Certification Examination

Study

Laboratory Analyst
Grade IV
2nd Edition

- ✓ 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 IV Study Guide, 2nd Edition

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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.

Section 2

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. Some test items requiring calculations are worth multiple points varying from two to five (possibly more). 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 IV position description, they do reflect the core competencies and essential duties required of any Grade IV 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 401 Weight: 5%

Interprets and evaluates data related to the physical properties, methods and interferences for the analysis of water and wastewater.

- *Color*
- *Turbidity*
- *Odor*
- *Alkalinity*
- *Hardness*
- *Conductivity*
- *Solids*
- *Temperature*
- *pH*
- *Acidity*
- *Salinity*
- *Oil and Grease*

KSA401 General Competencies

The Laboratory Analyst IV is expected to have mastered the test methods, its principle and interferences. The analyst understands the interrelationships between the different analyses and has the ability to interpret and evaluate data based on that.

KSA401 Math Competencies

Ability to calculate and alkalinity, hardness, solids, acidity and temperature conversions.

KSA401 Suggested Reading

- *Standard Methods for the Examination of Water and Wastewater* Sections 2010, 2020, 2110, 2120, 2130, 2150, 2310, 2320, 2340, 2510, 2520, 2540, 5520.
- *Lectures on Wastewater Analysis and Interpretation*, Lectures 14,15, 21

KSA 402 Weight: 11%

Interprets and evaluates data related to chemical properties, methods and interferences for the analysis of water and wastewater.

- *Dissolved oxygen*
- *Biochemical Oxygen Demand*
- *Chemical Oxygen Demand*
- *Chlorine residual (Total and Free)*
- *Sulfide*
- *Phosphorus methods (Orthophosphate, Total Phosphorus)*
- *Nitrogen methods (Ammonia, Nitrate, Nitrite, Total Kjeldahl Nitrogen)*
- *Major cations (Sodium, Calcium, Magnesium, Potassium)*
- *Major anions (Sulfate, Chloride, Fluoride, Nitrite, Nitrate, Bicarbonate)*
- *Cyanide*
- *Trace metals*
- *Volatile and semi-volatile organics, and pesticides*
- *TOC (Total Organic Carbon)*
- *Surfactants (MBAS)*
- *Priority pollutants*

KSA402 General Competencies

The Laboratory Analyst IV is expected to have mastered these test methods, its principle and interferences. The analyst understands the interrelationships between the different analyses (e.g. nitrogen methods, phosphorus methods, BOD-COD, etc.). The analyst has the ability to interpret and evaluate (including validation and invalidation) data. The analyst also has the ability to choose the best method for testing an analyte of interest based on sample matrix.

KSA402 Math Competencies

Ability to calculate results for corresponding tests using formulas, dilution factors and conversions as appropriate

KSA402 Suggested Reading

- *Standard Methods for the Examination of Water and Wastewater*, Sections 4010, 4020, 4500-CN, 4500-Cl,4500-F, 4500-N, 4500-NH3, 4500-NO2-, 4500-NO3-, 4500-Norg, 4500-O, 4500-P, 4500-S2-, 5010, 5020, 5210, 5220, 5310, 5540.
- EPA 600 series for organics, EPA method 300.0, EPA method 200.8.
- *Lectures on Wastewater Analysis and Interpretation*, Lectures 3-6, 8-13, 15, 21.

KSA 403 Weight: 4%

Interprets and evaluates data related to the microbiological properties, methods and interferences for

- *Heterotrophic Plate Count (HPC)*
- *Enterococcus*
- *Iterative methods (drinking water, ambient water, ground water, reclaimed water)*

KSA403 General Competencies

The Laboratory Analyst IV is expected to be an expert in microbiological properties, methods and interferences for analysis of water and wastewater. The analyst also provides supervision for junior staff in using the right method based on sample (wastewater, drinking water or reclaimed water) requirements. The analyst also develops alternative test protocol methods, as needed to meet the testing requirements of the lab, following correct protocol, which includes application for its approval. The analyst is also able to interpret and evaluate test data.

KSA403 Math Competencies

Serial dilution calculations and use of dilution factors.

KSA403 Suggested Reading

- *Standard Methods for the Examination of Water and Wastewater*, Sections: 9010, 9020, 9030, 9040, 9050, 9060, 9215, 9221, 9222, 9223.
- *Lectures on Wastewater Analysis and Interpretation*, Lectures 17,21;
- The Clean Water Act Alternate Test Procedure (ATP) program is described at 40 CFR 136.4 and 136.5.

KSA 404 Weight: 4%

Interprets, evaluates and reports acute and chronic toxicity data results

- *Toxicity Reduction Evaluation (TRE)*
- *Toxicity Identification Evaluation (TIE)*

KSA404 General Competencies

The Laboratory Analyst IV is expected to be knowledgeable in all aspects of Whole Effluent Toxicity testing. This includes facilities and equipment, dilution water, effluent sampling methods, holding times, temperature, organism culturing and handling, data analysis, report preparation. The WET test results (e.g. the log dose-response curve) are statistical evaluations of a biological phenomenon. The analyst should be able to interpret it with respect to the realities of the test and suggest if and when a TRE, TIE study need to be done.

KSA404 Math Competencies

The statistical methods used for analyzing test data in an acute and chronic toxicity test

KSA404 Suggested Reading

- *Standard Methods for the Examination of Water and Wastewater*, Sections 8010, 8020, 8711, 8712, 8910, 8921.
- The Whole Effluent Toxicity method listed in 40 CFR 136.3
- Lectures on Wastewater Analysis and Interpretation, Lectures 18,21.

KSA 405 Weight: 3%

Interprets and evaluates wastewater treatment process control data.

- *Process control topics (MLSS/SVI, MCRT, F/M, chlorination, dechlorination, volatile acids/alkalinity ratio)*
- *Microorganism speciation, counting and interpretation of results*
- *Digester sludge analysis*
- *Phases of the treatment process*
- *Plant process efficiency*

KSA405 General Competencies

A Laboratory Analyst IV is required to have mastered an understanding of waste water treatment processes including effluent discharge monitoring and process efficiency, activated sludge monitoring and chemicals used in treatment. The analyst is adept at applying lab results to plant processes and interpreting plant performance.

KSA405 Math Competencies

Conversion of laboratory results in mg/L to plant operating units of pounds and gallons.

KSA405 Suggested Reading

- *Standard Methods for the Examination of Water and Wastewater*, Sections 2540, 2530, 2710, 2720, 4500-Cl, 5020, 5560.
- *Lectures on Wastewater Analysis and Interpretation*, Lectures 17(Microscopic examination), 20, 21.
- Operation of Wastewater Treatment Plants-A field study training program, Chapter 21-Lessons 1, 2, 3.

KSA 406 Weight: 6%

Implements lab procedures and directs the collection of wastewater, sludge, receiving water and industrial waste samples

- *Chain of custody*
- *Sample type (grab and composite)*
- *Container type and preparation*
- *Preservation (pH adjustment)*
- *Hold time*
- *Sampling technique*
- *Proper labeling*
- *Storage condition*
- *Sample location*
- *QC (sample validation/invalidation)*
- *Ultra clean sampling methods*
- *Autosampler maintenance and programming (flow-based or time-based)*

KSA406 General Competencies

The Laboratory Analyst IV is expected to have mastered appropriate sampling techniques for a variety of sample matrices, including wastewater, sludges, biosolids, etc. The analyst must know the preservation requirements, potential interferences and mitigating techniques, and reason preservation is necessary for all analyses run in the lab. The analyst must know the required elements of a chain of custody form. The analyst must know where to find sampling requirements, and how to keep them current.

KSA406 Math Competencies

Ability to program a flow-based sampling schedule.

KSA406 Suggested Reading

- Code of Federal Regulations: TITLE 40, Chapter 1, Subchapter D, Part 136
- *Standard Methods for the Examination of Water and Wastewater*, Sections 1060, individual method sections.
- *Lectures on Wastewater Analysis and Interpretation*, Appendix B
- EPA Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels

KSA 407 Weight: 7%

Implements and evaluates techniques and equipment used in laboratory analysis.

- *Gravimetric (balance weighing)*
- *Titrimetric/volumetric (burette, pipette, graduated cylinder, titrators)*
- *Sterilization (autoclave, Bunsen burner)*
- *Colorimetric (visual observation, spectrophotometer/colorimeter)*
- *Electrometric (meters, probes/electrodes, LDO, ISE)*
- *Turbidimetric (Nephelometer)*
- *Thermometers (ranges and maximum temperature)*
- *Ion chromatographs*
- *Sample preparation (digestion, extraction, filtration, distillation)*
- *GC, GC/MS, ICP-OES/MS, cold vapor AAS, HPLC*

KSA407 General Competencies

The Laboratory Analyst IV is expected have advanced knowledge of laboratory instrumentation. This includes knowing the methods associated with an instrument, the instrument's operational range, and the instrument's QC and calibration requirements. The analyst must know the typical substances an instrument is used to measure, and why one type of instrument should be used versus an alternative instrument or method.

KSA407 Math Competencies

Ability to use significant figures appropriately. Ability to read a thermometer accurately.

KSA407 Suggested Reading

- *Standard Methods for the Examination of Water and Wastewater*, Sections 2130, 9010, 9020, 9030, 2120, 4500-NH_3, 4500-H^+, 4500-O.
- EPA Methods 300.0, 1668.

KSA 408 Weight: 5%

Directs operation and maintenance of test equipment.

- *Turbidimeters*
- *Dissolved oxygen meters*
- *pH meters*
- *Balances (analytical and top-loading)*
- *Ion chromatographs*
- *Spectrophotometers*
- *Conductivity meter*
- *Microscopes*
- *Autoclaves*
- *Ovens*
- *Incubators*
- *Refrigerators*
- *Water baths*
- *Titrators*
- *GC, GC/MS, ICP-OES/MS, cold vapor AAS, HPLC*
- *Reagent water purification system*

KSA408 General Competencies

The Laboratory Analyst IV is expected to know the maintenance requirements for all laboratory instrumentation. This includes knowing the frequency of maintenance, calibrations and standardizations must, and what must be done following maintenance to bring the instrument back into service. The analyst should be familiar with the benefits and drawbacks of service contracts.

KSA408 Math Competencies

N/A

KSA408 Suggested Reading

- *Standard Methods for the Examination of Water and Wastewater*, Sections 2130, 9010, 9020, 9030, 2120, 2510, 4500-NH_3, 4500-H^+, 4500-O.
- EPA Methods 300.0, 1668

KSA 409 Weight: 6%

Directs implementation of corrective action for laboratory hazards and follows proper safety procedures.

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

KSA409 General Competencies

The Laboratory Analyst IV is expected to have advanced knowledge of laboratory safety requirements. This includes fire prevention and response, the elements of a Chemical Hygiene Plan, the elements of a Safety Data Sheet, proper chemical storage, proper hazardous waste disposal, and spill response measures. The analyst must know the hazards associated with confined space sampling, and the correct use of PPE.

KSA409 Math Competencies

M/A

KSA409 Suggested Reading

- *Standard Methods for the Examination of Water and Wastewater,* Section 1090.
- Occupational Safety and Health Act of 1970 (OSH Act) and other relevant laws.

KSA 410 Weight: 4%

Ensures the correct preparation of reagents, calibration and quality control standards and essential laboratory supplies

- *Dilution of concentrated solutions*
- *Preparation of filters and dishes for residue testing*
- *Preparation of bacteriological culture media*
- *Create working standards from concentrated standards*
- *Verification of prepared reagent quality (standardization)*
- *Maintenance of chemical inventory*

KSA410 General Competencies

The Laboratory Analyst IV is adept at preparation of stock standards and reagents, and guides junior staff in standard preparation and standardization. The analyst also directs the use of internal, external and second source QC standards.

KSA410 Math Competencies

Calculations involving Normality, Molarity, percentage, and serial dilution.

KSA410 Suggested Reading

- *Standard Methods for the Examination of Water and Wastewater*, Sections 1010, 1020,1040,1050, 1070, 1080, 2540.
- *Lectures on Wastewater Analysis and Interpretation*, Lecture 7.

KSA 411 Weight: 3%

Ensure accurate calculations.

- *Significant figures*
- *Unit conversion*
- *Advanced algebraic and statistical calculations*
- *Solution preparation (dilution factors, normality, molarity)*
- *Sample dilution*
- *Graphing (linear regression)*
- *Standard curves*

KSA411 General Competencies

The Laboratory Analyst IV is an expert in mathematical and statistical concepts used in chemistry. The analyst also reviews and validates the work of junior staff.

KSA411 Math Competencies

Statistical concepts used in environmental science, including linear regression. The analyst has mastered the ability to apply dilution factors in standards and sample calculations, prepares graphical analysis of data, and reviews results applying correct significant figures.

KSA411 Suggested Reading

- *Standard Methods for the Examination of Water and Wastewater*, Sections 1010, 1020, 1030,1050.
- *Lectures on Wastewater Analysis and Interpretation*, Lectures 2, 21.

KSA 412 Weight: 4%

Ensures the enforcement of proper laboratory ethics.

KSA412 General Competencies

The Laboratory Analyst IV has the responsibility of ensuring that data produced by the lab is not fraudulent. Laboratory professionals are required to maintain high standards of lab practice. They are required to exercise sound judgment in performing and evaluating laboratory testing. The analyst is required to be alert and sensitive to actions by staff that may be improper, illegal or in violation of ethics policy and practices.

KSA412 Math Competencies

N/A

KSA412 Suggested Reading

- *Lectures on Wastewater Analysis and Interpretation*, Lecture 23.
- American Chemical Society, Chemical professionals code of conduct.

KSA 413 Weight: 6%

Manages, maintains and archives accurate and complete laboratory records and reports.

- *Routine documentation, including worksheet/log sheet entries*
- *Sample documentation*
- *Chain-of-custody forms*
- *Record data accurately*
- *Report non-conforming data*
- *Management of laboratory computerized database*
- *Technical reports (NPDES compliance)*
- *Standard Operating Procedures (SOP)*
- *Method development and validation*
- *Awareness of Process Operations SCADA*
- *Data integrity and legal defensibility*

KSA413 General Competencies

Laboratory documentation is a *prima facie* (first indicator) to auditors, legal authorities and others that the lab follows its procedures. The Laboratory Analyst IV oversees how the lab properly records, reports, maintains, manages and archives its data. The analyst is also an expert on standard operating procedures, new method development and its validation.

KSA413 Math Competencies

Mathematical, statistical and graphing concepts used in data handling.

KSA413 Suggested Reading

- *Standard Methods for the Examination of Water and Wastewater*, Sections 1010, 1020, 1030, 1040, 1050, 1060.
- *Lectures on Wastewater Analysis and Interpretation*, Lecture 2, 21

KSA 414 Weight: 9%

Implements and directs Quality Assurance/Quality Control program

- *Control charts*
- *Standards and reagents quality*
- *Reagent water quality (inhibitory residue and water suitability)*
- *Instrument maintenance records*
- *Establish MDLs and RLs*
- *Proficiency testing*
- *Documentation of corrective action*
- *DOC (Demonstration of Capability)*
- *Internal/external audits*
- *Concept of equivalency testing/Alternative Test Protocol (ATP)*
- *Correctness of analysis*
- *Quality assurance plan*
- *Equipment calibration and verification*
- *Training records*
- *Analytical and microbiological data quality*

KSA414 General Competencies

The Laboratory Analyst IV is responsible for managing, updating, and implementing the lab's QA/QC program. The analyst directs lab functions to ensure that methods are applied correctly, and that testing meets expected needs. The analyst is adept at specific quality controls along with how it fits in the overall quality assurance program. The analyst also implements training of new and current staff according to the established QA plan.

KSA414 Math Competencies

Mathematical, statistical and graphing concepts used in data handling.

KSA414 Suggested Reading

- *Standard Methods for the Examination of Water and Wastewater*, Sections 1010, 1020, 1030, 1040, 1050, 1070, 1080.
- *Lectures on Wastewater Analysis and Interpretation*, Lectures 2, 21, 23

KSA 415 Weight: 7%

Ensures adherence to government regulations

- *EPA regulations as applied to laboratories (Clean Water Act, 40 CFR Part 136)*
- *NPDES permit compliance and regulatory authority*
- *OSHA (IIPP, ERP, HCP)*
- *NFPA (chemical storage and labeling)*
- *Method Update Rule*
- *Laboratory accreditation*
- *Hazardous waste program*

KSA415 General Competencies

The Laboratory Analyst IV is responsible for attaining and maintaining laboratory accreditation for all laboratory methods used for regulatory compliance. The analyst also ensures that all laboratory policies are kept current to meet changing regulations.

KSA415 Math Competencies

Not applicable.

KSA415 Suggested Reading

- California ELAP
- EPA NPDES Wastewater Discharge Permit Monitoring Program
- OSHA and CAL-OSHA IIPP and Chemical Hygiene Plan regulation
- NFPA (need reference)
- California Code of Regulations (CCR), Title 22, Laboratory and Hazardous Waste regulations

KSA 416 Weight: 11%

Plans, organizes, staffs, directs, and controls the activities of the laboratory.

- *Establishes and maintains effective working relationships (coworkers, contractors, governmental agencies and the public)*
- *Communicates effectively both verbal and written*
- *Practices effective supervision of personnel*
- *Hires personnel and conducts performance evaluations*
- *Reviews and implements disciplinary/incentive actions*
- *Establishes goals and objectives consistent with agency goals and objectives*
- *Reviews and approves staff recommendations on division work organization, assignments, work schedules and training needs*
- *Establishes contracts or agreements with contract laboratories and vendors*
- *Coordinates laboratory services with other departments and agencies*

KSA416 General Competencies

The Laboratory Analyst IV must under supervision and with management organize laboratory duties to match agency. The analyst must identify and testing needs of the laboratory. The laboratory staff to ensure testing is and meets quality control requirements. communicate effectively with both laboratory staff and operations staff. The analyst must plan and regulatory and operational testing needs for the hire competent laboratory staff to match the analyst must effectively direct and control conducted per standard operating procedures

KSA416 Math Competencies

None.

KSA416 Suggested Reading

- *Supervision: Concepts and practices of Management*, University of Michigan
- *Lectures on Wastewater Analysis and Interpretation*, Lecture 23.
- *Utility Management,* Office of Water Programs Office of Water Programs – Sacramento State University.

KSA 417 Weight: 5%

Administers the preparation of the laboratory budget.

- *Monitor expenditures*
- *Estimate time, materials and equipment*
- *Suggest capital improvements*
- *Evaluate staffing needs*

KSA417 General Competencies

The Laboratory Analyst IV must monitor all laboratory expenses to ensure the laboratory operation stays within planned operating budget. The Analyst will need to know how to prepare cost justifications for the hiring of additional staff and/or purchasing new laboratory equipment or new capital improvements.

KSA417 Math Competencies

Basic math related to budget management and cost justification.

KSA417 Suggested Reading

Supervision: Concepts and practices of Management, University of Michigan.
Utility Management, Office of Water Programs Office of Water Programs – Sacramento State University.

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 IV 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 loading, 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 IV 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.

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

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.

Section 5

Practice Test

Practice Test

Select the best answer for each item below.

1. In the cyanide determination, which one of the following is not an interference?
   a. Sulfides
   b. Hydrogen cyanide
   c. Fatty acids
   d. Carbonates

2. Standard addition is best if the addition increases analyte:
   a. 0.3 to 0.6 times its original concentration.
   b. 1.5 to 3 times its original concentration.
   c. 3 to 6 times its original concentration.
   d. 15 to 30 times its original concentration.

3. Advantages of ion-selective electrodes do not include:
   a. wide-range of linear response.
   b. being unaffected by color or turbidity.
   c. interferences.
   d. short response time.

4.. Which gas chromatography detector(s) could be used for selective trace analysis of halogen-containing compounds?

   a. Flame ionization Detector (FID)
   b. Thermionic Selective Detector (TSD)
   c. Catalytic Combustion Detector (CCD)
   d. Electron Capture Detector

5. In atomic absorption spectrophotometry, a method not used for background correction is:
   a. beam chopping.
   b. Zeeman correction system.
   c. Doppler broadening correction system.
   d. Deuterium lamps.

6. In chromatography:
   a. the greater the ratio of partition coefficients between mobile and stationary phases, the greater the separation between two components of a mixture.
   b. the greater the ratio of partition coefficients between mobile and stationary phases, the smaller the separation between the two components of a mixture.
   c. the greater the ratio of partition coefficients between two components of a mixture, the greater the separation between the mobile and stationary phases.
   d. the smaller the ratio of partition coefficients between two components of a mixture, the greater the separation between the mobile and stationary phases.

7. A mass spectrometer is an instrument:
   a. containing a hollow graphite rod that can be heated electrically to about 2500°K to decompose and atomize a sample for analysis.
   b. which measures a sample that has been bombarded with electrons to produce charged molecular fragments that are separated according to their mass in a magnetic field.
   c. in which an electric potential exists at the junction between two different electrolyte solutions or substances.
   d. in which the analytes are immediately accelerated by a powerful radiofrequency field that oscillates about a load coil at a frequency of 27 MHz.

8. In gas chromatography:
   a. a mobile phase (a gas carrier) transports a sample through a stationary phase (column packing or capillary column coating), which is used to separate individual compounds.
   b. a sample is injected into an effluent stream and passed through a series of ion-exchanging columns.
   c. molecules are separated by size with no attractive interaction between the stationary phase and the solute.
   d. a mobile phase (a liquid carrier) transports a sample through a stationary phase (column packing or capillary column coating), which is used to separate individual compounds.

9. Inductively coupled plasma (ICP) is desirable in comparison to Atomic Absorption Spectrophotometry (AA) for the following reasons, with the exception of:
   a. the high temperature and stability in ICP eliminates much of the interferences encountered with AA.
   b. ICP is less expensive to purchase and operate.
   c. atomization in ICP is more complete.
   d. ICP can measure multiple analytes per sample injection

10. The genera that does not contain members of the coliform group is:
    a. *Enterobacter.*
    b. *Klebsiella.*
    c. *Aeromonas.*
    d. *Citrobacter.*

11. An organism associated with activated sludge treatment problems is the:
    a. *Sphaerotilus.*
    b. *Streptococcus.*
    c. *Salmonella.*
    d. *Rotifer.*

12. Particular problems associated with the detection of viruses of public health interest in the aquatic environment do not include:
    a. the small size of virus particles.
    b. the high virus concentrations in water and the variability in amounts and types that may be present.
    c. the various dissolved and suspended materials in water that interfere with virus detection.
    d. the present limitations of virus estimation and identification methods.

13. Short term toxicity tests are inappropriate for
    a. Obtaining toxicity data as rapidly and inexpensively as possible
    b. Obtaining the identification of a toxicant
    c. Screening test solution or materials for which toxicity data do not exist
    d. Determining chronic toxicity

14. Toxicity Reduction Evaluation (TRE) is a phased approach that:
    a. Identifies the species most vulnerable to the toxicant(s) of concern.
    b. Identifies the toxicant(s) of concern.
    c. Removes the toxicant from the wastewater treatment process.
    d. Stepwise process to identify the causative agents of toxicity.

15. Toxicity Identification Evaluation (TIE) achieves which function during a Toxicity Reduction Evaluation study?
    a. Identifies the species most vulnerable to the toxicant(s) of concern.
    b. Identifies the toxicant(s) of concern.
    c. Removes the toxicant from the wastewater treatment process.
    d. Stepwise process to identify the causative agents of toxicity.

16. Calculate the chlorine demand using the following data: the chlorinator is set at 250 lbs/day, the flow is 2.4 MGD, and the residual chlorine is 1.4 mg/L.

    a. 222 lbs/day

    b. 236 lbs/day

    c. 245 lbs/day

    d. 278 lbs/day

17. A sample of wastewater with an average flow of 100 gallons per capita per day contains 10 mL/L settable solids. The city has a population of 50,000 persons. The cubic feet of solids produced per day is:

    a. 70,600 cu ft.

    b. 6.68 cu ft.

    c. 6,684 cu ft.

    d. 374,000 cu ft.

18. A treatment plant has the following characteristics of suspended solids removal: the primary clarifier removes 39% of the applied suspended solids; the biological treatment removes 85% of the applied suspended solids; the secondary clarifier removes 16% of the applied suspended solids. The plant flow is 18.2 MGD. The wastewater influent has 215 mg/L suspended solids. Assuming that results can be reported to three significant figures, what is the amount of solids, in pounds/day, removed in the process?

    a. 11.4 pounds removed per day

    b. 4,054 pounds removed per day

    c. 11,400 pounds removed per day

    d. 30,100 pounds removed per day

19. A Quality Assurance/Quality Control document is a necessary component of the Environmental Laboratory Accreditation Program. Of the following, the one area that does not need to be covered in the document is:

    a. organization and responsibility.

    b. sampling procedures.

    c. assessment of precision and accuracy.

    d. standard operating procedures for each analysis.

20. The methods of analysis that are promulgated for use on most wastewater samples are found in:

    a. 29 CFR 1910.1450.

    b. 40 CFR 136.

    c. 40 CFR 403.

    d. 40 CFR 503.

21. Of the following, which section of the Code of Federal Regulations determines the concentrations of toxins, heavy metals, pathogens, and other pollutants found in biosolids?

    a. 29 CFR 1910.1450

    b. 40 CFR 136

    c. 40 CFR 403

    d. 40 CFR 503

22. A toxicant concentration producing death of test organisms, usually defined as a median value of 50%, is known as:

    a. a dose response concentration.

    b. an acute toxicity concentration.

    c. an LC_{50} value.

    d. an EC_{50} value.

23. As a laboratory supervisor, you must see that someone is primarily responsible for safety supervision. The most appropriate method of assigning this duty would be:

    a. to rotate the responsibility to someone new each month so everyone will feel involved in laboratory safety issues.

    b. to assign a permanent safety officer so that the individual can provide planning continuity and follow-up attention to reported hazards.

    c. to ask for a volunteer because volunteers tend to be more conscientious and capable because they have expressed an interest in the job.

    d. as a laboratory supervisor, you are ultimately responsible for laboratory safety and are unable to delegate this important responsibility.

24. When developing an Emergency Response Plan, the first step is to:

    a. inventory all chemicals in the laboratory.

    b. identify the tasks assigned to each group responding to emergency situations.

    c. identify the line of authority in an emergency.

    d. identify the hazards and dangers faced by the plant.

25. If a laboratory reports unacceptable data in a Proficiency Testing Study:

    a. the laboratory must determine the cause of the failure, perform corrective action, and repeat another study as soon as possible.

    b. the laboratory must determine the cause of the failure, and perform corrective action prior to participation in another study in the next calendar year.

    c. the laboratory must wait for the next Proficiency Testing Study to determine the cause of the failure.

    d. the laboratory must write a letter requesting leniency prior to participation in another study.

26. An application for laboratory accreditation (ELAP or NELAP) includes:

    a. laboratory information; personnel qualifications for the lab director and the quality assurance officer; fields of testing; invoice for fees; and the submission of a quality assurance manual.

    b. laboratory information; personnel qualifications for the lab director, the emergency response team leader, and the quality assurance officer; fields of testing; and the submission of a quality assurance manual.

    c. laboratory information; personnel qualifications for the lab director and the quality assurance officer; fields of testing; and the submission of a quality assurance manual and the standard operating procedures manual.

    d. laboratory information; personnel qualifications for the lab director, the quality assurance officer, and the safety officer; fields of testing; and the submission of a standard operating procedures manual.

27. The difference between duplicate determinations on randomly-selected routine samples is used in the development of quality control charts. One approach used to calculate the control limit specifies the following formula:

    UCL = D_4R, where D_4 = 3.27 is used for duplicates and R = the average difference of each of the duplicate samples.

    Ten duplicate determinations for a constituent is g/L are as follows:

152 and 160	163 and 158	148 and 154	142 and 151
150 and 160	160 and 154	145 and 149	162 and 155
156 and 157	159 and 151		

    The duplicate analyses for a wastewater sample were 180 and 167 g/L. Calculate the upper control and determine whether the analytical results for the plant sample are under control.

    a. The UCL = 6.3 g/L and the wastewater sample duplicate analysis is in control.

    b. The UCL = 6.3 g/L and the wastewater sample duplicate analysis is out of control.

    c. The UCL = 20.9 g/L and the wastewater sample duplicate analysis is in control.

    d. The UCL = 20.9 g/L and the wastewater sample duplicate analysis is out of control.

28. Calculate the method detection limit given the following information.

    A standard solution was analyzed 7 times with the following results in mg/L:

0.0356	0.0380
0.0352	0.0360
0.0371	0.0374
0.0346	

    Calculated mean = 0.0362

    Calculated standard deviation = 0.00125

    T Scores

Level of Certainty

N	90%	95%	99%	99.5%
1	3.078	6.314	31.821	63.657
2	1.886	2.920	6.965	9.925
3	1.638	2.353	4.541	5.841
4	1.533	2.132	3.747	4.604
5	1.476	2.015	3.365	4.032
6	1.440	1.943	3.143	3.707
7	1.415	1.865	2.998	3.499
8	1.397	1.860	2.896	3.355

a. 0.00393 mg/L
b. 0.00375 mg/L
c. 0.109 mg/L
d. 0.114 mg/L

29. In the management-by-exception concept:
    a. objectives are non-specific.
    b. tasks are closely managed.
    c. all activities are reported in detail.
    d. routine activities are not reported in detail.

30. When an employee has made a mistake or error, the least important of the following is:
    a. obtain all the facts.
    b. maintain calmness.
    c. have the employee admit the error.
    d. keep a record of the event.

31. The most effective way to obtain an employee's cooperation on a plan is to:
    a. let the employee know you will assume full responsibility.
    b. let the employee know that he or she will be held personally responsible for the plan.
    c. let the employee know your availability in the implementation of the plan.
    d. let the employee know his or her role in the implementation of the plan.

32. An organization chart for a utility can be helpful for several reasons. Which of the following is the least valid objective of an organization chart?

    a. To establish proper chain-of-command authority
    b. To help in making up project schedules
    c. To help in scheduling emergencies
    d. To help develop a budget

33. Successful communication requires mutual:

    a. understanding.
    b. confusion.
    c. transmission.
    d. agreement.

34. When a great deal of authority is delegated on many levels, an organization may be described as:

    a. authoritarian.
    b. centralized.
    c. decentralized.
    d. unstructured.

35. Recognition and job security are indications of:

    a. a good organization.
    b. a good supervisor.
    c. external morale factors.
    d. internal morale factors.

36. Generally, as an individual is promoted upward into a management position, reliance on personal technical skill:

    a. changes to the more complex.
    b. decreases.
    c. increases.
    d. remains the same.

37. How can the supervisor be certain that scheduled maintenance is completed?

    a. Ask the workers
    b. Hire someone to inspect completed work
    c. Use a form that compares work assigned with work completed
    d. Wait and see if there are any failures

38. Word has just come down from the upper management that operating funds are being cut. How should this be handled?
    a. Cut the supplies and repairs in order to balance the budget
    b. Fire some of the less productive old employees
    c. Keep it quiet and do what you have to do—the less said the better
    d. Let the other personnel know what the situation is and ask for their help

39. One job opening has become available which would be an advancement to any one of three qualified employees. How should this situation be handled?
    a. Hire an outsider to fill the position
    b. Pick one and notify all personnel of the change
    c. Split the work between the three and leave the position open
    d. Talk to the three as a group, explain the situation and make your selection, and then notify all personnel of the change

40. One of the employees in your crew complains about having to do a hard job. The proper thing to do is:
    a. explain that all employees must do their fair share of the hard work as well as the easier tasks.
    b. ignore the complaint.
    c. promise that the next assignments will be easier ones.
    d. tell the employee to shut up and work or quit and go home.

41. Occasionally some of the people on a work crew will indulge in active horseplay. This should be:
    a. discouraged because some of the workers might not like it.
    b. encouraged because it promotes good fellowship.
    c. permitted as it is a form of relaxation.
    d. stopped immediately because it is likely to cause an accident.

42. The managerial function which involves devising an appropriate system of pay is:
    a. controlling.
    b. organizing.
    c. planning.
    d. staffing.

43. The span of supervision is the:
    a. average length of time required to be in the organization before making supervisor.
    b. number of levels between the lowest employee and the boss.
    c. number of subordinates for each manager.
    d. number of supervisors in an organization.

44. If an organization's departments are organized by jobs to be done, this is known as departmentation by:
    a. customer.
    b. function.
    c. product.
    d. territory.

45. Decentralized authority describes the process of:
    a. changing an organization from centralized to decentralized.
    b. delegating authority to one's superiors instead of one's subordinates.
    c. delegating power for decisions to lower levels.
    d. retracting authority that has been previously delegated and probably changing functions and duties.

46. What term means that the employee reports to one specific supervisor, and that the delegation of authority comes from one particular supervisor to the employee?
    a. Formal organization
    b. Span of supervision
    c. Organizational chart
    d. Unity of command

47. The term "control" in management practices is:
    a. backward-looking.
    b. concentrating on the present.
    c. forward-looking.
    d. not connected to the other managerial functions.

48. If you are supervisor of two lead workers, one whose work is exceptionally good and a second whose work is substandard, what should you do?
    a. Demote the substandard lead worker and bring up a replacement from the ranks
    b. Discuss the performance problem with the substandard lead worker and offer to help before any other action is taken
    c. Find a replacement and then fire the substandard foreman
    d. Wait to see if the substandard foreman does better

49. Recruiting of new employees falls within which category?
    a. Directing
    b. Organizing
    c. Planning
    d. Staffing

50. The managerial function, which includes the guiding, teaching, motivating and supervising of Laboratory Analysts is:
    a. staffing.
    b. planning.
    c. organizing.
    d. directing.

51. “Essence of control” is:
    a. written records.
    b. testing.
    c. evaluation.
    d. action.

52. In the evaluation of an applicant for employment, which of the following may enter into your decision?
    a. Age
    b. Education level
    c. Minority classification
    d. All of the above

53. Why are good records important?
    a. To demonstrate a pattern of lawful behavior over time
    b. To demonstrate your good report-writing skills
    c. To provide a journal record all uncritical events
    d. To prepare for facility audits

54. What is the meaning of the term job applicant “paper screening”?
    a. Additional analysis of qualified applicants
    b. Elimination of applicants not qualified for the job
    c. Filing of unsuccessful applicants’ paperwork for future job openings
    d. Review of research papers submitted by a job applicant

55. Which one of the following questions is an acceptable interview question?
    a. What is your religious affiliation?
    b. What is the nationality of your parents or spouse?
    c. What is your age?
    d. What is your technical background?

56. What is the best approach to solving a discipline problem?
    a. Accept the employee’s solution to the problem
    b. Form a committee of peers to make a recommendation
    c. Ignore the problem and it will go away
    d. State the problem and then ask employee to suggest a solution

57. What is the best way to prevent sexual harassment?
    a. Ignore any accusations
    b. Require victims to prepare a written document
    c. Set an example by your own behavior
    d. Tell people sexual harassment is wrong

58. Why is written communication more demanding than oral communication?
    a. Ideas must be expressed clearly in full detail
    b. Important information may be missed
    c. It requires the use of highly technical terms
    d. There is no chance to clarify and explain ideas in response to an audience

59. What kinds of behavior are considered sexual harassment?
    a. Humiliating
    b. Annoying
    c. Invited
    d. Uninvited

60. When an employee breaks the rules and requires discipline, who is responsible for administering it?
    a. Fellow employees

b. The personnel office

c. The Supervisor

d. Upper management

61. You are asked to determine the cost per test of the COD analysis. Use the following information:

    The base salary of an analyst is $30,000; employer paid benefits add 35% to the base salary; administrative overhead adds another 45% to the base salary; there are 10 paid holidays, 15 days paid vacation leave and 12 days paid sick leave per year; the hourly salary is determined by dividing the monthly salary by 174. Each COD test requires an average of 20 minutes of labor from sample preparation to cleanup. Costs for chemicals, glassware, and equipment use average $1.00 per test. Disposal costs average $2000/year for reagents from 1,000 tests.

    What is the total cost per test?

    a. $11.62/test

    b. $8.62/test

    c. $20.24/test

    d. $13.04/test

62. You must select one of two approved methods for performing an analysis. Method A requires 30 minutes of analyst time per test and uses no special instruments. Method B requires 10 minutes of analyst time per test and uses an instrument costing $30,000. The Base salary for the analyst is $2,600 per month, employer paid benefits add 35% to the base salary, and administrative overhead adds another 45%. Assume there are 2,080 working hours per year. The instrument has a one-year full warranty; maintenance and repair costs for subsequent years are estimated to be $1,000 per year. The instrument has an eight-year service life. The test is now run on one sample at each of three locations, five days per week. Regulatory requirements may add one or two more sampling locations to the present requirements. The justification for expenditure for an instrument must show at least a 20% cost saving. (Assume there is no inflation in the salary for this example.) The recommendation you make is to:

    a. remain with Method A.

    b. purchase the equipment with the present requirements.

    c. purchase the equipment if one more sample location is added.

    d. purchase the equipment if two more sample locations are added.

END OF PRACTICE TEST

Test Answer Key

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

No.	Answer	KSA
1	b	402
2	b	402,414
3	c	402
4	d	402,407,408
5	c	407,408
6	a	402,407
7	b	407,408
8	a	407,408,402
9	b	407,408,417
10	c	403
11	a	405
12	b	405,403
13	d	404
14	d	404
15	b	404
16	a	405,4022
17	c	405
18	d	405
19	d	414
20	b	415
21	d	415
22	c	404
23	b	409,416
24	d	409
25	a	414,415,416
26	a	415,416
27	c	414
28	a	414
29	d	416
30	c	416
31	d	416
32	d	416
33	a	416
34	c	416
35	a	416

36	b	416
37	c	416
38	d	416
39	d	417
40	a	416
41	d	416
42	c	417
43	c	416
44	b	416
45	c	416
46	d	416
47	b	416
48	b	416
49	d	416,417
50	d	416
51	c	416
52	b	417,416
53	a	413,416
54	b	417,416
55	d	416,417
56	d	416,412
57	c	416,412
58	d	416
59	d	416
60	c	416
61	a	417
62	d	417

Selected Problem Solutions

16. Calculate the chlorine demand using the following data: the chlorinator is set at 250 lbs/day, the flow is 2.4 MGD, and the residual chlorine is 1.4 mg/L.

    First convert the residual chlorine concentration to mass, and then subtract it from the mass output of the chlorinator.

    $$\frac{2.4\ MG}{day} \times \frac{8.34\ lbs}{gal} \times \frac{1.4\ parts}{M\ parts} = 28\ lbs/day$$

    250 lbs/day - 28 lbs/day = 222 lbs/day

17. A sample of wastewater from a city of 50,000 population with an average flow of 100 gallons per capita per day contains 10 mL/L settleable solids. The cubic feet of solids produced per day is:

Calculate the flow in cubic feet (cu ft)/day using the population and the flow "per capita" or per person.

$$\frac{100 \text{ gal}}{\text{capita/day}} \times 50{,}000 \text{ capita} \times \frac{1 \text{ cu ft}}{7.48 \text{ gal}}$$
= 668,449 cu ft/day

The settleable unit mL/L is the same as parts/1,000 parts (p per k-p). Calculate the daily volume of settleable solids as follows:

$$\frac{10 \text{ p}}{\text{k-p}} \times 668{,}449 \text{ cu ft} \times \frac{\text{k-p}}{1{,}000 \text{ p}} = 6{,}684 \text{ cu ft}$$

18. A treatment plant has the following characteristics of suspended solids removal: the primary clarifier removes 39% of the applied suspended solids; the biological treatment removes 85% of the applied suspended solids; the secondary clarifier removes 16% of the applied suspended solids. The plant flow is 18.2 MGD. The wastewater influent has 215 mg/L suspended solids. Assuming that results can be reported to three significant figures, what is the amount of solids, in pounds/day, removed in the process?

    Applied suspended solids refers to the influent load. Solids added by biological growth in the biological treatment are ignored. The solids remaining in the effluent of each treatment unit become the solids applied to the next treatment unit. First, use the removal efficiencies across each treatment unit to calculate the solids remaining in the secondary effluent.

    215 mg/L x (1 - 0.39) x (1 - 0.85) x (1 - 0.16)

    =16.52 mg/L

    Calculate the mass of solids removed across the plant.

$$\frac{(215 - 16.52)}{\text{M}} \times \frac{8.34 \text{ lbs}}{\text{gal}} \times \frac{18.2 \text{ MG}}{\text{day}}$$
    = 30,126 lbs/day

    Round answer to three significant figures:

    30,100 lbs/day

27. The difference between duplicate determinations on randomly-selected routine samples is used in the development of quality control charts. One approach used to calculate the control limit specifies the following formula:

    UCL = D_4R, where D_4 = 3.27 is used for duplicates and R = the average difference of each of the duplicate samples.

    Ten duplicate determinations for a constituent is g/L are as follows:

152 and 160	163 and 158	148 and 154	142 and 151
150 and 160	160 and 154	145 and 149	162 and 155
156 and 157	159 and 151		

    The duplicate analyses for a wastewater sample were 180 and 167 g/L. Calculate the upper control and determine whether the analytical results for the plant sample are under control.

Using the formula given above, calculate the upper control limit by summing the difference between each set of duplicate analyses, divide by the number of duplicates, and multiply by D_4.

$$\frac{8 + 5 + 6 + 9 + 10 + 6 + 4 + 7 + 1 + 8}{10}$$

x 3.27 = 20.9 = upper control limit

The difference between the duplicates for the wastewater sample is 180 - 167 = 13. Thirteen is less than the upper control limit, therefore, the duplicate analysis on the wastewater sample is in control.

28. Calculate the method detection limit given the following information.

A standard solution was analyzed 7 times with the following results in mg/L:

0.0356 0.0380

0.0352 0.0360

0.0371 0.0374

0.0346

Calculated mean = 0.0362

Calculated standard deviation = 0.00125

T Scores
Level of Certainty

N	90%	95%	99%	99.5%
1	3.078	6.314	31.821	63.657
2	1.886	2.920	6.965	9.925
3	1.638	2.353	4.541	5.841
4	1.533	2.132	3.747	4.604
5	1.476	2.015	3.365	4.032
6	1.440	1.943	3.143	3.707
7	1.415	1.865	2.998	3.499
8	1.397	1.860	2.896	3.355

Standard Methods states: Analyze seven portions of this solution and calculate the standard deviation. Compute MDL from replicate measurements one to five times the actual MDL. From a table of the one-sided t distribution, select the value of t for 7 - 1 = 6 degrees of freedom at the 99% level; this value is 3.14. The product 3.14 times the standard deviation is the desired MDL.

3.14 x 0.001252 = 0.00393

61. You are asked to determine the cost per test of the COD analysis. Use the following information:

The base salary of an analyst is $30,000; employer paid benefits add 35% to the base salary;

administrative overhead adds another 45% to the base salary; there are 10 paid holidays, 15 days paid vacation leave and 12 days paid sick leave per year; the hourly salary is determined by dividing the monthly salary by 174. Each COD test requires an average of 20 minutes of labor from sample preparation to cleanup. Costs for chemicals, glassware, and equipment use average $1.00 per test. Disposal costs average $2000/year for reagents from 1,000 tests.

What is the total cost per test?

Determine the total cost of the analyst's time:

$$\frac{\$30{,}000 + (\$30{,}000 \times 0.35) + (\$30{,}000 \times 0.45)}{1 \text{ year}}$$

= $54,000/year

$$\frac{\$54{,}000}{\text{year}} \times \frac{1 \text{ year}}{12 \text{ mos}} \times \frac{1 \text{ month}}{174 \text{ hrs}} = \$25.86/\text{hr}$$

At 20 minutes analyst time per test:

$$\frac{\$25.86}{\text{hr}} \times \frac{1 \text{ hour}}{60 \text{ mins}} \times \frac{20 \text{ mins}}{\text{test}} = \$8.62/\text{test (analytical labor cost)}$$

Disposal costs:

$$\frac{\$2{,}000}{1{,}000 \text{ tests}} = \$2.00/\text{test}$$

Reagent costs = $1.00/test

Total costs per COD test:
$8.62 + $2.00 + $1.00 = $11.62

62. You must select one of two approved methods for performing an analysis. Method A requires 30 minutes of analyst time per test and uses no special instruments. Method B requires 10 minutes of analyst time per test and uses an instrument costing $30,000. Base salary for the analyst is $2,600 per month, employer paid benefits add 35% to the base salary, and overhead adds another 45%. Assume there are 2,080 working hours per year. The instrument has a one-year full warranty; maintenance and repair costs for subsequent years are estimated to be $1,000 per year. The instrument has an eight-year service life. The test is now run on one sample at each of three locations, five days per week. Regulatory requirements may add one or two more sampling locations to the present requirements. The justification for expenditure for an instrument must show at least a 20% cost saving. (Assume there is no inflation in the salary for this example.) The recommendation you make is to:

Determine total cost of analyst's time:

$$\frac{\$2{,}600 + (\$2{,}600 \times 0.35) + (\$2{,}600 \times 0.45)}{\text{month}}$$

= $4,680/month

$$\frac{\$4{,}680}{\text{month}} \times \frac{12 \text{ months}}{1 \text{ year}} \times \frac{1 \text{ year}}{2{,}080 \text{ hrs}} = \$27.00/\text{hr}$$

Method A:

Cost/sample (Analyst's time) =

$$\frac{\$27.00}{} \times \frac{1 \text{ hr}}{} \times \frac{30 \text{ mins}}{}$$

hr 60 mins sample
= $13.50/sample

Present workload = 15 samples/week

15 samples/week x $13.50/sample
= $202.50/week

With 1 additional sample point
= 20 samples/week

20 samples/week x $13.50/sample
= $270.00/week

With 2 additional sample points
= 25 samples/week

25 samples/week x $13.50/sample
= $337.50/week

Method B:

Cost/sample (Analyst's time) =

$\frac{\$27.00}{\text{hr}} \times \frac{1\ \text{hr}}{60\ \text{mins}} \times \frac{15\ \text{mins}}{\text{sample}} = \$6.75/\text{sample}$

Present workload = 15 samples/week

15 samples/week x $6.75/sample
= $101.25/week

With 1 additional sample point
= 20 samples/week

20 samples/week x $6.75/sample
= $135.00/week

With 2 additional sample points
= 25 samples/week

25 samples/week x $6.75/sample
= $168.75/week

Instrument costs:

$30,000 + (7 years x $1,000/year maintenance) = $37,000 over 8 years

$\frac{\$37,000}{8\ \text{years}} \times \frac{1\ \text{year}}{52\ \text{weeks}} = \$88.94/\text{week}$

Method B present workload
= $101.25 + $88.94 = $190.19/week

Method B with 1 additional sample point
= 20 samples/week = $135.00 + $88.94
= $223.94/week

Method B with 2 additional sample points
= 25 samples/week = $168.75 + $88.94
= $257.69/week

Method A / Method B relative costs:

Present workload = $\frac{\$190.19}{\$202.50} = 0.94$

With 1 additional sample point =

$\frac{\$223.94}{\$270.00} = 0.83$

With 2 additional sample points =

$\frac{\$257.69}{\$337.50} = 0.76$

The addition of two sample points would justify the expenditure due to a cost savings of >20%.

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

- *Standard Methods for the Examination of Water and Wastewater*
  Water Environment Federation
  601 Wythe Street
  Alexandria, VA 22314-1994
  800/666-0206
  www.wef.org
  (Please note that the latest Code of Federal Regulations, 40 CFR Part 136, should be referenced to determine which edition of Standard Methods applies for a given method.)

- *Lectures on Wastewater Analysis and Interpretation*
  Genium Group, Inc.
  1171 Riverfront Center
  Amsterdam, NY 12010
  800/842-1843
  genium@genium.com

- *Operation of Municipal Wastewater Treatment Plants – MOP 11, 5th Edition (3 volumes)*
  Order No: M05110WW Pub Date: 1996
  Water Environment Federation
  601 Wythe Street
  Alexandria, VA 22314-1994
  800/666-0206
  www.wef.org

- *Operation of Wastewater Treatment Plants, Volumes I and II*
  Office of Water Programs
  California State University, Sacramento (CSUS)
  6000 J Street
  Sacramento, CA 95819-6025 916-278-6142

http://owp.csus.edu

- *Methods for Chemical Analysis of Water and Wastes*
  U.S. Environmental Protection Agency, Revised March 1983
  EPA-600/4-79-020
  NTIS Order No: PB84128677
  National Technical Information Service (NTIS)
  5285 Port Royal Road
  Springfield, VA 22161
  800/553-6847 (order by phone)
  www.ntis.gov
  Online version available at www.epa.gov/clhtml/pubtitle.html

- *40 CFR (CFR Title 40: Protection of the Environment)*
  Available on-line at: www.epa.gov/epahome/cfr40.htm

- *Handbook for Analytical Quality Control in Water and Wastewater Laboratories*
  U.S. Environmental Protection Agency, 1979
  EPA-600/84-79-019
  NTIS Order No: PB297451
  National Technical Information Service (NTIS)
  5285 Port Royal Road
  Springfield, VA 22161
  800/553-6847 (Order by phone)
  www.ntis.gov

- *Microbiological Methods for Monitoring the Environment – Water and Wastes*
  Edited by R.H. Bordner, J.A. Winter, and P.V. Scarpino
  U.S. Environmental Protection Agency, 1978
  EPA-600/8-78-017
  NTIS Order No: PB290329
  National Technical Information Service (NTIS)
  5285 Port Royal Road
  Springfield, VA 22161
  800/553-6847 (Order by phone)
  www.ntis.gov

- *Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms, 4th Edition, August 1993*
  U.S. Environmental Protection Agency
  EPA-600/4-90-027F
  NTIS Order No: PB94114733
  National Technical Information Service (NTIS)
  5285 Port Royal Road
  Springfield, VA 22161
  800/553-6847 (Order by phone)
  www.ntis.gov
  Online version available at www.epa.gov/OST/WET/disk2/

- *The Clean Water Act: 25th Anniversary Edition*
  Order

No: PO7110WW
Pub. Date: 1997
Water Environment Federation
601 Wythe Street
Alexandria, VA 22314-1994
800-666-0206
www.wef.org

- *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*
  EPA Publication SW-846
  Available online at www.epa.gov/epaoswer/hazwaste/test/sw846.htm

- *Water Supply Operations (WSO) series Part V: Basic Science Concepts and Applications, Textbook*
  ISBN 0-89867-796-3
  Catalog No: 1959
  American Water Works Association (AWWA)
  6666 W. Quincy Avenue
  Denver, CEO 80235
  800/926-7337
  www.awwa.org

- *Laboratory Safety Pocket Handbook*
  Genium Publishing Corporation
  1171 Riverfront Center
  Amsterdam, NY 12010
  800/243-6486
  genium@genium.com

- *OSHA Regulations (Standards – 29 CFR)*
  Available online at: www.osha-slc.gov/pls/oshaweb/
  Available in print or on CD from:
  Government Institutes, Inc.
  4 Research Place, Suite 200
  Rockville, MD 20850
  301/921-2300

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

- *Supervision: Concepts and Practices of Management, 8th Edition*
  Raymond L. Hilgert and Edwin C. Leonard, Jr.
  ISBN 0-324-01389-2
  Pub Date: 2001
  South-Western College Publishing a division of Thomson Learning

5101 Madison Road
Cincinnati, OH 45227-1490
800/543-0487
www.swcollege.com

Grade IV Lab Analysts are expected to have mastered the skills learned for Grades I, II, and III, and candidates may wish to review the math and chemistry problems outlined in the CWEA study guides for Grades I, II, and III.

Secondary References

The information contained in the Primary Reference section above provides a solid base of knowledge for the Grade IV 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.

- *Chemical Technicians' Ready Reference Handbook*
  Gershon Shugar and Jack Ballinger
  ISBN 0070571864
  Pub Date: June 1, 1996
  McGraw-Hill Professional Publishing Group
  800/722-4729
  www.books.mcgraw-hill.com

- *Chemistry*
  John McMurry and Robert C. Fay
  ISBN 0-13-057677-8
  Pub Date: December 2000
  Prentice-Hall
  Pearson Education Company
  One Lake Street
  Upper Saddle River, NJ 07458-1813
  201/236-7000
  www.pearsonptg.com or other online booksellers

- *Quantitative Analytical Chemistry, 5th Edition*
  James S. Fritz and George H. Schenk
  ISBN 025104800
  Pub. Date: January 1987
  Prentice-Hall
  201/236-7000
  Purchase through amazon.com barnesandnoble.com or other online booksellers

- *Instrumental Methods of Analysis, 7th Edition*
  Hobart Hurd Willard, Frank A. Settle,
  John A. Dean, and Lynne L. Merritt
  ISBN 0534081428
  Pub. Date: October 1995 available through various online booksellers

- *Microbiology, An Introduction*
  Gerard Tortora, Berdell Funke,
  and Christine Case
  ISBN 0-8053-7597-X
  Benjamin Cummings (publisher)
  Pearson Education Company
  One Lake Street
  Upper Saddle River, NJ 07458-1813
  201/236-7000
  www.pearsonptg.com or other online booksellers

- *Brock's Biology of Microorganisms*
  Michael T. Madigan, John M. Martinko,
  and Jack Parker
  ISBN 0-13-081922-0
  Prentice-Hall
  Pearson Education Company
  One Lake Street
  Upper Saddle River, NJ 07458-1813
  201/236-7000
  www.pearsonptg.com or other online booksellers

- *Effective Supervisory Practices: Better Results Through Teamwork*
  ISBN: 0-87326-176-3
  ICM International
  City/Council Management Association
  800/745-8780
  www.icma.org

- *Math Text for Water and Wastewater Technology, 2nd Edition*
  Wright's Training
  P.O. Box 515
  Elmira, CA 92625
  707/448-3659
  Download form to order: www.wrights-trainingsite.com

- *Applied Math for Wastewater Plant Operators*
  Joanne Kirkpatrick Price
  ISBN 0877628092
  CRC Press
  800/272-7737
  www.crcpress.com

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

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

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.

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

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

$$D_1 \frac{\text{volume}}{\text{flow}}$$

$$D_1 \frac{675{,}460\ \cancel{\text{gal}}}{1{,}000{,}000\ \cancel{\text{gal}}/\text{day}} = \frac{675{,}460\ \cancel{\text{gal}}}{1} \cdot \frac{\text{day}}{1{,}000{,}000\ \cancel{\text{gal}}} = 0.675\ \text{days}$$

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

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

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) = $(3846.5\ \text{ft}^2)(47\ \text{ft.}) = 180{,}785.5\ \text{ft.}^3$

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: $\frac{6\ \cancel{\text{hrs}}}{1} \times \frac{60\ \text{min}}{1\ \cancel{\text{hr}}} = 360\ \text{min}$

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.

Appendix B

Glossary

Technical Terms

Accuracy: The nearness of a number to true value.

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

Aliquot: A portion of a sample with an exact volume.

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

Amperometry: The measurement of electrical current.

Analyte: The element or ion compound that is being measured; the element of interest.

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.

Autoclave: The instrument used to sterilize samples and equipment by use of heat and steam under pressure.

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

Batch: A group of samples prepared and analyzed at the same time.

Blank: A sample (usually deionized water) that is taken through all the steps of analysis to monitor for contamination in the process.

Calibration: The use of known standards to create an analytical curve based on the measured characteristic (e.g. absorbence) of the standards. The calibration is used to determine the measured characteristic of unknown samples.

Calibration Standards: A sequence of standard solutions of known concentration used to create a calibration curve.

Celsius: Temperature measurement scale where the freezing point of water is 0° and the boiling point of water is 100°. On this scale, room temperature is about 21°C, while on the Fahrenheit scale it is about 70°F.

Clean Water Act (CWA): The federal Clean Water Act 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 the authority for the U.S. EPA to establish pretreatment standards for existing and new sources discharging industrial wastewater to POTWs.

Coliform: A bacteria used as an indicator organism for tests of bacteriological purity.

Colorimetric: An analysis technique that compares color density to concentration. Color developing chemicals are added to both known standards and unknown samples.

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

Compound: A substance composed of two or more different chemical elements.

Conductivity: The reciprocal of electrical resistivity, related to electrical current density. In water samples dissolved salts contribute to conductivity.

Culture Medium: The nutrient material prepared for growth of microorganisms in a laboratory.

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

Desiccant: A chemical, such as calcium chloride, used in a desiccator to absorb moisture.

Desiccator: An airtight cabinet filled with desiccant, which provides a low-humidity environment in which samples may cool without absorbing atmospheric water.

Dilution: The process of reducing the concentration of a solution.

Duplicate: A second aliquot of a sample, which is treated the same as the first to determine the precision of the method.

Filtration: An analytical technique that is used to separate suspended solids from liquids (including dissolved solids). The solids (residue) are retained on the filter. The liquid (filtrate) passes through the filter.

Grab Sample: An individual sample collected to represent the flow at a given moment in time.

Gravimetric: An analytical technique that uses weight (mass) as the primary measurement to make lab determinations.

Hot Air Sterilization: Sterilization by the use of an oven at 170° for approximately 2 hours.

Inoculation: The act of introducing microorganisms into a culture medium.

Linear Range: The range of concentrations through which an analytical curve is linear.

Log/Work Book: A written record of sample receipt, preparation of standards, or documentation of other actions taken in the laboratory.

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

Media, Medium: The nutrient material prepared for growth of microorganisms in a laboratory.

Microorganism: A living organism too small to be seen with the naked eye, e.g., bacteria, fungi, protozoa, microscopic algae, viruses.

Molarity: Moles per liter, a measure of concentration.

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

Most Probable Number (MPN): A statistical determination of the number of coliform per 100 mL of water.

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 CWA, through the issuance of permits by either a federal or a state agency. NPDES permits regulate discharges into navigable waters from all point sources of pollution, including industries, municipal wastewater treatment plants, sanitary landfills, large agricultural feedlots, and return irrigation flows.

Normality: A measure of the concentration of a solution.

pH: 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).

Pathogen: A disease-causing organism.

Potentiometric: The measurement of the electric potential difference of a cell (voltage).

Pour Plate Method: A method of inoculating a solid nutrient medium by mixing bacteria in the melted medium and pouring the medium into a Petri dish to solidify.

Precision: The agreement of results for a sample and its replicates (duplicates).

Reagents: Chemicals and the solutions made from them.

Relative Percent Difference (RPD): The difference between two numbers divided by their mean. RPD statistically compares two values for closeness.

Reproducibility: The ability to reproduce the same results using an analytical method.

Serial Dilution: The process of diluting a sample several times in a sequential manner.

Spectrophotometer: An instrument used to measure the absorbence of light.

Standard Curve: The curve which plots concentrations of known standards versus measured characteristics (e.g., absorbence). The curve is used to determine the concentration of unknown samples based on their measured characteristics.

Standard Deviations: A statistical measurement of how closely data are clustered about the mean value.

Streaking: The technique (streak plate method) of isolating a culture by spreading microorganisms over the surface of a solid culture medium.

Titration: An analytical technique that involves the use of a standard of known concentration and volume to determine the concentration of a sample with known volume. This technique utilizes a buret.

Turbidimeter: The instrument used to measure the cloudiness of a sample. The instrument, also called a ephelometer, provides results in NTUs (Nephelometric Turbidity Units).

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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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.

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.

Appendix C

Common Acronyms and Abbreviations

AA atomic absorption
AC power 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
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
F Fahrenheit
F/M food to microorganism ratio
ft feet (foot)
ft^2 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

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
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
NOCA National Organization for Competency Assurance
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)
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)
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 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
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