.0.

Normality: A measure of the concentration of a solution.

Oxidation-Reduction: Reactions involving the transfer of electrons, with oxidation being the loss of electrons and reduction being the gain of electrons. ORP, or oxidation-reduction potential, is a qualitative measure of the state of oxidation in metal waste treatment systems. ORP is used to control the chemical addition to optimize the oxidation of compounds such as cyanide or reduction of metals such as hexavalent chromium.

Parshall Flume: An open channel flow measuring device with a constricted throat that produces a head or water depth that is related to discharge.

Pass-Through: The passage of untreated pollutants through a POTW which could violate applicable water quality standards or NPDES effluent limitations.

pH: The negative logarithm of the hydrogen ion (H^+) concentration; the measure of the relative acidity or alkalinity of a solution on a scale from 0 (acidic) to 14 (basic).

Pollutants of Concern (POC): Compounds in wastewater that pose a potential threat to the POTW or its ability to comply with environmental standards.

Positive Displacement Pumps: Pumps that use pistons, diaphragm action, etc., to convey liquid. The discharge rate of these pumps does not vary with inlet or outlet pressure.

Pretreatment Standard: Any regulation promulgated by the EPA in accordance with Sections 307(b) and (c) of the Clean Water Act, applying to a specific category of industrial users and providing limitations on the introduction of pollutants into POTWs. This term includes BMPS, the prohibited discharge standards under 40 CFR 403.5, and local limits [per 40 CFR 403.3 (j)].

Precipitation: Part of a treatment process that takes dissolved pollutants out of solution to form a precipitate that can be removed by filtration or settling.

Printed Circuit Board: A circuit for electronic apparatus made by depositing conductive material, usually copper, on an insulating surface.

Process-Inhibition: The concentration of a pollutant that will reduce the effectiveness or efficiency of a biological treatment process in the POTW.

Publicly Owned Treatment Works (POTW): A treatment works which is owned by a state, municipality, city, town, special sewer district, or other publicly owned and financed entity, as opposed to a privately owned (industrial) treatment facility. This definition includes any devices and systems used in the storage, treatment, recycling and reclamation of municipal sewage or industrial wastes of liquid nature. It also includes sewers, pipes and other conveyances only if they convey wastewater to a POTW treatment plant. The term can also mean the municipality (public entity) which has jurisdiction over the indirect discharges to and the discharges from such a treatment works.

Settling: The treatment process by which settleable or floatable solids are removed from wastewater by gravity separation in a tank or other vessel.

Sludge Quality Standard: Allowable concentration or mass of a pollutant in POTW sludge, or biosolids, used for land application, found in 40 CFR 503.

Specific Gravity: (1) The weight of a particle, substance, or chemical solution in relation to the weight of an equal volume of water. Water has a specific gravity of 1.000 at 4°C (39°F). (2) The weight of a particular gas in relation to an equal volume of air at the same temperature and pressure. Air has a specific gravity of 1.0. Chlorine, as a gas, has a specific gravity of 2.5.

Total Suspended Solids (TSS): Residue (expressed as mg/L) that is removed from a wastewater sample by a standard laboratory filtration procedure.

Turbine Meter: A positive displacement meter with an internal turbine turned by the water flow. Flow is proportional to the turbine rotation speed.

V-notch Weir: A triangular sharp-crested weir for measurement of liquid discharge in open channels.

Volatile Solvents: A solvent that is capable of being evaporated or changed to a vapor at relatively low temperatures.

Weir: A dam built across an open channel over which liquid flows, usually through some type of opening or notch.

Wet Well: A compartment or tank in which wastewater is collected. The suction pipe of a pump may be connected to the wet well or a submersible pump may be located in the wet well.

Worker Right-to-Know Laws: Legislation that requires employers to inform employees of the possible health effects resulting from contact with hazardous substances. At locations where this legislation is in force, employers must provide employees with information regarding any hazardous substances that they might be exposed to under normal working conditions or reasonably foreseeable emergency conditions resulting from workplace conditions. OSHA's Hazard Communication Standard (HCS) (29 CFR Part 1910.1200) is the federal regulation. There are also state statutes that are called Right-to-Know Laws.

Management and Supervision Terms

Ability: The quality of being able to perform; a natural or acquired skill or talent.

Accident: Unplanned or uncontrolled event in which action or reaction of an object, material, or person results in personal injury.

Accountability: Non-assigned liability for the manner in which an organizational obligation held by a member is discharged, either personally or by subordinates.

Active listening: Conscious process of securing information through full attention, intent listening, and alert observation.

Affirmative Action: In-company program designed to remedy current and future employment inequities. Americans with Disabilities Act (ADA): Prohibits employment discrimination based on a person’s mental or physical disability.

Appraisal interview: Meeting held between a supervisor and an employee to review performance rating and, using the evaluation as a basis, to discuss overall quality of work performed, and methods of improvement, if necessary.

Arbitration: Labor dispute or employee grievance settlement by an impartial umpire selected through mutual agreement by organization and worker’s union.

Attrition: Reduction in a work force due to natural events and causes, (e.g., retirement, death, resignation), as opposed to planned reductions (e.g., discharges, layoffs, early retirement).

Authority: The power needed to do a specific job, or to carry out one’s responsibilities, usually handed down from immediate bosses or superior.

Body language: Nonverbal body movements, facial expressions and/or gestures that project or reveal underlying attitudes and sentiments.

Budget: Plan, or forecast, especially of allowable expenses in operation of a department.

Budgetary control: Planning and reporting system incorporating standards for operating conditions and results, as well as costs and expenses, within a single document.

Certification Exam: An examination administered by a state or professional association that candidates take to indicate a level of professional competence.

Chain-of-Command: Formal channels in an organization that distributes authority from top down.

Code of Federal Regulations (CFR): A publication of the United States Government that contains all of the proposed and finalized federal regulations, including environmental.

Collective bargaining: Process of give-and-take engaged in by management and collective employees representatives to reach formal, written agreement about wages, hours, and working conditions.

Communication process: Giving and receiving information and understanding, such as between a supervisor and an employee, leading to a desired action or attitude.

Computerized Maintenance Management System (CMMS): A computerized system to assist with the effective and efficient management of maintenance activities through application of computerized elements including: work orders, routine standard jobs, bills of materials, application parts, and lists of numerous other features.

Competition: Relatively healthy struggle among individuals or organizational groups to excel in striving to meet mutually beneficial goals.

Conflict: Disruptive clash of interests, objectives, or personalities, between individuals or groups within an organization.

Control: To exercise authoritative influence over; the authority or ability to manage and/or direct.
Cost-benefit analysis: Technique for weighing pros and cons of alternative actions, in which both intangible benefits as well as costs are assigned dollar values.

Cost variance report: Listing of allowable expenses compared with actual expenses incurred.

Decision-making: Part of the problem-solving process that entails evaluation of alternative solutions and a choice of an effective action.

Delegation: The act in which authority is given to another person in the organization to accomplish a specific job.

Differential treatment: The act of treating a minority or protected group member differently from other applicants or employees.

Discipline: Imposition by management—in such a manner as to encourage more constructive behavior—of a penalty on an employee for infraction of a rule, regulation, or standard.

Discrimination: Managerial action or decision based on favoring or disfavoring one person or group member over another on the basis of race, color, ethnic or national origin, sex, age, handicap, Vietnam era war service, or union membership.

Division of work: Principle that performance is more efficient when a large job is broken down into smaller, specialized tasks.

Due process: Employee's legal entitlement to a fair hearing, usually before an impartial party and with appropriate representation, before discipline can be meted out.

Employee turnover: Measure of how many people come to work for an organization and do not remain employed by that organization, for whatever reason.

Ergonomics: Study of how workers react to their physical environment; used in design of more comfortable and productive workstations.

Equal Employment Opportunity (EEO): System of organizational justice, stipulated by law, that applies to all aspects of employment; intended to provide equal opportunity for all members of the labor force.

Feedback: Process of relaying measurement of actual performance back to an individual or unit, so that action can be taken to correct, or narrow, the variance.

Gantt Chart: Chart that enables a planner to schedule tasks in the most productive sequence, and that also provides a visual means for observing and controlling progress.

Geographical Information System (GIS): An integrated system of computer hardware, software, and trained personnel linking topographic, demographic, utility, facility, images, and other resource data that are geographically referenced.

Grievance: Job-related complaint stemming from an injury or injustice, real or imaginary, suffered by an employee, for which relief or redress from management is sought.

Grievance procedure: Formalized, systematic channel for employees to follow in bringing complaints to the attention of management.

Hazard: Potentially dangerous object, material, condition, or practice present in the workplace, to which employees must be alert and from which they must be protected.

Hostile Work Environment: Conditions such as harassment, offensive speech, or unwelcomed conduct, that create an abusive, antagonistic, or inhospitable work place.

Information Management System (IMS): System comprised of data processing devices, programs, and people that collects, analyzes, exchanges, and delivers information to an organization in such a manner as to aid managers in making decisions.

Information: Dates, past or present facts, observations, or conclusions, collected in numbers and words that have been selected, arranged, and analyzed (processed) to make them useful for a specific human (managerial) activity.

Injury Illness Prevention Plan: Plan required by California Senate Bill (SB) 198 to establish, implement, and maintain an effective program helping assure employee safety while on the job.
It includes eight elements: management assignments and responsibilities, safety communications system with the employees, system assuring employee compliance with safe working practices, scheduled inspections and compliance system, accident investigation, health and safety training and instruction, and record-keeping and documentation.

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Job breakdown analysis: Segmentation of a job into key elements, or steps, which require an employee to perform, induce, or supervise an action that advances work toward completion.

Job evaluation: Systematic technique for determining job worth, compared with other jobs in an organization.

Just cause: Reason for a disciplinary action that is accurate, appropriate, well founded, deserved and meets the test of prior notification of unacceptable behavior and its penalty.

Knowledge: Information that can be learned from reading, listening to an expert, or keenly observing a situation; often a prerequisite to skill development.

Management: Process of obtaining, deploying, and utilizing a variety of essential resources in support of an organization's objectives.

Management by objectives (MBO): Planning and control technique where supervisors and their immediate superiors agree on goals to be attained and/or standards to be maintained.

Management development: Systematic program for improving the knowledge, attitudes, and skills of supervisors and managers.

Management principles: Set of guidelines established for carrying out the management process.

Management process: General sequence of five unique functions—planning, organizing, staffing, directing or activating, and controlling—provided by managers for any organization.
Manager: An individual who plans, organizes, directs, and controls work of others in an organization.

Material Safety Data Sheets (MSDS): Sheets providing information about manufactured chemicals, as required by the Hazard Communication Rule (HCR).

Mentor: Knowledgeable, often influential, individual who takes an interest in, and advises, another person concerning that person's career.

Morale: Measure of the extent of voluntary cooperation—as well as the intensity of desire—to meet common work goals, as demonstrated by an individual or work group.

Motivation: Process that impels someone to behave in a certain manner in order to satisfy highly individual needs.

Networking: Informal process of getting to know, and create confidence among others who—through mutual exchange—help advance one's career.

Non-managerial employees: Workers who receive direction from managers, who perform specific, designated tasks, and who are responsible only for their own performance.

Organizing: Deciding who does what work and delegating authority to the appropriate person.

Organization: Structure derived from systematically grouping tasks to be performed, and from prescribing formal relationships that strengthen the ability of people to work together more effectively.

Performance appraisal: Formal and systematic evaluation of how well a person performs work and fills an appropriate role in the organization.

Penalty: Punishment or forfeiture imposed as discipline by management on an employee.

Personality: An individual's unique way of behaving and of interpreting events and the actions of others.

PERT Chart: Graphic technique for planning a project in which a large number of tasks must be coordinated, by showing the relationship between tasks and critical bottlenecks that may delay progress towards completion.

Policies: Broad guidelines, philosophy, or principles which management establishes and follows in support of organizational goals.

Procedures: Methods, prescribed by management, for the proper and consistent forms, sequences, and channels to be followed by individuals and units of an organization.

Productivity: Measure of efficiency that compares operational output value with cost of resources used.

Progressive Discipline: Providing increasingly harsh penalties for substandard performance or broken rules, as the condition continues or the infraction is repeated.

Quid pro quo: An equal exchange or substitution; e.g., as applied to sexual harassment, when a supervisor threatens to fire or not promote an employee if they do not provide sexual favors in return.

Regulations: Special rules, orders, and controls set forth by management, restricting the conduct of units and or individuals within an organization.

Reprimand: Severe expression of disapproval or censure by management of an employee, usually written as well as oral, and retained in an employee's personal file.

Responsibilities: Those duties one is held accountable for.

Responsibility: Duty or obligation to perform a prescribed task or service or attain an objective.
Retributive: Punishment inflicted as vengeance.

Reverse discrimination: Notion that implementation of affirmative action deprives qualified members of non-protected groups of their rightful opportunities.

Satisfaction: State that exists when motivating needs—such as interesting and challenging work, full use of one's capabilities, or recognition for achievement—are met.

Schedules: Detailed assignments dictating how facilities, equipment, and/or individuals are used, according to times and dates, in accomplishment of organizational objectives.

Sexual Harassment: Unwanted sexual advances, requests for sexual favors, or other visual, verbal, or physical conduct of a sexual nature, which is conditioned upon an employment benefit, unreasonably interferes with an individual's work performance, or creates an offensive work environment.

Skill: The capacity to perform a job related action by blending relevant knowledge and physical or perceptual ability.

Specification: Collection of standardized dimensions and characteristics pertaining to a product, process, or service.

Stereotype: Characterization of an individual on the basis of a standardized, oversimplified view of characteristics believed to be held in common by a group to which the individual is assumed to belong.

Supervisor: Manager who is in charge of, and coordinates, activities of a group of employees engaged in related activities within a department, section, or unit of an organization.

Suspension: Temporary removal by management of an employee privilege (such as the right to report to work and receive pay for it) until proper actions have been determined and imposed.

Time budget: Charting technique for planning the systematic distribution of a supervisor's time.

Theory X: Negative approach to human relations in which a supervisor presumes most people don't like to work and thus need to be pushed or threatened.

Theory Y: Positive approach to human relations whereby a supervisor presumes that, given meaningful work, most people will try hard to achieve, especially when there is an opportunity to improve their self-regard.
Tolerance: Permissible deviation, or variance, from a standard.

Type A individual: Person characterized by high standards of achievement and an urgency to attain them, who is especially susceptible to stress.

Unfair labor practices: Practices engaged in by management or labor unions that are judged by federal labor law to be improper, especially when they interfere with the right to organize or when they discriminate against labor union activities.

Unity of Command: Principle that each individual should report to only one boss.

Unity of Direction: Principle that there should be a single set of goals and objectives that unites the activities of everyone in an organization.

Variance: Gap, or deviation, between actual performance, condition, or result and a standard of expected performance, condition, or result.

Warning: A reprimand so worded as to give formal notice to an employee that repetition of a particular form of unacceptable behavior will draw a penalty.

Worker's compensation: Financial reparations or awards granted by an employer to an employee who has suffered an on-the-job injury or illness that is judged to have permanently restricted the employee's earning capacity.

Acknowledgement/Credit: Many of the terms and definitions found in this glossary have been taken from the 6th Edition of *What Every Supervisor Should Know*, by L. Bittle and J. Newstrom. These definitions are reproduced, in part or in whole, with permission of The McGraw-Hill Companies. Most of the remaining terms and definitions have been taken from the 1st Edition *of Utility Management: A Field Study Training Program*, prepared by L. Lindsay for the California State University Sacramento Foundation. These definitions are copyrighted and reproduced by permission of the Office of Water Programs, CSUS.

AA	atomic absorption
AC	alternating current
AC	acre
AF	acre-foot (feet)
AFY	acre-foot per year
AMSA	Association of Metropolitan Sewerage Agencies
ANSI	American National Standards Institute
APHA	American Public Health Association
AS	activated sludge
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWT	advanced wastewater treatment
AWWA	American Water Works Association
BECP	Business Emergency and Contingency Plan
BMP	Best Management Practice
BMR	Baseline Monitoring Report
BNR	biological nutrient removal
BOD5	biochemical oxygen demand after 5 days
BTU	British thermal unit
C	Celsius
Cal-OSHA	California Occupational Safety and Health Act
Cal-EPA	California Environmental Protection Administration
CBOD	carbonaceous biochemical oxygen demand
CCE	carbon chloroform extract
CCR	California Code of Regulations
cf	cubic feet (foot)
CFR	Code of Federal Regulations
cfs	cubic feet per second

CH4	Methane
CIU	Categorical Industrial User
CM	common mode
CMOM	Capacity Management, Operations, and Maintenance
COD	chemical oxygen demand
CPU	central processing unit
CRWA	California Rural Water Association
CSP	confined-space permit
CT	current transformer
CWA	Clean Water Act
CWEA	California Water Environment Association
DAF	dissolved air flotation
DO	dissolved oxygen
DOHS	California Department of Health Services
DV/DT	(V/T) The change in voltage per change in time.
DWF	dry weather flow
DWR	Department of Water Resources
EIS	Environmental Impact Statement
EMF	electromotive force or voltage
EPA	U.S. Environmental Protection Agency
ERP	Enforcement Response Plan or Emergency Response Plan
F	Fahrenheit
F/M	food to microorganism ratio
ft	feet (foot)
ft2	square foot
ft^3	cubic feet
FTU	formazin turbidity unit
GAC	granular activated carbon
gal	gallon
GFI	ground fault interrupter
GPD	gallons per day
GPM	gallons per minute
GTAW	gas tungsten arc welding

H2S hydrogen sulfide

HCP&ERP Hazard Communications Program and Emergency Response Plan

Hp horsepower

HPLC high-performance liquid chromatography

Hz Hertz

IC ion chromatograph

ICE Institute for Credentialing Excellence (formerly NOCA)

ICP inductively coupled plasma

IEEE Institute of Electrical and Electronics Engineers

IIPP Injury and Illness Prevention Plan

IML Interface Management Language

JTU Jackson Turbidity Unit

K Kilo, a prefix meaning 1,000

KVA kilovolt amperes

kw kilowatt

kwh kilowatt hour

L liter

lb pound

M Mega, a metric prefix meaning 1,000,000

m meter

M mole or molar

MA millamps

MBAS methylene blue active substance

MCL maximum contaminant level

MCLG maximum contaminant level goal

MCRT mean cell residence time

MDL method detection limit

MG million gallons

mg milligram

mg/L milligrams per liter

MGD million gallons per day

min minute

MIS Manufacturing Information System

mL	milliliter
MLSS	mixed liquor suspended solids
MLVSS	mixed liquor volatile suspended solids
MMI	Man Machine Interface
MOP	Manual of Practice
MPN	most probable number
MR&R	Monitoring and Reporting Requirements
MS	mass spectrometer
MSDS	Material Safety Data Sheets
MTBF	mean time between failures
MTTR	mean time to repair
N	normal
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NEPA	National Environmental Policy Act
NM	Normal Mode
NOD	nitrogenous oxygen demand
NPDES	National Pollutant Discharge Elimination System
NPSH	net positive suction head
NTU	nephelometric turbidity unit(s)
O&M	operation and maintenance
OCT	Operator Certification Test (State of California)
OES	Office of Emergency Services
OMR	operations, maintenance, and replacement
OOC	Office of Operator Certification (SWRCB)
OSHA	Occupational Safety and Health Administration/Act
OTE	oxygen transfer efficiency
P	Pico, a metric prefix meaning one millionth of a millionth, or one trillionth (10–12)
PC	personal computer
PCB	polychlorinated biphenyls
pH	potential of hydrogen
P&ID	piping and instrumentation diagram

PID	proportional gain, integral action time and derivative action time
PLC	Programmable Logic Controller
POTW	Publicly Owned Treatment Works
PPB	parts per billion
PPE	Personal Protective Equipment
PPM	parts per million
prct	percent
psi	pound per square inch
PSIA	pounds per square inch absolute
PSID	pounds per square inch differential
PSIG	pounds per square inch gage
PVC	polyvinyl chloride (pipe)
QA/QC	quality assurance/quality control
RAS	return activated sludge
RBC	rotating biological contactor
RCP	reinforced concrete pipe
RFI	Radio Frequency Interference
RMS	root mean square
RTD	resistance temperature device
RWQCB	Regional Water Quality Control Board (State of California)
SCADA	Supervisory Control and Data Acquisition
SCR	semiconductor (or silicon) controlled rectifier
SD	standard deviation
SDI	sludge volume index
sec	second
SI	System Internationale D'Unites (metric units)
SMR	Self-Monitoring Report
SS	suspended solids
SSO	sanitary sewer overflow
SVI	sludge volume index
SVR	sludge volume ratio
SWRCB	(California) State Water Resources Control Board
TAC	Technical Advisory Committee

TC total carbon

TCP Technical Certification Program

TDS total dissolved solids

TF trickling filter

THD total harmonic distortion

TIC total inorganic carbon

TMDL total maximum daily load

TOC total organic carbon

TOD total oxygen demand

TS total solids

TSS total suspended solids

TU turbidity unit

m micro, a metric prefix meaning one millionth

UPS uninterruptible power supply

USB universal serial bus

USEPA United States Environmental Protection Agency

V volt

VAC volts of alternating current

VCP vitrified clay pipe

VFD variable frequency drive

VOC volatile organic chemicals

VOM volt Ohm meter

VSR volatile solids reduction

VSS volatile suspended solids

W watt

WAN wide area network

WDO/WDR Waste Discharge Order/Waste Discharge Requirement

WEF Water Environment Federation

WRP water reclamation plant

WWF wet weather flow

WWTF wastewater treatment facility

WWTP wastewater treatment plant (same as POTW)

yr year

Certification Path & Gap Analysis Tool

Certification Path & Gap Analysis Tool

Knowledge, Skills Abilities -- Gap Analysis Tool *(for exams starting April 2016)*

Laboratory Analyst Grade I	Do It All The Time	Limited Experience	Never Do This
101. Understands the basic knowledge of physical properties and methods for analysis of water and wastewater: Color, Turbidity, Odor, Alkalinity, Hardness, Conductivity, Solids, Temperature, pH. (13%)			
102. Understands the basic knowledge of chemical properties and methods for analysis of water and wastewater: Dissolved oxygen, Biochemical Oxygen Demand, Chemical Oxygen Demand, Chlorine residual (Total and Free), Sulfide. (10%)			
103. Understands the basic knowledge of microbiological properties and methods for analysis of water and wastewater: Coliform by Multiple Tube Fermentation, Coliform by Enzyme Substrate Test, Heterotrophic Plate Count (HPC). (8%)			
104. Collection of samples of wastewater, sludge, receiving water and industrial waste in accordance with established lab procedures: Chain of custody, Sample type (grab and composite), Container type and preparation, Preservation, Hold time, Sampling techniques, Proper labeling, Storage condition. (13%)			
105. Utilizes techniques and equipment used in laboratory analysis: Gravimetric (balance weighing), Titrimetric/volumetric (burette, pipette, graduated cylinder),Sterilization (autoclave, Bunsen burner, oven), Colorimetric (visual observation, spectrophotometer/colorimeter), Electrometric (meters, probes/electrodes), Turbidimetric (Nephelometer), Thermometers (ranges and max temp). (7%)			
106. Operates, maintains and performs routine calibration on basic test equipment: Turbidimeters, Dissolved oxygen meters, pH meters, Balances (analytical and top-loading), Conductivity meters. (8%)			
107. Recognizes laboratory hazards and follows proper safety procedures: Chemical handling, storage, disposal, and spill response; Personal Protective Equipment (PPE), Biological and chemical hygiene, Engineering controls (fume hoods, etc.), Safety Data Sheet (SDS), Physical hazards (burns, sharps, compressed gas, electrical safety, fire, etc.), Good housekeeping. (10%)			

Knowledge, Skills Abilities -- Gap Analysis Tool *(for exams starting April 2016)*

Laboratory Analyst Grade I	Do It All The Time	Limited Experience	Never Do This
108. Prepares solutions and essential laboratory supplies: Dilution of concentrated solutions, Preparation of filters and dishes for residue testing, Preparation of bacteriological culture media. (5%)			
109. Performs accurate calculations: Significant figures: proper rounding, Unit conversion, Basic algebraic and statistical calculations, Solution preparation (dilution factors, normality, molarity), Sample dilution, Scientific notation. (5%)			
110. Understands and practices proper laboratory ethics. (4%)			
111. Documents and maintains accurate and complete laboratory records: Routine documentation, including worksheet/log sheet entries; Sample documentation, Chain-of-custody forms, Record data accurately, Report non-conforming data, Awareness of LIMS (Laboratory Information Management Systems), Data integrity and legal defensibility. (10%)			
112. Understands basic concepts of Quality Assurance/Quality Control: Control charts, Data quality, Standard and reagent quality, Reagent water quality, DOC (Demonstration of Competency). (7%)			
Total Per Category			

If you have mostly "do it all the time" boxes checked, you may want to explore the next higher grade.
If you have a mix of the "do it all the time" & "limited experience", this is likely the right grade.
If you have mostly "never do this," you may want to explore a lower grade or get more experience.

Appendix D

Certification Path & Gap Analysis Tool

CWEA Certification Prep Sessions -- My Action Plan

In order to be the prepared for my certification exam, I have identified the following gaps between the knowledge, skills and abilities required and my current knowledge and skills. I plan on working in the following areas as described below.

Action Item	Where am I now? Where do I need to be? What will it take to fill the gap?	Resources to Use: (books, training, online, community college, local section)	Due Date