

# **SAFE DRINKING WATER ACT RULES AND REGULATIONS CONTINUING EDUCATION COURSE**





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***<http://www.abctlc.com/PDF/SDWAAssignment.pdf>***

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If the course is not accepted for CEU credit, we will give you the course free if you ask your State to accept it for credit and we receive the approval letter.

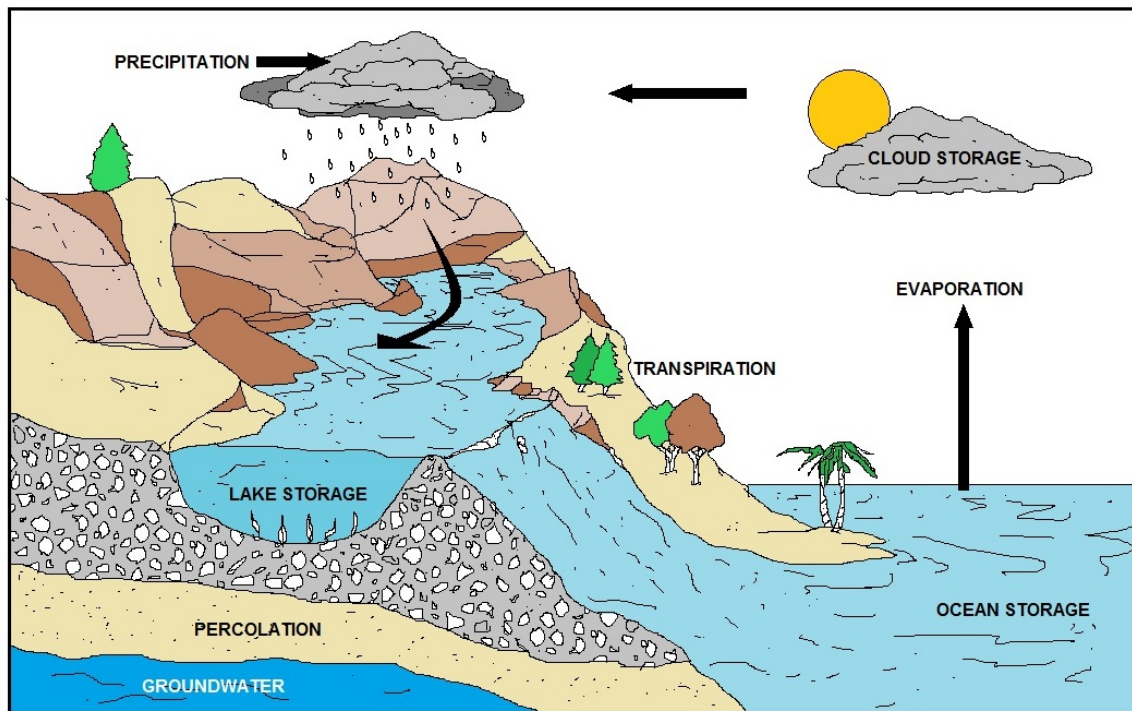
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## BASIC WATER CYCLE

### Contributing Editors

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Pete Greer S.M.E., retired biology instructor.

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## **Technical Learning College's Scope and Function**

Technical Learning College (TLC) offers affordable continuing education for today's working professionals who need to maintain licenses or certifications. TLC holds approximately eighty different governmental approvals for granting of continuing education credit.

TLC's delivery method of continuing education can include traditional types of classroom lectures and distance-based courses or independent study. Most TLC's distance based or independent study courses are offered in a print based format and you are welcome to examine this material on your computer with no obligation. Our courses are designed to be flexible and for you do finish the material on your leisure. Students can also receive course materials through the mail. The CEU course or e-manual will contain all your lessons, activities and assignments.

Most CEU courses allow students to submit lessons using e-mail or fax, however some courses require students to submit lessons by postal mail. (See the course description for more information.) Students have direct contact with their instructor—primarily by e-mail. TLC's CEU courses may use such technologies as the World Wide Web, e-mail, CD-ROMs, videotapes and hard copies. (See the course description.) Make sure you have access to the necessary equipment before enrolling, i.e., printer, Microsoft Word and/or Adobe Acrobat Reader. Some courses may require proctored exams depending upon your state requirements.

### **Flexible Learning**

At TLC, there are no scheduled online sessions you need contend with, nor are you required to participate in learning teams or groups designed for the "typical" younger campus based student. You will work at your own pace, completing assignments in time frames that work best for you. TLC's method of flexible individualized instruction is designed to provide each student the guidance and support needed for successful course completion.

We will beat any other training competitor's price for the same CEU material or classroom training. Student satisfaction is guaranteed.

### **Course Structure**

TLC's online courses combine the best of online delivery and traditional university textbooks. Online you will find the course syllabus, course content, assignments, and online open book exams. This student friendly course design allows you the most flexibility in choosing when and where you will study.

### **Classroom of One**

TLC Online offers you the best of both worlds. You learn on your own terms, on your own time, but you are never on your own. Once enrolled, you will be assigned a personal Student Service Representative who works with you on an individualized basis throughout your program of study. Course specific faculty members are assigned at the beginning of each course providing the academic support you need to successfully complete each course.

**Satisfaction Guaranteed**

Our Iron-Clad, Risk-Free Guarantee ensures you will be another satisfied TLC student.

We have many years of experience, dealing with thousands of students. We assure you, our customer satisfaction is second to none. This is one reason we have taught more than 10,000 students.

Our administrative staff is trained to provide the best customer service in town. Part of that training is knowing how to solve most problems on the spot with an exchange or refund.

**TLC Continuing Education Course Material Development**

Technical Learning College (TLC's) continuing education course material development was based upon several factors; extensive academic research, advice from subject matter experts, data analysis, task analysis and training needs assessment process information gathered from other states.



We welcome you to complete the assignment in Word. You can easily find the assignment at [www.abctlc.com](http://www.abctlc.com). Once complete, just simply fax or e-mail the answer key along with the registration page to us and allow two weeks for grading. Once we grade it, we will mail a certificate of completion to you. Call us if you need any help.

*This course contains EPA's federal rule requirements. Please be aware that each state implements drinking water regulations that may be more stringent than EPA's regulations. Check with your state environmental agency for more information.*



# **CEU Course Description**

## **SDWA RULES AND REGULATIONS CEU TRAINING COURSE**

**Water Distribution, Well Drillers, Pump Installers, Water Treatment Operators.** The target audience for this course is the person interested in working in a water treatment or distribution facility and/or wishing to maintain CEUs for certification license or to learn how to do the job safely and effectively, and/or to meet education needs for promotion. This CEU course will review various and complex Environmental Protection Agency's Safe Drinking Water Act Rules and Regulation relating to water/wastewater operations, sampling and operator certification.

**Prerequisites:** None

### **Course Procedures for Registration and Support**

All of Technical Learning College correspondence courses have complete registration and support services offered. Delivery of services will include, e-mail, web site, telephone, fax and mail support. TLC will attempt immediate and prompt service.

### **Instructions for Written Assignments**

The SDWA Rules and Regulations CEU training course uses a multiple-choice answer key, or equivalent answer sheet. The students must use a number two pencil, make dark marks, and erase completely to change an answer. You can find an extra copy of the assignment and complete Student Support on the Website under the Assignment Page. Each student will receive a feedback form as part of their study packet. You will be able to find this form in the front of the course assignment or lesson.

### **Security and Integrity**

All students are required to do their own work. All lesson sheets and final exams are not returned to the student to discourage sharing of answers. Any fraud or deceit and the student will forfeit all fees and the appropriate agency will be notified.

### **Grading Criteria**

TLC will offer the student either pass/fail or a standard letter grading assignment. If TLC is not notified, you will only receive a pass/fail notice.

### **Required Texts**

The SDWA Rules and Regulations CEU training course comes complete with a summary of the SDWA's rules and Regulations. You will be able to find the entire law on line at [www.epa.gov](http://www.epa.gov). No other materials are needed.

### **Recordkeeping and Reporting Practices**

TLC will keep all student records for a minimum of seven years. It is your responsibility to give the completion certificate to the appropriate agencies. We will send the required information to Texas, Indiana and Pennsylvania for your certificate renewals.

### **ADA Compliance**

TLC will make reasonable accommodations for persons with documented disabilities. Students should notify TLC and their instructors of any special needs. Course content may vary from this outline to meet the needs of this particular group.

## Educational Mission

### The educational mission of TLC is:

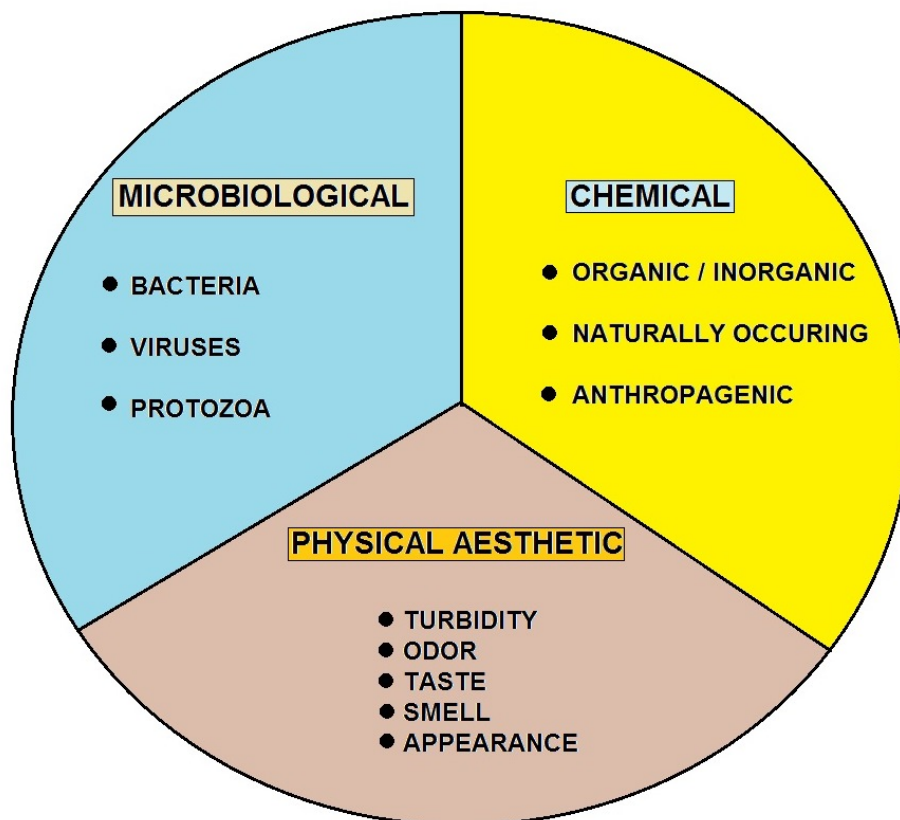
*To provide TLC students with comprehensive and ongoing training in the theory and skills needed for the environmental education field,*

*To provide TLC students opportunities to apply and understand the theory and skills needed for operator certification,*

*To provide opportunities for TLC students to learn and practice environmental educational skills with members of the community for the purpose of sharing diverse perspectives and experience,*

*To provide a forum in which students can exchange experiences and ideas related to environmental education,*

*To provide a forum for the collection and dissemination of current information related to environmental education, and to maintain an environment that nurtures academic and personal growth.*



## WATER QUALITY BROKEN DOWN INTO 3 BROAD CATEGORIES

*This course contains EPA's federal rule requirements. Please be aware that each state implements drinking water regulations that may be more stringent than EPA's regulations. Check with your state environmental agency for more information.*

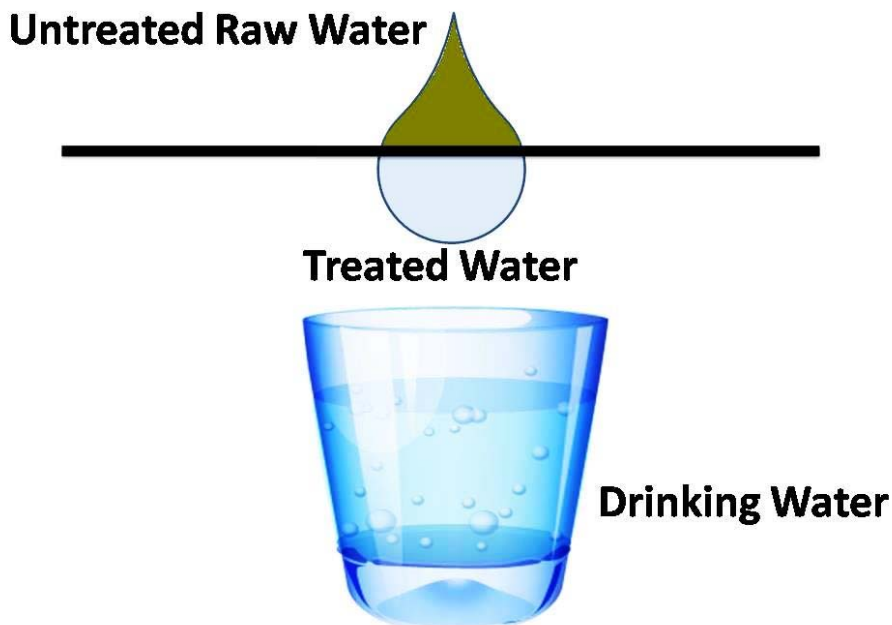
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## SDWA REGULATION CEU TRAINING COURSE

All of the SDWA questions will come from summary or the definitions section which is included in this packet. You are expected to read and understand all this information.

You will have 90 days from receipt of this manual to complete in order to receive your Professional Development Hours (PDHs) or Continuing Education Units (CEUs) or Training Credits. A score of 70 % is necessary to pass this course. If you should need any assistance, please email all concerns and the final test to [info@tlch2o.com](mailto:info@tlch2o.com).



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## LIST OF ACRONYMS

### Acronym Full Phrase

AA: Approval Authority  
AO: Administrative Order  
BAT: Best Available Technology Economically Achievable  
BCT: Best Conventional Pollutant Control Technology  
BMP: Best Management Practices  
BMR: Baseline Monitoring Report  
BOD5: 5-day Biochemical Oxygen Demand  
BPJ: Best Professional Judgment  
BPT: Best Practicable Control Technology Currently Available  
CA: Control Authority  
CFR: Code of Federal Regulations  
CIU: Categorical Industrial User  
CSO: Combined Sewer Overflow  
CWA: Clean Water Act (formerly referred to as the Federal Water Pollution Control Act or Federal Water Pollution Control Act Amendments of 1972) Pub. L. 92-500, as amended by Pub. L. 95-217, Pub. L. 95-576, Pub. L. 96-483, Pub. L. 97-117, and Pub. L. 100-4, 33 U.S.C. 1251 et seq.  
CWF: Combined Wastestream Formula  
CWT: Centralized Waste Treater  
DMR: Discharge Monitoring Report  
DSE: Domestic Sewage Exclusion  
DSS: Domestic Sewage Study  
ELG: Effluent Limitations Guideline  
EPA: Environmental Protection Agency  
EPCRA: Emergency Preparedness and Community Right to Know Act  
ERP: Enforcement Response Plan  
FDF: Fundamentally Different Factors  
FR: Federal Register  
FWA: Flow Weighted Average  
gpd: Gallons per Day  
IU: Industrial User  
LEL: Lower Explosive Limit  
MAHL: Maximum Allowable Headworks Loading  
MAIL: Maximum Allowable Industrial Loading  
MGD: Million Gallons per Day  
MSDS: Material Safety Data Sheet. Now call an SDS  
NAICS: North American Industry Classification System (replaces SIC coding system in 1998)  
NOV: Notice of Violation  
NPDES: National Pollutant Discharge Elimination System  
NRDC: Natural Resources Defense Council  
NSPS: New Source Performance Standard  
O&G: Oil and Grease  
O&M: Operations and Maintenance  
OCPSF: Organic Chemicals, Plastics, and Synthetic Fibers  
P2: Pollution Prevention

PCI: Pretreatment Compliance Inspection  
PCS: Permit Compliance System  
PIRT: Pretreatment Implementation Review Task Force  
POTW: Publicly Owned Treatment Works  
PSES: Pretreatment Standards for Existing Sources  
PSNS: Pretreatment Standards for New Sources  
QA/QC: Quality Assurance/Quality Control  
RCRA: Resource Conservation and Recovery Act  
SIC: Standard Industrial Classification  
SIU: Significant Industrial User  
SPCC: Spill Prevention Control and Countermeasures  
SNC: Significant Noncompliance  
SSO: Sanitary Sewer Overflow  
SUO: Sewer Use Ordinance  
TCLP: Toxicity Characteristic Leaching Procedure  
TIE: Toxicity Identification Evaluation  
TOMP: Toxic Organic Management Program  
TRE: Toxicity Reduction Evaluation  
TRI: Toxic Release Inventory  
TSS: Total Suspended Solids  
TTO: Total Toxic Organics  
USC: United States Code  
UST: Underground Storage Tank  
WET: Whole Effluent Toxicity  
WWTP: Wastewater Treatment Plant



## Safe Drinking Water Act (SDWA)

On August 6, 1996, President Clinton signed the Reauthorization of the Safe Drinking Water Act, bringing to a successful conclusion to years of work on the part of water professionals and a broad range of public interest groups throughout the nation. This new law strikes a balance among federal, state, local, urban, rural, large and small water systems in a manner that improves the protection of public health and brings reason and good science to the regulatory process.

### **The major elements of this law include: Assignment Starts Here Question 1**

The law updates the standard-setting process by focusing regulations on contaminants known to pose greater public health risks.

- It replaces the current law's demand for 25 additional standards every three years with a new process based on occurrence, relative risk, and cost-benefit considerations.
- It also requires the EPA to select at least five new candidate contaminants to consider for regulation every five years.
- The EPA is directed to require public water systems to provide customers with annual "Consumer Confidence Reports" in newspapers and by direct mail.
- The reports must list levels of regulated contaminants along with Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs), along with plainly worded definitions of both.
- The EPA must establish a toll-free hot line customers can call to get additional information.
- The EPA is required to publish guidelines for states to develop water source assessment programs that delineate protection areas and assess contamination risks.
- The EPA is required to identify technologies that are affordable for small systems to comply with drinking water regulations.
- Technical assistance funds and Small System Technical Assistance Centers are authorized to meet the training and technical needs of small systems.
- States are authorized to grant variances for compliance with drinking water regulations for systems serving 3,300 or fewer persons.
- The EPA is required to publish certification guidelines for operators of community and nontransient noncommunity public water systems.
- States that do not have operator certification programs that meet the requirements of the guidelines will lose 20 percent of their SRLF grant.
- A source water petition program for voluntary, incentive-based partnerships among public water systems and others to reduce contamination in source water is authorized.
- The law establishes a new State Revolving Loan Fund (SRLF) of \$1 billion per year to provide loans to public water systems to comply with the new SDWA.
- It also requires states to allocate 15 percent of the SRLF to systems serving 10,000 or fewer people unless no eligible projects are available for loans.
- It also allows states to jointly administer SDWA and Clean Water Act loan programs and transfer up to 33 percent between the two accounts.
- States must ensure that all new systems have compliance capacity and that all current systems maintain capacity, or lose 20 percent of their SRLF grant.
- The reports must also include a plainly worded statement of the health concerns for any contaminants for which there has been a violation, describe the utility's sources of drinking



water and provide data on unregulated contaminants for which monitoring is required, including *Cryptosporidium* and radon.

Although the EPA will continue to provide policy, regulations and guidance, state governments will now have more regulatory flexibility allowing for improved communication between water providers and their local regulators. Increased collaboration will result in solutions that work better and are more fully supported by the regulated community. States that have a source water assessment program may adopt alternative monitoring requirements to provide permanent monitoring relief for public water systems in accordance with EPA guidance.



**Safe Drinking Water Act of 1974**  
**(PL 93-523) as amended by:**

- The Safe Drinking Water Act Amendments of 1986
- National Primary Drinking Water Regulations, 40 CFR 141
- National Interim Primary Drinking Water Regulations Implementation, 40 CFR 142
- National Secondary Drinking Water Regulations, 40 CFR 143

**Question 22**

This is the primary Federal legislation protecting drinking water supplied by public water systems (those serving more than 25 people). The Environmental Protection Agency (EPA) is lead agency and is mandated to set standards for drinking water. The EPA establishes national standards of which the states are responsible for enforcing.

The act provides for the establishment of primary regulations for the protection of the public health and secondary regulations relating to the taste, odor, and appearance of drinking water. Primary drinking water regulations, by definition, include either a maximum contaminant level (MCL) or, when a MCL is not economically or technologically feasible, a prescribed treatment technique which would prevent adverse health effects to humans. An MCL is the permissible level of a contaminant in water that is delivered to any user of a public water system. Primary and secondary drinking water regulations are stated in 40 CFR 141 and 143, respectively. As amended in 1986, the EPA is required to set maximum contaminant levels for 83 contaminants deemed harmful to humans (with specific deadlines). It also has authority over groundwater. Water agencies are required to monitor water to ensure it meets standards.



## **National Drinking Water Regulations**

The Act instructs the EPA on how to select contaminants for regulation and specifies how EPA must establish national primary drinking water regulations once a contaminant has been selected (Section 1412). As of late 1996, the EPA had promulgated 84 drinking water regulations.

## **Contaminant Selection**

P.L. 104-182 establishes a new process for the EPA to select contaminants for regulatory consideration based on occurrence, health effects, and meaningful opportunity for health risk reduction. By February 1998 and every 5 years thereafter, the EPA must publish a list of contaminants that may warrant regulation. Starting in 2001, and every 5 years thereafter, the EPA must determine whether or not to regulate at least 5 of the listed contaminants. The Act directs the EPA to evaluate contaminants that present the greatest health concern and to regulate contaminants that occur at concentration levels and frequencies of public health concern.

The law also includes a schedule for the EPA to complete regulations for disinfectants and disinfection byproducts (D/DBPs) and *Cryptosporidium* (a waterborne pathogen).

## **Standard Setting**

Developing national drinking water regulations is a two-part process. For each contaminant that the EPA has determined merits regulation, the EPA must set a non-enforceable maximum contaminant level goal (MCLG) at a level at which no known or anticipated adverse health effects occur, and which allows an adequate margin of safety. The EPA must then set an enforceable standard, a maximum contaminant level (MCL), as close to the MCLG as is "*feasible*" using best technology, treatment techniques, or other means available (taking costs into consideration).

Standards are generally based on technologies that are affordable for large communities; however, under P.L. 104-182, each regulation establishing an MCL must list any technologies, treatment techniques or other means that comply with the MCL and that are affordable for three categories of small public water systems. The 1996 Amendments authorize the EPA to set a standard at other than the feasible level if the feasible level would lead to an increase in health risks by increasing the concentration of other contaminants or by interfering with the treatment processes used to comply with other SDWA regulations.

In such cases, the standard or treatment techniques must minimize the overall health risk. Also, when proposing a regulation, the EPA must now publish a determination as to whether or not the benefits of the standard justify the costs. If EPA determines that the benefits do not justify the costs, the EPA may, with certain exceptions, promulgate a standard that maximizes health risk reduction benefits at a cost that is justified by the benefits.

## **Risk Assessment**

P.L. 104-182 adds risk assessment and communication provisions to SDWA. When developing regulations, the EPA is now required to: (1) use the best available, peer-reviewed science and supporting studies and data; and (2) make publicly available a risk assessment document that discusses estimated risks, uncertainties, and studies used in the assessment.

When proposing drinking water regulations, the EPA must publish a health risk reduction and cost analysis. The law permits the EPA to promulgate an interim standard without first preparing a benefit-cost analysis or making a determination as to whether the benefits of a regulation would justify the costs if the EPA determines that a contaminant presents an urgent threat to public health.

New regulations generally become effective 3 years after promulgation. Up to 2 additional years may be allowed if the EPA (or a state in the case of an individual system) determines the time is needed for capital improvements. Section 1412 includes specific provisions for arsenic, sulfate, and radon. The law authorizes states to grant Systems variances from a regulation if raw water quality prevents meeting the standards despite application of best technology (Section 1415). A new provision authorizes small system variances based on best affordable technology.

States may grant these variances to systems serving 3,300 or fewer persons if the system cannot afford to comply (through treatment, an alternative water source, or restructuring) and the variance ensures adequate protection of public health; states may grant variances to systems serving between 3,300 and 10,000 persons with EPA approval. To receive a small system variance, the system must install a variance technology identified by EPA. The variance technology need not meet the MCL, but must protect public health.

The EPA must identify variance technologies for existing regulations. Variances are not available for microbial contaminants. The Act also provides for exemptions if a regulation cannot be met for other compelling reasons (including costs) and if the system was in operation before the effective date of a standard or treatment requirement (Section 1416).

An exemption is intended to give a public water system more time to comply with a regulation and can be issued only if it will not result in an unreasonable health risk. Small systems may receive exemptions for up to 9 years.

### **State Primacy**

The primary enforcement responsibility for public water systems lies with the states, provided they adopt regulations as stringent as the national requirements, adopt authority for administrative penalties, develop adequate procedures for enforcement, maintain records, and create a plan for providing emergency water supplies (Section 1413). Currently, 55 of 57 states and territories have primacy authority. P.L. 104-182 authorizes \$100 million annually for the EPA to make grants to states to carry out the public water system supervision program. States may also use a portion of their SRLF grant for this purpose (Section 1443). Whenever the EPA finds that a public water system in a state with primary enforcement authority does not comply with regulations, the Agency must notify the state and the system and provide assistance to bring the system into compliance. If the state fails to commence enforcement action within 30 days after the notification, the EPA is authorized to issue an administrative order or commence a civil action.

### **Nonprimacy State**

In a non-primacy state, the EPA must notify an elected local official (if any has jurisdiction over the water system) before commencing an enforcement action against the system (Section 1414). Primacy states may establish alternative monitoring requirements to provide interim monitoring relief for systems serving 10,000 or fewer persons for most contaminants, if a contaminant is not detected in the first quarterly sample. States with approved source water protection programs may adopt alternative monitoring requirements to provide permanent monitoring relief to qualified systems for chemical contaminants (Section 1418).

P.L. 104-182 requires states to adopt programs for training and certifying operators of community and nontransient noncommunity systems. The EPA must publish guidelines specifying minimum standards for operator certification by February 1999. Two years thereafter, the EPA must withhold 20% of a state's SRLF grant unless the state has an operator certification program

(Section 1419). States are also required to establish capacity development programs based on EPA guidance.

State programs must include: 1) legal authority to ensure that new systems have the technical, financial, and managerial capacity to meet SDWA requirements; and 2) a strategy to assist existing systems that are experiencing difficulties to come into compliance. The EPA is required to withhold a portion of SRF grants from states that do not have compliance development strategies (Section 1420).

### **Underground Injection Control**

Another provision of the Act requires the EPA to promulgate regulations for state underground injection control (UIC) programs to protect underground sources of drinking water. These regulations contain minimum requirements for the underground injection of wastes in five well classes to protect underground sources of drinking water and to require that a state prohibit, by December 1977, any underground injection that was not authorized by state permit (Section 1421).

### **Ground Water Protection Grant Programs**

The Act contains three additional ground water protection programs. Added in 1986, Section 1427 established procedures for demonstration programs to develop, implement, and assess critical aquifer protection areas already designated by the Administrator as sole source aquifers. Section 1428, also added in 1986, and established an elective state program for protecting wellhead areas around public water system wells. If a state established a wellhead protection program by 1989, and the EPA approved the state's program, then the EPA may award grants covering between 50% and 90% of the costs of implementing the program. Section 1429, added by P.L. 104-182 authorizes the EPA to make 50% grants to states to develop programs to ensure coordinated and comprehensive protection of ground water within the states.

### **Source Water Protection Programs**

P.L. 104-182 broadens the pollution prevention focus of the Act to embrace surface water as well as ground water protection. New Section 1453 directs the EPA to publish guidance for states to implement source water assessment programs that delineate boundaries of assessment areas from which systems receive their water, and identify the origins of contaminants in delineated areas to determine systems' susceptibility to contamination. States with approved assessment programs may adopt alternative monitoring requirements to provide systems with monitoring relief under Section 1418.

New Section 1454 authorizes a source water petition program based on voluntary partnerships between state and local governments. States may establish a program under which a community water system or local government may submit a source water quality partnership petition to the state requesting assistance in developing a voluntary partnership to: (1) reduce the presence of contaminants in drinking water; (2) receive financial or technical assistance; and (3) develop a long-term source water protection strategy. This section authorizes \$5 million each year for grants to states to support petition programs. Also, states may use up to 10% of their annual SRF capitalization grant for the source water assessment activities or for the petition program.

### **State Revolving Funds**

Section 1452, added by P.L. 104-182 authorizes a State Revolving Loan Fund (**SRF**) program to help systems finance improvements needed to comply with drinking water regulations. The law authorizes the EPA to make grants to states to capitalize SDWA SRFs, which states then use to make loans to public water systems. States must match 20% of the federal grant.

Grants will be allotted to states using the formula for distributing state PWSS grants through FY1997; then, grants will be allotted based on a needs survey. Each state will receive at least 1% of funds. The District of Columbia will receive 1% of funds as well. A state may transfer up to 33% of the grant to the Clean Water Act (CWA) SRF, or an equivalent amount from the CWA SRF to the SDWA SRF.

Drinking water SRFs may be used to provide loan and grant assistance for expenditures that the EPA has determined will facilitate compliance or significantly further the Act's health protection objectives. States must make available 15% of their annual allotment for loan assistance to systems that serve 10,000 or fewer persons. States may use up to 30% of their SRF grant to provide grants or forgive loan principle to help economically disadvantaged communities. Also, states may use a portion of funds for technical assistance, source water protection and capacity development programs, and for operator certification.



### **Other Provisions**

Public water systems must notify customers of violations with potential for serious health effects within 24 hours. Systems must also issue to customer's annual reports on contaminants detected in their drinking water (Section 1414).

Section 1417 requires any pipe, solder, or flux used in the installation or repair of public water systems or of plumbing in residential or nonresidential facilities providing drinking water to be "lead free" (as defined in the Act). As of August 1998, it will be unlawful to sell pipes, plumbing fittings or fixtures that are not "lead free" or to sell solder or flux that is not lead free (unless it is properly labeled); with the exception of pipes used in manufacturing or industrial processing. P.L. 104-182 sets limits on the amount of lead that may leach from new plumbing fixtures, and allows one year for a voluntary standard to be established before requiring the EPA to take regulatory action. The Administrator has emergency powers to issue orders and commence civil action if a contaminant likely to enter a public drinking water supply system poses a substantial threat to public health and state or local officials have not taken adequate action (Section 1431).

If a chemical necessary for water treatment is not reasonably available, the Administrator can issue a "certification of need," in which case the President can order an allocation of the chemical to those needing it (Section 1441). The EPA is provided authority to conduct research, studies, and demonstrations related to the causes, treatment, control, and prevention of diseases resulting from contaminants in water. The Agency is directed to provide technical assistance to the states and municipalities in administering their public water system regulatory responsibilities.

The law authorizes annually, \$15 million for technical assistance to small systems and Indian Tribes, and \$25 million for health effects research (Section 1442). P.L. 104-182 authorizes additional appropriations for drinking water research, not to exceed \$26.6 million annually.

The Administrator may make grants to develop and demonstrate new technologies for providing safe drinking water and to investigate health implications involved in the reclamation/reuse of waste waters (Section 1444).

Also, suppliers of water who may be subject to regulation under the Act are required to establish and maintain records, monitor, and provide any information that the Administrator requires to carry out the requirements of the Act (Section 1445). The Administrator may also enter and inspect the property of water suppliers to enable him/her to carry out the purposes of the Act. Failure to comply with these provisions may result in criminal penalties. The Act established a National Drinking Water Advisory Council, composed of 15 members (with at least 2 representing rural systems), to advise, consult, and make recommendations to the Administrator on activities and policies derived from the Act (Section 1446).

### **National Security**

Any federal agency having jurisdiction over federally owned and maintained public water systems must comply with all federal, state, and local drinking water requirements as well as any underground injection control programs (Section 1447). The Act provides for waivers in the interest of national security. Procedures for judicial review are outlined (Section 1448), and provision for citizens' civil actions is made (Section 1449). Citizen suits may be brought against any person or agency allegedly in violation of provisions of the Act, or against the Administrator for alleged failure to perform any action or duty which is not discretionary.

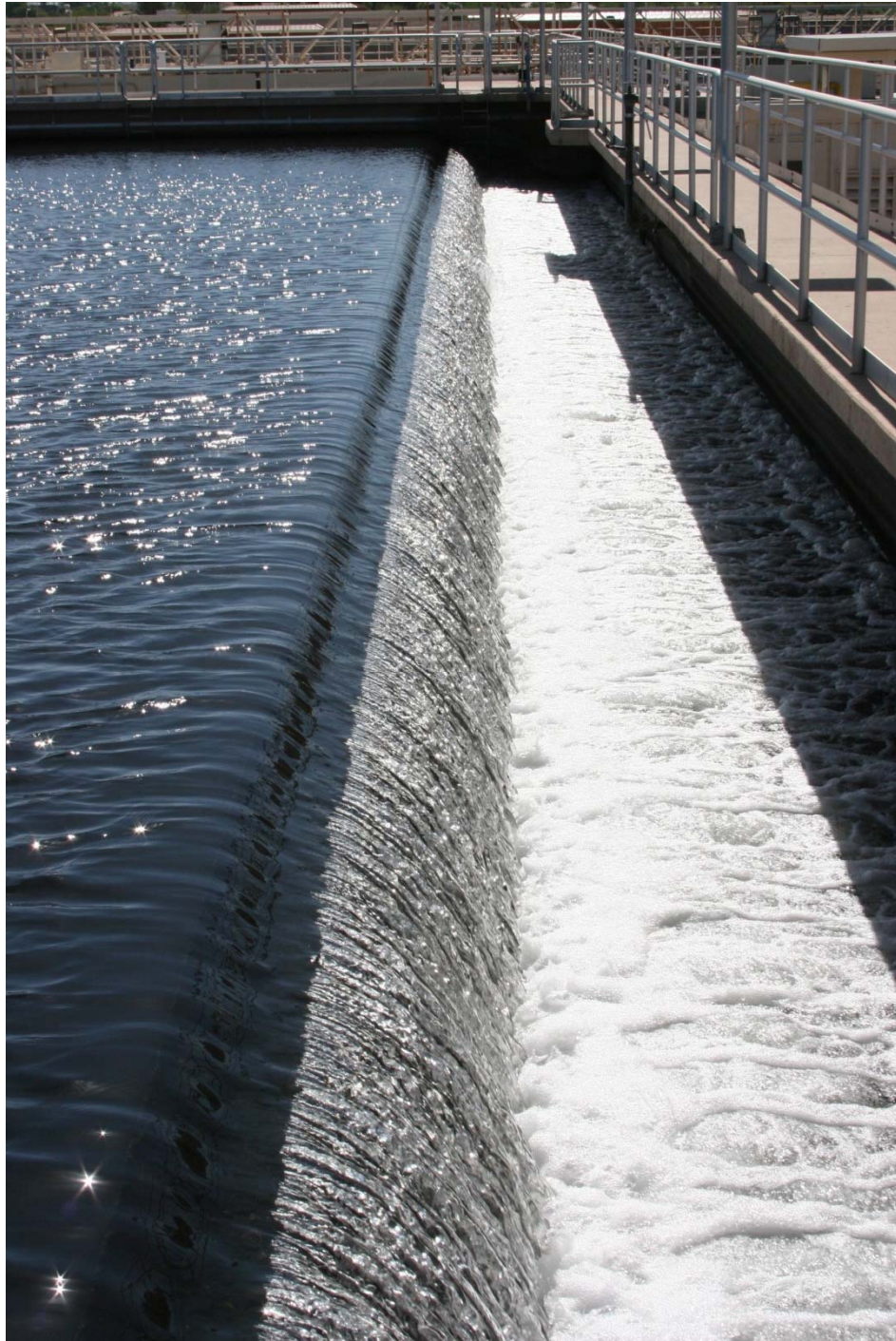
The EPA may use the new estrogenic substances screening program created in the Food Quality Protection Act of 1996 (P.L. 104-170) to provide for testing of substances that may be found in drinking water if the Administrator determines that a substantial population may be exposed to such substances (Section 1457). The EPA is directed to conduct drinking water studies involving subpopulations at greater risk and biological mechanisms, and studies to support several rules including those addressing D/DBPs and *Cryptosporidium*.

The Act includes a provision amending the Federal Food, Drug, and Cosmetic Act, generally requiring the Secretary of Health and Human Services to issue bottled drinking water standards for contaminants regulated under the Safe Drinking Water Act. Other provisions of P.L. 104-182 authorize water and wastewater grants for colonies and Alaska rural and native villages, and authorize the transfer of the Washington (D.C.) Aqueduct to a regional authority. The 1996 Amendments also authorize a \$50 million per year grant program for additional infrastructure and watershed protection projects; the conference report lists, and directs the EPA to give priority consideration to 24 such projects.



Because of the events of 9/11, we have to prepare for an attack on our water distribution system. This includes preparing for hurricanes, floods and terrorist actions.





### **Surface Water Treatment Rule (SWTR)**

The rule specifies maximum contaminant level goals for *Giardia lamblia*, viruses and *Legionella*, and promulgated filtration and disinfection requirements for public water systems using surface water sources or by ground water sources under the direct influence of surface water. The regulations also specify water quality, treatment and watershed protection criteria under which filtration may be avoided.



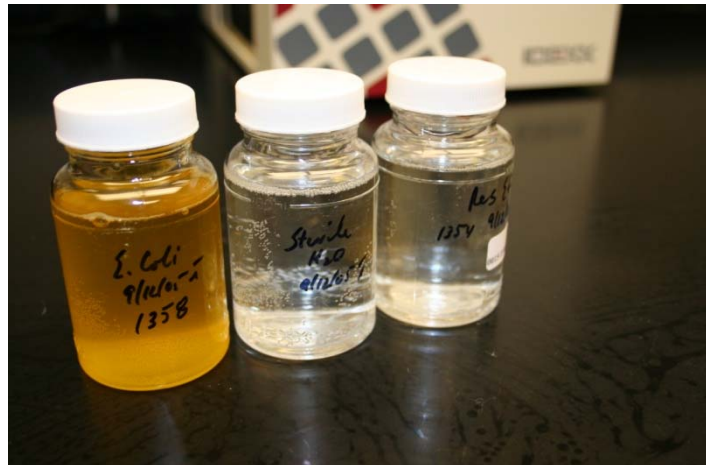
Common water distribution sample bottles, Radiochems, VOCs, (Volatile Organic Compounds), TTHMs, Total Trihalomethanes), Nitrate, Nitrite.

Most of these sample bottles will come with the preservative already inside the bottle. Some bottles will come with a separate preservative (acid) for the field preservation. Slowly add the acid or other preservative to the water sample; not water to the acid or preservative.

**Bac-T Sample Bottle**, often referred to as a Standard Sample, 100 mls. Notice the white powder inside the bottle. That is Sodium Thiosulfate, a de-chlorination agent. Be careful not to wash-out this chemical while sampling. Notice the custody seal on the bottle.

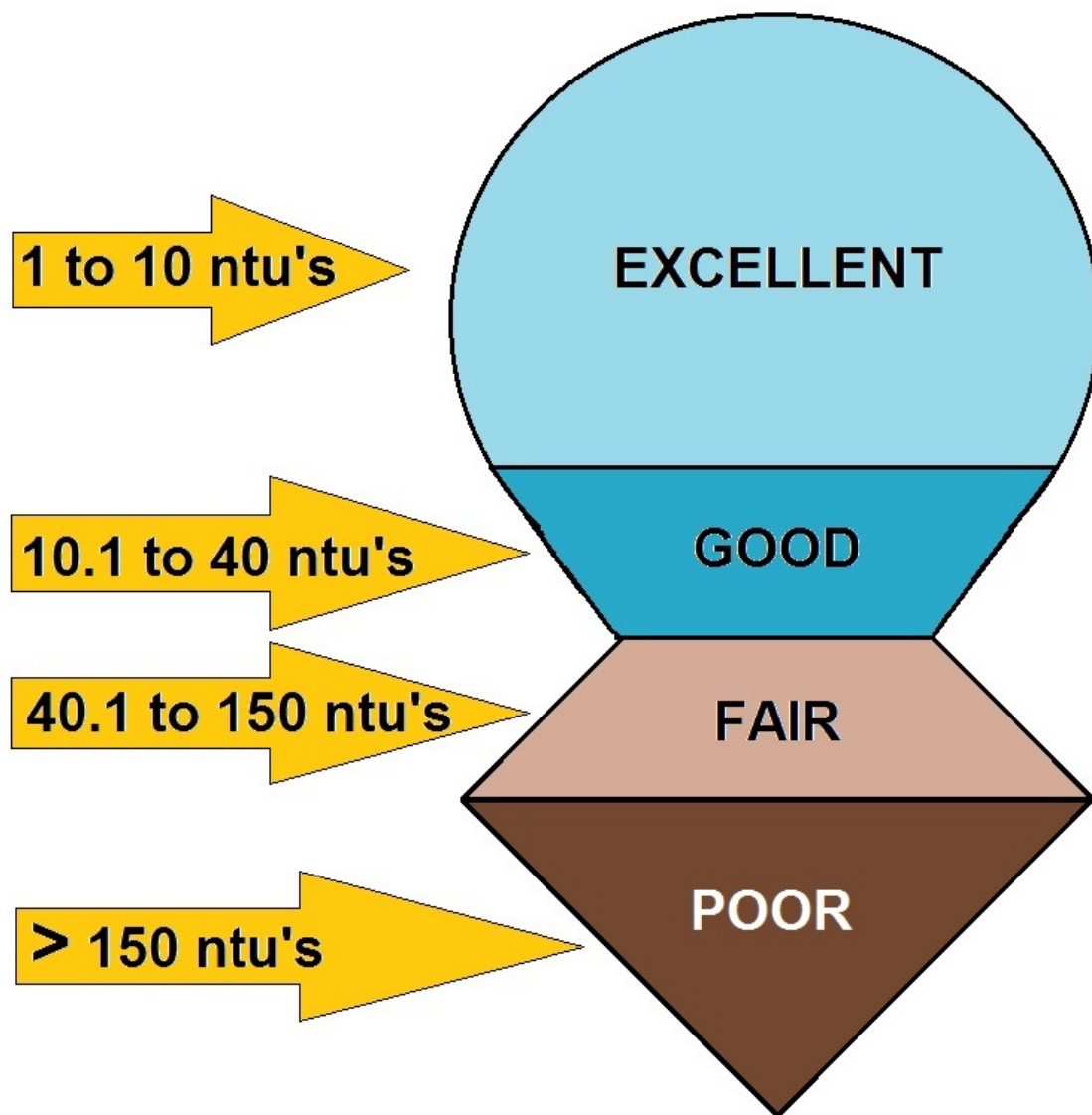


**Coliform bacteria** are common in the environment and are generally not harmful. However, the presence of these bacteria in drinking water is usually a result of a problem with the treatment system or the pipes which distribute water, and indicates that the water may be contaminated with germs that can cause disease.



The bottle with the yellow color on the left indicates coliform bacteria is present. If the bottle fluoresces under a black light, fecal bacteria is present.





**TURBIDITY (ntu's) PARAMETERS FOR WATER QUALITY**



## National Primary Drinking Water Regulations

| Inorganic Chemicals                    | MCLG <sup>1</sup><br>(mg/L) <sup>4</sup> | MCL <sup>2</sup><br>or TT <sup>3</sup><br>(mg/L) <sup>4</sup> | Potential Health Effects<br>from Ingestion of Water  | Sources of Contaminant in<br>Drinking Water   |
|--|--|---|--|---|
| Antimony                               | 0.006                                    | 0.006   | Increase in blood cholesterol;<br>decrease in blood glucose  | Discharge from petroleum<br>refineries; fire retardants;<br>ceramics; electronics; solder   |
| Arsenic                                | none <sup>5</sup>                        | 0.010   | Skin damage; circulatory<br>system problems; increased<br>risk of cancer   | Discharge from semiconductor<br>manufacturing; petroleum<br>refining; wood preservatives;<br>animal feed additives;<br>herbicides; erosion of natural<br>deposits |
| Asbestos<br>(fiber >10<br>micrometers) | 7 million<br>fibers per<br>Liter         | 7 MFL   | Increased risk of developing<br>benign intestinal polyps   | Decay of asbestos cement in<br>water mains; erosion of natural<br>deposits  |
| Barium                                 | 2  | 2   | Increase in blood pressure   | Discharge of drilling wastes;<br>discharge from metal refineries;<br>erosion of natural deposits  |
| Beryllium                              | 0.004                                    | 0.004   | Intestinal lesions   | Discharge from metal refineries<br>and coal-burning factories;<br>discharge from electrical,<br>aerospace, and defense<br>industries                              |
| Cadmium                                | 0.005                                    | 0.005   | Kidney damage  | Corrosion of galvanized pipes;<br>erosion of natural deposits;<br>discharge from metal refineries;<br>runoff from waste batteries and<br>paints                   |
| Chromium (total)                       | 0.1                                      | 0.1   | Some people who use water<br>containing chromium well in<br>excess of the MCL over many<br>years could experience allergic<br>dermatitis   | Discharge from steel and pulp<br>mills; erosion of natural<br>deposits  |
| Copper                                 | 1.3                                      | Action<br>Level=1.<br>3; TT <sup>6</sup>                      | Short term exposure:<br>Gastrointestinal distress.<br>Long term exposure: Liver or<br>kidney damage. Those with<br>Wilson's Disease should<br>consult their personal doctor if<br>their water systems exceed the<br>copper action level. | Corrosion of household<br>plumbing systems; erosion of<br>natural deposits; leaching from<br>wood preservatives   |
| Cyanide (as free<br>cyanide)           | 0.2                                      | 0.2   | Nerve damage or thyroid<br>problems  | Discharge from steel/metal<br>factories; discharge from plastic<br>and fertilizer factories   |
| Fluoride                               | 4.0                                      | 4.0   | Bone disease (pain and<br>tenderness of the bones);<br>Children may get mottled<br>teeth.  | Water additive which promotes<br>strong teeth; erosion of natural<br>deposits; discharge from<br>fertilizer and aluminum factories                                |
| Lead                                   | zero                                     | Action<br>Level=0.<br>015; TT <sup>6</sup>                    | Infants and children: Delays in<br>physical or mental<br>development.<br>Adults: Kidney problems; high<br>blood pressure   | Corrosion of household<br>plumbing systems; erosion of<br>natural deposits  |

|                                |        |       |  |  |
|--------------------------------|--------|-------|--|--|
| Inorganic Mercury              | 0.002  | 0.002 | Kidney damage  | Erosion of natural deposits; discharge from refineries and factories; runoff from landfills and cropland |
| Nitrate (measured as Nitrogen) | 10     | 10    | "Blue baby syndrome" in infants under six months - life threatening without immediate medical attention.<br>Symptoms: Infant looks blue and has shortness of breath. | Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits              |
| Nitrite (measured as Nitrogen) | 1      | 1     | "Blue baby syndrome" in infants under six months - life threatening without immediate medical attention.<br>Symptoms: Infant looks blue and has shortness of breath. | Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits              |
| Selenium                       | 0.05   | 0.05  | Hair or fingernail loss; numbness in fingers or toes; circulatory problems   | Discharge from petroleum refineries; erosion of natural deposits; discharge from mines                   |
| Thallium                       | 0.0005 | 0.002 | Hair loss; changes in blood; kidney, intestine, or liver problems  | Leaching from ore-processing sites; discharge from electronics, glass, and pharmaceutical companies      |

| Organic Chemicals    | MCLG <sup>1</sup><br>(mg/L) <sup>4</sup> | MCL <sup>2</sup><br>or TT <sup>3</sup><br>(mg/L) <sup>4</sup> | Potential Health Effects from Ingestion of Water                        | Sources of Contaminant in Drinking Water                                |
|----------------------|--|---|---|---|
| Acrylamide           | zero                                     | TT <sup>2</sup>   | Nervous system or blood problems; increased risk of cancer              | Added to water during sewage/wastewater treatment                       |
| Alachlor             | zero                                     | 0.002   | Eye, liver, kidney or spleen problems; anemia; increased risk of cancer | Runoff from herbicide used on row crops                                 |
| Atrazine             | 0.003                                    | 0.003   | Cardiovascular system problems; reproductive difficulties               | Runoff from herbicide used on row crops                                 |
| Benzene              | zero                                     | 0.005   | Anemia; decrease in blood platelets; increased risk of cancer           | Discharge from factories; leaching from gas storage tanks and landfills |
| Benzo(a)pyrene       | zero                                     | 0.0002  | Reproductive difficulties; increased risk of cancer                     | Leaching from linings of water storage tanks and distribution lines     |
| Carbofuran           | 0.04                                     | 0.04  | Problems with blood or nervous system; reproductive difficulties.       | Leaching of soil fumigant used on rice and alfalfa                      |
| Carbon tetrachloride | zero                                     | .005  | Liver problems; increased risk of cancer                                | Discharge from chemical plants and other industrial activities          |
| Chlordane            | zero                                     | 0.002   | Liver or nervous system problems; increased risk of cancer              | Residue of banned termiticide   |
| Chlorobenzene        | 0.1                                      | 0.1   | Liver or kidney problems  | Discharger from chemical and agricultural chemical factories            |
| 2,4-D                | 0.07                                     | 0.07  | Kidney, liver, or adrenal gland problems                                | Runoff from herbicide used on row crops                                 |
| Dalapon              | 0.2                                      | 0.2   | Minor kidney changes  | Runoff from herbicide used on rights of way                             |

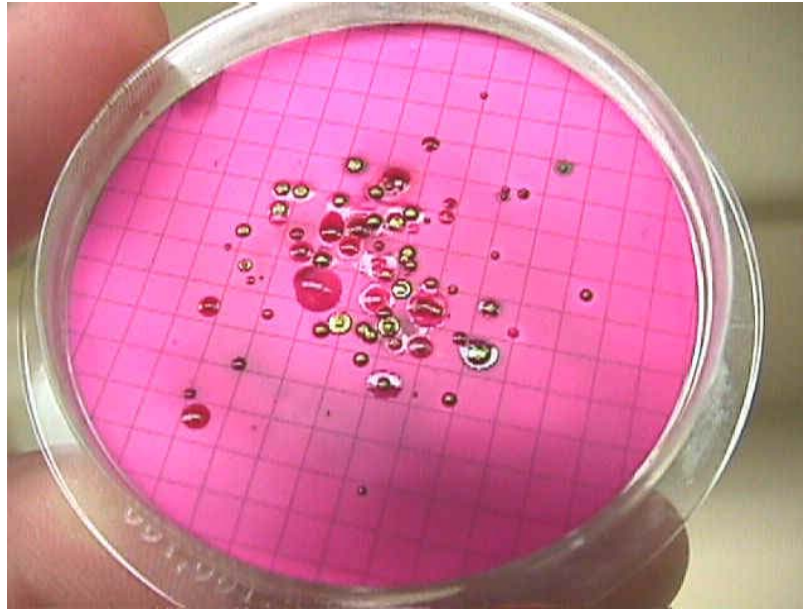
|                                    |        |                 |   |   |
|------------------------------------|--------|-----------------|---|---|
| 1,2-Dibromo-3-chloropropane (DBCP) | zero   | 0.0002          | Reproductive difficulties; increased risk of cancer                           | Runoff/leaching from soil fumigant used on soybeans, cotton, pineapples, and orchards     |
| o-Dichlorobenzene                  | 0.6    | 0.6             | Liver, kidney, or circulatory system problems                                 | Discharge from industrial chemical factories  |
| p-Dichlorobenzene                  | 0.075  | 0.075           | Anemia; liver, kidney or spleen damage; changes in blood                      | Discharge from industrial chemical factories  |
| 1,2-Dichloroethane                 | zero   | 0.005           | Increased risk of cancer  | Discharge from industrial chemical factories  |
| 1-1-Dichloroethylene               | 0.007  | 0.007           | Liver problems  | Discharge from industrial chemical factories  |
| cis-1, 2-Dichloroethylene          | 0.07   | 0.07            | Liver problems  | Discharge from industrial chemical factories  |
| trans-1,2-Dichloroethylene         | 0.1    | 0.1             | Liver problems  | Discharge from industrial chemical factories  |
| Dichloromethane                    | zero   | 0.005           | Liver problems; increased risk of cancer                                      | Discharge from pharmaceutical and chemical factories                                      |
| 1-2-Dichloropropane                | zero   | 0.005           | Increased risk of cancer  | Discharge from industrial chemical factories  |
| Di(2-ethylhexyl)adipate            | 0.4    | 0.4             | General toxic effects or reproductive difficulties                            | Leaching from PVC plumbing systems; discharge from chemical factories                     |
| Di(2-ethylhexyl)phthalate          | zero   | 0.006           | Reproductive difficulties; liver problems; increased risk of cancer           | Discharge from rubber and chemical factories  |
| Dinoseb                            | 0.007  | 0.007           | Reproductive difficulties   | Runoff from herbicide used on soybeans and vegetables                                     |
| Dioxin (2,3,7,8-TCDD)              | zero   | 0.00000003      | Reproductive difficulties; increased risk of cancer                           | Emissions from waste incineration and other combustion; discharge from chemical factories |
| Diquat                             | 0.02   | 0.02            | Cataracts   | Runoff from herbicide use   |
| Endothall                          | 0.1    | 0.1             | Stomach and intestinal problems   | Runoff from herbicide use   |
| Endrin                             | 0.002  | 0.002           | Nervous system effects  | Residue of banned insecticide   |
| Epichlorohydrin                    | zero   | TT <sup>2</sup> | Stomach problems; reproductive difficulties; increased risk of cancer         | Discharge from industrial chemical factories; added to water during treatment process     |
| Ethylbenzene                       | 0.7    | 0.7             | Liver or kidney problems  | Discharge from petroleum refineries   |
| Ethylene dibromide                 | zero   | 0.00005         | Stomach problems; reproductive difficulties; increased risk of cancer         | Discharge from petroleum refineries   |
| Glyphosate                         | 0.7    | 0.7             | Kidney problems; reproductive difficulties                                    | Runoff from herbicide use   |
| Heptachlor                         | zero   | 0.0004          | Liver damage; increased risk of cancer  | Residue of banned termiticide   |
| Heptachlor epoxide                 | zero   | 0.0002          | Liver damage; increased risk of cancer  | Breakdown of heptachlor   |
| Hexachlorobenzene                  | zero   | 0.001           | Liver or kidney problems; reproductive difficulties; increased risk of cancer | Discharge from metal refineries and agricultural chemical factories                       |
| Hexachlorocyclopentadiene          | 0.05   | 0.05            | Kidney or stomach problems  | Discharge from chemical factories   |
| Lindane                            | 0.0002 | 0.0002          | Liver or kidney problems  | Runoff/leaching from insecticide used on cattle, lumber, gardens                          |
| Methoxychlor                       | 0.04   | 0.04            | Reproductive difficulties   | Runoff/leaching from insecticide used on fruits, vegetables, alfalfa, livestock           |

|                                  |                   |        |   |   |
|----------------------------------|-------------------|--------|---|---|
| Oxamyl (Vydate)                  | 0.2               | 0.2    | Slight nervous system effects   | Runoff/leaching from insecticide used on apples, potatoes, and tomatoes |
| Polychlorinated biphenyls (PCBs) | zero              | 0.0005 | Skin changes; thymus gland problems; immune deficiencies; reproductive or nervous system difficulties; increased risk of cancer | Runoff from landfills; discharge of waste chemicals                     |
| Pentachlorophenol                | zero              | 0.001  | Liver or kidney problems; increased risk of cancer  | Discharge from wood preserving factories                                |
| Picloram                         | 0.5               | 0.5    | Liver problems  | Herbicide runoff  |
| Simazine                         | 0.004             | 0.004  | Problems with blood   | Herbicide runoff  |
| Styrene                          | 0.1               | 0.1    | Liver, kidney, and circulatory problems   | Discharge from rubber and plastic factories; leaching from landfills    |
| Tetrachloroethylene              | zero              | 0.005  | Liver problems; increased risk of cancer  | Discharge from factories and dry cleaners                               |
| Toluene                          | 1                 | 1      | Nervous system, kidney, or liver problems   | Discharge from petroleum factories                                      |
| Total Trihalomethanes (TTHMs)    | none <sup>5</sup> | 0.10   | Liver, kidney or central nervous system problems; increased risk of cancer  | Byproduct of drinking water disinfection                                |
| Toxaphene                        | zero              | 0.003  | Kidney, liver, or thyroid problems; increased risk of cancer  | Runoff/leaching from insecticide used on cotton and cattle              |
| 2,4,5-TP (Silvex)                | 0.05              | 0.05   | Liver problems  | Residue of banned herbicide   |
| 1,2,4-Trichlorobenzene           | 0.07              | 0.07   | Changes in adrenal glands   | Discharge from textile finishing factories                              |
| 1,1,1-Trichloroethane            | 0.20              | 0.2    | Liver, nervous system, or circulatory problems  | Discharge from metal degreasing sites and other factories               |
| 1,1,2-Trichloroethane            | 0.003             | 0.005  | Liver, kidney, or immune system problems  | Discharge from industrial chemical factories                            |
| Trichloroethylene                | zero              | 0.005  | Liver problems; increased risk of cancer  | Discharge from petroleum refineries                                     |
| Vinyl chloride                   | zero              | 0.002  | Increased risk of cancer  | Leaching from PVC pipes; discharge from plastic factories               |
| Xylenes (total)                  | 10                | 10     | Nervous system damage   | Discharge from petroleum factories; discharge from chemical factories   |

| Radionuclides                        | MCLG <sup>1</sup><br>(mg/L) <sup>4</sup> | MCL <sup>2</sup><br>or TT <sup>3</sup><br>(mg/L) <sup>4</sup> | Potential Health Effects<br>from Ingestion of Water | Sources of Contaminant in<br>Drinking Water |
|--------------------------------------|--|---|---|---|
| Beta particles and photon emitters   | none <sup>5</sup>                        | 4 millirems per year  | Increased risk of cancer                            | Decay of natural and man-made deposits      |
| Gross alpha particle activity        | none <sup>5</sup>                        | 15 picocuries per Liter (pCi/L)                               | Increased risk of cancer                            | Erosion of natural deposits                 |
| Radium 226 and Radium 228 (combined) | none <sup>5</sup>                        | 5 pCi/L   | Increased risk of cancer                            | Erosion of natural deposits                 |

| Microorganisms   | MCLG <sup>1</sup><br>(mg/L) <sup>4</sup> | MCL <sup>2</sup><br>or TT <sup>3</sup><br>(mg/L) <sup>4</sup> | Potential Health Effects<br>from Ingestion of Water  | Sources of Contaminant in<br>Drinking Water             |
|--|--|---|--|---|
| <i>Giardia lamblia</i>   | zero                                     | TT <sup>8</sup>   | Giardiasis, a gastroenteric disease  | Human and animal fecal waste                            |
| Heterotrophic plate count                                      | N/A                                      | TT <sup>8</sup>   | HPC has no health effects, but can indicate how effective treatment is at controlling microorganisms.  | n/a   |
| <i>Legionella</i>  | zero                                     | TT <sup>8</sup>   | Legionnaire's Disease, commonly known as pneumonia   | Found naturally in water; multiplies in heating systems |
| Total Coliforms (including fecal coliform and <i>E. Coli</i> ) | zero                                     | 5.0% <sup>9</sup>   | Used as an indicator that other potentially harmful bacteria may be present <sup>10</sup>  | Human and animal fecal waste                            |
| Turbidity  | N/A                                      | TT <sup>8</sup>   | Turbidity has no health effects but can interfere with disinfection and provide a medium for microbial growth. It may indicate the presence of microbes. | Soil runoff   |
| Viruses (enteric)  | zero                                     | TT <sup>8</sup>   | Gastroenteric disease  | Human and animal fecal waste                            |

*This course contains EPA's federal rule requirements. Please be aware that each state implements drinking water regulations that may be more stringent than EPA's regulations. Check with your state environmental agency for more information.*



**Coliform Bacteria on a Petri Dish. Bottom picture, SimPlate for HPC counts.** IDEXX's SimPlate for HPC method is used for the quantification of heterotrophic plate count (HPC) in water. It is based on the Multiple Enzyme Technology which detects viable bacteria in water by testing for the presence of key enzymes known to be present in these little organisms. This technique uses enzyme substrates that produce a blue fluorescence when metabolized by waterborne bacteria. The sample and media are added to a SimPlate Plate, incubated and then examined for fluorescing wells. The number of wells corresponds to a Most Probable Number (MPN) of total bacteria in the original sample. The MPN values generated by the SimPlate for HPC method correlate with the Pour Plate method using the Total Plate Count Agar incubated at 35°C for 48 hours as described in *Standard Methods for the Examination of Water and Wastewater, 19<sup>th</sup> Edition*.



## National Secondary Drinking Water Regulations

National Secondary Drinking Water Regulations (NSDWRs or secondary standards) are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water.

The EPA recommends secondary standards to water systems but does not require systems to comply. However, states may choose to adopt them as enforceable standards.

| Contaminant            | Secondary Standard      |
|------------------------|-------------------------|
| Aluminum               | 0.05 to 0.2 mg/L        |
| Chloride               | 250 mg/L                |
| Color                  | 15 (color units)        |
| Copper                 | 1.0 mg/L                |
| Corrosivity            | noncorrosive            |
| Fluoride               | 2.0 mg/L                |
| Foaming Agents         | 0.5 mg/L                |
| Iron                   | 0.3 mg/L                |
| Manganese              | 0.05 mg/L               |
| Odor                   | 3 threshold odor number |
| pH                     | 6.5-8.5                 |
| Silver                 | 0.10 mg/L               |
| Sulfate                | 250 mg/L                |
| Total Dissolved Solids | 500 mg/L                |
| Zinc                   | 5 mg/L                  |

## Important Notes

<sup>1</sup> Maximum Contaminant Level Goal (MCLG) - The maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health effect of persons would occur, and which allows for an adequate margin of safety. MCLGs are non-enforceable public health goals.

<sup>2</sup> Maximum Contaminant Level (MCL) - The maximum permissible level of a contaminant in water which is delivered to any user of a public water system. MCLs are enforceable standards. The margins of safety in MCLGs ensure that exceeding the MCL slightly does not pose significant risk to public health.

<sup>3</sup> Treatment Technique - An enforceable procedure or level of technical performance which public water systems must follow to ensure control of a contaminant.

<sup>4</sup> Units are in milligrams per Liter (mg/L) unless otherwise noted.

<sup>5</sup> MCLGs were not established before the 1986 Amendments to the Safe Drinking Water Act. Therefore, there is no MCLG for this contaminant.

<sup>6</sup> Lead and copper are regulated in a Treatment Technique which requires systems to take tap water samples at sites with lead pipes or copper pipes that have lead solder and/or are served by lead service lines. The action level, which triggers water systems into taking treatment steps if exceeded in more than 10% of tap water samples, for copper is 1.3 mg/L, and for lead is 0.015mg/L.

<sup>7</sup> Each water system must certify, in writing, to the state (using third-party or manufacturer's certification) that when acrylamide and epichlorohydrin are used in drinking water systems, the combination (or product) of dose and monomer level does not exceed the levels specified, as follows:

- **Acrylamide** = 0.05% dosed at 1 mg/L (or equivalent)
- **Epichlorohydrin** = 0.01% dosed at 20 mg/L (or equivalent)

<sup>8</sup> The Surface Water Treatment Rule requires systems using surface water or ground water under the direct influence of surface water to (1) disinfect their water, and (2) filter their water or meet criteria for avoiding filtration so that the following contaminants are controlled at the following levels:

- ***Giardia lamblia***: 99.9% killed/inactivated  
Viruses: 99.99% killed/inactivated
- ***Legionella***: No limit, but EPA believes that if *Giardia* and viruses are inactivated, *Legionella* will also be controlled.
- **Turbidity**: At no time can turbidity (cloudiness of water) go above 5 Nephelometric turbidity units (NTU); systems that filter must ensure that the turbidity go no higher than 1 NTU (0.5 NTU for conventional or direct filtration) in at least 95% of the daily samples in any month.
- **HPC**: NO more than 500 bacterial colonies per milliliter.

<sup>9</sup> No more than 5.0% samples total coliform-positive in a month. (For water systems that collect fewer than 40 routine samples per month, no more than one sample can be total coliform-positive). Every sample that has total coliforms must be analyzed for fecal coliforms. There cannot be any fecal coliforms.

<sup>10</sup> Fecal coliform and *E. coli* are bacteria whose presence indicates that the water may be contaminated with human animal wastes. Microbes in these wastes can cause diarrhea, cramps, nausea, headaches, or other symptoms.



## New EPA Rules

### Arsenic

Arsenic is a chemical that occurs naturally in the earth's crust. When rocks, minerals, and soil erode, they release arsenic into water supplies. When people either drink this water or eat animals and plants that drink it, they are exposed to arsenic. For most people in the U.S., eating and drinking are the most common ways that people are exposed to arsenic, although it can also come from industrial sources. Studies have linked long-term exposure of arsenic in drinking water to a variety of cancers in humans.

To protect human health, an EPA standard limits the amount of arsenic in drinking water. In January 2001, the EPA revised the standard from 50 parts per billion (ppb), ordered that it fall to 10 ppb by 2006. After adopting 10ppb as the new standard for arsenic in drinking water, the EPA decided to review the decision to ensure that the final standard was based on sound science and accurate estimates of costs and benefits. In October 2001, the EPA decided to move forward with implementing the 10 ppb standard for arsenic in drinking water.

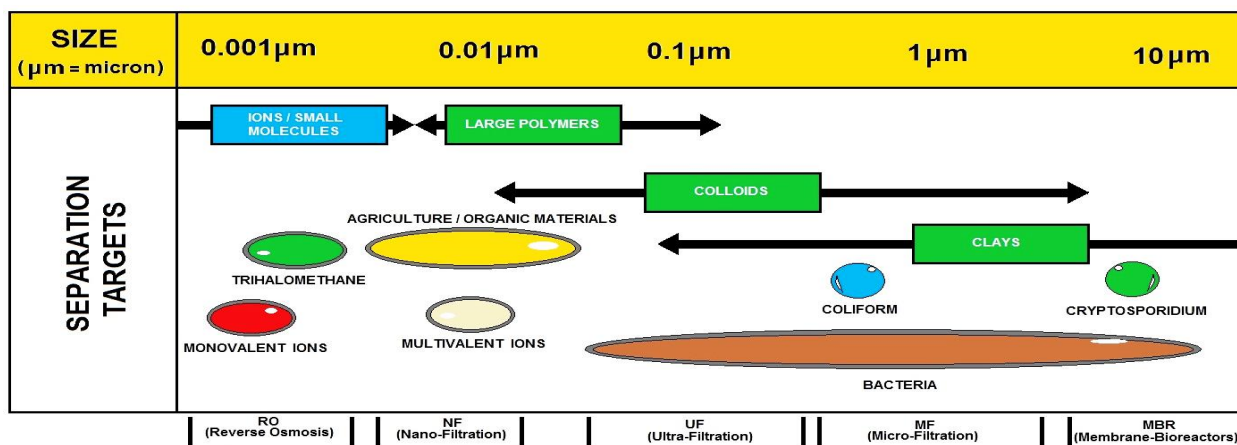


More information on the rulemaking process and the costs and benefits of setting the arsenic limit in drinking water at 10 ppb can be found at [www.epa.gov/safewater/arsenic.html](http://www.epa.gov/safewater/arsenic.html).

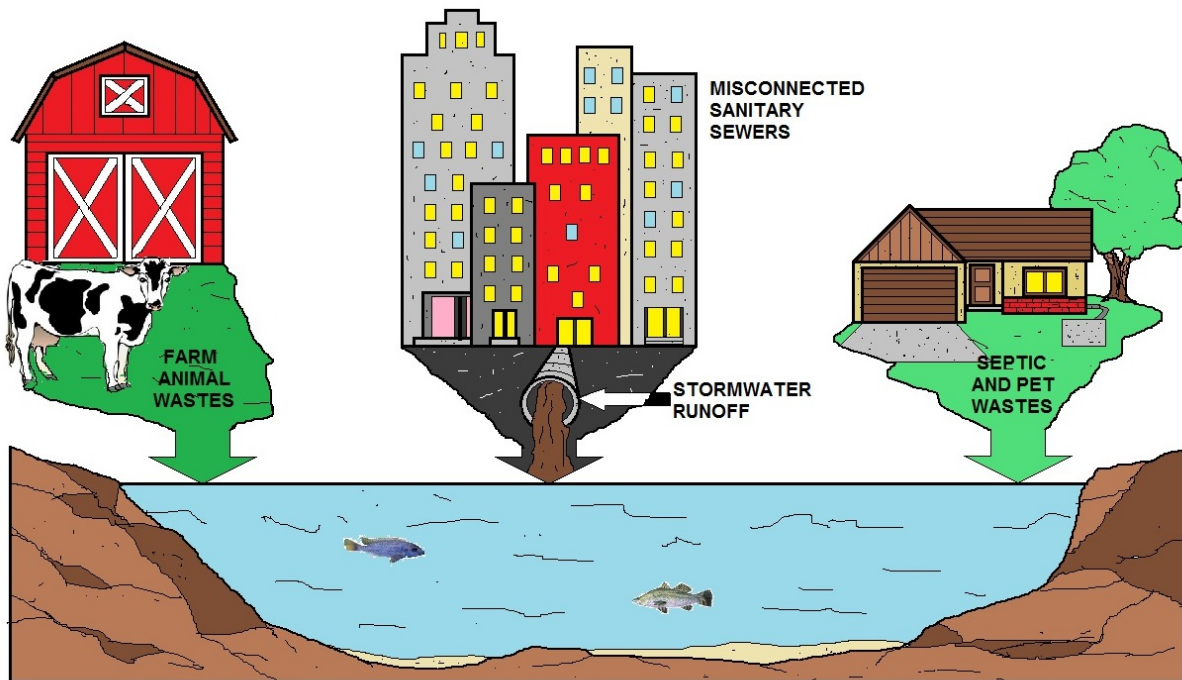
### ICR

The EPA has collected data required by the Information Collection Rule (ICR) to support future regulation of microbial contaminants, disinfectants, and disinfection byproducts. The rule is intended to provide EPA with information on chemical byproducts that form when disinfectants used for microbial control react with chemicals already present in source water (disinfection byproducts (DBPs)); disease-causing microorganisms (pathogens), including *Cryptosporidium*; and engineering data to control these contaminants.

Drinking water microbial and disinfection byproduct information collected for the ICR is now available in the EPA's Envirofacts Warehouse website.



## REMOVAL METHODS



**EXAMPLES OF SOURCES OF FECAL COLIFORM BACTERIA**

## **Other Related EPA Water Treatment Rules**

### **Filter Backwash Recycling Rule (FBRR)**

The Filter Backwash Recycling Rule (FBRR) regulates the recycling of filter backwash water within the treatment process of public water systems. The FBRR requires surface water systems to review their recycle practices and to modify any recycle practices that may compromise microbial control or contribute to violations of the drinking water regulations. Recycle flows can be a source of concentrated microbial pathogens and chemical contaminants.

### **IESWTR**

The Interim Enhanced Surface Water Treatment Rule (IESWTR) builds on the requirements of the Surface Water Treatment Rule. IESWTR specifies treatment requirements to address *Cryptosporidium* and other microbial contaminants in public water systems serving 10,000 or more persons.

The rule balances the need for treatment with potential increases in disinfection by-products. The materials found on this page are intended to assist public water systems and state in the implementation of the IESWTR.

## Disinfection Rules Stages 1 & 2 DBPR

*The following are EPA's federal rule requirements. Please be aware that each state implements drinking water regulations that may be more stringent than EPA's regulations. Check with your state environmental agency for more information.*

### Stage 2 DBPR

EPA finalized the Stage 2 Disinfectants and Disinfection Byproduct Rule (DBPR) to reduce potential health risks from DBPs. The Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) is being finalized and implemented at the same time as the Stage 2 DBPR to ensure that drinking water is safe from both microbial pathogens and DBPs.

### General Requirements

To comply with the Stage 2 Disinfectants and Disinfection Byproducts Rule (Stage 2 DBPR), published on January 4, 2006 (71 FR 388) systems must do the following:

- **Conduct an Initial Distribution System Evaluation (IDSE)** to find locations in the distribution system that have high levels of TTHM and HAA5 and that can be used as compliance monitoring sites for the Stage 2 DBPR.
- **Use a locational running annual average (LRAA) calculation to determine compliance** with the Stage 2 DBPR maximum contaminant levels (MCLs) of:
  - 0.080 mg/L for total trihalomethanes (TTHM), and
  - 0.060 mg/L for five haloacetic acids (HAA5).

**Note:** The MCL values are the same as the Stage 1 MCLs; only the calculation method changes.

- **Monitor for Stage 2 compliance** at the required number of locations for each system's retail population
- **Identify when TTHM or HAA5 levels exceed the operational evaluation level** and, when this happens, look at source water, operational practices, and treatment to find ways to reduce TTHM and HAA5 concentrations in the distribution system. Each of these general requirements are covered in more detail in the rest of this guidance manual. The Stage 2 DBPR is an extension of the Stage 1 Disinfectants and Disinfection Byproducts Rule (Stage 1 DBPR). Systems must also continue to comply with the other requirements of the Stage 1 DBPR in addition to meeting the requirements of the Stage 2 DBPR. This includes compliance with the MCLs for bromate (for systems using ozone) and chlorite (for systems using chlorine dioxide), the MRDLs for chlorine or chloramine (depending on the residual disinfectant used), as well as TOC removal requirements.

### Compliance Timeline

Your compliance schedule for the Stage 2 DBPR are based on whether your system is part of a *combined distribution system*:

- If your system **is** part of a combined distribution system, you must comply with the revised MCLs by the same date as required for the largest system in your combined distribution system.

Example: if your system serves 8,000 people, but you purchase water from a system that serves 250,000 people, you must comply by the dates shown in Schedule 1.

- If your system **is not** part of a combined distribution system, compliance dates are based on the population served by your system.

If you are using this guidance manual, you likely serve fewer than 10,000 people and you must comply by the dates shown in Schedule 4.

**Your State (or EPA) should have sent you a letter telling you what schedule you are on. If you did not receive this letter or you have questions about your schedule, contact your State (contact information is listed in Appendix C).**

**Note:** You are on the same schedule for Stage 2 DBPR compliance as you were on for the IDSE.

The timeline on the next page shows important dates for the Stage 2 DBPR as well as periods for *Cryptosporidium* and *E. coli* required under the LT2ESWTR.

**Note:** The figure shows the 2-year period after systems must begin compliance as a “possible extension.” States may give you up to an additional 2 years to comply if you need time to install capital improvements.

### **How Does this Rule Relate to Other Federal, State, and Local Requirements?**

As noted earlier, the Stage 2 DBPR is an extension of the Stage 1 Disinfectants and Disinfection Byproducts Rule (Stage 1 DBPR). The Stage 2 DBPR and the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) were published together to address the balance between protection from microbial pathogens and the potential health effects from disinfectants and their byproducts. You are still required to continue to meet all existing federal requirements. You may call the Safe Drinking Water Hotline at (800) 426-4791 (e-mail: [hotline-sdwa@epa.gov](mailto:hotline-sdwa@epa.gov)) for more information on other drinking water rules.

### **Where do DBPs come from?**

Chlorine and other chemical disinfectants have been widely used by public water systems (along with filtration) to protect the public from microbial pathogens in drinking water. DBPs are formed when certain disinfectants react with DBP precursors (organic and inorganic materials) in source waters. In most cases, natural organic matter (NOM) is an important factor that affects the levels of DBPs that form (NOM is usually measured as TOC). The levels of DBPs in drinking water can vary significantly from one point in a distribution system to another, as many continue to form in the distribution system. DBP levels are generally higher in surface water systems because surface water usually contains higher DBP precursor levels and requires stronger disinfection.

### **Ensuring Safe Drinking Water**

All drinking water systems want to provide water that is safe. One aspect of providing safe drinking water is limiting the levels of DBPs in it. Long-term exposure to DBPs has been linked to bladder cancer, and possibly colon and rectal cancers. More recent studies have shown that shorter-term exposure to high levels of DBPs may be associated with adverse reproductive and developmental health effects.

Limiting the levels of DBPs in your drinking water may require you to make some adjustments to your current operations, such as:

- Making operational improvements at the plant or in the distribution system
- Modifying current treatment operations to remove more DBP precursors or form lower levels of DBPs
- Upgrading or installing a new treatment technology

### What Does Compliance Monitoring Involve?

Monitoring requirements for TTHM and HAA5 are based on your source water type and the population your system serves. Note that this is different than the Stage 1 DBPR monitoring requirements that were based on the number of treatment plants in your system.

With population-based monitoring, there are five categories of small systems under the Stage 2 DBPR:

- Subpart H systems that serve fewer than 500 people.
- Subpart H systems that serve 500 to 3,300 people.
- Subpart H systems that serve 3,301 to 9,999 people.
- Ground water systems that serve fewer than 500 people.
- Ground water systems that serve 500 to 9,999 people.

If you do not know what type of system you are, you should contact your State to confirm this information.

## Older Stage 1 DBPR Information

### Disinfection Byproduct Regulations

In December 1998, the EPA established the Stage 1 Disinfectants/Disinfection Byproducts Rule that requires public water systems to use treatment measures to reduce the formation of disinfection byproducts and to meet the following specific standards:

|                                     |                             |
|-------------------------------------|-----------------------------|
| <b>Total Trihalomethanes (TTHM)</b> | 80 parts per billion (ppb)  |
| <b>Haloacetic Acids (HAA5)</b>      | 60 ppb                      |
| <b>Bromate</b>                      | 10 ppb                      |
| <b>Chlorite</b>                     | 1.0 parts per million (ppm) |

Trihalomethanes were regulated at a maximum allowable annual average level of 100 parts per billion for water systems serving over 10,000 people under the Total Trihalomethane Rule finalized by the EPA in 1979. The Stage 1 Disinfectant/Disinfection Byproduct Rule standards became effective for trihalomethanes and other disinfection byproducts listed above in December 2001 for large surface water public water systems. Those standards became effective in December 2003 for small surface water and all ground water public water systems.

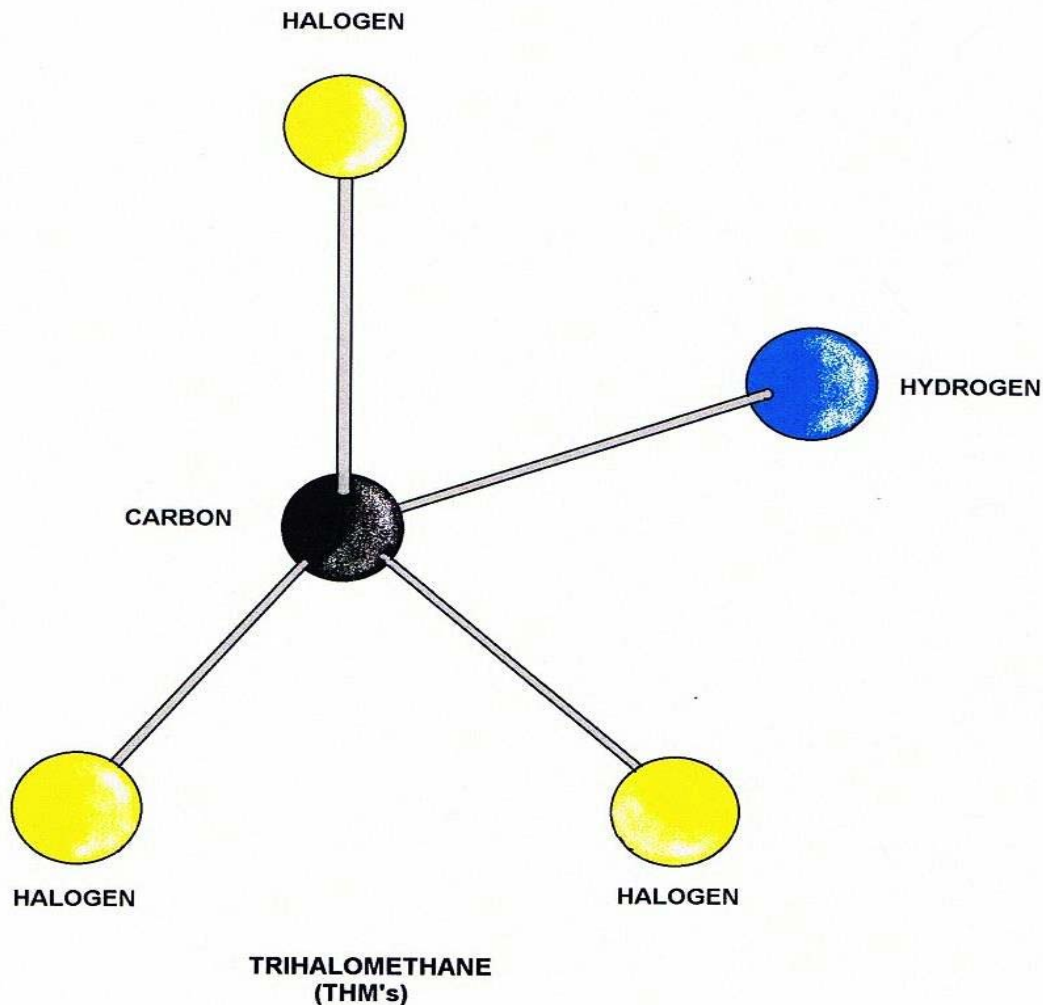
**Disinfection byproducts** are formed when disinfectants used in water treatment plants react with bromide and/or natural organic matter (i.e., decaying vegetation) present in the source water. Different disinfectants produce different types or amounts of disinfection byproducts. Disinfection byproducts for which regulations have been established have been identified in drinking water, including trihalomethanes, haloacetic acids, bromate, and chlorite.

**Trihalomethanes (THM)** are a group of four chemicals that are formed along with other disinfection byproducts when chlorine or other disinfectants used to control microbial contaminants in drinking water react with naturally occurring organic and inorganic matter in water. The trihalomethanes are chloroform, bromodichloromethane, dibromochloromethane, and bromoform. The EPA has published the Stage 1 Disinfectants/Disinfection Byproducts Rule to regulate total trihalomethanes (TTHM) at a maximum allowable annual average level of 80 parts per billion.

This new standard replaced the old standard of a maximum allowable annual average level of 100 parts per billion back in December 2001 for large surface water public water systems. The standard became effective for the first time back in December 2003 for small surface water and all ground water systems.

**Haloacetic Acids (HAA5)** are a group of chemicals that are formed along with other disinfection byproducts when chlorine or other disinfectants used to control microbial contaminants in drinking water react with naturally occurring organic and inorganic matter in water. The regulated haloacetic acids, known as HAA5, are: monochloroacetic acid, dichloroacetic acid, trichloroacetic acid, monobromoacetic acid, and dibromoacetic acid. EPA has published the Stage 1 Disinfectants/Disinfection Byproducts Rule to regulate HAA5 at 60 parts per billion annual average.

This standard became effective for large surface water public water systems back in December 2001 and for small surface water and all ground water public water systems back in December 2003.



## Revised Total Coliform Rule (RTCR)

*The following are EPA's federal rule requirements. Please be aware that each state implements drinking water regulations that may be more stringent than EPA's regulations. Check with your state environmental agency for more information.*

EPA published the Revised Total Coliform Rule (RTCR) in the Federal Register (FR) on February 13, 2013 (78 FR 10269). It is the revision to the 1989 Total Coliform Rule (TCR).

### Why revise the 1989 TCR?

The 1996 amendments to the Safe Drinking Water Act [Section 1412(b) (9)] require the Administrator to review and revise, as appropriate, each national primary drinking water regulation not less often than every six years. EPA published its decision to revise the TCR in July 2003 as part of its National Primary Drinking Water Regulation (NPDWR) review.

### The RTCR:

- Upholds the purpose of the 1989 TCR to protect public health by ensuring the integrity of the drinking water distribution system and monitoring for the presence of microbial contamination.
- Requires public water systems (PWSs) to meet a legal limit for *E. coli*, as demonstrated by required monitoring.
- Specifies the frequency and timing of required microbial testing based on population served, public water system type and source water type: ground water or surface water.

### When must PWSs comply with the RTCR requirements?

Unless a State determines an earlier effective date, all PWSs must comply with the RTCR requirements starting April 1, 2016. All PWSs include:

- Community Water Systems (CWSs),
- Non-Transient Non-Community Water Systems (NTNCWSs), and
- Transient Non-Community Water Systems (TNCWSs).

### Minor Corrections to the Revised Total Coliform Rule (RTCR)

Minor corrections to the final RTCR became effective on April 28, 2014. No comments were received on the Direct Final Rule published on February 26, 2014 and the corrections therefore became effective without further notice. See the **Direct Final Rule** Federal Register Notice.

### Revised Total Coliform Rule (RTCR) – Final Rule

On February 13, 2013, EPA published in the Federal Register the revisions to the 1989 TCR. EPA anticipates greater public health protection under the Revised Total Coliform Rule (RTCR) requirements. The RTCR:

- Requires public water systems that are vulnerable to microbial contamination to identify and fix problems; and
- Establishes criteria for systems to qualify for and stay on reduced monitoring, which could reduce water system burden and provide incentives for better system operation.

Public water systems (PWSs) and primacy agencies must comply with the revised requirements by April, 2016. Until then, PWSs and primacy agencies must continue complying with the 1989 TCR.

**What are the key provisions PWSs must comply with under the RTCR?**

| Provision Category  | Key Provisions   |
|---|--|
| Contaminant Level   | <ul style="list-style-type: none"> <li>• Addresses the presence of total coliforms and E. coli in drinking water.</li> <li>• For E. coli (EC), the Maximum Contaminant Level Goal (MCLG) is set at zero and the Maximum Contaminant Level (MCL) is based on the occurrence of a condition that includes routine and repeat samples.</li> <li>• For total coliforms (TC), PWSs must conduct a Level 1 or Level 2 assessment of their system when they exceed a specified frequency of total coliform occurrence. Other events such as an MCL violation or failure to take repeat samples following a routine total coliform-positive sample will also trigger an assessment. Any sanitary defects identified during an assessment must be corrected by the PWS. These are the treatment technique requirements of the RTCR.</li> </ul>                  |
| Monitoring  | <ul style="list-style-type: none"> <li>• Develop and follow a sample siting plan that designates the PWS's collection schedule and location of routine and repeat water samples.</li> <li>• Collect routine water samples on a regular basis (monthly, quarterly, annually) and have them tested for the presence of total coliforms by a state certified laboratory.</li> <li>• Analyze all routine or repeat samples that are total coliform positive (TC+) for E. coli.</li> <li>• Collect repeat samples (at least 3) for each TC+ positive routine sample.</li> <li>• For PWSs on quarterly or annual routine sampling, collect additional routine samples (at least 3) in the month after a TC+ routine or repeat sample.</li> <li>• Seasonal systems must monitor and certify the completion of a state-approved start-up procedures</li> </ul> |
| Level 1 and Level 2 Assessments and Corrective Actions                    | <ul style="list-style-type: none"> <li>• PWSs are required to conduct a Level 1 or Level 2 assessment if certain conditions indicate that they might be vulnerable to contamination, and fix any sanitary defects within a required timeframe.</li> </ul>  |
| Reporting and Recordkeeping   | <ul style="list-style-type: none"> <li>• PWSs are required to report certain items to their states. These reporting and recordkeeping requirements are essentially the same as under TCR with the addition of Level 1 and Level 2 requirements.</li> </ul>   |
| Violations, Public Notification (PN) and Consumer Confidence Report (CCR) | <ul style="list-style-type: none"> <li>• PWSs incur violations if they do not comply with the requirements of the RTCR. The violation types are essentially the same as under the TCR with few changes. The biggest change is no acute or monthly MCL violation for total coliform positive samples only.</li> <li>• PN is required for violations incurred. Within required timeframes, the PWS must use the required health effects language and notify the public if they did not comply with</li> </ul>  |



|  |   |
|--|---|
|  | <p>certain requirements of the RTCR. The type of PN depends on the severity of the violation.</p> <ul style="list-style-type: none"> <li>Community water systems (CWSs) must use specific language in their CCRs when they must conduct an assessment or if they incur an E. coli MCL violation.</li> </ul> |
|--|---|

## More on the Current Stage 2 DBP Rule

*The following are EPA's federal rule requirements. Please be aware that each state implements drinking water regulations that may be more stringent than EPA's regulations. Check with your state environmental agency for more information.*

The Stage 2 DBP rule is one part of the Microbial and Disinfection Byproducts Rules (MDBPs), which are a set of interrelated regulations that address risks from microbial pathogens and disinfectants/disinfection byproducts. The Stage 2 DBP rule focuses on public health protection by limiting exposure to DBPs, specifically total trihalomethanes (TTHM) and five haloacetic acids (HAA5), which can form in water through disinfectants used to control microbial pathogens. This rule will apply to all community water systems and nontransient noncommunity water systems that add a primary or residual disinfectant other than ultraviolet (UV) light or deliver water that has been disinfected by a primary or residual disinfectant other than UV.

Amendments to the SDWA in 1996 require EPA to develop rules to balance the risks between microbial pathogens and disinfection byproducts (DBPs). The Stage 1 Disinfectants and Disinfection Byproducts Rule and Interim Enhanced Surface Water Treatment Rule, promulgated in December 1998, were the first phase in a rulemaking strategy required by Congress as part of the 1996 Amendments to the Safe Drinking Water Act.

The Stage 2 Disinfectants and Disinfection Byproducts Rule (Stage 2 DBPR) builds upon the Stage 1 DBPR to address higher risk public water systems for protection measures beyond those required for existing regulations. The Stage 2 DBPR and the Long Term 2 Enhanced Surface Water Treatment Rule are the second phase of rules required by Congress. These rules strengthen protection against microbial contaminants, especially *Cryptosporidium*, and at the same time, reduce potential health risks of DBPs.

### **What is the Stage 2 DBPR?**

The Stage 2 Disinfection Byproducts Rule will reduce potential cancer and reproductive and developmental health risks from disinfection byproducts (DBPs) in drinking water, which form when disinfectants are used to control microbial pathogens. Over 260 million individuals are exposed to DBPs.

This final rule strengthens public health protection for customers by tightening compliance monitoring requirements for two groups of DBPs, trihalomethanes (TTHM) and haloacetic acids (HAA5). The rule targets systems with the greatest risk and builds incrementally on existing rules. This regulation will reduce DBP exposure and related potential health risks and provide more equitable public health protection. The Stage 2 DBPR is being promulgated simultaneously with the Long Term 2 Enhanced Surface Water Treatment Rule to address concerns about risk tradeoffs between pathogens and DBPs.

***What does the rule require?***

Under the Stage 2 DBPR, systems will conduct an evaluation of their distribution systems, known as an Initial Distribution System Evaluation (IDSE), to identify the locations with high disinfection byproduct concentrations. These locations will then be used by the systems as the sampling sites for Stage 2 DBPR compliance monitoring. Compliance with the maximum contaminant levels for two groups of disinfection byproducts (TTHM and HAA5) will be calculated for each monitoring location in the distribution system. This approach, referred to as the locational running annual average (LRAA), differs from current requirements, which determine compliance by calculating the running annual average of samples from all monitoring locations across the system.

The Stage 2 DBPR also requires each system to determine if they have exceeded an operational evaluation level, which is identified using their compliance monitoring results. The operational evaluation level provides an early warning of possible future MCL violations, which allows the system to take proactive steps to remain in compliance.

A system that exceeds an operational evaluation level is required to review their operational practices and submit a report to their state that identifies actions that may be taken to mitigate future high DBP levels, particularly those that may jeopardize their compliance with the DBP MCLs.

***Who must comply with the rule?***

Entities potentially regulated by the Stage 2 DBPR are community and nontransient noncommunity water systems that produce and/or deliver water that is treated with a primary or residual disinfectant other than ultraviolet light.

A community water system (CWS) is a public water system that serves year-round residents of a community, subdivision, or mobile home park that has at least 15 service connections or an average of at least 25 residents.

A nontransient noncommunity water system (NTNCWS) is a water system that serves at least 25 of the same people more than six months of the year, but not as primary residence, such as schools, businesses, and day care facilities.

***What are disinfection byproducts (DBPs)?***

Disinfectants are an essential element of drinking water treatment because of the barrier they provide against waterborne disease-causing microorganisms. Disinfection byproducts (DBPs) form when disinfectants used to treat drinking water react with naturally occurring materials in the water (e.g., decomposing plant material).

Total trihalomethanes (TTHM - chloroform, bromoform, bromodichloromethane, and dibromochloromethane) and haloacetic acids (HAA5 - monochloro-, dichloro-, trichloro-, monobromo-, dibromo-) are widely occurring classes of DBPs formed during disinfection with chlorine and chloramine. The amount of trihalomethanes and haloacetic acids in drinking water can change from day to day, depending on the season, water temperature, amount of disinfectant added, the amount of plant material in the water, and a variety of other factors.

***Are THMs and HAAs the only disinfection byproducts?***

No. The four THMs (TTHM) and five HAAs (HAA5) measured and regulated in the Stage 2 DBPR act as indicators for DBP occurrence. There are many other known DBPs, in addition to the possibility of unidentified DBPs present in disinfected water.

## Microbial Regulations

One of the key regulations developed and implemented by the United States Environmental Protection Agency (USEPA) to counter pathogens in drinking water is the Surface Water Treatment Rule.

Among its provisions, the rule requires that a public water system, using surface water (or ground water under the direct influence of surface water) as its source, have sufficient treatment to reduce the source water concentration of *Giardia* and viruses by at least 99.9% and 99.99%, respectively. The Surface Water Treatment Rule specifies treatment criteria to assure that these performance requirements are met; they include turbidity limits, disinfectant residual and disinfectant contact time conditions.

### Disinfectant Review Statements:

Disinfectant residual: The CT values for disinfection are used to determine the disinfection efficiency based upon time and what other parameter?

Bacteria, Virus and Intestinal parasites: What types of organisms may transmit waterborne diseases?

Disinfection By-Products (DBPs): The products created due to the reaction of chlorine with organic materials (e.g. leaves, soil) present in raw water during the water treatment process. The EPA has determined that these DBPs can cause cancer.

How is the effectiveness of disinfection determined? *From the results of coliform testing.*

The treatment of water to inactivate, destroy, and/or remove pathogenic bacteria, viruses, protozoa, and other parasites.

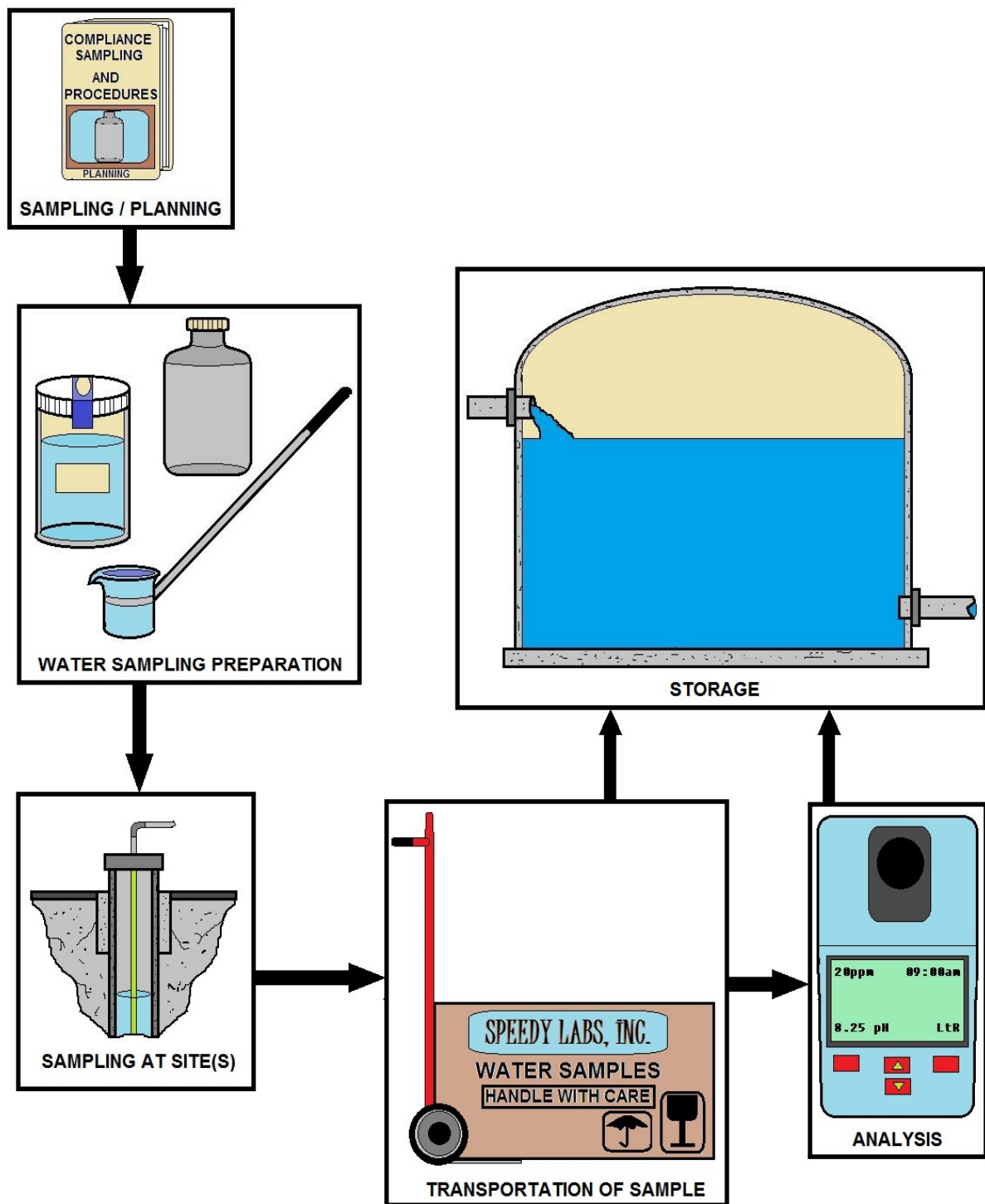
What types of source water are required by law to treat water using filtration and disinfection? *Groundwater under the direct influence of surface water, and related surface water sources.*

**E. Coli, *Escherichia coli*:** A bacterium commonly found in the human intestine. For water quality analyses purposes, it is considered an indicator organism. These are considered evidence of water contamination. Indicator organisms may be accompanied by pathogens, but do not necessarily cause disease themselves.



pH Strips

pH is on a scale from 0-14. 7 is considered neutral and acid is on the 0 to 7 side and the base is 7-14. pH is known as the Power of Hydroxyl Ion activity.



## WATER SAMPLING FLOW CHART

## **New EPA Rules for Distribution Reduction of Lead in Drinking Water Act**

Congress passed Public Law 111-380 or The Reduction of Lead in Drinking Water Act, in 2010. It's set to go into effect Jan. 4, 2014, which means municipalities, water districts and developers who work with and pay for water infrastructure need to be preparing.

Lead, a metal found in natural deposits, is commonly used in household plumbing materials and water service lines. The greatest exposure to lead is swallowing or breathing in lead paint chips and dust.

But lead in drinking water can also cause a variety of adverse health effects. In babies and children, exposure to lead in drinking water above the action level can result in delays in physical and mental development, along with slight deficits in attention span and learning abilities. In adults, it can cause increases in blood pressure. Adults who drink this water over many years could develop kidney problems or high blood pressure.

Lead is rarely found in source water, but enters tap water through corrosion of plumbing materials. Homes built before 1986 are more likely to have lead pipes, fixtures and solder. However, new homes are also at risk: even legally "lead-free" plumbing may contain up to 8 percent lead. The most common problem is with brass or chrome-plated brass faucets and fixtures which can leach significant amounts of lead into the water, especially hot water.

Congress enacted the Reduction of Lead in Drinking Water Act on January 4, 2011, to amend Section 1417 of the Safe Drinking Water Act (SDWA) regarding the use and introduction into commerce of lead pipes, plumbing fittings or fixtures, solder and flux. The Act established a prospective effective date of January 4, 2014, which provided a three year timeframe for affected parties to transition to the new requirements.

### **Pervasive Environmental Contaminant**

Lead is a pervasive environmental contaminant. The adverse health effects of lead exposure in children and adults are well documented, and no safe blood lead threshold in children has been identified. Lead can be ingested from various sources, including lead paint and house dust contaminated by lead paint, as well as soil, drinking water, and food. The concentration of lead, total amount of lead consumed, and duration of lead exposure influence the severity of health effects. Because lead accumulates in the body, all sources of lead should be controlled or eliminated to prevent childhood lead poisoning.

Beginning in the 1970s, lead concentrations in air, tap water, food, dust, and soil began to be substantially reduced, resulting in significantly reduced blood lead levels (BLLs) in children throughout the United States. However, children are still being exposed to lead, and many of these children live in housing built before the 1978 ban on lead-based residential paint. These homes might contain lead paint hazards, as well as drinking water service lines made from lead, lead solder, or plumbing materials that contain lead. Adequate corrosion control reduces the leaching of lead plumbing components or solder into drinking water.

The majority of public water utilities are in compliance with the Safe Drinking Water Act Lead and Copper Rule (LCR) of 1991. However, some children are still exposed to lead in drinking water. EPA is reviewing LCR, and additional changes to the rule are expected that will further protect public health.

Childhood lead poisoning prevention programs should be made aware of the results of local public water system lead monitoring measurement under LCR and consider drinking water as a potential cause of increased BLLs, especially when other sources of lead exposure are not identified.

This review describes a selection of peer-reviewed publications on childhood lead poisoning, sources of lead exposure for adults and children, particularly children aged <6 years, and LCR. What is known and unknown about tap water as a source of lead exposure is summarized, and ways that children might be exposed to lead in drinking water are identified.

This report does not provide a comprehensive review of the current scientific literature but builds on other comprehensive reviews, including the *Toxicological Profile for Lead* and the 2005 CDC statement *Preventing Lead Poisoning Among Young Children*). When investigating cases of children with BLLs at or above the reference value established as the 97.5 percentile of the distribution of BLLs in U.S. children aged 1–5 years, drinking water should be considered as a source. The recent recommendations from the CDC Advisory Committee on Childhood Lead Poisoning Prevention to reduce or eliminate lead sources for children before they are exposed underscore the need to reduce lead concentrations in drinking water as much as possible.

## **Background**

Lead is a relatively corrosion-resistant, dense, ductile, and malleable metal that has been used by humans for at least 5,000 years. During this time, lead production has increased from an estimated 10 tons per year to 1,000,000 tons per year, accompanying population and economic growth. The estimated average BLL for Native Americans before European settlement in the Americas was calculated as 0.016  $\mu\text{g}/\text{dL}$ . During 1999–2004, the estimated average BLL was 1.9  $\mu\text{g}/\text{dL}$  for the non-institutionalized population aged 1–5 years in the United States, approximately 100 times higher than ancient background levels, indicating that substantial sources of lead exposure exist in the environment.

## **January 4, 2014**

On January 4, 2014, the "Reduction of Lead in Drinking Water Act" becomes effective nationwide. This amendment to the 1974 Safe Drinking Water Act reduces the allowable lead content of drinking water pipes, pipe fittings and other plumbing fixtures. Specifically, as of January 4, 2014, it shall be illegal to install pipes, pipe fittings, and other plumbing fixtures that are not "lead free." "Lead free" is defined as restricting the permissible levels of lead in the wetted surfaces of pipes, pipe fittings, other plumbing fittings and fixtures to a weighted average of not more than 0.25%.

This new requirement does not apply to pipes, pipe fittings, plumbing fittings or fixtures that are used exclusively for non-potable services such as manufacturing, industrial processing, irrigation, outdoor watering, or any other uses where water is not anticipated to be used for human consumption.

The law also excludes toilets, bidets, urinals, fill valves, flushometer valves, tub fillers, shower valves, service saddles, or water distribution main gate valves that are 2 inches in diameter or larger.

Accordingly, effective January 4, 2014, only accepted products that are "lead free" may be utilized with regards to any plumbing providing water for human consumption (unless meeting the exception outlined above). Installers and inspectors may check their products to determine if they meet these requirements by looking to see if the products are certified to the following standards:

- A. NSF/ANSI 61-G;
- B. NSF/ANSI 61, section 9-G; OR
- C. Both NSF/ANSI 61 AND NSF/ANSI 372.

As existing products may still be utilized for non-potable purposes. The burden of following these requirements shall be on installers. Plumbing inspectors (who will be covering these requirements in continuing education) shall have the right to question installers, who must be able to prove that no non-compliant products are installed on or after January 4, 2014.

#### **What does the law say?**

It reduces the maximum amount of lead that can be used in the wetted surfaces of service brass from 8 percent to 0.25 percent. It prohibits the sale of traditional brass pipe fittings, valves and meters for potable water applications as well as their installation after Jan. 4, 2014.

#### **Does The Reduction of Lead in Drinking Water Act apply to all water infrastructure?**

No. Service brass used in industrial or non-potable infrastructure is exempt from the law. Also, the law only applies to wetted surfaces. Saddles and other exterior pipe are also exempt.

#### **Are there any exceptions to the New Regulations?**

Exceptions to the new lead-free law include: pipes, pipe fittings, plumbing fittings, or fixtures, including backflow preventers, that are used exclusively for non-potable services such as manufacturing, industrial processing, irrigation, outdoor watering, or any other uses where the water is not anticipated to be used for human consumption. In addition, toilets, bidets, urinals, fill valves, flushometer valves, tub fillers, shower valves, service saddles, or water distribution main gate valves that are 2 inches in diameter or larger are excluded from the new lead-free law.

#### **Who does the New Regulations apply to?**

If you use or introduce into commerce any pipe, valves, plumbing fittings or fixtures, solder, or flux intended to convey or dispense water for human consumption, your products must comply with the law. Additionally, if you introduce into commerce solder or flux, your products must comply with the law.

#### **If I am a homeowner, how do I know my water system is lead-free?**

Many manufacturers have already complied with the January 4th, 2014 implementation date of the federal "Reduction of Lead in Drinking Water Act." Even without federal certification requirements regarding the lead content of plumbing products, California's mandate for third-party certification will be followed by most manufacturers seeking a



single approval path that covers both federal and state requirements. For that reason, it is important to use and install only clearly marked low-lead products.

If you are a homeowner and are concerned about potential lead exposure from your private water system, have your water tested by a state certified water testing laboratory in your area.

**Is there a difference between low-lead and no-lead brass?**

No. There are several terms flying around to refer to the low-lead service brass products – no lead, lead free, low lead, and others. They all refer to the same products: service brass with 0.25 percent or less lead on wetter surfaces.

**How are the new alloys different?**

Functionally, there is almost no difference. For water utilities and contractors working with the material, it will handle just like traditional service brass. The difference is in the manufacturing. Lead has traditionally been used to fill gaps, seal the surface and create a smooth pipe interior that doesn't have gaps or pits where debris can settle and erode the metal.

Instead of lead, manufacturers will have to use different and more expensive materials and take more care in the manufacturing process. That means the cost of the new low-lead brass will be 25 to 40 percent higher than traditional brass pipe fittings and meters.

**What are the biggest concerns for developers, municipalities and water districts?**

There are two big concerns that should inspire anyone responsible for laying water infrastructure to act soon. If you have inventory of traditional service brass, now is the time to find a place to use it. Work ahead on projects if you can because that inventory will be wasted if you don't use it before January 2014.

The second concern is cost. If you don't have an inventory of traditional brass but you have upcoming projects, this might be the ideal time to start them. Order traditional brass pipe fittings and meters from suppliers who are offering their traditional service brass at steep discounts ahead of the new law. After the law goes into effect, service brass costs will skyrocket and significantly increase your costs.

**Lead-free Alternatives**

There are several materials that utilities should consider when selecting a lead-free meter alternative. Various options include epoxy coated ductile and cast iron, stainless steel, low lead bronze and composite.

When choosing a lead-free alternative material, utilities must consider traditional meter requirements such as strong flow capability and durability. However, the difference between lead-free and zero lead meters should also be considered. Some "lead-free" meters contain as much as 0.25 percent lead.

While a 0.25 percentage of lead in meters allows utilities to meet current regulations, implementing these "lead-free" meters could put utilities at risk for the cost of another meter change out should future regulations require complete lead elimination from water meters.

Most water meters are expected to last more than 20 years, meaning that the next amendment to SDWA could come before the meter fleet must be replaced. This could be potentially devastating for utility companies still using older systems should completely lead-free meters become mandated.

### **Composite Meters**

Composite meters are one example of a zero lead alternative that is not susceptible to future no-lead regulations. This meter material is also gaining popularity due to its strength and cost stability. Composite meters do not depend on metal pricing fluctuations and, more importantly, have zero lead as opposed to low lead or even bronze meters.

Made of materials that have already proven their strength and durability in the automotive and valve industries, composite meters boast longevity and resistance to corrosion from aggressive water and from the chlorinated chemicals used to make water drinkable. Composite meters are also equipped to withstand the pressure required to maintain a water system.

Composite meters are constructed using a blend of plastic and fiberglass. When compared to bronze water meter products, composites are lighter and require less time and energy to manufacture, ship and install. Composite meters attached with composite threads have been found to eliminate the “friction feeling” typically experienced with metal threads and metal couplings, facilitating easier installation.

Through comprehensive testing, composite meters have demonstrated a burst pressure that is significantly greater than bronze and an equal longevity. Composite technology today allows for better, more environmentally friendly composite products that will last up to 25 years in residential applications. Manufacturers have a wide range of “lead-free” or zero lead products on the market and it is critical that utilities consider all of their options when selecting a new fleet of meters.

Most importantly, everyone deserves access to safe, clean water. It is essential that manufacturers continually develop and deliver products that meet the highest standards for safety, quality, reliability and accuracy to ensure availability to, and conservation of, this most precious resource.

### **Lead in Drinking Water**

Lead is unlikely to be present in source water unless a specific source of contamination exists. However, lead has long been used in the plumbing materials and solder that are in contact with drinking water as it is transported from its source into homes. Lead leaches into tap water through the corrosion of plumbing materials that contain lead. The greater the concentration of lead in drinking water and the greater amount of lead-contaminated drinking water consumed, the greater the exposure to lead. In children, lead in drinking water has been associated both with BLLs  $\geq 10 \mu\text{g/dL}$  as well as levels that are higher than the U.S. GM level for children ( $1.4 \mu\text{g/dL}$ ) but are  $< 10 \mu\text{g/dL}$ .

### **History of Studies on Lead in Water**

In 1793, the Duke of Württemberg, Germany, warned against the use of lead in drinking water pipes, and in 1878, lead pipes were outlawed in the area as a result of concerns about the adverse health effects of lead in water. In the United States, the adverse health consequences of lead-contaminated water were recognized as early as 1845.

A survey conducted in 1924 in the United States indicated that lead service lines were more prevalent in New England, the Midwest, Montana, New York, Oklahoma, and Texas.

A nationwide survey conducted in 1990 indicated that 3.3 million lead service lines were in use, and the areas where they were most likely to be used were, again, the Midwestern and northeastern regions of the United States. This survey also estimated that approximately 61,000 lead service lines had been removed through voluntary programs during the previous 10 years.

Research on exposure to lead in water increased as concern about the topic increased, and efforts were made to establish a level of lead in water that, at the time of the studies, was considered acceptable. A 1972 study in Edinburgh, Scotland, obtained 949 first-flush water samples (i.e., samples of water from the tap that have been standing in the plumbing pipes for at least 6 hours) matched with 949 BLLs, as well as 205 running water samples matched to 205 BLLs. No dose-response relationship could be determined when comparing BLLs with four levels of lead in both first-flush water and in running water ( $<0.24 \mu\text{mol/L}$ ;  $0.24\text{--}0.47 \mu\text{mol/L}$ ;  $0.48\text{--}1.43 \mu\text{mol/L}$ ; and  $\geq 1.44 \mu\text{mol/L}$ ).

The study concluded that the findings challenged whether it was necessary to lower the water lead concentration to  $<100 \text{ ppb}$ , which at that time was the acceptable concentration established by the World Health Organization. However, the study also reported that low levels of environmental lead exposure could have adverse health effects; therefore, knowing the degree of lead exposure from household water relative to other sources is important. Another study, in 1976, of 129 randomly selected homes in Caernarvonshire, England, reported a similar finding, describing the relationship between blood and water lead as slight.

### **Monitoring and Reporting**

To ensure that drinking water supplied by **all** public water supply systems as defined by the EPA meet Federal and State requirements, water system operators are required to collect samples regularly and have the water tested. The regulations specify minimum sampling frequencies, sampling locations, testing procedures, methods of keeping records, and frequency of reporting to the State. The regulations also mandate special reporting procedures to be followed if a contaminant exceeds an MCL.

All systems must provide periodic monitoring for microbiological contaminants and some chemical contaminants. The frequency of sampling and the chemicals that must be tested for depend on the physical size of the water system, the water source, and the history of analyses. General sampling procedures are covered in more detail under the topic of Public Health Considerations to follow.

State policies vary on providing laboratory services. Some States have laboratory facilities available to perform all required analyses or, in some cases, a certain number of the required analyses for a system. In most States, there is a charge for all or some of the laboratory services. Sample analyses that are required and cannot be performed by a State laboratory must be taken or sent to a State-certified private laboratory.

If the analysis of a sample exceeds an MCL, resampling is required, and the State should be contacted immediately for special instructions. There is always the possibility that such a sample was caused by a sampling or laboratory error, but it must be handled as though it actually was caused by contamination of the water supply.

The results of all water analyses must be periodically sent to the State of origin. Failure to have the required analysis performed or to report the results to the State usually will result in the water system being required to provide PN. States typically have special forms for submitting data, and specify a number of days following the end of the monitoring period by which the form is due.

### **General Disinfection Requirements**

Disinfection is absolutely required for all water systems using surface water sources. Various chemicals other than chlorine can be used for treatment of surface water, but as the water enters the distribution system, it must carry a continuous chlorine residual that will be retained throughout the distribution system. Water samples from points on the distribution system must be analyzed periodically to make sure an adequate chlorine residual is being maintained.

In spite of the fact that use of chlorine has almost completely eliminated occurrences of waterborne diseases in the United States, there is no concern for byproducts formed when chlorine reacts with naturally occurring substances in raw water (such as decaying vegetation containing humic and fulvic acids). The first group of byproduct chemicals identified was tri-halo-methane (THM), a group of organic chemicals that are known carcinogens (cancer-forming) to some animals, so they are assumed also to be carcinogenic to humans. Other byproducts of disinfection have been identified that may be harmful, and there also is concern now that disinfectants themselves may cause some adverse health reactions.

### **Consumer Confidence Reports**

One of the very significant provisions of the 1996 SDWA amendments is the consumer confidence report (CCR) requirement. The purpose of the CCR is to provide all water customers with basic facts regarding their drinking water so that individuals can make decisions about water consumption based on their personal health. This directive has been likened to the requirement that packaged food companies disclose what is in their food product.

The reports must be prepared yearly by every community water supply system. Water systems serving more than 10,000 people must mail the report to customers. Small systems must notify customers as directed by the State primacy agency. Beginning in the year 2000, reports were to be delivered by July 1 of the calendar year.

A water system that only distributes purchased water (i.e., a satellite system) must prepare the report for their consumers. Information on the source water and chemical analyses must be furnished to the satellite system by the system selling the water (parent company).

| FACTOR  | TYPE       | SOURCE(S)  | PROBLEM  |
|---|------------|--|--|
| FECAL COLIFORM BACTERIA                       | BIOLOGICAL | HUMAN SEWAGE;<br>LIVESTOCK WASTE                 | POSSIBLE PRESENCE OF PATHOGENIC (DISEASE-CAUSING) ORGANISMS                                  |
| DISSOLVED OXYGEN (DO)                         | CHEMICAL   | AIR;<br>AQUATIC PLANTS                           | LOW LEVELS CAN KILL AQUATIC ORGANISMS  |
| NITROGEN AND PHOSPHORUS                       | CHEMICAL   | FERTILIZERS AND DETERGENTS FROM LAWNS AND RUNOFF | EXCESSIVE ALGAE GROWTH CAN LEAD TO LOW DO  |
| ZINC, ARSENIC, LEAD, MERCURY, CADMIUM, NICKEL | CHEMICAL   | LANDFILLS; INDUSTRIAL DISCHARGES; RUNOFF         | GENETIC MUTATIONS OR DEATH IN FISH & WILDLIFE (HUMAN HEALTH THREATS AS WELL)                 |
| SALT  | CHEMICAL   | SALTWATER INTRUSION (IF NEAR OCEAN)              | KILLS FRESHWATER SPECIES OF PLANTS AND ANIMALS   |
| MUD, SAND, OTHER SOLID PARTICLES (TURBIDITY)  | PHYSICAL   | EROSION AND RUNOFF FROM DEVELOPMENT; AGRICULTURE | REDUCES PHOTOSYNTHESIS IN AQUATIC VEGETATION; INTERFERES WITH RESPIRATION IN AQUATIC ANIMALS |

## WATER QUALITY FACTORS

| DISINFECTION OF WATER                        |  |
|--|--|
| DISINFECTANT                                 | WHAT DISINFECTANT IS USED FOR  |
| OZONE (O <sub>3</sub> )                      | USED IN DESTROYING BACTERIA, ODORS AND VIRUSES (Scrambles DNA in Viruses to prevent reproduction)              |
| CHLORINE (Cl <sub>2</sub> )                  | USED TO KILL DISEASE-CAUSING PATHOGENS SUCH AS BACTERIA, VIRUSES AND PROTOZOANS                                |
| POTASSIUM PERMANGANATE (KMnO <sub>4</sub> )  | USED TO REMOVE IRON AND HYDROGEN SULFIDE, AND ALSO USED IN TREATMENT PLANTS TO CONTROL ZEBRA MUSSEL FORMATIONS |
| COPPER SULFATE (CuSO <sub>4</sub> )          | USED CONTROL PLANT AND ALGAE GROWTH  |
| CALCIUM HYPOCHLORITE (Ca(ClO) <sub>2</sub> ) | DESTROYS DISEASE-CAUSING ORGANISMS INCLUDING BACTERIA, YEAST, FUNGUS, SPORES AND VIRUSES                       |
| CALCIUM HYDROXIDE (Lime) (CaO)               | USED FOR pH CONTROL IN WATER TREATMENT TO PREVENT CORROSION OF PIPING  |

## TYPES OF DISINFECTION FOR WATER TREATMENT

## Distribution System Water Quality Problems

### Turbidity

Turbidity is caused by particles suspended in water. These particles scatter or reflect light rays, making the water appear cloudy. Turbidity is expressed in nephelometric turbidity units (ntu) and a reading in excess of 5 ntu is generally noticeable to water system customers.

Besides the appearance being unpleasant to customers, turbidity in water is significant from a public health standpoint because suspended particles could shelter micro-organisms from the disinfectant and allow them to still be viable when they reach the customer.

EPA regulations direct that, for most water systems, the turbidity of water entering the distribution system must be equal or less than 0.5 ntu in at least 95 percent of the measurements taken each month. At no time may the turbidity exceed 5 ntu.

Turbidity changes in the distribution system can indicate developing problems. Increases in turbidity may be caused by changes in velocity or inadequate flushing following main replacement.



### Hardness

Hardness is a measure of the concentration of calcium and magnesium in water. Water hardness usually comes from water contacting rock formations, such as water from wells in limestone formations. Soft ground water may occur where topsoil is thin and limestone formations are sparse or absent. Most surface water is of medium hardness.

Hard and soft water are both satisfactory for human consumption, but customers may object to very hard water because of the scale it forms in plumbing fixtures and on cooking utensils. Hardness is also a problem for some industrial and commercial users because of scale buildup in boilers and other equipment.

Water generally is considered most satisfactory for household use when the hardness is between 75 and 100 mg/L as calcium carbonate ( $\text{CaCO}_3$ ). Water with 300 mg/L of hardness usually is considered **hard**. Very soft water of 30 mg/L or less is found in some section of the United States. Soft water usually is quite corrosive, and may have to be treated to reduce the corrosivity.

## Iron

Iron occurs naturally in rocks and soils and is one of the most abundant elements. It occurs in two forms. Ferrous iron (Fe<sup>2+</sup>) is in a dissolved state, and water containing ferrous iron is colorless. Ferric iron (Fe<sup>3+</sup>) has been oxidized, and water containing it is rust-colored. Water from some well sources contains significant levels of dissolved iron, which is colorless, but rapidly turns brown as air reaches the water and oxidizes the iron.

There are no known harmful effects to humans from drinking water containing iron, but NSDWR suggest a limit of 0.5 mg/L. At high levels, the staining of plumbing fixtures and clothing becomes objectionable. Iron also provides nutrient source for some bacteria that grow in distribution systems and wells. Iron bacteria, such as *Gallionella*, cause red water, tastes and odors, clogged pipes, and pump failure.

Whenever tests on water samples show increased iron concentrations between the point where water enters the distribution system and the consumer's tap, either corrosion, iron bacteria, or both are probably taking place. If the problem is caused by bacteria, flushing mains, shock chlorination, and carrying increased residual chlorine are alternatives to consider.

## Manganese

Manganese in ground water creates problems similar to iron. It does not usually discolor the water, but will stain washed clothes and plumbing fixtures black; this is very unpopular with customers. Consumption of manganese has no known harmful effects on humans, but the NSDWR recommend a concentration not to exceed 0.05 mg/L to avoid customer complaints.

## Water Quality Safeguards

The **critical** safeguard for water distribution system operations are

- continuous positive pressure in the mains; 20 pounds per square inch (psi) minimum residual pressure is recommended;
- maintenance of chlorine residual;
- cross-connection control; and
- frequent testing.

## References

*Water Supply Systems• Vol. II: Evaluation Methods October 2008 FEMA U.S. Fire Administration Harry E. Hickey, Ph.D.*

*EPA Office of Water (4601M), Office of Ground Water and Drinking Water, Distribution System Issue Paper, Finished Water Storage Facilities*



## Storage Water Quality Problems



### **Turbidity**

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Besides the appearance being unpleasant to customers, turbidity in water is significant from a public health standpoint because suspended particles could shelter micro-organisms from the disinfectant and allow them to still be viable when they reach the customer.

EPA regulations direct that, for most water systems, the turbidity of water entering the distribution system must be equal or less than 0.5 ntu in at least 95 percent of the measurements taken each month. At no time may the turbidity exceed 5 ntu.

Turbidity changes in the distribution system can indicate developing problems. Increases in turbidity may be caused by changes in velocity or inadequate flushing following main replacement.

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There are no known harmful effects to humans from drinking water containing iron, but NSDWR suggest a limit of 0.5 mg/L. At high levels, the staining of plumbing fixtures and clothing becomes objectionable.

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Whenever tests on water samples show increased iron concentrations between the point where water enters the distribution system and the consumer's tap, either corrosion, iron bacteria, or both are probably taking place. If the problem is caused by bacteria, flushing mains, shock chlorination, and carrying increased residual chlorine are alternatives to consider.

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## Water Quality Safeguards



The **critical** safeguard for water distribution system operations are

- continuous positive pressure in the mains; 20 pounds per square inch (psi) minimum residual pressure is recommended;
- maintenance of chlorine residual;
- cross-connection control; and
- frequent testing.

Continuous positive pressure as recommended above is absolutely necessary to prevent backsiphonage and the entry of contaminants into the water system. This can be achieved primarily by maintaining an adequate water supply and storage capable of meeting peak water demands. If water demands are so great during peak demand periods that pressure declines in parts of the systems, either water use must be restricted or the water system must be upgraded to be capable of supplying more water.

System pressure also may be reduced during a main break because of the large amount of escaping water. The best safeguards against having serious pressure loss during a main break are to have adequate system storage and to be well-organized to shut down the leaking section of water main swiftly. The latter involves having personnel on call at all time to respond to emergencies, knowing where all the valves are, and having a valve exercise program so that valves are sure to operate when needed.

The ultimate proof of the bacteriological safety of the water in the distribution system comes through frequent sampling. Samples collected to meet State requirements should be considered a minimum. Additional samples should be collected following construction and repair work as well as in response to customer complaints that could be the result of water system contamination. A distribution system can become contaminated from an outside source by accident or intention in the framework of the world climate today. Contamination problems need to be identified and appropriate action taken immediately after detection.

The design and evaluation of municipal water supply systems is based on both theoretical and applied hydraulics. Hydraulics is the branch of science that defines the mathematical laws of liquids at rest and in motion. This text material is confined to fundamental principles and what is generally referred to as **applied hydraulics**.

These fundamentals are essential for understanding many of the considerations involved in the design of a municipal water supply system, the periodic testing of water systems, and the proper evaluation of water systems to assess a given community's water supply with respect to providing adequate water supplies.

A municipal water supply system has the objective of providing an adequate and reliable water supply to meet the following demands:

- residential occupancy water consumption;
- commercial occupancy water consumption;
- industrial occupancy consumption;
- municipal and educational building use;
- Needed Fire Flows (NFFs) that are available from a planned location of fire hydrants throughout the municipality; and
- water for special community needs that include parks and recreation, street cleaning, decorative water fountains, sale of water to contractors through metered water from fire hydrants, etc.

The primary objective of the following material is to present the fundamental concept of hydraulics applied to municipal water systems, in order for municipal officials and fire officials to better understand the design and evaluation of public-sector water delivery systems.

Some fundamental hydraulic problems are provided to establish principles used to meet the above objective. A number of tables and charts are provided for future reference by the user of this material in actually working with a specific water supply system.

## **Reference**

*EPA Office of Water (4601M), Office of Ground Water and Drinking Water, Distribution System Issue Paper, Finished Water Storage Facilities*

*Water Supply Systems• Vol. II: Evaluation Methods October 2008 FEMA U.S. Fire Administration Harry E. Hickey, Ph.D.*

# Water Treatment System

Your heart and lungs play a vital role in keeping you alive. If you don't take care of your body and how your blood circulates, you will die. Our body works very similar to the water system we operate. Our lungs clean the blood exchanging carbon dioxide with oxygen; our water treatment plant treats the water by taking impurities out. Our heart pumps the blood to our lungs and out to other vital organs; our water pump stations deliver the water to our systems and to the customers.

What happens if our arteries become clogged and damaged or we lose circulation? The blood flow will no longer make its way back to the lungs or the lungs will no longer be able to send the purified blood to the vital organs. The same can happen if we have problems with our water transmission lines or distribution lines.

## Water Treatment Basics

Water is a powerful solvent that is capable of dissolving almost everything it comes in contact with. For instance, water can pick up harmless minerals from the earth, such as calcium, magnesium, carbonates and sulfates. These give the water a pleasing taste as well as beneficial health qualities. This is also because water utilities across the country have in place effective processes to remove contaminants that cause waterborne diseases. The most commonly used processes include filtration, flocculation and sedimentation, and disinfection.

## Flocculation/Sedimentation

The flocculation process coagulates (joins together) particles with alum and metal salts so that they settle out of the water as sediment. Sedimentation is simply a gravity process that removes flocculated particles from the water.

## Filtration

Filtration removes remaining particles from the water supply. Those particles may include silt, natural organic matter, iron and manganese, and microorganisms. Filtration clarifies water and improves the effectiveness of disinfection.

## Disinfection (Chlorination, Ozonation)

Water is then disinfected to ensure that dangerous microbes are killed. Chlorine-based disinfectants or ozone are used because they are very effective. Chlorine-based disinfectants also provide residual protection against biological contamination in the water distribution system. This is a critical step to assure our water is safe all the way to the consumer's tap.



## Groundwater and Wells

A well can be easily contaminated if it is not properly constructed or if toxic materials are released into the well. Toxic material spilled or dumped near a well can leach into the aquifer and contaminate the groundwater drawn from that well.



## Contaminated Wells

Contaminated wells used for drinking water are especially dangerous. Wells can be tested to see what chemicals may be in the well and if they are present in dangerous quantities.

Groundwater is withdrawn from wells to provide water for everything from drinking water for the home and business to water to irrigate crops to industrial processing water. When water is pumped from the ground, the dynamics of groundwater flow change in response to this withdrawal. Groundwater flows slowly through water-bearing formations (aquifers) at different rates. In some places, where groundwater has dissolved limestone to form caverns and large openings, its rate of flow can be relatively fast but this is exceptional.



Well with a mineral oil sealed vertical turbine pump.

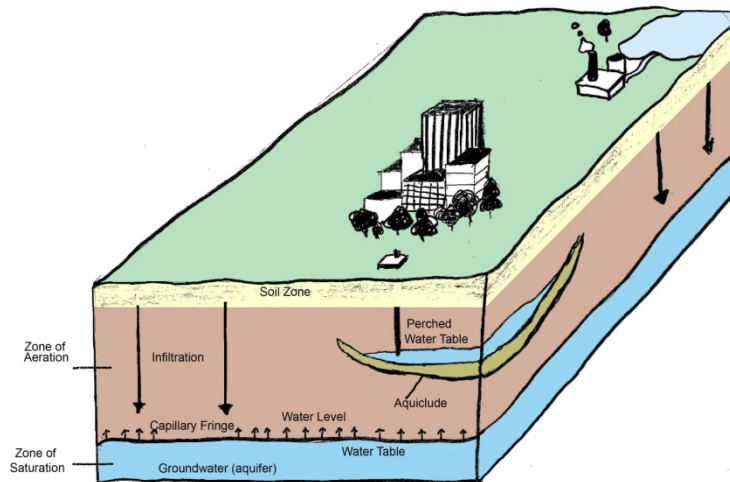
## Aquifer

Many terms are used to describe the nature and extent of the groundwater resource. The level below which all the spaces are filled with water is called the *water table*. Above the water table lies the *unsaturated zone*. Here the spaces in the rock and soil contain both air and water. Water in this zone is called *soil moisture*. The entire region below the water table is called the *saturated zone* and water in this saturated zone is called *groundwater*.

*Fractured aquifers* are cracks, joints, or fractures in solid rock, through which groundwater moves. Examples of fractured aquifers include granite and basalt. Limestones are often fractured aquifers, but here the cracks and fractures may be enlarged by solution, forming large channels or even caverns. Limestone terrain where solution has been very active is termed *karst*.

Porous media such as sandstone may become so highly cemented or recrystallized that all of the original space is filled. In this case, the rock is no longer a porous medium.

However, if it contains cracks it can still act as a fractured aquifer. Most of the aquifers of importance to us are unconsolidated porous media such as sand and gravel. Some very porous materials are not permeable. Clay, for instance, has many spaces between its grains, but the spaces are not large enough to permit free movement of water.



Groundwater usually flows downhill with the slope of the water table. Like surface water, groundwater flows toward, and eventually drains into, streams, rivers, lakes and the oceans.

Groundwater flow in the aquifers underlying springs or surface drainage basins, however, does not always mirror the flow of water on the surface.

Therefore, groundwater may move in different directions below the ground than the water flowing on the surface.



Vertical Turbine Well



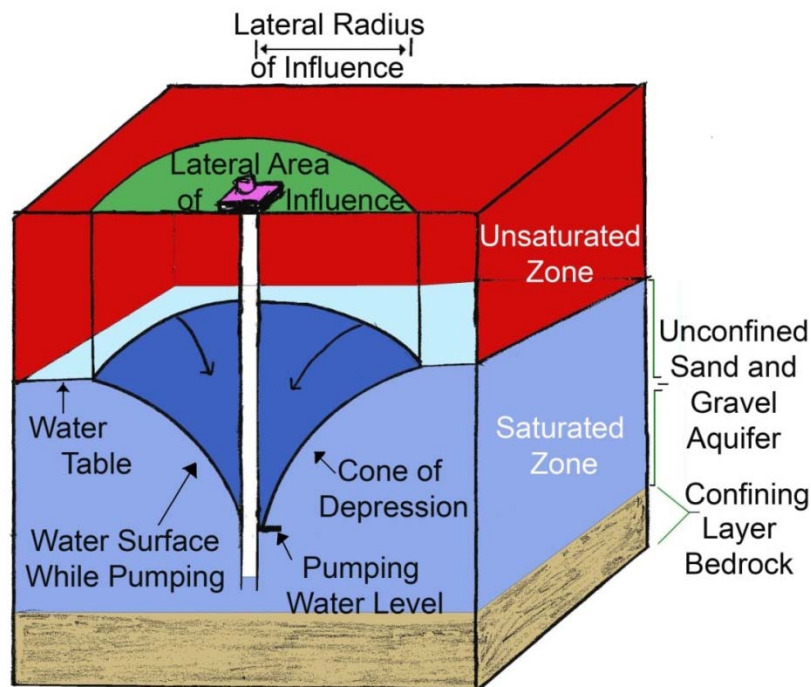
*Unconfined aquifers* are those that are bounded by the water table. Some aquifers, however, lie beneath layers of impermeable materials. These are called *confined aquifers*, or some-times *artesian aquifers*. A well in such an aquifer is called an *artesian well*. The water in these wells rises higher than the top of the aquifer because of confining pressure. If the water level rises above the ground surface a *flowing artesian well* occurs.

The *piezometric surface* is the level to which the water in an artesian aquifer will rise.

## Cone of Depression

When pumping begins, water begins to flow towards the well in contrast to the natural direction of groundwater movement. The water level in the well falls below the water table in the surrounding aquifer.

As a result, water begins to move from the aquifer into the well. As pumping continues, the water level in the well continues to increase until the rate of flow into the well equals the rate of withdrawal from pumping. The movement of water from an aquifer into a well results in the formation of a cone of depression. The cone of depression describes a three-dimensional inverted cone surrounding the well that represents the volume of water removed as a result of pumping. Drawdown is the vertical drop in the height between the water level in the well prior to pumping and the water level in the well during pumping.



When a well is installed in an unconfined aquifer, water moves from the aquifer into the well through small holes or slits in the well casing or, in some types of wells, through the open bottom of the well. The level of the water in the well is the same as the water level in the aquifer. Groundwater continues to flow through and around the well in one direction in response to gravity.



## Common Water Quality Definitions

### Units of Measurement

**mg/l** = Milligrams per liter. One milligram per liter equals one packet of artificial sweetener sprinkled into 250 gallons of iced tea.

**µg/l** = Micrograms per liter. One microgram per liter is equal to one packet of artificial sweetener sprinkled into an Olympic-size swimming pool.

**NTU** = Nephelometric Turbidity Units. A measurement on the cloudiness of the water.

**pCi/l** = Picocuries per liter. A measure of radioactivity.

### Acronyms

**Maximum Contaminant Level (MCL)** - The highest level of a contaminant that is allowed in drinking water.

**Maximum Contaminant Level Goal (MCLG)** - The level of a contaminant in drinking water below which there is no known or expected risk to health.

**Treatment Technique (TT)** - A required process intended to reduce the level of a contaminant in drinking water.

**Action Level (AL)** - The concentration of a contaminant that, if exceeded, triggers treatment or other requirements which a water system must follow.

## Timeline of Existing Federal Water and State Drinking Water Quality Regulations



**National Interim Primary Drinking Water Regulations (NIPDWR)** Promulgated 1975-1981 Contained 7 contaminants Targeted: Trihalomethanes, Arsenic, and Radionuclides Established 22 drinking water standards.

**Phase 1 Standards** Promulgated 1987 Contained 8 contaminants Targeted: VOCs.

**Phase 2 Standards** Promulgated 1991 Contained 36 contaminants Targeted: VOCs, SOC's, and IOC's.

**Phase 5 Standards** Promulgated 1992 Contained 23 contaminants Targeted: VOCs, SOC's, and IOC's.

**Surface Water Treatment Rule (SWTR)** Promulgated 1989 Contained 5 contaminants Targeted: Microbiological and Turbidity.

**Stage 1 Disinfectant/Disinfection By-product (D/DBP) Rule** Promulgated 1998 Contained 14 contaminants Targeted: DBPs and precursors.

**Interim Enhanced Surface Water Treatment Rule (IESWTR)** Promulgated 1998 Contained 2 contaminants Targeted: Microbiological and Turbidity.

**Radionuclide Rule** Promulgated 2000 Contained 4 contaminants Targeted: Radionuclides.

**Arsenic Rule** Promulgated 2001 Contained 1 contaminant Targeted: Arsenic.

**Filter Backwash Recycling Rule** Promulgated 2001 Contained - Targeted: Microbiological and Turbidity.

# Water Sampling Terms, and Definitions

## Microbes

**Coliform bacteria** are common in the environment and are generally not harmful. However, the presence of these bacteria in drinking water is usually a result of a problem with the treatment system or the pipes which distribute water, and indicates that the water may be contaminated with germs that can cause disease.

**Fecal Coliform and E. coli** are bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Microbes in these wastes can cause short-term effects, such as diarrhea, cramps, nausea, headaches, or other symptoms.

**Turbidity** has no health effects. However, turbidity can interfere with disinfection and provide a medium for microbial growth. Turbidity may indicate the presence of disease causing organisms. These organisms include bacteria, viruses, and parasites that can cause symptoms such as nausea, cramps, diarrhea, and associated headaches.

**Cryptosporidium** is a parasite that enters lakes and rivers through sewage and animal waste. It causes cryptosporidiosis, a mild gastrointestinal disease. However, the disease can be severe or fatal for people with severely weakened immune systems. The EPA and the CDC have prepared advice for those with severely compromised immune systems who are concerned about *Cryptosporidium*.

**Giardia lamblia** is a parasite that enters lakes and rivers through sewage and animal waste. It causes gastrointestinal illness (e.g. diarrhea, vomiting, and cramps).

## Radionuclides

**Alpha emitters.** Certain minerals are radioactive and may emit a form of radiation known as alpha radiation. Some people who drink water containing alpha emitters in excess of the EPA standard over many years may have an increased risk of getting cancer.

**Beta/photon emitters.** Certain minerals are radioactive and may emit forms of radiation known as photons and beta radiation. Some people who drink water containing beta and photon emitters in excess of the EPA standard over many years may have an increased risk of getting cancer.

**Combined Radium 226/228.** Some people who drink water containing radium 226 or 228 in excess of EPA standard over many years may have an increased risk of getting cancer.

**Radon** gas can dissolve and accumulate in underground water sources, such as wells, and in the air in your home. Breathing radon can cause lung cancer. Drinking water containing radon presents a risk of developing cancer. Radon in air is more dangerous than radon in water.

## Inorganic Contaminants

Antimony  
Asbestos  
Barium  
Beryllium

Cadmium  
Chromium  
Copper

Cyanide  
Mercury  
Nitrate

Nitrite  
Selenium  
Thallium

**Arsenic.** Some people who drink water containing arsenic in excess of the EPA standard over many years could experience skin damage or problems with their circulatory system, and may have an increased risk of getting cancer.

**Fluoride.** Many communities add fluoride to their drinking water to promote dental health. Each community makes its own decision about whether or not to add fluoride. The EPA has set an enforceable drinking water standard for fluoride of 4 mg/L (some people who drink water containing fluoride in excess of this level over many years could get bone disease, including pain and tenderness of the bones). The EPA has also set a secondary fluoride standard of 2 mg/L to protect against dental fluorosis. Dental fluorosis, in its moderate or severe forms, may result in a brown staining and/or pitting of the permanent teeth. This problem occurs only in developing teeth, before they erupt from the gums. Children under nine should not drink water that has more than 2 mg/L of fluoride.

**Lead** typically leaches into water from plumbing in older buildings. Lead pipes and plumbing fittings have been banned since August 1998. Children and pregnant women are most susceptible to lead health risks. For advice on avoiding lead, see the EPA's "*Lead in Your Drinking Water*" fact sheet.

***Synthetic Organic Contaminants, including pesticides & herbicides***

|                           |                       |                                  |
|---------------------------|-----------------------|----------------------------------|
| 2,4-D                     | Dibromochloropropane  | Hexachlorobenzene                |
| 2,4,5-TP (Silvex)         | Dinoseb               | Hexachlorocyclopentadiene        |
| Acrylamide                | Dioxin (2,3,7,8-TCDD) | Lindane                          |
| Alachlor                  | Diquat                | Methoxychlor                     |
| Atrazine                  | Endothall             | Oxamyl [Vydate]                  |
| Benzoapyrene              | Endrin                | PCBs [Polychlorinated biphenyls] |
| Carbofuran                | Epichlorohydrin       | Pentachlorophenol                |
| Chlordane                 | Ethylene dibromide    | Picloram                         |
| Dalapon                   | Glyphosate            | Simazine                         |
| Di 2-ethylhexyl adipate   | Heptachlor            | Toxaphene                        |
| Di 2-ethylhexyl phthalate | Heptachlor epoxide    |                                  |

***Volatile Organic Contaminants***

|                          |                            |                        |
|--------------------------|----------------------------|------------------------|
| Benzene                  | trans-1,2-Dichloroethylene | 1,2,4-Trichlorobenzene |
| Carbon Tetrachloride     | Dichloromethane            | 1,1,1,-Trichloroethane |
| Chlorobenzene            | 1,2-Dichloroethane         | 1,1,2-Trichloroethane  |
| o-Dichlorobenzene        | 1,2-Dichloropropane        | Trichloroethylene      |
| p-Dichlorobenzene        | Ethylbenzene               | Toluene                |
| 1,1-Dichloroethylene     | Styrene                    | Vinyl Chloride         |
| cis-1,2-Dichloroethylene | Tetrachloroethylene        | Xylenes                |

**Point-of-Entry P.O.E.** will usually be a designated sampling point on a water treatment or distribution system.

## Examples of Water Sampling Letters and Forms

January 13, 2017

Wyatt Curtiss  
1718 West Van Buren Street  
Sunflower, AZ 85007

Dear Mr. Curtiss:

The City of Sunflower initially responded to your water quality concerns on May 19, 2015. We found insufficient chlorine in the drinking water at your business. We proceeded to flush and redirect the water in your area.

We resampled your area on two additional dates:

| Address               | May 28, 2011    |     | July 25, 2011   |     |
|-----------------------|-----------------|-----|-----------------|-----|
|                       | Chlorine (mg/L) | CFU | Chlorine (mg/L) | CFU |
| 310 N. 17th Professor | 0.3             | 780 | 0.8             | <1  |
| 1708 W. Van Buren St. | 0.2             | 305 | 0.6             | 8   |

Currently our results indicate good conditions in your area. According to our testing method, a CFU (Colony Forming Units) count of bacteria below 500 is considered adequately disinfected (passing). Other evidence of good water quality is the absence of Total Coliform and the *Escherichia coli* bacteria. This is indicated by the "-" (negative) results in the "Total Coliform" and the "E. Coli" columns of the Bacteriological Analysis Form.

Quality control is documented on the bottom of the Bacteriological Analysis Form. The results are normal and indicate that the incubator was kept at the correct temperature and that we were looking for the correct organisms.

All tests indicate that the drinking water being provided is safe. Should you have any questions regarding drinking water quality in the City of Sunflower, please contact me at 474-8888. Our office hours are 8:00 a.m. to 5:00 p.m., Monday through Friday.

Sincerely,

Bill Fields  
Water Quality Inspector

<DATE>

<NAME>

<ADDRESS>

Dear <NAME>:

Thank you for collecting drinking water samples from your home for the City of Sunflower's Lead and Copper monitoring program. You will be receiving the test results soon -- if you haven't received them already.

Our tests show there is essentially no lead or copper in water coming to you from our water treatment plants. But we also need to know if our drinking water leaches lead or copper from your household plumbing. The only way we can learn this information is to analyze samples from inside your home.

Thanks again for your help. With the information we gain we can do an even better job of making sure your tap water meets all federal and state health and safety regulations.

Sincerely,

Chris Mitchell  
Mayor



June 11, 2019

Mr. Doc Curtiss  
1008 East Northern Avenue  
Sunflower, Arizona 85020

Dear Mr. Curtiss:

The City of Sunflower responded to your water quality concerns on 11/27/19. We collected a bacteriological sample and checked the chlorine level at your home. The results are recorded on our worksheet, the Bacteriological Analysis Form, and are attached to this letter.

Our results indicate excellent conditions with 10 Colony Forming Units (CFU) per site. According to our testing method, a CFU count below 500 is considered adequately disinfected (passing). Other evidence of good water quality is the absence of Total Coliform and the Escherichia Coli bacteria. This is indicated by the "-" (negative) results in the Total Coliform and the E. Coli columns of the Bacteriological Analysis Form.

Quality control is documented on the bottom of the Bacteriological Analysis Form. The results are normal and indicate that the incubator was kept at the correct temperature and that we were looking for the correct organisms.

The chlorine level was checked at the same sampling site. The chlorine level was adequate with a reading of 0.7 mg/L.

All tests indicate that the drinking water being provided is safe. Should you have any questions, please contact me at 232-9508. Our office hours are 8:00 a.m. to 5:00 p.m., Monday through Friday.

Sincerely,

Bill Fields  
Water Quality Inspector

## **Facts About Water Taste and Odor *Customer Letter Example***

Musty or earthy odors are something common to water systems that use surface water (rivers, streams and lakes) as a source of their drinking water. These odors are natural and are usually the result of algae growth. The growth is most common when air and water temperatures begin to drop in the fall as a result of changes in the weather. A certain temperature range makes algae grow more quickly in the surface water. The odor may occur intermittently through January.

Some people find the odor objectionable and/or a nuisance, but it represents no health hazard. The odor affects only the aesthetic quality of the water.

The Water Services Department treats water at treatment plants to ensure it meets all health and safety standards. We add chlorine to the water to protect against harmful organisms. The department regularly tests the drinking water for about 150 different compounds.

If you experience a musty odor in the water you drink, try the following:

- First, fill a water bottle and leave it uncapped on the counter for 30 to 60 minutes.
- Then, refrigerate the water for a few hours.
- If there still is some odor, try running the tap for 15 to 30 seconds before filling the water jug.
- Finally, inexpensive carbon filters can be added at the faucet to help eliminate the odors. However, remember to follow directions concerning maintenance such as cleaning or replacing the filter.

During seasonal changes, our water often contains 10-15 parts per trillion of the natural compound that creates the musty odor. Some people can detect the odor when there is as little as five parts per trillion in the water. For purposes of comparison, five parts per trillion is comparable to five seconds in 32,000 years.

Remember, the odor is seasonal and is not a health hazard. It usually occurs in the fall and disappears sometime during the winter.

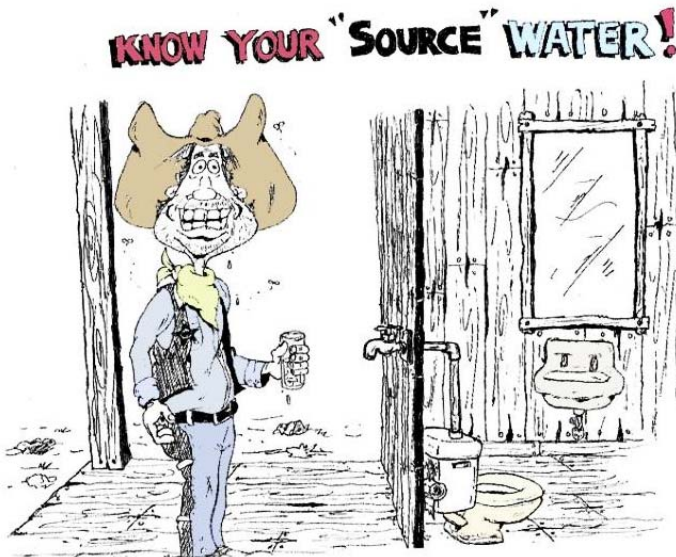
## Troubleshooting Table for Sampling Monitoring

### Problem

1. Positive Total Coliform.
2. Chlorine taste and odor.
3. Inability to maintain an adequately free chlorine residual at the furthest points of the distribution system or at dead end lines.

### Possible Cause

- 1A. Improper sampling technique.
- 1B. Contamination entering distribution system.
- 1C. Inadequate chlorine residual at the sampling site.
- 1D. Growth of biofilm in the distribution system.
- 2A. High total chlorine residual and low free residual.
- 3A. Inadequate chlorine dose at treatment plant.
- 3B. Problems with chlorine feed equipment.
- 3C. Ineffective distribution system flushing program.
- 3D. Growth of biofilm in the distribution system.



### Possible Solution

- 1A/ Check distribution system for low pressure conditions, possibly due to line breaks or excessive flows that may result in a backflow problem.
- 1B. Insure that all staff are properly trained in sampling and transport procedures as described in the TCR.
- 1C. Check the operation of the chlorination feed system. Refer to issues described in the sections on pumps and hypochlorination systems. Insure that residual test is being performed properly.
- 1D. Thoroughly flush effected areas of the distribution system. Superchlorination may be necessary in severe cases.
- 2A. The free residual should be at least 85% of the total residual. Increase the chlorine dose rate to get past the breakpoint in order to destroy some of the combined residual that causes taste and odor problems. Additional system flushing may also be required.
- 3A. Increase chlorine feed rate at point of application.
- 3B. Check operation of chlorination equipment.
- 3C. Review distribution system flushing program and implement improvements to address areas of inadequate chlorine residual.
- 3D. Increase flushing in area of biofilm problem.

**Health advisories** provide additional information on certain contaminants. Health advisories are guidance values based on health effects other than cancer. These values are set for different durations of exposure (e.g., one-day, ten-day, longer-term, and lifetime).

|               |                                     | MICROBIOLOGICAL SAFETY | CHEMICAL SAFETY | CUSTOMER AESTHETICS | EASE OF MONITORING | ABILITY TO TREAT DIFFICULT WATER | COST OF OPERATING | CAPITAL COSTS | STATE OF COMMERCIAL DEVELOPMENT | SCALE-UP | WASTE PRODUCTION AND ENERGY USE | RELIABILITY |
|---------------|-------------------------------------|------------------------|-----------------|---------------------|--------------------|----------------------------------|-------------------|---------------|---------------------------------|----------|---------------------------------|-------------|
| GROUNDWATER   | CHLORINE                            | —                      | —               | —                   | +                  | +                                | +                 | +             | +                               | +        | +                               | —           |
|               | UF ONLY                             | —                      | +               | +                   | —                  | +                                | ●                 | ●             | —                               | —        | ●                               | —           |
|               | UV ONLY                             | +                      | +               | +                   | ●                  | +                                | +                 | ●             | +                               | +        | ●                               | ●           |
|               | Alternate + Residual (1)            | +                      | ●               | ●                   | +                  | +                                | ●                 | —             | +                               | +        | +                               | +           |
| SURFACE WATER | CHLORINE ONLY                       | —                      | —               | —                   | +                  | —                                | +                 | +             | +                               | +        | +                               | +           |
|               | Conventional pre-treat + CHLORINE   | +                      | —               | —                   | +                  | —                                | ●                 | ●             | +                               | +        | ●                               | —           |
|               | UF ONLY                             | —                      | —               | ●                   | —                  | —                                | ●                 | ●             | —                               | —        | ●                               | —           |
|               | Conventional pre-treat +UF          | ●                      | +               | +                   | —                  | +                                | —                 | —             | —                               | —        | —                               | —           |
|               | Conventional pre-treat + OZONE + UF | —                      | ●               | —                   | —                  | +                                | —                 | —             | —                               | —        | —                               | —           |
|               | MF + UV                             | ●                      | +               | —                   | ●                  | —                                | +                 | ●             | —                               | —        | ●                               | +           |
|               | Conventional pre-treat + UV         | ●                      | +               | +                   | ●                  | —                                | +                 | ●             | +                               | +        | ●                               | ●           |
|               | Conventional pre-treat + OZONE + UV | +                      | ●               | +                   | +                  | +                                | —                 | —             | +                               | +        | ●                               | +           |
|               | Alternative + Residual (2)          | +                      | ●               | ●                   | +                  | +                                | —                 | —             | +                               | +        | +                               | +           |

Conventional pre-treat = Coagulation / Sedimentation  
 UF - Ultrafiltration MF - Microfiltration  
 + = Better than average  
 — = Worse than average  
 ● = Average

(1) UF + Chlorine residual or Conv + UV + Chlorine residual  
 (2) Conv pre-treat + UF + Chlorine residual or MF + UV + Chlorine residual or Conv pre-treat + UV + Residual

## ASSESSMENT TO DETERMINE EFFECTIVE DISINFECTION METHODS

# Glossary

## A

**ABIOGENESIS:** The concept of spontaneous generation (that life can come from non-life). This idea was refuted by Pasteur.

**ABIOTIC:** The non-living components of an organism's environment. The term abiotic is also used to denote a process which is not facilitated by living organisms.

**ABORAL:** Pertaining to the region of the body opposite that of the mouth. Normally used to describe radially symmetrical animals.

**ABSCISIC ACID (ABA):** A plant hormone that generally acts to inhibit growth, promote dormancy, and help the plant withstand stressful conditions.

**ABSENCE OF OXYGEN:** The complete absence of oxygen in water described as Anaerobic.

**ABSOLUTE ZERO:** A theoretical condition concerning a system at zero Kelvin where a system does not emit or absorb energy (all atoms are at rest).

**ABSORPTION SPECTRUM:** The range of a material's ability to absorb various wavelengths of light. The absorption spectrum is studied to evaluate the function of photosynthetic pigments.

**ACCESSORY PIGMENT:** A photosynthetic pigment which absorbs light and transfers energy to chlorophylls during photosynthesis. Because accessory pigments have different absorption optima than chlorophylls, presence of accessory pigments allows photosynthetic systems to absorb light more efficiently than would be possible otherwise.

**ACCURACY:** How close a value is to the actual or true value; also see precision. How closely an instrument measures the true or actual value.

**ACELLULAR:** Not within cells. Sometimes used as a synonym for unicellular (but multinucleate). Unicellular also pertains to single-celled organisms.

**ACETYL COA:** Acetyl CoenzymeA is the entry compound for the Krebs cycle in cellular respiration; formed from a fragment of pyruvic acid attached to a coenzyme.

**ACETYLCHOLINE:** A neurotransmitter substance that carries information across vertebrate neuromuscular junctions and some other synapses.

**ACID AND BASE ARE MIXED:** When an acid and a base are mixed, an explosive reaction occurs and decomposition products are created under certain conditions.

**ACID ANHYDRIDE:** A compound with two acyl groups bound to a single oxygen atom.

**ACID DISSOCIATION CONSTANT:** An equilibrium constant for the dissociation of a weak acid.

**ACID RAIN:** Rain that is excessively acidic due to the presence of acid: causing pollutants in the atmosphere. Pollutants include nitrogen and sulfur oxides due to burning of coal and oil.

**ACID:** Slowly add the acid to water while stirring. An operator should not mix acid and water or acid to a strong base.

**ACIDOSIS:** A condition whereby the hydrogen ion concentration of the tissues is increased (and pH decreased). Respiratory acidosis is due to the retention of CO<sub>2</sub>; metabolic acidosis by retention of acids due either to kidney failure or diarrhea.

**ACOELOMATE:** Lacking a coelom.

**ACQUIRED IMMUNITY:** Results from exposure to foreign substances or microbes (also called natural immunity).

**ACROSOME:** An organelle at the tip of a sperm cell that helps the sperm penetrate the egg.

**ACTH (adrenocorticotrophic hormone):** A proteinaceous hormone from the anterior pituitary that stimulates the adrenal cortex. Used to stimulate the production of cortisol.

**ACTIN:** A globular protein that links into chains, two of which twist helically about each other, forming microfilaments in muscle and other contractile elements in cells.

**ACTINIDES:** The fifteen chemical elements that are between actinium (89) and lawrencium (103).

**ACTION POTENTIAL:** The stimulus-triggered change in the membrane potential of an excitable cell, caused by selective opening and closing of ion channels.

**ACTION SPECTRUM:** A graph which illustrates the relationship between some biological activity and wavelength of light.

**ACTIVATED CARBON FILTRATION:** Can remove organic chemicals that produce off-taste and odor. These compounds are not dangerous to health but can make the water unpleasant to drink. Carbon filtration comes in several forms, from small filters that attach to sink faucets to large

tanks that contain removable cartridges. Activated carbon filters require regular maintenance or they can become a health hazard.

**ACTIVATED CHARCOAL (GAC or PAC):** Granular Activated Charcoal or Powered Activated Charcoal. Used for taste and odor removal. A treatment technique that is not included in the grading of a water facility.

**ACTIVATED COMPLEX:** A structure that forms because of a collision between molecules while new bonds are formed.

**ACTIVATED SLUDGE PROCESS:** A biological wastewater treatment process in which a mixture of wastewater and biologically enriched sludge is mixed and aerated to facilitate aerobic decomposition by microbes.

**ACTIVATED SLUDGE:** The biologically active solids in an activated sludge process wastewater treatment plant.

**ACTIVATING ENZYME:** An enzyme that couples a low-energy compound with ATP to yield a high-energy derivative.

**ACTIVATION ENERGY:** In a chemical reaction, the initial investment required to energize the bonds of the reactants to an unstable transition state that precedes the formation of the products. The minimum energy that must be input to a chemical system.

**ACTIVE SITE:** That specific portion of an enzyme that attaches to the substrate by means of weak chemical bonds.

**ACTIVE TRANSPORT:** The movement of a substance across a biological membrane against its concentration or electrochemical gradient with the help of energy input and specific transport proteins.

**ADAPTATION:** Any genetically controlled characteristic that increases an organism's fitness, usually by helping the organism to survive and reproduce in the environment it inhabits.

**ADAPTIVE RADIATION:** This refers to the rapid evolution of one or a few forms into many different species that occupy different habitats within a new geographical area.

**ADDITION REACTION:** Within organic chemistry, when two or more molecules combine to make a larger one.

**ADHESION:** In chemistry, the phenomenon whereby one substance tends to cling to another substance. Water molecules exhibit adhesion, especially toward charged surfaces.

**ADP (Adenosine diphosphate):** A doubly phosphorylated organic compound that can be further phosphorylated to form ATP.

**ADRENAL GLAND:** An endocrine gland located adjacent to the kidney in mammals. It is composed of an outer cortex, and a central medulla, each involved in different hormone-mediated phenomena.

**ADRENALIN:** A hormone produced by the pituitary that stimulates the adrenal cortex.

**ADSORB:** Hold on a surface.

**ADSORPTION CLARIFIERS:** The concept of the adsorption clarifier package plant was developed in the early 1980s. This technology uses an up-flow clarifier with low-density plastic bead media, usually held in place by a screen. This adsorption media is designed to enhance the sedimentation/clarification process by combining flocculation and sedimentation into one step. In this step, turbidity is reduced by adsorption of the coagulated and flocculated solids onto the adsorption media and onto the solids already adsorbed onto the media. Air scouring cleans adsorption clarifiers followed by water flushing. Cleaning of this type of clarifier is initiated more often than filter backwashing because the clarifier removes more solids. As with the tube-settler type of package plant, the sedimentation/clarification process is followed by mixed-media filtration and disinfection to complete the water treatment.

**ADSORPTION:** *Not to be confused with absorption.* Adsorption is a process that occurs when a gas or liquid solute accumulates on the surface of a solid or a liquid (adsorbent), forming a film of molecules or atoms (the adsorbate). It is different from absorption, in which a substance diffuses into a liquid or solid to form a solution. The term sorption encompasses both processes, while desorption is the reverse process. Adsorption is present in many natural physical, biological, and chemical systems, and is widely used in industrial applications such as activated charcoal, synthetic resins, and water purification. Adsorption, ion exchange, and chromatography are sorption processes in which certain adsorbates are selectively transferred from the fluid phase to the surface

of insoluble, rigid particles suspended in a vessel or packed in a column. Similar to surface tension, adsorption is a consequence of surface energy. In a bulk material, all the bonding requirements (be they ionic, covalent, or metallic) of the constituent atoms of the material are filled by other atoms in the material. However, atoms on the surface of the adsorbent are not wholly surrounded by other adsorbent atoms, and therefore can attract adsorbates. The exact nature of the bonding depends on the details of the species involved, but the adsorption process is generally classified as physisorption (characteristic of weak van der Waals forces) or chemisorption (characteristic of covalent bonding).

**ADVANCED:** New, unlike the ancestral condition.

**AERATION:** The addition of air or oxygen to water or wastewater, usually by mechanical means, to increase dissolved oxygen levels and maintains aerobic conditions. The mixing of air into a liquid or solid.

**AEROBIC DIGESTION:** Sludge stabilization process involving direct oxidation of biodegradable matter and oxidation of microbial cellular material.

**AEROBIC:** The condition of requiring oxygen; an aerobe is an organism which can live and grow only in the presence of oxygen.

**AGE STRUCTURE:** The relative numbers of individuals of each age in a population.

**AGGLOMERATION:** A jumbled cluster or mass of varied parts. The act or process of agglomerating.

**AGNATHAN:** A member of a jawless class of vertebrates represented today by the lampreys and hagfishes.

**AGONISTIC BEHAVIOR:** A type of behavior involving a contest of some kind that determines which competitor gains access to some resource, such as food or mates.

**AIDS (acquired immune deficiency syndrome):** A condition in which the body's helper T lymphocytes are destroyed, leaving the victim subject to opportunistic diseases.

**AIR ENTRAINMENT:** The dissolution or inclusion of air bubbles into water.

**AIR GAP SEPARATION:** A physical separation space that is present between the discharge vessel and the receiving vessel; for an example, a kitchen faucet.

**AIR HOOD:** The most suitable protection when working with a chemical that produces dangerous fumes.

**ALCOHOL:** Any of a class of organic compounds in which one or more - OH groups are attached to a carbon compound.

**ALDEHYDE:** An organic molecule with a carbonyl group located at the end of the carbon skeleton.

**ALGAE:** Microscopic plants that are free-living and usually live in water. They occur as single cells floating in water, or as multicellular plants like seaweed or strands of algae that attach to rocks.

**ALKALI METALS:** The metals of Group 1 on the periodic table.

**ALKALINE:** Having a pH of more than 7. Alkaline solutions are also said to be basic.

**ALKALINITY:** Alkalinity or AT is a measure of the ability of a solution to neutralize acids to the equivalence point of carbonate or bicarbonate. Alkalinity is closely related to the acid neutralizing capacity (ANC) of a solution and ANC is often incorrectly used to refer to alkalinity. However, the acid neutralizing capacity refers to the combination of the solution and solids present (e.g., suspended matter, or aquifer solids), and the contribution of solids can dominate the ANC (see carbonate minerals below). The alkalinity is equal to the stoichiometric sum of the bases in solution. In the natural environment carbonate alkalinity tends to make up most of the total alkalinity due to the common occurrence and dissolution of carbonate rocks and presence of carbon dioxide in the atmosphere. Other common natural components that can contribute to alkalinity include borate, hydroxide, phosphate, silicate, nitrate, dissolved ammonia, the conjugate bases of some organic acids and sulfide. Solutions produced in a laboratory may contain a virtually limitless number of bases that contribute to alkalinity. Alkalinity is usually given in the unit mEq/L (milliequivalent per liter). Commercially, as in the pool industry, alkalinity might also be given in the unit ppm or parts per million. Alkalinity is sometimes incorrectly used interchangeably with basicity. For example, the pH of a solution can be lowered by the addition of CO<sub>2</sub>. This will reduce the basicity; however, the alkalinity will remain unchanged.

**ALKALINE EARTH METALS:** The metals of Group 2 on the periodic table.



**ALLANTOIS:** One of the four extraembryonic membranes found associated with developing vertebrates; it serves in gas exchange and as a repository for the embryo's nitrogenous waste. In humans, the allantois is involved in early blood formation and development of the urinary bladder.

**ALLELE:** Alternate forms of a gene which may be found at a given location (locus) on members of a homologous set of chromosomes. Structural variations between alleles may lead to different phenotypes for a given trait.

**ALLOMER:** A substance that has different composition than another, but has the same crystalline structure.

**ALLOMETRIC:** The variation in the relative rates of growth of various parts of the body, which helps shape the organism.

**ALLOPATRIC SPECIATION:** A type of speciation which occurs when a population becomes segregated into two populations by some sort of geographic barrier (also called geographic speciation). This phenomenon is presumed to have been the mechanism whereby many species of organisms evolved.

**ALLOPOLYPLOID:** A common type of polyploid species resulting from two different species interbreeding and combining their chromosomes.

**ALL-OR-NONE:** (event) An action that occurs either completely or not at all, such as the generation of an action potential by a neuron.

**ALLOSTERIC ENZYME:** An enzyme that can exist in two or more conformations.

**ALLOSTERIC SITE:** A receptor on an enzyme molecule which is remote from the active site. Binding of the appropriate molecule to the allosteric site changes the conformation of the active site, making it either more or less receptive to the substrate.

**ALLOTROPY:** Elements that can have different structures (and therefore different forms), such as Carbon (diamonds, graphite, and fullerene).

**ALPHA AND BETA RADIOACTIVITY:** Represent two common forms of radioactive decay. Radioactive elements have atomic nuclei so heavy that the nucleus will break apart, or disintegrate spontaneously. When decay occurs, high-energy particles are released. These high-energy particles are called radioactivity. Although radioactivity from refined radioactive elements can be dangerous, it is rare to find dangerous levels of radioactivity in natural waters. An alpha particle is a doubly-charged helium nucleus comprised of two protons, two neutrons, and no electrons. A beta particle is a high-speed electron. Alpha particles do not penetrate matter easily, and are stopped by a piece of paper. Beta particles are much more penetrating and can pass through a millimeter of lead.

**ALPHA HELIX:** A spiral shape constituting one form of the secondary structure of proteins, arising from a specific hydrogen: bonding structure.

**ALTERNATION OF GENERATIONS:** Occurrences of a multicellular diploid form, the sporophyte, with a multicellular haploid form, the gametophyte.

**ALTERNATIVE DISINFECTANTS:** Disinfectants - other than chlorination (halogens) - used to treat water, e.g. ozone, ultraviolet radiation, chlorine dioxide, and chloramine. There is limited experience and scientific knowledge about the by-products and risks associated with the use of alternatives.

**ALTRUISM:** The willingness of an individual to sacrifice its fitness for the benefit of another.

**ALUMINUM SULFATE:** The chemical name for Alum. The molecular formula of Alum is  $\text{Al}_2(\text{SO}_4)_3 \cdot 14\text{H}_2\text{O}$ . It is a cationic polymer.

**ALVEOLUS:** One of the dead-end, multilobed air sacs that constitute the gas exchange surface of the lungs.

**AMINO ACID:** An organic molecule possessing a carboxyl ( $\text{COOH}$ ) and amino group. Amino acids serve as the monomers of polypeptides and proteins.

**AMINO GROUP:** A functional group consisting of a nitrogen atom bonded to two hydrogens; can act as a base in solution, accepting a hydrogen ion and acquiring a charge of +1.

**AMINOACYL:** tRNA synthetases- A family of enzymes, at least one for each amino acid, that catalyze the attachment of an amino acid to its specific tRNA molecule.

**AMMONIA:** A chemical made with Nitrogen and Hydrogen and used with chlorine to disinfect water. Most ammonia in water is present as the ammonium ion rather than as ammonia.

**AMMONIA:**  $\text{NH}_3$  A chemical made with Nitrogen and Hydrogen and used with chlorine to

disinfect water. Most ammonia in water is present as the ammonium ion rather than as ammonia.  
AMMONIATOR: AA control device which meters gaseous ammonia directly into water under positive pressure.

AMOEBIA: Amoeba (sometimes amoeba or ameba, plural amoebae) is a genus of protozoa that moves by means of pseudopods, and is well-known as a representative unicellular organism. The word amoeba or ameba is variously used to refer to it and its close relatives, now grouped as the Amoebozoa, or to all protozoa that move using pseudopods, otherwise termed amoeboids.

(Movement) A streaming locomotion characteristic of Amoeba and other protists, as well as some individual cells, such as white blood cells, in animals.

AMP (Adenosine monophosphate): A singly phosphorylated organic compound that can be further phosphorylated to form ADP.

AMYLASE: A starch-digesting enzyme.

ANABOLISM: A metabolic pathway of biosynthesis that consumes energy to build a large molecule from simpler ones.

ANAEROBIC CONDITIONS: When anaerobic conditions exist in either the metalimnion or hypolimnion of a stratified lake or reservoir, water quality problems may make the water unappealing for domestic use without costly water treatment procedures. Most of these problems are associated with Reduction in the stratified waters.

ANAEROBIC DIGESTION: Sludge stabilization process where the organic material in biological sludges are converted to methane and carbon dioxide in an airtight reactor.

ANAEROBIC: Without oxygen. An organism which lives in the absence of oxygen is called an anaerobe. An abnormal condition in which color and odor problems are most likely to occur.

ANAEROBIC: An abnormal condition in which color and odor problems are most likely to occur.

ANAGENESIS: A pattern of evolutionary change involving the transformation of an entire population, sometimes to a state different enough from the ancestral population to justify renaming it as a separate species; also called phyletic.

ANALOGOUS: Characteristics of organisms which are similar in function (and often in structure) but different in embryological and/or evolutionary origins.

ANALYST: The analyst must have at least 2 years of college lecture and laboratory course work in microbiology or a closely related field. The analyst also must have at least 6 months of continuous bench experience with environmental protozoa detection techniques and IFA microscopy, and must have successfully analyzed at least 50 water and/or wastewater samples for *Cryptosporidium* and *Giardia*. Six months of additional experience in the above areas may be substituted for two years of college.

ANCESTRAL TRAIT: Trait shared by a group of organisms as a result of descent from a common ancestor.

ANEROID: Using no fluid, as in aneroid barometer.

ANEUPLOIDY: A chromosomal aberration in which certain chromosomes are present in extra copies or are deficient in number.

ANION: Negatively charged ions.

ANISOGAMOUS: Reproducing by the fusion of gametes that differ only in size, as opposed to gametes that are produced by oogamous species. Gametes of oogamous species, such as egg cells and sperm, are highly differentiated.

ANNUAL: A plant that completes its entire life cycle in a single year or growing season.

ANODE: The positive side of a dry cell battery or a cell.

ANOXIC: A biological environment that is deficient in molecular oxygen, but may contain chemically bound oxygen, such as nitrates and nitrites.

ANTERIOR: Referring to the head end of a bilaterally symmetrical animal.

ANTHROPOMORPHISM: Attributing a human characteristic to an inanimate object or a species other than a human.

ANTIBIOTIC: A chemical that kills or inhibits the growth of bacteria, often via transcriptional or translational regulation.

ANTIBODY: A protein, produced by the B lymphocytes of the immune system that binds to a particular antigen.

**ANTICODON:** The specialized base triplet on one end of a tRNA molecule that associates with a particular complementary codon on an mRNA molecule during protein synthesis.

**ANTIDIURETIC HORMONE:** A hormone important in osmoregulation (it acts to reduce the elimination of water from the body).

**ANTIGEN:** A foreign macromolecule that does not belong to the host organism and that elicits an immune response.

**APOMORPHIC CHARACTER:** A derived phenotypic character, or homology, that evolved after a branch diverged from a phylogenetic tree.

**APOSEMATIC COLORATION:** Serving as a warning, with reference particularly to colors and structures that signal possession of a defensive device.

**AQUEOUS SOLUTION:** A solution in which water is the solvent.

**AQUIFER PARAMETERS:** Referring to such attributes as specific capacity, aquifer storage, transmissivity, hydraulic conductivity, gradient, and water levels. Refers to all of the components of Darcy's Law and related parameters.

**ARCHAEBACTERIA:** A lineage of prokaryotes, represented today by a few groups of bacteria inhabiting extreme environments. Some taxonomists place archaeobacteria in their own kingdom, separate from the other bacteria.

**ARCHENTERON:** The endoderm-lined cavity formed during the gastrulation process that develops into the digestive tract of the animal.

**ARISTOTLE:** A Greek philosopher often credited as the first to use empirical and deductive methods in logic.

**AROMATICITY:** Chemical property of conjugated rings that results in unusual stability. See also benzene.

**ARTIFICIAL SELECTION:** The selective breeding of domesticated plants and animals to encourage the occurrence of desirable traits.

**AS NITROGEN:** An expression that tells how the concentration of a chemical is expressed mathematically. The chemical formula for the nitrate ion is  $\text{NO}_3$ , with a mass of 62. The concentration of nitrate can be expressed either in terms of the nitrate ion or in terms of the principal element, nitrogen. The mass of the nitrogen atom is 14. The ratio of the nitrate ion mass to the nitrogen atom mass is 4.43. Thus a concentration of 10 mg/L nitrate expressed as nitrogen would be equivalent to a concentration of 44.3 mg/L nitrate expressed as nitrate ion. When dealing with nitrate numbers it is very important to know how numeric values are expressed.

**AS:** The chemical symbol of Arsenic.

**ASCUS:** The elongate spore sac of a fungus of the Ascomycota group.

**ASEPTIC:** Free from the living germs of disease, fermentation, or putrefaction.

**ASEXUAL:** A type of reproduction involving only one parent that produces genetically identical offspring by budding or division of a single cell or the entire organism into two or more parts.

**ASSORTATIVE MATING:** A type of nonrandom mating in which mating partners resemble each other in certain phenotypic characters.

**ASYMMETRIC CARBON:** A carbon atom covalently bonded to four different atoms or groups of atoms.

**ASYNCHRONOUS:** Not occurring at the same time.

**ATOM:** The general definition of an ion is an atom with a positive or negative charge. Electron is the name of a negatively charged atomic particle.

**ATOMIC NUMBER:** The number representing an element which corresponds with the number of protons within the nucleus.

**ATOMIC ORBITAL:** The region where the electron of the atom may be found.

**ATOMIC THEORY:** The physical theory of the structure, properties and behavior of the atom.

**ATOMIC WEIGHT:** The total atomic mass, which is the mass in grams of one mole of the atom (relative to that of  $^{12}\text{C}$ , which is designated as 12).

**ATP (Adenosine triphosphate):** A triply phosphorylated organic compound that functions as "energy currency" for organisms, thus allowing life forms to do work; it can be hydrolyzed in two steps (first to ADP and then to AMP) to liberate 7.3 Kcal of energy per mole during each hydrolysis.

**ATPASE:** An enzyme that functions in producing or using ATP.

**AUTOGENOUS MODEL:** A hypothesis which suggests that the first eukaryotic cells evolved by the specialization of internal membranes originally derived from prokaryotic plasma membranes.

**AUTOIMMUNE DISEASE:** An immunological disorder in which the immune system goes awry and turns against itself.

**AUTONOMIC NERVOUS SYSTEM:** A subdivision of the motor nervous system of vertebrates that regulates the internal environment; consists of the sympathetic and parasympathetic subdivisions.

**AUTOPOLYPLOID:** A type of polyploid species resulting from one species doubling its chromosome number to become tetraploids, which may self-fertilize or mate with other tetraploids.

**AUTOSOME:** Chromosomes that are not directly involved in determining sex.

**AUTOTROPH:** An organism which is able to make organic molecules from inorganic ones either by using energy from the sun or by oxidizing inorganic substances.

**AUXIN:** One of several hormone compounds in plants that have a variety of effects, such as phototropic response through stimulation of cell elongation, stimulation of secondary growth, and development of leaf traces and fruit.

**AUXOTROPH:** A nutritional mutant that is unable to synthesize and that cannot grow on media lacking certain essential molecules normally synthesized by wild-type strains of the same species.

**AVOGADRO'S NUMBER:** Is the number of particles in a mole of a substance ( $6.02 \times 10^{23}$ ).

**AXON:** A typically long outgrowth, or process, from a neuron that carries nerve impulses away from the cell body toward target cells.

**AXONEME:** An internal flagellar structure that occurs in some protozoa, such as *Giardia*, *Spironucleous*, and *Trichomonas*.

## B

**BACKFLOW PREVENTION:** To stop or prevent the occurrence of, the unnatural act of reversing the normal direction of the flow of liquid, gases, or solid substances back in to the public potable (drinking) water supply. See Cross-connection control.

**BACKFLOW:** To reverse the natural and normal directional flow of a liquid, gases, or solid substances back in to the public potable (drinking) water supply. This is normally an undesirable effect.

**BACKSIPHONAGE:** A liquid substance that is carried over a higher point. It is the method by which the liquid substance may be forced by excess pressure over or into a higher point.

**BACTERIA:** Small, one-celled animals too small to be seen by the naked eye. Bacteria are found everywhere, including on and in the human body. Humans would be unable to live without the bacteria that inhabit the intestines and assist in digesting food. Only a small percentage of bacteria cause disease in normal, healthy humans. Other bacteria can cause infections if they get into a cut or wound. Bacteria are the principal concern in evaluating the microbiological quality of drinking water, because some of the bacteria-caused diseases that can be transmitted by drinking water are potentially life-threatening.

**BACTERIOPHAGE:** Any of a group of viruses that infect specific bacteria, usually causing their disintegration or dissolution. A bacteriophage (from 'bacteria' and Greek phagein, 'to eat') is any one of a number of viruses that infect bacteria. The term is commonly used in its shortened form, phage. Typically, bacteriophages consist of an outer protein hull enclosing genetic material. The genetic material can be ssRNA (single stranded RNA), dsRNA, ssDNA, or dsDNA between 5 and 500 kilo base pairs long with either circular or linear arrangement. Bacteriophages are much smaller than the bacteria they destroy - usually between 20 and 200 nm in size.

**BACTERIUM:** A unicellular microorganism of the Kingdom Monera. Bacteria are prokaryotes; their cells have no true nucleus. Bacteria are classified into two groups based on a difference in cell walls, as determined by Gram staining.

**BALANCED POLYMORPHISM:** A type of polymorphism in which the frequencies of the coexisting forms do not change noticeably over many generations.

**BARITE:** Processed barium sulfate often used to increase drilling fluid densities in mud rotary.

**BAROMETER:** A device used to measure the pressure in the atmosphere.

**BARR BODY:** The dense object that lies along the inside of the nuclear envelope in cells of female mammals, representing the one inactivated X chromosome.

**BASAL BODY:** A cell structure identical to a centriole that organizes and anchors the microtubule assembly of a cilium or flagellum.

**BASE PAIRING:** Complementary base pairing refers to the chemical affinities between specific base pairs in a nucleic acid: adenine always pairs with thymine, and guanine always pairs with cytosine. In pairing between DNA and RNA, the uracil of RNA always pairs with adenine. Complementary base pairing is not only responsible for the DNA double helix, but it is also essential for various in vitro techniques such as PCR (polymerase chain reaction). Complementary base pairing is also known as Watson-Crick pairing.

**BASE:** A substance that reduces the hydrogen ion concentration in a solution.

**BASE:** A substance that accepts a proton and has a high pH; a common example is sodium hydroxide (NaOH).

**BASEMENT MEMBRANE:** The floor of an epithelial membrane on which the basal cells rest.

**BASIDIUM:** The spore-bearing structure of Basidiomycota.

**BATESIAN MIMICRY:** A type of mimicry in which a harmless species looks like a different species that is poisonous or otherwise harmful to predators.

**B-CELL LYMPHOCYTE:** A type of lymphocyte that develops in the bone marrow and later produces antibodies, which mediate humoral immunity.

**BEHAVIORAL ECOLOGY:** A heuristic approach based on the expectation that Darwinian fitness (reproductive success) is improved by optimal behavior.

**BELT PRESS:** A dewatering device utilizing two opposing synthetic fabric belts, revolving over a series of rollers to “squeeze” water from the sludge.

**BENCH TEST:** A small-scale test or study used to determine whether a technology is suitable for a particular application.

**BENIGN TUMOR:** A noncancerous abnormal growth composed of cells that multiply excessively but remain at their place of origin in the body.

**BENTHIC:** Pertaining to the bottom region of an aquatic environment.

**BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE (BAT):** A level of technology based on the best existing control and treatment measures that are economically achievable within the given industrial category or subcategory.

**BEST MANAGEMENT PRACTICES (BMPs):** Schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the U.S. BMPs also include treatment requirements, operating procedures and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

**BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE (BPT):** A level of technology represented by the average of the best existing wastewater treatment performance levels within an industrial category or subcategory.

**BEST PROFESSIONAL JUDGMENT (BPJ):** The method used by a permit writer to develop technology-based limitations on a case-by-case basis using all reasonably available and relevant data.

**BETA PLEATED SHEET:** A zigzag shape, constituting one form of the secondary structure of proteins formed of hydrogen bonds between polypeptide segments running in opposite directions.

**BILATERAL SYMMETRY:** The property of having two similar sides, with definite upper and lower surfaces and anterior and posterior ends. The Bilateria are members of the branch of Eumetazoa (Kingdom Animalia) which possess bilateral symmetry.

**BILE:** A mixture of substances containing bile salts, which emulsify fats and aid in their digestion and absorption.

**BINARY FISSION:** The kind of cell division found in prokaryotes, in which dividing daughter cells each receive a copy of the single parental chromosome.

**BINOMIAL NOMENCLATURE:** Consisting of two names. In biology, each organism is given a *genus* name and a *species* name (i.e., the human is *Homo sapiens*).

**BIOCHEMICAL OXYGEN DEMAND (BOD):** The BOD test is used to measure the strength of wastewater. The BOD of wastewater determines the milligrams per liter of oxygen required during stabilization of decomposable organic matter by aerobic bacteria action. Also, the total milligrams of oxygen required over a five-day test period to biologically assimilate the organic contaminants

in one liter of wastewater maintained at 20 degrees Centigrade.

**BIOCHEMISTRY:** The chemistry of organisms.

**BIOGENESIS:** A central concept of biology, that living organisms are derived from other living organisms (contrasts to the concept of abiogenesis, or spontaneous generation, which held that life could be derived from inanimate material).

**BIOGEOCHEMICAL CYCLE:** A circuit whereby a nutrient moves between both biotic and abiotic components of ecosystems.

**BIOGEOGRAPHY:** The study of the past and present distribution of species.

**BIOLOGICAL MAGNIFICATION:** Increasing concentration of relatively stable chemicals as they are passed up a food chain from initial consumers to top predators.

**BIOLOGICAL SPECIES:** A population or group of populations whose members have the potential to interbreed. This concept was introduced by Ernst Mayr.

**BIOMASS:** The total weight of all the organisms, or of a designated group of organisms, in a given area

**BIOME:** A large climatic region with characteristic sorts of plants and animals.

**BIOSOLIDS:** Solid organic matter recovered from municipal wastewater treatment that can be beneficially used, especially as a fertilizer. "Biosolids" are solids that have been stabilized within the treatment process, whereas "sludge" has not.

**BIOSPHERE:** The region on and surrounding the earth which is capable of supporting life. Theoretically, the concept may be ultimately expanded to include other regions of the universe.

**BMR:** The basal metabolic rate is the minimal energy (in kcal) required by a homeotherm to fuel itself for a given time. Measured within the thermoneutral zone for a postabsorptive animal at rest.

**BODY FEED:** Coating or bulking material added to the influent of material to be treated. This adds "body" to the material during filtration cycle.

**BOILING POINT ELEVATION:** The process where the boiling point is elevated by adding a substance.

**BOILING POINT:** The temperature in which the substance starts to boil.

**BOILING:** The phase transition of liquid vaporizing.

**BOND:** The attraction and repulsion between atoms and molecules that is a cornerstone of chemistry.

Both measurements (mg/L or KH) are usually expressed "as  $\text{CaCO}_3$ " – meaning the amount of hardness expressed as if calcium carbonate was the sole source of hardness. Every bicarbonate ion only counts for half as much carbonate hardness as a carbonate ion does. If a solution contained 1 liter of water and 50 mg  $\text{NaHCO}_3$  (baking soda), it would have a carbonate hardness of about 18 mg/L as  $\text{CaCO}_3$ . If you had a liter of water containing 50 mg of  $\text{Na}_2\text{CO}_3$ , it would have a carbonate hardness of about 29 mg/L as  $\text{CaCO}_3$ . Carbonate hardness supplements non-carbonate (a.k.a. "permanent") hardness where hard ions are associated with anions such as Chloride that do not precipitate out of solution when heated. Carbonate hardness is removed from water through the process of softening. Softening can be achieved by adding lime in the form of  $\text{Ca}(\text{OH})_2$ , which reacts first with  $\text{CO}_2$  to form calcium carbonate precipitate, reacts next with multi-valent cations to remove carbonate hardness, then reacts with anions to replace the non-carbonate hardness due to multi-valent cations with non-carbonate hardness due to calcium. The process requires recarbonation through the addition of carbon-dioxide to lower the pH which is raised during the initial softening process.

**BREAK POINT CHLORINATION:** The process of chlorinating the water with significant quantities of chlorine to oxidize all contaminants and organic wastes and leave all remaining chlorine as free chlorine.

**BRIDGING:** The tendency of sediment, filter, or seal media to create an obstruction if installed in too small an annulus or to rapidly. Also can occur within filter packs requiring development.

**BROMINE:** Chemical disinfectant (HALOGEN) that kills bacteria and algae. This chemical disinfectant has been used only on a very limited scale for water treatment because of its handling difficulties. This chemical causes skin burns on contact, and a residual is difficult to obtain.

**BRONSTED-LOWREY ACID:** A chemical species that donates a proton.

**BRONSTED-LOWREY BASE:** A chemical species that accepts a proton.

**BUFFER:** Chemical that resists pH change, e.g. sodium bicarbonate

**BUFFERED SOLUTION:** An aqueous solution consisting of a weak acid and its conjugate base or a weak base and its conjugate acid that resists changes in pH when strong acids or bases are added.

**BULKING SLUDGE:** A phenomenon that occurs in activated sludge plants whereby the sludge occupies excessive volumes and will not concentrate readily. This condition refers to a decrease in the ability of the sludge to settle and consequent loss over the settling tank weir. Bulking in activated sludge aeration tanks is caused mainly by excess suspended solids (SS) content. Sludge bulking in the final settling tank of an activated sludge plant may be caused by improper balance of the BOD load, SS concentration in the mixed liquor, or the amount of air used in aeration. A poor or slow settling activated sludge that results from the prevalence of filamentous organisms.

**BURETTE (also BURET):** Glassware used to dispense specific amounts of liquid when precision is necessary (e.g. titration and resource dependent reactions).

## C

**Ca:** The chemical symbol for calcium.

**CADMIUM:** A contaminant that is usually not found naturally in water or in very small amounts.

**CAKE:** Dewatered sludge material with a satisfactory solids concentration to allow handling as a solid material.

**CALCIUM HARDNESS:** A measure of the calcium salts dissolved in water.

**CALCIUM ION:** Is divalent because it has a valence of +2.

**CALCIUM, MAGNESIUM AND IRON:** The three elements that cause hardness in water.

**CaOCl<sub>2</sub>·4H<sub>2</sub>O:** The molecular formula of Calcium hypochlorite.

**CARBON DIOXIDE GAS:** The pH will decrease and alkalinity will change as measured by the Langelier index after pumping carbon dioxide gas into water.

**CARBON DIOXIDE GAS:** The pH will decrease and alkalinity will change as measured by the Langelier index after pumping carbon dioxide gas into water.

**CARBONATE HARDNESS:** Carbonate hardness is the measure of Calcium and Magnesium and other hard ions associated with carbonate (CO<sub>3</sub><sup>2-</sup>) and bicarbonate (HCO<sub>3</sub><sup>-</sup>) ions contained in a solution, usually water. It is usually expressed either as parts per million (ppm or mg/L), or in degrees (KH - from the German "Karbonathärte"). One German degree of carbonate hardness is equivalent to about 17.8575 mg/L. Both measurements (mg/L or KH) are usually expressed "as CaCO<sub>3</sub>" – meaning the amount of hardness expressed as if calcium carbonate was the sole source of hardness. Every bicarbonate ion only counts for half as much carbonate hardness as a carbonate ion does. If a solution contained 1 liter of water and 50 mg NaHCO<sub>3</sub> (baking soda), it would have a carbonate hardness of about 18 mg/L as CaCO<sub>3</sub>. If you had a liter of water containing 50 mg of Na<sub>2</sub>CO<sub>3</sub>, it would have a carbonate hardness of about 29 mg/L as CaCO<sub>3</sub>.

**CARBONATE, BICARBONATE AND HYDROXIDE:** Chemicals that are responsible for the alkalinity of water.

**CAROLUS LINNAEUS:** Swedish botanist and originator of the binomial nomenclature system of taxonomic classification

**CATALYST:** A chemical compound used to change the rate (either to speed up or slow down) of a reaction, but is regenerated at the end of the reaction.

**CATHODIC PROTECTION:** An operator should protect against corrosion of the anode and/or the cathode by painting the copper cathode. Cathodic protection interrupts corrosion by supplying an electrical current to overcome the corrosion-producing mechanism. Guards against stray current corrosion.

**CATION:** Positively charged ion.

**CAUSTIC SODA:** Also known as sodium hydroxide and is used to raise pH.

**CAUSTIC:** NaOH (also called Sodium Hydroxide) is a strong chemical used in the treatment process to neutralize acidity, increase alkalinity or raise the pH value.

**CEILING AREA:** The specific gravity of ammonia gas is 0.60. If released, this gas will accumulate first at the ceiling area. Cl<sub>2</sub> gas will settle on the floor.

**CELL POTENTIAL:** The force in a galvanic cell that pulls electron through reducing agent to oxidizing agent.



**CENTRATE:** The liquid remaining after solids have been removed in a centrifuge.

**CENTRIFUGAL FORCE:** That force when a ball is whirled on a string that pulls the ball outward. On a centrifugal pump, it is that force which throws water from a spinning impeller.

**CENTRIFUGAL PUMP:** A pump consisting of an impeller fixed on a rotating shaft and enclosed in a casing, having an inlet and a discharge connection. The rotating impeller creates pressure in the liquid by the velocity derived from centrifugal force.

**CENTRIFUGE:** A dewatering device relying on centrifugal force to separate particles of varying density such as water and solids. Equipment used to separate substances based on density by rotating the tubes around a centered axis

**CESIUM (also Caesium):** Symbol Cs- A soft, silvery-white ductile metal, liquid at room temperature, the most electropositive and alkaline of the elements, used in photoelectric cells and to catalyze hydrogenation of some organic compounds.

**CHAIN OF CUSTODY (COC):** A record of each person involved in the possession of a sample from the person who collects the sample to the person who analyzes the sample in the laboratory.

**CHELATION:** A chemical process used to control scale formation in which a chelating agent "captures" scale-causing ions and holds them in solution.

**CHEMICAL FEED RATE:** Chemicals are added to the water in order to improve the subsequent treatment processes. These may include pH adjusters and coagulants. Coagulants are chemicals, such as alum, that neutralize positive or negative charges on small particles, allowing them to stick together and form larger particles that are more easily removed by sedimentation (settling) or filtration. A variety of devices, such as baffles, static mixers, impellers and in-line sprays, can be used to mix the water and distribute the chemicals evenly.

**CHEMICAL LAW:** Certain rules that pertain to the laws of nature and chemistry.

**CHEMICAL OXIDIZER:**  $\text{KMnO}_4$  is used for taste and odor control because it is a strong oxidizer which eliminates many organic compounds.

**CHEMICAL OXIDIZER:**  $\text{KMnO}_4$  or Potassium Permanganate is used for taste and odor control

**CHEMICAL OXYGEN DEMAND (COD):** The milligrams of oxygen required to chemically oxidize the organic contaminants in one liter of wastewater.

**CHEMICAL REACTION RATE:** In general, when the temperature decreases, the chemical reaction rate also decreases. The opposite is true for when the temperature increases.

**CHEMICAL REACTION:** The change of one or more substances into another or multiple substances.

**CHEMICAL SLUDGE:** Sludge resulting from chemical treatment processes of inorganic wastes that are not biologically active.

**CHEMISORPTION:** (or chemical adsorption) Is adsorption in which the forces involved are valence forces of the same kind as those operating in the formation of chemical compounds.

**CHLORAMINES:** A group of chlorine ammonia compounds formed when chlorine combines with organic wastes in the water. Chloramines are not effective as disinfectants and are responsible for eye and skin irritation as well as strong chlorine odors.

**CHLORINATION:** The process in water treatment of adding chlorine (gas or solid hypochlorite) for purposes of disinfection.

**CHLORINE DEMAND:** Amount of chlorine required to react on various water impurities before a residual is obtained. Also, means the amount of chlorine required to produce a free chlorine residual of 0.1 mg/l after a contact time of fifteen minutes as measured by iodometric method of a sample at a temperature of twenty degrees in conformance with Standard methods.

**CHLORINE FEED:** Chlorine may be delivered by vacuum-controlled solution feed chlorinators. The chlorine gas is controlled, metered, introduced into a stream of injector water and then conducted as a solution to the point of application.

**CHLORINE, FREE:** Chlorine available to kill bacteria or algae. The amount of chlorine available for sanitization after the chlorine demand has been met. Also known as chlorine residual.

**CHLORINE:** A chemical used to disinfect water. Chlorine is extremely reactive, and when it comes in contact with microorganisms in water it kills them. Chlorine is added to swimming pools to keep the water safe for swimming. Chlorine is available as solid tablets for swimming pools. Some public water system's drinking water treatment plants use chlorine in a gas form because of the large

volumes required. Chlorine is very effective against algae, bacteria and viruses. Protozoa are resistant to chlorine because they have thick coats; protozoa are removed from drinking water by filtration.

**CHRONIC:** A stimulus that lingers or continues for a relatively long period of time, often one-tenth of the life span or more. Chronic should be considered a relative term depending on the life span of an organism. The measurement of chronic effect can be reduced growth, reduced reproduction, etc., in addition to lethality.

**CIRCULATION:** The continual flow of drilling fluid from injection to recovery and recirculation at the surface.

**CLARIFIER:** A settling tank used to remove suspended solids by gravity settling. Commonly referred to as sedimentation or settling basins, they are usually equipped with a motor driven chain and flight or rake mechanism to collect settled sludge and move it to a final removal point.

**CLEAR WELL:** A large underground storage facility sometimes made of concrete. A clear well or a plant storage reservoir is usually filled when demand is low. The final step in the conventional filtration process, the clearwell provides temporary storage for the treated water. The two main purposes for this storage are to have filtered water available for backwashing the filter and to provide detention time (or contact time) for the chlorine (or other disinfectant) to kill any microorganisms that may remain in the water.

**CIO<sub>2</sub>:** The molecular formula of Chlorine dioxide.

**COAGULATION:** The best pH range for coagulation is between 5 and 7. Mixing is an important part of the coagulation process you want to complete the coagulation process as quickly as possible. A chemical added to initially destabilize, aggregate, and bind together colloids and emulsions to improve settleability, filterability, or drainability.

**COLIFORM TESTING:** The effectiveness of disinfection is usually determined by Coliform bacteria testing. A positive sample is a bad thing and indicates that you have bacteria contamination.

**COLIFORM:** Bacteria normally found in the intestines of warm-blooded animals. Coliform bacteria are present in high numbers in animal feces. They are an indicator of potential contamination of water. Adequate and appropriate disinfection effectively destroys coliform bacteria. Public water systems are required to deliver safe and reliable drinking water to their customers 24 hours a day, 365 days a year. If the water supply becomes contaminated, consumers can become seriously ill. Fortunately, public water systems take many steps to ensure that the public has safe, reliable drinking water. One of the most important steps is to regularly test the water for coliform bacteria. Coliform bacteria are organisms that are present in the environment and in the feces of all warm-blooded animals and humans. Coliform bacteria will not likely cause illness. However, their presence in drinking water indicates that disease-causing organisms (pathogens) could be in the water system. Most pathogens that can contaminate water supplies come from the feces of humans or animals. Testing drinking water for all possible pathogens is complex, time-consuming, and expensive. It is relatively easy and inexpensive to test for coliform bacteria. If coliform bacteria are found in a water sample, water system operators work to find the source of contamination and restore safe drinking water. There are three different groups of coliform bacteria; each has a different level of risk.

**COLLIOD:** Mixture of evenly dispersed substances, such as many milks.

**COLLOIDAL SUSPENSIONS:** Because both iron and manganese react with dissolved oxygen to form insoluble compounds, they are not found in high concentrations in waters containing dissolved oxygen except as colloidal suspensions of the oxide.

**COLORIMETRIC MEASUREMENT:** A means of measuring an unknown chemical concentration in water by measuring a sample's color intensity.

**COMBINED CHLORINE:** The reaction product of chlorine with ammonia or other pollutants, also known as chloramines.

**COMBUSTION:** An exothermic reaction between an oxidant and fuel with heat and often light

**COMMUNITY WATER SYSTEM:** A water system which supplies drinking water to 25 or more of the same people year-round in their residences.

**COMPLIANCE CYCLE:** A 9-calendar year time-frame during which a public water system is required to monitor. Each compliance cycle consists of 3 compliance periods.

**COMPLIANCE PERIOD:** A 3-calendar year time-frame within a compliance cycle.

**COMPOSITE SAMPLE:** A water sample that is a combination of a group of samples collected at various intervals during the day. A combination of individual samples of water or wastewater taken at predetermined intervals to minimize the effect of variability of individual samples. To have significant meaning, samples for laboratory tests on wastewater should be representative of the wastewater. The best method of sampling is proportional composite sampling over several hours during the day. Composite samples are collected because the flow and characteristics of the wastewater are continually changing. A composite sample will give a representative analysis of the wastewater conditions.

**COMPOSTING:** Stabilization process relying on the aerobic decomposition of organic matter in sludge by bacteria and fungi.

**COMPOUND:** A substance that is made up of two or more chemically bonded elements.

**CONDENSATION:** The process that changes water vapor to tiny droplets or ice crystals.

**CONDUCTOR:** Material that allows electric flow more freely.

**CONTACT STABILIZATION PROCESS:** Modification of the activated sludge process where raw wastewater is aerated with activated sludge for a short time prior to solids removal and continued aeration in a stabilization tank.

**CONTACT TIME:** If the water temperature decreases from 70°F (21°C) to 40°F (4°C). The operator needs to increase the detention time to maintain good disinfection of the water.

**CONTAINS THE ELEMENT CARBON:** A simple definition of an organic compound.

**CONTAMINANT:** Any natural or man-made physical, chemical, biological, or radiological substance or matter in water, which is at a level that may have an adverse effect on public health, and which is known or anticipated to occur in public water systems.

**CONTAMINATION:** A degradation in the quality of groundwater in result of the it's becoming polluted with unnatural or previously non-existent constituents.

**CONTROL TASTE AND ODOR PROBLEMS:** KMnO<sub>4</sub> Potassium permanganate is a strong oxidizer commonly used to control taste and odor problems.

**COPPER:** The chemical name for the symbol Cu.

**CORROSION:** The removal of metal from copper, other metal surfaces and concrete surfaces in a destructive manner. Corrosion is caused by improperly balanced water or excessive water velocity through piping or heat exchangers.

**CORROSION:** The removal of metal from copper, other metal surfaces and concrete surfaces in a destructive manner. Corrosion is caused by improperly balanced water or excessive water velocity through piping or heat exchangers.

**CORROSIVITY:** The Langelier Index measures corrosivity.

**COUPON:** A coupon placed to measure corrosion damage in the water mains.

**COVALENT BOND:** Chemical bond that involves sharing electrons.

**CROSS-CONNECTION:** A physical connection between a public water system and any source of water or other substance that may lead to contamination of the water provided by the public water system through backflow. Might be the source of an organic substance causing taste and odor problems in a water distribution system.

**CROSS-CONTAMINATION:** The mixing of two unlike qualities of water. For example, the mixing of good water with a polluting substance like a chemical.

**CRYPTOSPORIDIUM:** A disease-causing parasite, resistant to chlorine disinfection. It may be found in fecal matter or contaminated drinking water. Cryptosporidium is a protozoan pathogen of the Phylum Apicomplexa and causes a diarrheal illness called cryptosporidiosis. Other apicomplexan pathogens include the malaria parasite Plasmodium, and Toxoplasma, the causative agent of toxoplasmosis. Unlike Plasmodium, which transmits via a mosquito vector, Cryptosporidium does not utilize an insect vector and is capable of completing its life cycle within a single host, resulting in cyst stages which are excreted in feces and are capable of transmission to a new host.

**CRYSTAL:** A solid that is packed with ions, molecules or atoms in an orderly fashion.

**CUVETTE:** Glassware used in spectroscopic experiments. It is usually made of plastic, glass or quartz and should be as clean and clear as possible.

**CYANOBACTERIA:** Cyanobacteria, also known as blue-green algae, blue-green bacteria or Cyanophyta, is a phylum of bacteria that obtain their energy through photosynthesis. The name "cyanobacteria" comes from the color of the bacteria (Greek: kyanós = blue). They are a significant component of the marine nitrogen cycle and an important primary producer in many areas of the ocean, but are also found on land.

**CYANURIC ACID:** White, crystalline, water-soluble solid,  $C_3H_3O_3N_3 \cdot 2H_2O$ , used chiefly in organic synthesis. Chemical used to prevent the decomposition of chlorine by ultraviolet (UV) light.

**CYST:** A phase or a form of an organism produced either in response to environmental conditions or as a normal part of the life cycle of the organism. It is characterized by a thick and environmentally resistant cell wall.

## D

**DAILY MAXIMUM LIMITATIONS:** The maximum allowable discharge of pollutants during a 24 hour period. Where daily maximum limitations are expressed in units of mass, the daily discharge is the total mass discharged over the course of the day. Where daily maximum limitations are expressed in terms of a concentration, the daily discharge is the arithmetic average measurement of the pollutant concentration derived from all measurements taken that day.

**DANGEROUS CHEMICALS:** The most suitable protection when working with a chemical that produces dangerous fumes is to work under an air hood.

**DARCY'S LAW:** ( $Q=KIA$ ) A fundamental equation used in the groundwater sciences to determine aquifer characteristics, where  $Q$ =Flux,  $K$ =Hydraulic Conductivity (Permeability),  $I$  = Hydraulic Gradient (change in head), and  $A$  = Cross Sectional Area of flow.

**DECANT:** Separation of a liquid from settled solids by removing the upper layer of liquid after the solids have settled.

**DECIBELS:** The unit of measurement for sound.

**DECOMPOSE:** To decay or rot.

**DECOMPOSITION OF ORGANIC MATERIAL:** The decomposition of organic material in water produces taste and odors.

**DEIONIZATION:** The removal of ions, and in water's case mineral ions such as sodium, iron and calcium.

**DELIQUESCE:** Substances that absorb water from the atmosphere to form liquid solutions.

**DEMINERALIZATION PROCESS:** Mineral concentration of the feed water is the most important consideration in the selection of a demineralization process. Acid feed is the most common method of scale control in a membrane demineralization treatment system.

**DENITRIFICATION:** A biological process by which nitrate is converted to nitrogen gas.

**DENTAL CARIES PREVENTION IN CHILDREN:** The main reason that fluoride is added to a water supply.

**DEPOLARIZATION:** The removal of hydrogen from a cathode.

**DEPOSITION:** Settling of particles within a solution or mixture.

**DESICCANT:** When shutting down equipment which may be damaged by moisture, the unit may be protected by sealing it in a tight container. This container should contain a desiccant.

**DESORPTION:** Desorption is a phenomenon whereby a substance is released from or through a surface. The process is the opposite of sorption (that is, adsorption and absorption). This occurs in a system being in the state of sorption equilibrium between bulk phase (fluid, i.e. gas or liquid solution) and an adsorbing surface (solid or boundary separating two fluids). When the concentration (or pressure) of substance in the bulk phase is lowered, some of the sorbed substance changes to the bulk state. In chemistry, especially chromatography, desorption is the ability for a chemical to move with the mobile phase. The more a chemical desorbs, the less likely it will adsorb, thus instead of sticking to the stationary phase, the chemical moves up with the solvent front. In chemical separation processes, stripping is also referred to as desorption as one component of a liquid stream moves by mass transfer into a vapor phase through the liquid-vapor interface.

**DETENTION LAG:** Is the period of time between the moment of change in a chlorinator control system and the moment when the change is sensed by the chlorine residual indicator.

DEVELOPMENT: The cleaning of the well and bore once construction is complete.

DIATOMACEOUS EARTH: A fine silica material containing the skeletal remains of algae.

DIGESTER: A tank or vessel used for sludge digestion.

DIGESTION: The biological decomposition of organic matter in sludge resulting in partial gasification, liquefaction, and mineralization of putrescible and offensive solids.

DIPOLE MOMENT: The polarity of a polar covalent bond.

DIPOLE: Electric or magnetic separation of charge.

DIRECT CURRENT: A source of direct current (DC) may be used for standby lighting in a water treatment facility. The electrical current used in a DC system may come from a battery.

DISINFECT: The application of a chemical to kill most, but not all, microorganisms that may be present. Chlorine is added to public water drinking systems drinking water for disinfection. Depending on your state rule, drinking water must contain a minimum of 0.2 mg/L free chlorine. Disinfection makes drinking water safe to consume from the standpoint of killing pathogenic microorganisms including bacteria and viruses. Disinfection does not remove all bacteria from drinking water, but the bacteria that can survive disinfection with chlorine are not pathogenic bacteria that can cause disease in normal healthy humans.

DISINFECTION BY-PRODUCTS (DBPs): The products created due to the reaction of chlorine with organic materials (e.g. leaves, soil) present in raw water during the water treatment process. The EPA has determined that these DBPs can cause cancer. Chlorine is added to drinking water to kill or inactivate harmful organisms that cause various diseases. This process is called disinfection. However, chlorine is a very active substance and it reacts with naturally occurring substances to form compounds known as disinfection byproducts (DBPs). The most common DBPs formed when chlorine is used are trihalomethanes (THMs), and haloacetic acids (HAAs).

DISINFECTION: The treatment of water to inactivate, destroy, and/or remove pathogenic bacteria, viruses, protozoa, and other parasites.

DISSOLUTION or SOLVATION: The spread of ions in a monosaccharide.

DISSOLVED OXYGEN: Can be added to zones within a lake or reservoir that would normally become anaerobic during periods of thermal stratification.

DISSOLVED SOLIDS: Solids in solution that cannot be removed by filtration with a 0.45 micron filter.

DISTILLATION, REVERSE OSMOSIS AND FREEZING: Processes that can be used to remove minerals from the water.

DOUBLE BOND: Sharing of two pairs of electradsodes.

DRY ACID: A granular chemical used to lower pH and or total alkalinity.

## E

E. COLI, Escherichia coli: A bacterium commonly found in the human intestine. For water quality analyses purposes, it is considered an indicator organism. These are considered evidence of water contamination. Indicator organisms may be accompanied by pathogens, but do not necessarily cause disease themselves.

EARTH METAL: See alkaline earth metal.

E. COLI, Escherichia coli: A bacterium commonly found in the human intestine. For water quality analyses purposes, it is considered an indicator organism. These are considered evidence of water contamination. Indicator organisms may be accompanied by pathogens, but do not necessarily cause disease themselves.

ECDYSONE: A steroid hormone that triggers molting in arthropods.

ECOLOGICAL EFFICIENCY: The ratio of net productivity at one trophic level to net productivity at the next lower level.

ECOLOGICAL NICHE: The sum total of an organism's utilization of the biotic and abiotic resources of its environment. The fundamental niche represents the theoretical capabilities and the realized niche represents the actual role.

ECOLOGY: The study of how organisms interact with their environments.

ECOSYSTEM: The sum of physical features and organisms occurring in a given area.

ECTODERM: The outermost tissue layer of an animal embryo. Also, tissue derived from an embryonic ectoderm.

**ECTOTHERM:** An organism that uses environmental heat and behavior to regulate its body temperature.

**EDWARD JENNER:** A pioneer of vaccination; used vaccination with material from cowpox lesions to protect people against smallpox.

**EFFECTIVENESS OF CHLORINE:** The factors which influence the effectiveness of chlorination the most are pH, turbidity and temperature. Effectiveness of Chlorine decreases occurs during disinfection in source water with excessive turbidity.

**EFFECTOR:** The part of an organism that produces a response to a stimulus.

**EFFLUENT:** Partially or completely treated water or wastewater flowing out of a basin or treatment plant.

**ELECTRIC CHARGE:** A measured property (coulombs) that determine electromagnetic interaction

**ELECTRICAL SYNAPSE:** A junction between two neurons separated only by a gap junction, in which the local currents sparking the action potential pass directly between the cells.

**ELECTROCARDIOGRAM:** A plot of electrical activity of the heart over the cardiac cycle; measured via multiple skin electrodes.

**ELECTROCHEMICAL CELL:** Using a chemical reaction's current, electromotive force is made

**ELECTROCHEMICAL GRADIENT:** Combined electrostatic and osmotic-concentration gradient, such as the chemiosmotic gradient of mitochondria and chloroplasts.

**ELECTROGENIC PUMP:** An ion transport protein generating voltage across a membrane.

**ELECTROLYTE:** A solution that conducts a certain amount of current and can be split categorically as weak and strong electrolytes.

**ELECTROMAGNETIC RADIATION:** A type of wave that can go through vacuums as well as material and classified as a self-propagating wave.

**ELECTROMAGNETIC SPECTRUM:** The entire spectrum of radiation; ranges in wavelength from less than a nanometer to more than a kilometer.

**ELECTROMAGNETISM:** Fields that have electric charge and electric properties that change the way that particles move and interact.

**ELECTROMOTIVE FORCE:** A device that gains energy as electric charges pass through it.

**ELECTRON MICROSCOPE:** A microscope that focuses an electron beam through a specimen, resulting in resolving power a thousandfold greater than that of a light microscope. A transmission EM is used to study the internal structure of thin sections of cells; a scanning EM is used to study the ultrastructure of surfaces.

**ELECTRON SHELLS:** An orbital around the atom's nucleus that has a fixed number electrons (usually two or eight).

**ELECTRON TRANSPORT CHAIN:** A series of enzymes found in the inner membranes of mitochondria and chloroplasts. These are involved in transport of protons and electrons either across the membrane during ATP synthesis.

**ELECTRON:** A subatomic particle with a net charge that is negative. The name of a negatively charged atomic particle.

**ELECTRONEGATIVITY:** A property exhibited by some atoms whereby the nucleus has a tendency to pull electrons toward itself.

**ELECTRONIC CHARGE UNIT:** The charge of one electron ( $1.6021 \times 10^{-19}$  coulomb).

**ELECTROSTATIC FORCE:** The attraction between particles with opposite charges.

**ELECTROSTATIC GRADIENT:** The free-energy gradient created by a difference in charge between two points, generally the two sides of a membrane.

**ELEMENT:** Any substance that cannot be broken down into another substance by ordinary chemical means. An atom that is defined by its atomic number.

**ELEMENTARY BUSINESS PLAN:** Technical Capacity, Managerial Capacity, and Financial Capacity make up the elementary business plan. To become a new public water system, an owner shall file an elementary business plan for review and approval by state environmental agency.

**ELIMINATION:** The release of unabsorbed wastes from the digestive tract.

**EMERGENCY RESPONSE TEAM:** A local team that is thoroughly trained and equipped to deal with emergencies, e.g. chlorine gas leak. In case of a chlorine gas leak, get out of the area and notify your local emergency response team in case of a large uncontrolled chlorine leak.

**EMERGENT PROPERTY:** A property exhibited at one level of biological organization but not exhibited at a lower level. For example, a population exhibits a birth rate, an organism does not.

**EMPIRICAL FORMULA:** Also called the simplest formula, gives the simplest whole :number ratio of atoms of each element present in a compound.

**EMULSION:** A suspension, usually as fine droplets of one liquid in another. A mixture made up of dissimilar elements, usually of two or more mutually insoluble liquids that would normally separate into layers based on the specific gravity of each liquid.

**ENERGONIC:** A phenomenon which involves uptake of energy.

**ENDOCRINE:** A phenomenon which relates to the presence of ductless glands of the type typically found in vertebrates. The endocrine system involves hormones, the glands which secrete them, the molecular hormone receptors of target cells, and interactions between hormones and the nervous system.

**ENDOCYTOSIS:** A process by which liquids or solid particles are taken up by a cell through invagination of the plasma membrane.

**ENDODERM:** The innermost germ layer of an animal embryo.

**ENDODERMIS:** A plant tissue, especially prominent in roots, that surrounds the vascular cylinder; all endodermal cells have Casparian strips.

**ENDOMEMBRANE SYSTEM:** The system of membranes inside a eukaryotic cell, including the membranous vesicles which associate with membrane sheets and/or tubes.

**ENDOMETRIUM:** The inner lining of the uterus, which is richly supplied with blood vessels that provide the maternal part of the placenta and nourish the developing embryo.

**ENDONUCLEASE:** An enzyme that breaks bonds within nucleic acids. A restriction endonuclease is an enzyme that breaks bonds only within a specific sequence of bases.

**ENDOPLASMIC RETICULUM:** A system of membrane-bounded tubes and flattened sacs, often continuous with the nuclear envelope, found in the cytoplasm of eukaryotes. Exists as rough ER, studded with ribosomes, and smooth ER, lacking ribosomes.

**ENDORPHIN:** A hormone produced in the brain and anterior pituitary that inhibits pain perception.

**ENDOSKELETON:** An internal skeleton.

**ENDOSPERM:** A nutritive material in plant seeds which is triploid (3n) and results from the fusion of three nuclei during double fertilization.

**ENDOSYMBIOTIC:** 1) An association in which the symbiont lives within the host 2) A widely accepted hypothesis concerning the evolution of the eukaryotic cell: the idea that eukaryotes evolved as a result of symbiotic associations between prokaryote cells. Aerobic symbionts ultimately evolved into mitochondria; photosynthetic symbionts became chloroplasts.

**ENDOTHELIUM:** The innermost, simple squamous layer of cells lining the blood vessels; the only constituent structure of capillaries.

**ENDOTHERMIC:** In chemistry, a phenomenon in which energy is absorbed by the reactants. In physiology, this term concerns organisms whose thermal relationship with the environment is dependent substantially on internal production of heat.

**ENDOTOXIN:** A component of the outer membranes of certain gram-negative bacteria responsible for generalized symptoms of fever and ache.

**ENERGY:** A system's ability to do work. The capacity to do work by moving matter against an opposing force.

**ENHANCED COAGULATION:** The process of joining together particles in water to help remove organic matter.

**ENHANCER:** A DNA sequence that recognizes certain transcription factors that can stimulate transcription of nearby genes.

**ENTAMOEBIA HISTOLYTICA:** Entamoeba histolytica, another water-borne pathogen, can cause diarrhea or a more serious invasive liver abscess. When in contact with human cells, these amoebae are cytotoxic. There is a rapid influx of calcium into the contacted cell, it quickly stops all membrane movement save for some surface blebbing. Internal organization is disrupted,



organelles lyse, and the cell dies. The ameba may eat the dead cell or just absorb nutrients released from the cell.

**ENTERIC:** Rod-shaped, gram-negative, aerobic but can live in certain anaerobic conditions; produce nitrite from nitrate, acids from glucose; include *Escherichia coli*, *Salmonella* (over 1000 types), and *Shigella*.

**ENTEROVIRUS:** A virus whose presence may indicate contaminated water; a virus that may infect the gastrointestinal tract of humans.

**ENTHALPY:** Measure of the total energy of a thermodynamic system (usually symbolized as H).

**ENTROPY:** The amount of energy not available for work in a closed thermodynamic system (usually symbolized as S).

**ENVELOPE:** 1) (nuclear) The surface, consisting of two layers of membrane, that encloses the nucleus of eukaryotic cells. 2) (virus) A structure which is present on the outside of some viruses (exterior to the capsid).

**ENVIRONMENT:** Water, air, and land, and the interrelationship that exists among and between water, air and land and all living things. The total living and nonliving aspects of an organism's internal and external surroundings.

**ENZYME:** A protein, on the surface of which are chemical groups so arranged as to make the enzyme a catalyst for a chemical reaction. A protein that speeds up (catalyzes) a reaction.

**EPICOTYL:** A portion of the axis of a plant embryo above the point of attachment of the cotyledons; forms most of the shoot.

**EPIDERMIS:** The outermost portion of the skin or body wall of an animal.

**EPINEPHRINE:** A hormone produced as a response to stress; also called adrenaline.

**EPIPHYTE:** A plant that nourishes itself but grows on the surface of another plant for support, usually on the branches or trunks of tropical trees.

**EPISOME:** Genetic element at times free in the cytoplasm, at other times integrated into a chromosome.

**EPISTASIS:** A phenomenon in which one gene alters the expression of another gene that is independently inherited.

**EPITHELIUM:** An animal tissue that forms the covering or lining of all free body surfaces, both external and internal.

**EPITOPE:** A localized region on the surface of an antigen that is chemically recognized by antibodies; also called antigenic determinant.

**EPPENDORF TUBE:** Generalized and trademarked term used for a type of tube; see microcentrifuge.

**EQUATION:** A precise representation of the outcome of a chemical reaction, showing the reactants and products, as well as the proportions of each.

**EQUILIBRIUM:** In a reversible reaction, the point at which the rate of the forward reaction equals that of the reverse reaction. (Constant) At equilibrium, the ratio of products to reactants. (potential) The membrane potential for a given ion at which the voltage exactly balances the chemical diffusion gradient for that ion.

**ERNST MAYR:** Formulated the biological species concept.

**ERYTHROCYTE:** A red blood corpuscle.

**ESOPHAGUS:** An anterior part of the digestive tract; in mammals it leads from the pharynx to the stomach.

**ESSENTIAL:** 1) An amino or fatty acid which is required in the diet of an animal because it cannot be synthesized. 2) A chemical element required for a plant to grow from a seed and complete the life cycle.

**ESTIVATION:** A physiological state characterized by slow metabolism and inactivity, which permits survival during long periods of elevated temperature and diminished water supplies.

**ESTRADIOL:** 1,3,5(10)-estratriene- 3,17 beta-diol C<sub>18</sub>H<sub>24</sub>O<sub>2</sub>. This is the natural hormone - present in pure form in the urine of pregnant mares and in the ovaries of pigs.

**ESTROGEN:** Any of a group of vertebrate female sex hormones.

**ESTROUS CYCLE:** In female mammals, the higher primates excepted, a recurrent series of physiological and behavioral changes connected with reproduction.

**ESTRUS:** The limited period of heat or sexual receptivity that occurs around ovulation in female mammals having estrous cycles.

**ESTUARY:** That portion of a river that is close enough to the sea to be influenced by marine tides.

**ETHYLENE:** The only gaseous plant hormone, responsible for fruit ripening, growth inhibition, leaf abscission, and aging.

**EUBACTERIA:** The lineage of prokaryotes that includes the cyanobacteria and all other contemporary bacteria except archaeobacteria.

**EUCHROMATIN:** The more open, unraveled form of eukaryotic chromatin, which is available for transcription.

**EUCOELOMATE:** An animal whose body cavity is completely lined by mesoderm, the layers of which connect dorsally and ventrally to form mesenteries.

**EUGLENA:** Euglena are common protists, of the class Euglenoidea of the phylum Euglenophyta. Currently, over 1000 species of Euglena have been described. Marin et al. (2003) revised the genus so and including several species without chloroplasts, formerly classified as *Astasia* and *Khawkinia*. Euglena sometimes can be considered to have both plant and animal features.

Euglena gracilis has a long hair-like thing that stretches from its body. You need a very powerful microscope to see it. This is called a flagellum, and the euglena uses it to swim. It also has a red eyespot. Euglena gracilis uses its eyespot to locate light. Without light, it cannot use its chloroplasts to make itself food.

**EUKARYOTE:** A life form comprised of one or more cells containing a nucleus and membrane-bound organelles. Included are members of the Kingdoms Protista, Fungi, Plantae and Animalia.

**EUMETAZOA:** Members of the subkingdom that includes all animals except sponges.

**EUTROPHIC:** A highly productive condition in aquatic environments which owes to excessive concentrations of nutrients which support the growth of primary producers.

**EVAGINATED:** Folded or protruding outward.

**EVAPORATIVE COOLING:** The property of a liquid whereby the surface becomes cooler during evaporation, owing to the loss of highly kinetic molecules to the gaseous state.

**EVOLUTION:** A theory that all of the changes that have transformed life on earth from its earliest beginnings to the diversity that characterizes it today. As used in biology, the term evolution means descent with change. See Intelligent Design.

**EVOLUTION:** Any process of formation or growth; development: the evolution of a language; the evolution of the airplane. A product of such development; something evolved: The exploration of space is the evolution of decades of research.

**EXCITABLE CELLS:** A cell, such as a neuron or a muscle cell that can use changes in its membrane potential to conduct signals.

**EXCITATORY POSTSYNAPTIC POTENTIAL:** An electrical change (depolarization) in the membrane of a postsynaptic neuron caused by the binding of an excitatory neurotransmitter from a presynaptic cell to a postsynaptic receptor. This phenomenon facilitates generation of an action potential in the PSP.

**EXCRETION:** Release of materials which arise in the body due to metabolism (e.g., CO<sub>2</sub>, NH<sub>3</sub>, H<sub>2</sub>O).

**EXERGONIC:** A phenomenon which involves the release of energy.

**EXOCYTOSIS:** A process by which a vesicle within a cell fuses with the plasma membrane and releases its contents to the outside.

**EXON:** A part of a primary transcript (and the corresponding part of a gene) that is ultimately either translated (in the case of mRNA) or utilized in a final product, such as tRNA.

**EXOSKELETON:** An external skeleton, characteristic of members of the phylum, Arthropoda.

**EXOTHERMIC:** A process or reaction that is accompanied by the creation of heat.

**EXOTOXIN:** A toxic protein secreted by a bacterial cell that produces specific symptoms even in the absence of the bacterium.

**EXPONENTIAL:** (population growth) The geometric increase of a population as it grows in an ideal, unlimited environment.

**EXTRAEMBRYONIC MEMBRANES:** Four membranes (yolk sac, amnion, chorion, allantois) that support the developing embryo in reptiles, birds, and mammals.

**EXTRINSIC:** External to, not a basic part of; as in extrinsic isolating mechanism.

## F

**F PLASMID:** The fertility factor in bacteria, a plasmid that confers the ability to form pili for conjugation and associated functions required for transfer of DNA from donor to recipient.

**F:** The chemical symbol of Fluorine.

**F1 GENERATION:** The first filial or hybrid offspring in a genetic cross-fertilization.

**F2 GENERATION:** Offspring resulting from interbreeding of the hybrid F1 generation.

**FACILITATED DIFFUSION:** Passive movement through a membrane involving a specific carrier protein; does not proceed against a concentration gradient.

**FACULTATIVE:** An organism which exhibits the capability of changing from one habit or metabolic pathway to another, when conditions warrant. (anaerobe) An organism that makes ATP by aerobic respiration if oxygen is present but that switches to fermentation under anaerobic conditions.

**FARADAY CONSTANT:** A unit of electrical charge widely used in electrochemistry and equal to ~ 96,500 coulombs. It represents 1 mol of electrons, or the Avogadro number of electrons:  $6.022 \times 10^{23}$  electrons.  $F = 96\,485.339\,9(24)\text{ C/mol}$ .

**FARADAY'S LAW OF ELECTROLYSIS:** A two part law that Michael Faraday published about electrolysis. The mass of a substance altered at an electrode during electrolysis is directly proportional to the quantity of electricity transferred at that electrode. The mass of an elemental material altered at an electrode is directly proportional to the element's equivalent weight.

**FAT:** A biological compound consisting of three fatty acids linked to one glycerol molecule.

**FATE MAP:** A means of tracing the fates of cells during embryonic development.

**FATTY ACID:** A long carbon chain carboxylic acid. Fatty acids vary in length and in the number and location of double bonds; three fatty acids linked to a glycerol molecule form fat.

**FAUCET WITH AN AERATOR:** When collecting a water sample from a distribution system, a faucet with an aerator should not be used as a sample location.

**FAUNA:** The animals of a given area or period.

**FEATURE DETECTOR:** A circuit in the nervous system that responds to a specific type of feature, such as a vertically moving spot or a particular auditory time delay.

**FECAL COLIFORM:** A group of bacteria that may indicate the presence of human or animal fecal matter in water. Total coliform, fecal coliform, and *E. coli* are all indicators of drinking water quality. The total coliform group is a large collection of different kinds of bacteria. Fecal coliforms are types of total coliform that mostly exist in feces. *E. coli* is a sub-group of fecal coliform. When a water sample is sent to a lab, it is tested for total coliform. If total coliform is present, the sample will also be tested for either fecal coliform or *E. coli*, depending on the lab testing method.

**FECES:** Indigestible wastes discharged from the digestive tract.

**FEEDBACK:** The process by which a control mechanism is regulated through the very effects it brings about. Positive feedback is when the effect is amplified; negative feedback is when the effect tends toward restoration of the original condition. Feedback inhibition is a method of metabolic control in which the end-product of a metabolic pathway acts as an inhibitor of an enzyme within that pathway.

**FERMENTATION:** Anaerobic production of alcohol, lactic acid or similar compounds from carbohydrate resulting from glycolysis.

**FERRIC CHLORIDE:** An iron salt commonly used as a coagulant. Chemical formula is  $\text{FeCl}_3$ .

**FIBRIN:** The activated form of the blood: clotting protein fibrinogen, which aggregates into threads that form the fabric of the clot.

**FIBROBLAST:** A type of cell in loose connective tissue that secretes the protein ingredients of the extracellular fibers.

**FIBRONECTINS:** A family of extracellular glycoproteins that helps embryonic cells adhere to their substrate as they migrate.

**FILTER AID:** A polymer or other material added to improve the effectiveness of the filtration process.

**FILTER CAKE:** The layer of solids that is retained on the surface of a filter.

**FILTER CLOGGING:** An inability to meet demand may occur when filters are clogging.

**FILTER PRESS:** A dewatering device where sludge is pumped onto a filtering medium and water is forced out of the sludge, resulting in a "cake".

**FILTER:** A device utilizing a granular material, woven cloth or other medium to remove pollutants from water, wastewater or air.

**FILTRATE:** Liquid remaining after removal of solids with filtration.

**FILTRATION METHODS:** The conventional type of water treatment filtration method includes coagulation, flocculation, sedimentation, and filtration. Direct filtration method is similar to conventional except that the sedimentation step is omitted. Slow sand filtration process does not require pretreatment, has a flow of 0.1 gallons per minute per square foot of filter surface area, and is simple to operate and maintain. The Diatomaceous earth method uses a thin layer of fine siliceous material on a porous plate. This type of filtration medium is only used for water with low turbidity. Sedimentation, adsorption, and biological action treatment methods are filtration processes that involve a number of interrelated removal mechanisms. Demineralization is primarily used to remove total dissolved solids from industrial wastewater, municipal water, and seawater.

**FILTRATION RATE:** A measurement of the volume of water applied to a filter per unit of surface area in a given period of time.

**FILTRATION:** The process of passing water through materials with very small holes to strain out particles. Most conventional water treatment plants used filters composed of gravel, sand, and anthracite. These materials settle into a compact mass that forms very small holes. Particles are filtered out as treated water passes through these holes. These holes are small enough to remove microorganisms including algae, bacteria, and protozoans, but not viruses. Viruses are eliminated from drinking water through the process of disinfection using chlorine. A series of processes that physically removes particles from water. A water treatment step used to remove turbidity, dissolved organics, odor, taste and color.

**FINISHED WATER:** Treated drinking water that meets minimum state and federal drinking water regulations.

**FLOC SHEARING:** Likely to happen to large floc particles when they reach the flocculation process.

**FITNESS:** The extent to which an individual passes on its genes to the next generation. Relative fitness is the number of offspring of an individual compared to the mean.

**FIXATION:** 1) Conversion of a substance into a biologically more usable form, for example, CO<sub>2</sub> fixation during photosynthesis and N<sub>2</sub> fixation. 2) Process of treating living tissue for microscopic examination.

**FIXED ACTION PATTERN (FAP):** A highly: stereotyped behavior that is innate and must be carried to completion once initiated.

**FLACCID:** Limp; walled cells are flaccid in isotonic surroundings, where there is no tendency for water to enter.

**FLAGELLIN:** The protein from which prokaryotic flagella are constructed.

**FLAGELLUM:** A long whip-like appendage that propels cells during locomotion in liquid solutions. The prokaryote flagellum is comprised of a protein, flagellin. The eukaryote flagellum is longer than a cilium, but as a similar internal structure of microtubules in a "9 + 2" arrangement.

**FLAME CELL:** A flagellated cell associated with the simplest tubular excretory system, present in flatworms: it acts to directly regulate the contents of the extracellular fluid.

**FLOC SHEARING:** Likely to happen to large floc particles when they reach the flocculation process.

**FLOC SHEARING:** Likely to happen to large floc particles when they reach the flocculation process.

**FLOCCULANTS:** Flocculants, or flocculating agents, are chemicals that promote flocculation by causing colloids and other suspended particles in liquids to aggregate, forming a floc. Flocculants are used in water treatment processes to improve the sedimentation or filterability of small particles. For example, a flocculant may be used in swimming pool or drinking water filtration to aid removal of microscopic particles which would otherwise cause the water to be cloudy and which would be difficult or impossible to remove by filtration alone. Many flocculants are multivalent cations such as aluminum, iron, calcium or magnesium. These positively charged molecules interact with negatively charged particles and molecules to reduce the barriers to aggregation. In addition, many of these chemicals, under appropriate pH and other conditions

such as temperature and salinity, react with water to form insoluble hydroxides which, upon precipitating, link together to form long chains or meshes, physically trapping small particles into the larger floc.

**FLOCCULATION BASIN:** A compartmentalized basin with a reduction of speed in each compartment. This set-up or basin will give the best overall results.

**FLOCCULATION:** The process of bringing together destabilized or coagulated particles to form larger masses that can be settled and/or filtered out of the water being treated. Conventional coagulation–flocculation–sedimentation practices are essential pretreatments for many water purification systems—especially filtration treatments. These processes agglomerate suspended solids together into larger bodies so that physical filtration processes can more easily remove them. Particulate removal by these methods makes later filtering processes far more effective. The process is often followed by gravity separation (sedimentation or flotation) and is always followed by filtration. A chemical coagulant, such as iron salts, aluminum salts, or polymers, is added to source water to facilitate bonding among particulates. Coagulants work by creating a chemical reaction and eliminating the negative charges that cause particles to repel each other. The coagulant-source water mixture is then slowly stirred in a process known as flocculation. This water churning induces particles to collide and clump together into larger and more easily removable clots, or “flocs.” The process requires chemical knowledge of source water characteristics to ensure that an effective coagulant mix is employed. Improper coagulants make these treatment methods ineffective. The ultimate effectiveness of coagulation/flocculation is also determined by the efficiency of the filtering process with which it is paired.

**FLOOD RIM:** The point of an object where the water would run over the edge of something and begin to cause a flood.

**FLORA:** The plants of a given area or period.

**FLOW CYTOMETER:** A particle-sorting instrument capable of counting protozoa.

**FLOW MUST BE MEASURED:** A recorder that measures flow is most likely to be located in a central location.

**FLUID FEEDER:** An animal that lives by sucking nutrient-rich fluids from another living organism.

**FLUID MOSAIC MODEL:** The currently accepted model of cell membrane structure, which envisions the membrane as a mosaic of individually inserted protein molecules drifting laterally in a fluid bilayer of phospholipids.

**FLUORIDE FEEDING:** Always review fluoride feeding system designs and specifications to determine whether locations for monitoring readouts and dosage controls are convenient to the operation center and easy to read and correct.

**FLUORIDE:** High levels of fluoride may stain the teeth of humans. This is called Mottling. This chemical must not be overfed due to a possible exposure to a high concentration of the chemical. The most important safety considerations to know about fluoride chemicals are that all fluoride chemicals are extremely corrosive. These are the substances most commonly used to furnish fluoride ions to water: Sodium fluoride, Sodium silicofluoride and Hydrofluosilicic acid.

**FLUX:** The term flux describes the rate of water flow through a semipermeable membrane. When the water flux decreases through a semipermeable membrane, it means that the mineral concentration of the water is increasing.

**FLY ASH:** The noncombustible particles in flue gas. Often used as a body feed or solidification chemical.

**FOLLICLE STIMULATING HORMONE (FSH):** A gonadotropic hormone of the anterior pituitary that stimulates growth of follicles in the ovaries of females and function of the seminiferous tubules in males.

**FOLLICLE:** A jacket of cells around an egg cell in an ovary.

**FOOD CHAIN:** Sequence of organisms, including producers, consumers, and decomposers, through which energy and materials may move in a community.

**FOOD WEB:** The elaborate, interconnected feeding relationships in an ecosystem.

**FOOT CANDLE:** Unit of illumination; the illumination of a surface produced by one standard candle at a distance of one foot.

**FORMATION OF TUBERCLES:** This condition is of the most concern regarding corrosive water effects on a water system. It is the creation of mounds of rust inside the water lines.

**Formation:** A series of layers, deposits, or bodies of rock, which are geologically similar and related in depositional environment or origin. A formation can be clearly distinguished relative to bounding deposits or formations due to its particular characteristics and composition.

**FORMULA:** A precise representation of the structure of a molecule or ion, showing the proportion of atoms which comprise the material.

**FOUNDER EFFECT:** The difference between the gene pool of a population as a whole and that of a newly isolated population of the same species.

**FRACTIONATION:** An experimental technique which involves separation of parts of living tissue from one another using centrifugation.

**Fracture:** A discrete break in a rock or formation.

**FRAGMENTATION:** A mechanism of asexual reproduction in which the parent plant or animal separates into parts that reform whole organisms.

**FRAMESHIFT MUTATION:** A mutation occurring when the number of nucleotides inserted or deleted is not a multiple of 3, thus resulting in improper grouping into codons.

**FREE CHLORINE RESIDUAL:** Regardless of whether pre-chlorination is practiced or not, a free chlorine residual of at least 10 mg/L should be maintained in the clear well or distribution reservoir immediately downstream from the point of post-chlorination. The reason for chlorinating past the breakpoint is to provide protection in case of backflow.

**FREE CHLORINE:** In disinfection, chlorine is used in the form of free chlorine or as hypochlorite ion.

**FREE ENERGY OF ACTIVATION:** See Activation energy.

**FREE ENERGY:** Usable energy in a chemical system; energy available for producing change.

**FREE OIL:** Non-emulsified oil that separates from water, in a given period of time.

**FREEZING:** Phase transition from liquid to solid.

**FREQUENCY DEPENDENT SELECTION:** A decline in the reproductive success of a morph resulting from the morph's phenotype becoming too common in a population; a cause of balanced polymorphism in populations.

**FREQUENCY:** Number of cycles per unit of time. Unit: 1 hertz = 1 cycle per 1 second.

**FUNCTIONAL GROUP:** One of several groups of atoms commonly found in organic molecules. A functional group contributes somewhat predictable properties to the molecules which possess them.

**FUNDAMENTAL NICHE:** The total resources an organism is theoretically capable of utilizing.

## G

**G:** (protein) A membrane protein that serves as an intermediary between hormone receptors and the enzyme adenylate cyclase, which converts ATP to cAMP in the second messenger system in non-steroid hormone action. Depending on the system, G proteins either increase or decrease cAMP production.

**G1 PHASE:** The first growth phase of the cell cycle, consisting of the portion of interphase before DNA synthesis is initiated.

**G2 PHASE:** The second growth phase of the cell cycle, consisting of the portion of interphase after DNA synthesis but before mitosis.

**GAIA HYPOTHESIS:** An idea, first formulated by James E. Lovelock in 1979, which suggests that the biosphere of the earth exists as a "superorganism" which exhibits homeostatic self-regulation of the environment-biota global system.

**GALVANIC CELL:** Battery made up of electrochemical with two different metals connected by salt bridge.

**GAMETANGIUM:** The reproductive organ of bryophytes, consisting of the male antheridium and female archegonium; a multi-chambered jacket of sterile cells in which gametes are formed.

**GAMETE:** A sexual reproductive cell that must usually fuse with another such cell before development begins; an egg or sperm.

**GAMETOPHYTE:** A haploid plant that can produce gametes.

**GANGLION:** A structure containing a group of cell bodies of neurons.

**GAP JUNCTION:** A narrow gap between plasma membranes of two animal cells, spanned by protein channels. They allow chemical substances or electrical signals to pass from cell to cell.

**GAS:** Particles that fill their container though have no definite shape or volume.

**GASTRULA:** A two-layered, later three-layered, animal embryonic stage.

**GASTRULATION:** The process by which a blastula develops into a gastrula, usually by an involution of cells.

**GATED ION CHANNEL:** A membrane channel that can open or close in response to a signal, generally a change in the electrostatic gradient or the binding of a hormone, transmitter, or other molecular signal.

**GEL ELECTROPHORESIS:** In general, electrophoresis is a laboratory technique used to separate macromolecules on the basis of electric charge and size; the technique involves application of an electric field to a population of macromolecules which disperse according to their electric mobilities. In gel electrophoresis, the porous medium through which the macromolecules move is a gel.

**GEL:** Colloid in which the suspended particles form a relatively orderly arrangement.

**GENE AMPLIFICATION:** Any of the strategies that give rise to multiple copies of certain genes, thus facilitating the rapid synthesis of a product (such as rRna for ribosomes) for which the demand is great.

**GENE CLONING:** Formation by a bacterium, carrying foreign genes in a recombinant plasmid, of a clone of identical cells containing the replicated foreign genes.

**GENE DELIVERY:** This is a general term for the introduction of new genetic elements into the genomes of living cells. The delivery problem is essentially conditioned by the fact that the new genetic elements are usually large, and by the presence of the outer cell membrane and the nuclear membrane acting as barriers to incorporation of the new DNA into the genome already present in the nucleus. Viruses possess various natural biochemical methods for achieving gene delivery; artificial gene delivery is one of the essential problems of "genetic engineering". The most important barrier is apparently the outer cell membrane, which is essentially a lipid barrier, and introduction of any large complex into the cell requires a fusion of one kind or another with this membrane. Liposomes, which consist of lipid membranes themselves, and which can fuse with outer cell membranes, are thus potential vehicles for delivery of many substances, including DNA.

**GENE FLOW:** The movement of genes from one part of a population to another, or from one population to another, via gametes.

**GENE POOL:** The sum total of all the genes of all the individuals in a population.

**GENE REGULATION:** Any of the strategies by which the rate of expression of a gene can be regulated, as by controlling the rate of transcription.

**GENE:** The hereditary determinant of a specified characteristic of an individual; specific sequences of nucleotides in DNA.

**GENETIC DRIFT:** Change in the gene pool as a result of chance and not as a result of selection, mutation, or migration.

**GENETIC RECOMBINATION:** The general term for the production of offspring that combine traits of the two parents.

**GENETICS:** The science of heredity; the study of heritable information.

**GENOME:** The cell's total complement of DNA.

**GENOMIC EQUIVALENCE:** The presence of all of an organism's genes in all of its cells.

**GENOMIC IMPRINTING:** The parental effect on gene expression. Identical alleles may have different effects on offspring depending on whether they arrive in the zygote via the ovum or via the sperm.

**GENOMIC LIBRARY:** A set of thousands of DNA segments from a genome, each carried by a plasmid or phage.

**GENOTYPE:** The particular combination of genes present in the cells of an individual.

**GENUS:** A taxonomic category above the species level, designated by the first word of a species' binomial Latin name.

**GEOCHEMISTRY:** The chemistry of and chemical composition of the Earth.

**GIARDIA LAMBLIA:** *Giardia lamblia* (synonymous with *Lamblia intestinalis* and *Giardia duodenalis*) is a flagellated protozoan parasite that colonizes and reproduces in the small intestine, causing giardiasis. The giardia parasite attaches to the epithelium by a ventral adhesive disc, and reproduces via binary fission. Giardiasis does not spread via the bloodstream, nor does it spread to other parts of the gastro-intestinal tract, but remains confined to the lumen of the



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**GIARDIASIS, HEPATITIS OR TYPHOID:** Diseases that may be transmitted through the contamination of a water supply but not AIDS.

**GIBBS ENERGY:** Value that indicates the spontaneity of a reaction (usually symbolized as G).

**GIS – GRAPHIC INFORMATION SYSTEM:** Detailed information about the physical locations of structures such as pipes, valves, and manholes within geographic areas with the use of satellites.

**GLIAL CELL:** A non-conducting cell of the nervous system that provides support, insulation, and protection for the neurons.

**GLIDING:** Rod-shaped, gram-negative, mostly aerobic; glide on secreted slimy substances; form colonies, frequently with complex fruiting structures.

**GLOMERULUS:** A capillary bed within Bowman's capsule of the nephron; the site of ultrafiltration.

**GLUCOSE:** A six carbon sugar which plays a central role in cellular metabolism.

**GLYCOCALYX:** The layer of protein and carbohydrates just outside the plasma membrane of an animal cell; in general, the proteins are anchored in the membrane, and the carbohydrates are bound to the proteins.

**GLYCOGEN:** A long, branched polymer of glucose subunits that is stored in the muscles and liver of animals and is metabolized as a source of energy.

**GLYCOLYSIS:** A metabolic pathway which occurs in the cytoplasm of cells and during which glucose is oxidized anaerobically to form pyruvic acid.

**GLYCOPROTEIN:** A protein with covalently linked sugar residues. The sugars may be bound to OH side chains of the polypeptide (O: linked) or the amide nitrogen of asparagine side chains (N: linked).

**GLYCOSIDIC:** A type of bond which links monosaccharide subunits together in di- or polysaccharides.

**GLYOXYSOME:** A type of microbody found in plants, in which stored lipids are converted to carbohydrates.

**GOLGI APPARATUS:** A system of concentrically folded membranes found in the cytoplasm of eukaryotic cells. Plays a role in the production and release of secretory materials such as the digestive enzymes manufactured in the pancreas.

**GONADOTROPIN:** Refers to a member of a group of hormones capable of promoting growth and function of the gonads. Includes hormones such as follicle stimulating hormone (FSH) and luteinizing hormone (LH) which are stimulatory to the gonads.

**GOOD CONTACT TIME, pH and LOW TURBIDITY:** These are factors that are important in providing good disinfection when using chlorine.

**GPM:** Gallons per minute.

**GRAB SAMPLE:** A sample which is taken from a water or wastestream on a one-time basis with no regard to the flow of the water or wastestream and without consideration of time. A single grab sample should be taken over a period of time not to exceed 15 minutes. A single water or wastewater sample taken at a time and place representative of total discharge.

**GRADED POTENTIAL:** A local voltage change in a neuron membrane induced by stimulation of a neuron, with strength proportional to the strength of the stimulus and lasting about a millisecond.

**GRANUM:** A stack-like grouping of photosynthetic membranes in a chloroplast

**GRAVITROPISM:** A response of a plant or animal in response to gravity.

**GRAVITY BELT THICKENER:** A sludge dewatering device utilizing a filter belt to promote gravity drainage of water. Usually precedes additional dewatering treatment.

**GRAVITY FILTER:** A filter that operates at atmospheric pressure.

**GRAVITY THICKENING:** A sedimentation basin designed to operate at high solids loading rates.

**GREENHOUSE EFFECT:** The warming of the Earth due to atmospheric accumulation of carbon dioxide which absorbs infrared radiation and slows its escape from the irradiated Earth.

**GREGOR MENDEL:** The first to make quantitative observations of the patterns of inheritance and proposing plausible explanations for them.

**GROWTH FACTOR:** A protein that must be present in a cell's environment for its normal growth and development.

**GT:** Represents (Detention time) x (mixing intensity) in flocculation.

**GUARD CELL:** A specialized epidermal cell that regulates the size of stoma of a leaf.

**GYMNOSPERM:** A vascular plant that bears naked seeds not enclosed in any specialized chambers.

## H

**H<sub>2</sub>SO<sub>4</sub>:** The molecular formula of Sulfuric acid.

**HABIT:** In biology, the characteristic form or mode of growth of an organism.

**HABITAT:** The kind of place where a given organism normally lives.

**HABITUATION:** The process that results in a long-lasting decline in the receptiveness of interneurons to the input from sensory neurons or other interneurons (sensitization, adaptation).

**HALF:** The average amount of time it takes for one-half of a specified quantity of a substance to decay or disappear.

**HALIDES:** A halide is a binary compound, of which one part is a halogen atom and the other part is an element or radical that is less electronegative than the halogen, to make a fluoride, chloride, bromide, iodide, or astatide compound. Many salts are halides. All Group 1 metals form halides with the halogens and they are white solids. A halide ion is a halogen atom bearing a negative charge. The halide anions are fluoride (F), chloride (Cl), bromide (Br), iodide (I) and astatide (At). Such ions are present in all ionic halide salts.

**HALL EFFECT:** Refers to the potential difference (Hall voltage) on the opposite sides of an electrical conductor through which an electric current is flowing, created by a magnetic field applied perpendicular to the current. Edwin Hall discovered this effect in 1879.

**HALOACETIC ACIDS:** Haloacetic acids are carboxylic acids in which a halogen atom takes the place of a hydrogen atom in acetic acid. Thus, in a monohaloacetic acid, a single halogen would replace a hydrogen atom. For example, chloroacetic acid would have the structural formula CH<sub>2</sub>ClCO<sub>2</sub>H. In the same manner, in dichloroacetic acid two chlorine atoms would take the place of two hydrogen atoms (CHCl<sub>2</sub>CO<sub>2</sub>H).

**HALOGENS:** Group 7 on the Periodic Table and are all non-metals.

**HAPLOID:** The condition of having only one kind of a given type of chromosome.

**HARD WATER:** Hard water causes a buildup of scale in household hot water heaters. Hard water is a type of water that has high mineral content (in contrast with soft water). Hard water primarily consists of calcium (Ca<sup>2+</sup>), and magnesium (Mg<sup>2+</sup>) metal cations, and sometimes other dissolved compounds such as bicarbonates and sulfates. Calcium usually enters the water as either calcium carbonate (CaCO<sub>3</sub>), in the form of limestone and chalk, or calcium sulfate (CaSO<sub>4</sub>), in the form of other mineral deposits. The predominant source of magnesium is dolomite (CaMg(CO<sub>3</sub>)<sub>2</sub>). Hard water is generally not harmful. The simplest way to determine the hardness of water is the lather/froth test: soap or toothpaste, when agitated, lathers easily in soft water but not in hard water. More exact measurements of hardness can be obtained through a wet titration. The total water 'hardness' (including both Ca<sup>2+</sup> and Mg<sup>2+</sup> ions) is read as parts per million or weight/volume (mg/L) of calcium carbonate (CaCO<sub>3</sub>) in the water. Although water hardness usually only measures the total concentrations of calcium and magnesium (the two most prevalent, divalent metal ions), iron, aluminum, and manganese may also be present at elevated levels in some geographical locations.

**HARDNESS:** A measure of the amount of calcium and magnesium salts in water. More calcium and magnesium lead to greater hardness. The term "hardness" comes from the fact that it is hard to get soap suds from soap or detergents in hard water. This happens because calcium and magnesium react strongly with negatively-charged chemicals like soap to form insoluble compounds.

**HARDY-WEINBERG THEOREM:** An axiom maintaining that the sexual shuffling of genes alone cannot alter the overall genetic makeup of a population.

**HARTSHORN:** The antler of a hart, formerly used as a source of ammonia. Ammonium carbonate.

**HAUSTORIUM:** In parasitic fungi, a nutrient-absorbing hyphal tip that penetrates the tissues of the host but remains outside the host cell membranes.

**HAVERSIAN SYSTEM:** One of many structural units of vertebrate bone, consisting of concentric layers of mineralized bone matrix surrounding lacunae, which contain osteocytes, and a central canal, which contains blood vessels and nerves.

**HAZARDS OF POLYMERS:** Slippery and difficult to clean-up are the most common hazards associated with the use of polymers in a water treatment plant.

**HEAD:** The measure of the pressure of water expressed in feet of height of water. 1 PSI = 2.31 feet of water or 1 foot of head equals about a half a pound of pressure or .433 PSI. There are various types of heads of water depending upon what is being measured. Static (water at rest) and Residual (water at flow conditions).

**HEADWORKS:** The facility at the "head" of the water source where water is first treated and routed into the distribution system.

**HEALTH ADVISORY:** An EPA document that provides guidance and information on contaminants that can affect human health and that may occur in drinking water, but which the EPA does not currently regulate in drinking water.

**HEAT OF VAPORIZATION:** The amount of energy absorbed by a substance when it changes state to a gas. Water absorbs approximately 580 calories per gram when it changes from liquid water to water vapor.

**HEAT:** The total amount of kinetic energy due to molecular motion in a body of matter. Heat is energy in its most random form.

**HEAT:** Energy transferred from one system to another by thermal interaction.

**HELPER T CELL:** A type of T cell that is required by some B cells to help them make antibodies or that helps other T cells respond to antigens or secrete lymphokines or interleukins.

**HEMAGGLUTININ:** A surface antigen on influenza viruses which controls infectivity by associating with receptors on host erythrocytes or other cells.

**HEMATOPOIESIS:** The formation of blood.

**HEMATOPOIETIC STEM CELLS:** Cells found in the bone marrow of adult mammals which give rise to erythroid stem cells, lymphoid stem cells, and myeloid stem cells. Such cells give rise to erythrocytes and a variety of types of lymphocytes and leucocytes.

**HEMOGLOBIN:** An iron-containing respiratory pigment found in many organisms.

**HEMOLymph:** In invertebrates with open circulatory systems, the body fluid that bathes tissues.

**HEMOPHILIA:** A genetic disease resulting from an abnormal sex-linked recessive gene, characterized by excessive bleeding following injury.

**HEPATIC:** Pertaining to the liver.

**HEREDITY:** A biological phenomenon whereby characteristics are transmitted from one generation to another by virtue of chemicals (i.e. DNA) transferred during sexual or asexual reproduction.

**HERPESVIRUS:** A double stranded DNA virus with an enveloped, icosahedral capsid.

**HERTZ:** The term used to describe the frequency of cycles in an alternating current (AC) circuit. A unit of frequency equal to one cycle per second.

**HETEROCHROMATIN:** Non-transcribed eukaryotic chromatin that is so highly compacted that it is visible with a light microscope during interphase.

**HETEROCHRONY:** Evolutionary changes in the timing or rate of development.

**HETEROCYST:** A specialized cell that engages in nitrogen fixation on some filamentous cyanobacteria.

**HETEROGAMY:** The condition of producing gametes of two different types (contrast with isogamy).

**HETEROMORPHIC:** A condition in the life cycle of all modern plants in which the sporophyte and gametophyte generations differ in morphology.

**HETEROSPOROUS:** Referring to plants in which the sporophyte produces two kinds of spores that develop into unisexual gametophytes, either male or female.

**HETEROTROPH:** An organism dependent on external sources of organic compounds as a means of obtaining energy and/or materials. Such an organism requires carbon ("food") from its environment in an organic form. (synonym-organotroph).

**HETEROTROPHIC PLATE COUNT:** A test performed on drinking water to determine the total number of all types of bacteria in the water.

**HETEROZYGOTE ADVANTAGE:** A mechanism that preserves variation in eukaryotic gene pools by conferring greater reproductive success on heterozygotes over individuals homozygous for any one of the associated alleles.

**HETEROZYGOUS:** The condition whereby two different alleles of the gene are present within the same cell.

**HF:** The molecular formula of Hydrofluoric acid.

**HIGH TURBIDITY CAUSING INCREASED CHLORINE DEMAND:** May occur or be caused by the inadequate disinfection of water.

**HISTAMINE:** A substance released by injured cells that causes blood vessels to dilate during an inflammatory response.

**HISTOLOGY:** The study of tissues.

**HISTONE:** A type of protein characteristically associated with the chromosomes of eukaryotes.

**HIV-1:** Acute human immunodeficiency virus type 1 is the subtype of HIV (human immune deficiency virus) that causes most cases of AIDS in the Western Hemisphere, Europe, and Central, South, and East Africa. HIV is a retrovirus (subclass lentivirus), and retroviruses are single-stranded RNA viruses that have an enzyme called reverse transcriptase. With this enzyme the viral RNA is used as a template to produce viral DNA from cellular material. This DNA is then incorporated into the host cell's genome, where it codes for the synthesis of viral components. An HIV-1 infection should be distinguished from AIDS. Acquired immunodeficiency syndrome (AIDS) is a secondary immunodeficiency syndrome resulting from HIV infection and characterized by opportunistic infections, malignancies, neurologic dysfunction, and a variety of other syndromes.

**HOLOBLASTIC:** A type of cleavage in which there is complete division of the egg, as in eggs having little yolk (sea urchin) or a moderate amount of yolk (frog).

**HOME RANGE:** An area within which an animal tends to confine all or nearly all its activities for a long period of time.

**HOMEBOX:** Specific sequences of DNA that regulate patterns of differentiation during development of an organism.

**HOMEOSTASIS:** A phenomenon whereby a state or process (for example, within an organism) is regulated automatically despite the tendency for fluctuations to occur.

**HOMEOTHERMIC:** Capable of regulation of constancy with respect to temperature.

**HOMEOTIC GENES:** Genes that control the overall body plan of animals by controlling the developmental fate of groups of cells.

**HOMEOTIC:** (mutation) A mutation in genes regulated by positional information that results in the abnormal substitution of one type of body part in place of another.

**HOMOLOGOUS CHROMOSOMES:** Chromosomes bearing genes for the same characters.

**HOMOLOGOUS STRUCTURES:** Characters in different species which were inherited from a common ancestor and thus share a similar ontogenetic pattern.

**HOMOLOGY:** Similarity in characteristics resulting from a shared ancestry.

**HOMOPLASY:** The presence in several species of a trait not present in their most common ancestor. Can result from convergent evolution, reverse evolution, or parallel evolution.

**HOMOSPOROUS:** Referring to plants in which a single type of spore develops into a bisexual gametophyte having both male and female sex organs.

**HOMOZYGOUS:** Having two copies of the same allele of a given gene.

**HORMONE:** A control chemical secreted in one part of the body that affects other parts of the body.

**HOST RANGE:** The limited number of host species, tissues, or cells that a parasite (including viruses and bacteria) can infect.

**HUMORAL IMMUNITY:** The type of immunity that fights bacteria and viruses in body fluids with antibodies that circulate in blood plasma and lymph, fluids formerly called humors.

**HYBIRD VIGOR:** Increased vitality (compared to that of either parent stock) in the hybrid offspring of two different, inbred parents.

**HYBIRD:** In evolutionary biology, a cross between two species. In genetics, a cross between two genetic types.

**HYBIRDIZATION:** The process whereby a hybrid results from interbreeding two species; 2) DNA hybridization is the comparison of whole genomes of two species by estimating the extent of hydrogen bonding that occurs between single-stranded DNA obtained from the two species.

**HYBRIDOMA:** A hybrid cell that produces monoclonal antibodies in culture, formed by the fusion of a myeloma cell with a normal antibody-producing lymphocyte.

**HYDRATED LIME:** The calcium hydroxide product that results from mixing quicklime with water. Chemical formula is  $\text{CaOH}_2$ .

**HYDRATION SHELL:** A "covering" of water molecules which surrounds polar or charged substances in aqueous solutions. The association is due to the charged regions of the polar water molecules themselves.

**hydraulic conductivity:** A primary factor in Darcy's Law, the measure of a soil or formations ability to transmit water, measured in gallons per day (gpd) See also Permeability and Darcy's Law.

**HYDRIDES:** Hydride is the name given to the negative ion of hydrogen, H. Although this ion does not exist except in extraordinary conditions, the term hydride is widely applied to describe compounds of hydrogen with other elements, particularly those of groups 1–16. The variety of compounds formed by hydrogen is vast, arguably greater than that of any other element. Various metal hydrides are currently being studied for use as a means of hydrogen storage in fuel cell-powered electric cars and batteries. They also have important uses in organic chemistry as powerful reducing agents, and many promising uses in hydrogen economy.

**HYDROCARBON:** Any compound made of only carbon and hydrogen.

**HYDROCHLORIC AND HYPOCHLOROUS ACIDS:** HCL and HOCL: The compounds that are formed in water when chlorine gas is introduced.

**HYDROFLUOSILICIC ACID:** ( $\text{H}_2\text{SiF}_6$ ) a clear, fuming corrosive liquid with a pH ranging from 1 to 1.5. Used in water treatment to fluoridate drinking water.

**HYDROGEN BOND:** A type of bond formed when the partially positive hydrogen atom of a polar covalent bond in one molecule is attracted to the partially negative atom of a polar covalent bond in another.

**HYDROGEN ION:** A single proton with a charge of +1. The dissociation of a water molecule ( $\text{H}_2\text{O}$ ) leads to the generation of a hydroxide ion ( $\text{OH}^-$ ) and a hydrogen ion ( $\text{H}^+$ ).

**HYDROGEN SULFIDE OR CHLORINE GAS:** These chemicals can cause olfactory fatigue.

**HYDROGEN SULFIDE:** A toxic gas formed by the anaerobic decomposition of organic matter. Chemical formula is  $\text{H}_2\text{S}$ .

**Hydrologic Cycle: (Water Cycle)** The continual process of precipitation (rain and snowfall), evaporation (primarily from the oceans), percolation (recharge to groundwater), runoff (surface water), and transpiration (plants) constituting the renew ability and recycling of each component.

**HYDROLYSIS:** The chemical reaction that breaks a covalent bond through the addition of hydrogen (from a water molecule) to the atom forming one side of the original bond, and a hydroxyl group to the atom on the other side.

**HYDROPHILIC:** Having an affinity for water.

**HYDROPHOBIC INTERACTION:** A type of weak chemical bond formed when molecules that do not mix with water coalesce to exclude the water.

**HYDROPHOBIC:** The physicochemical property whereby a substance or region of a molecule resists association with water molecules. Does not mix readily with water.

**HYDROSTATIC:** Pertaining to the pressure and equilibrium of fluids. A hydrostatic skeleton is a skeletal system composed of fluid held under pressure in a closed body compartment; the main skeleton of most cnidarians, flatworms, nematodes, and annelids.

**HYDROXYL GROUP:** A functional group consisting of a hydrogen atom joined to an oxygen atom by a polar covalent bond. Molecules possessing this group are soluble in water and are called alcohols.

**HYDROXYL ION:** The OH<sup>-</sup> ion.

**HYGROSCOPIC:** Absorbing or attracting moisture from the air.

**HYPEROSMOTIC:** A solution with a greater solute concentration than another, a hypoosmotic solution. If the two solutions are separated from one another by a membrane permeable to water, water would tend to move from the hypo- to the hyperosmotic side.

**HYPERPOLARIZATION:** An electrical state whereby the inside of the cell is made more negative relative to the outside than was the case at resting potential. A neuron membrane is hyperpolarized if the voltage is increased from the resting potential of about -70 mV, reducing the chance that a nerve impulse will be transmitted.

**HYPERTROPHY:** Abnormal enlargement, excessive growth.

**HYPHA:** A fungal filament.

**HYPOCHLORITE (OCL-) AND ORGANIC MATERIALS:** Heat and possibly fire may occur when hypochlorite is brought into contact with an organic material.

**HYPOCHLORITE AND ORGANIC MATERIALS:** Heat and possibly fire may occur when hypochlorite is brought into contact with an organic material.

**HYPOCOTYL:** The portion of the axis of a plant embryo below the point of attachment of the cotyledons; forms the base of the shoot and the root.

**HYPOLIMNION:** The layer of water in a thermally stratified lake that lies below the thermocline, is noncirculating, and remains perpetually cold.

**HYPOOSMOTIC SOLUTION:** A solution with a lesser solute concentration than another, a hyperosmotic solution. If the two solutions are separated from one another by a membrane permeable to water, water would tend to move from the hypo- to the hyperosmotic side.

**HYPOTHESIS:** A formal statement of supposition offered to explain observations. Note that a hypothesis is only useful if it can be tested. Even if correct, it is not scientifically useful if untestable.

**HYPOTHETICO-DEDUCTIVE:** A method used to test hypotheses. If deductions formulated from the hypothesis are tested and proven false, the hypothesis is rejected.

I

**IMAGINAL DISK:** An island of undifferentiated cells in an insect larva, which are committed (determined) to form a particular organ during metamorphosis to the adult.

**IMBIBITION:** The soaking of water into a porous material that is hydrophilic.

**IMMUNE RESPONSE:** 1) A primary immune response is the initial response to an antigen, which appears after a lag of a few days. 2) A secondary immune response is the response elicited when the animal encounters the same antigen at a later time. The secondary response is normally more rapid, of greater magnitude and of longer duration than the primary response.

**IMMUNOGLOBULINE:** The class of proteins comprising the antibodies.

**IMMUNOLOGICAL:** 1) Immunological distance is the amount of difference between two proteins as measured by the strength of the antigen: antibody reaction between them. 2) Immunological tolerance is a mechanism by which an animal does not mount an immune response to the antigenic determinants of its own macromolecules.

**IMMUNOMAGNETIC SEPARATION (IMS):** A purification procedure that uses microscopic, magnetically responsive particles coated with an antibodies targeted to react with a specific pathogen in a fluid stream. Pathogens are selectively removed from other debris using a magnetic field.

**IMPERVIOUS:** Not allowing, or allowing only with great difficulty, the movement of water.

**IMPRINTING:** A type of learned behavior with a significant innate component, acquired during a limited critical period.

In practice, water with an LSI between -0.5 and +0.5 will not display enhanced mineral dissolving or scale forming properties. Water with an LSI below -0.5 tends to exhibit noticeably increased dissolving abilities while water with an LSI above +0.5 tends to exhibit noticeably increased scale forming properties.

**In Series:** Several components being connected one to the other without a bypass, requiring each component to work dependent on the one before it.

**IN SERIES:** Several components being connected one to the other without a bypass, requiring each component to work dependent on the one before it.

**IN SITU:** Treatment or disposal methods that do not require movement of contaminated material.

**IN VITRO FERTILIZATION:** Fertilization of ova in laboratory containers followed by artificial implantation of the early embryo in the mother's uterus.

**INCINERATION:** The process of reducing the volume of a material by burning and reducing to ash if possible.

**INCLINED PLATE SEPARATOR:** A series of parallel inclined plates that can be used to increase the efficiency of clarifiers and gravity thickeners.

**INCOMPLETE DOMINANCE:** A type of inheritance in which F1 hybrids have an appearance that is intermediate between the phenotypes of the parental varieties.

**INDETERMINATE:** 1) A type of cleavage exhibited during the embryonic development in deuterostomes, in which each cell produced by early cleavage divisions retains the capacity to develop into a complete embryo; 2) A type of growth exhibited by plants: they continue to grow as long as they live, because they always retain meristematic cells capable of undergoing mitosis.

**INDICATOR:** A special compound added to solution that changes color depending on the acidity of the solution; different indicators have different colors and effective pH ranges.

**INDIRECT REUSE:** The beneficial use of reclaimed water into natural surface waters or groundwater.

**INDUCED FIT:** The change in shape of the active site of an enzyme so that it binds more snugly to the substrate, induced by entry of the substrate.

**INDUCTION:** 1) The ability of one group of embryonic cells to influence the development of another. 2) A method in logic which proceeds from the specific to general and develops a general statement which explains all of the observations. Commonly used to formulate scientific hypotheses.

**INDUSTRIAL MELANISM:** Melanism which has resulted from blackening of environmental surfaces (tree bark, etc.) by industrial pollution. This favors survival of melanic forms such as moths which rest on tree bark and are less likely to be seen by predators.

**INDUSTRIAL WASTEWATER:** Liquid wastes resulting from industrial processes.

**INFECTIOUS PATHOGENS/MICROBES/GERMS:** Are considered disease-producing bacteria, viruses and other microorganisms.

**INFECTIOUS:** 1) An infectious disease is a disease caused by an infectious microbial or parasitic agent. 2) Infectious hepatitis is the former name for hepatitis A. 3) Infectious mononucleosis is an acute disease that affects many systems, caused by the Epstein: Barr virus.

**Infiltration:** The percolation of fluid into soil or formation. See also percolation.

**INFLAMMATORY RESPONSE:** A line of defense triggered by penetration of the skin or mucous membranes, in which small blood vessels in the vicinity of an injury dilate and become leakier, enhancing infiltration of leukocytes; may also be widespread in the body.

**INFLUENT:** Water or wastewater flowing into a basin or treatment plant.

**INFORMATION COLLECTION RULE:** ICR EPA collected data required by the Information Collection Rule (May 14, 1996) to support future regulation of microbial contaminants, disinfectants, and disinfection byproducts. The rule was intended to provide EPA with information on chemical byproducts that form when disinfectants used for microbial control react with chemicals already present in source water (disinfection byproducts (DBPs)); disease-causing microorganisms (pathogens), including *Cryptosporidium*; and engineering data to control these contaminants.

**INGESTION:** A heterotrophic mode of nutrition in which other organisms or detritus are eaten whole or in pieces.

**INHIBITORY POSTSYNAPTIC POTENTIAL:** An electrical charge (hyperpolarization) in the membrane of a postsynaptic neuron caused by the binding of an inhibitory neurotransmitter from a presynaptic cell to a postsynaptic receptor.

**INITIAL MONITORING YEAR:** An initial monitoring year is the calendar year designated by the Department within a compliance period in which a public water system conducts initial monitoring at a point of entry.

**INITIAL PRECISION AND RECOVERY (IPR):** Four aliquots of spiking suspension analyzed to establish the ability to generate acceptable precision and accuracy. An IPR is performed prior to the first time this method is used and any time the method or instrumentation is modified.



**INNER CELL MASS:** A cluster of cells in a mammalian blastocyst that protrudes into one end of the cavity and subsequently develops into the embryo proper and some of the extraembryonic membranes.

**INORGANIC CHEMISTRY:** A part of chemistry concerned with inorganic compounds.

**INORGANIC COMPOUND:** Compounds that contain no carbon or contain only carbon bound to elements other than hydrogen.

**INORGANIC COMPOUND:** Compounds that do not contain carbon, though there are exceptions.

**INORGANIC CONTAMINANTS:** Mineral-based compounds such as metals, nitrates, and asbestos. These contaminants are naturally-occurring in some water, but can also get into water through farming, chemical manufacturing, and other human activities. EPA has set legal limits on 15 inorganic contaminants.

**INORGANIC IONS:** Present in all waters. Inorganic ions are essential for human health in small quantities, but in larger quantities they can cause unpleasant taste and odor or even illness. Most community water systems will commonly test for the concentrations of seven inorganic ions: nitrate, nitrite, fluoride, phosphate, sulfate, chloride, and bromide. Nitrate and nitrite can cause an illness in infants called methemoglobinemia. Fluoride is actually added to the drinking water in some public water systems to promote dental health. Phosphate, sulfate, chloride, and bromide have little direct effect on health, but high concentrations of inorganic ions can give water a salty or briny taste.

**INOSITOL TRIPHOSPHATE:** The second messenger, which functions as an intermediate between certain non-steroid hormones and the third messenger, a rise in cytoplasmic  $Ca^{++}$  concentration.

**INSERTION:** A mutation involving the addition of one or more nucleotide pairs to a gene.

**INSIGHT LEARNING:** The ability of an animal to perform a correct or appropriate behavior on the first attempt in a situation with which it has had no prior experience.

**INSOLUBLE COMPOUNDS:** are types of compounds cannot be dissolved. When iron or manganese reacts with dissolved oxygen (DO) insoluble compound are formed.

**INSULATOR:** Material that resists the flow of electric current.

**INSULIN:** The vertebrate hormone that lowers blood sugar levels by promoting the uptake of glucose by most body cells and promoting the synthesis and storage of glycogen in the liver; also stimulates protein and fat synthesis; secreted by endocrine cells of the pancreas called islets of Langerhans.

**INTAKE FACILITIES:** One of the more important considerations in the construction of intake facilities is the ease of operation and maintenance over the expected lifetime of the facility. Every intake structure must be constructed with consideration for operator safety and for cathodic protection.

**INTEGRAL PROTEIN:** A protein of biological membranes that penetrates into or spans the membrane.

**INTERBREED:** To breed with another kind or species; hybridize.

**INTERFERON:** A chemical messenger of the immune system, produced by virus: infected cells and capable of helping other cells resist the virus.

**INTERLEUKIN:** 1: A chemical regulator (cytokine) secreted by macrophages that have ingested a pathogen or foreign molecule and have bound with a helper T cell; stimulates T cells to grow and divide and elevates body temperature. Interleukin: 2, secreted by activated T cells, stimulates helper T cells to proliferate more rapidly.

**INTERMEDIATE FILAMENT:** A component of the cytoskeleton that includes all filaments intermediate in size between microtubules and microfilaments.

**INTERNEURON:** An association neuron; a nerve cell within the central nervous system that forms synapses with sensory and motor neurons and integrates sensory input and motor output.

**INTERNODE:** The segment of a plant stem between the points where leaves are attached.

**INTERSTITIAL CELLS:** Cells scattered among the seminiferous tubules of the vertebrate testis that secrete testosterone and other androgens, the male sex hormones.

**INTERSTITIAL FLUID:** The internal environment of vertebrates consisting of the fluid filling the spaces between cells.

**INTERTIDAL ZONE:** The shallow zone of the ocean where land meets water.

**INTRINSIC RATE OF INCREASE:** The difference between number of births and number of deaths, symbolized as  $r_{max}$ ; maximum population growth rate.

**INTROGRESSION:** Transplantation of genes between species resulting from fertile hybrids mating successfully with one of the parent species.

**INTRON:** The noncoding, intervening sequence of coding region (exon) in eukaryotic genes.

**INVAGINATION:** The buckling inward of a cell layer, caused by rearrangements of microfilaments and microtubules; an important phenomenon in embryonic development.

**INVERSION:** 1) An aberration in chromosome structure resulting from an error in meiosis or from mutagens; reattachment in a reverse orientation of a chromosomal fragment to the chromosome from which the fragment originated. 2) A phenomenon which occurs during early development of sponges at which time the external ciliated cells become inward-directed.

**INVERTEBRATE:** An animal without a backbone; invertebrates make up about 95% of animal species.

**ION EXCHANGE:** An effective treatment process used to remove iron and manganese in a water supply. The hardness of the source water affects the amount of water an ion exchange softener may treat before the bed requires regeneration.

**ION:** A charged chemical formed when an atom or group of atoms has more or less electrons than protons (rather than an equal number). A molecule that has gained or lost one or more electrons.

**IONIC BOND:** A chemical bond due to attraction between oppositely charged ions.

**IONIZATION:** The breaking up of a compound into separate ions.

**IRON AND MANGANESE:** Fe and Mn In water they can usually be detected by observing the color of the inside walls of filters and the filter media. If the raw water is pre-chlorinated, there will be black stains on the walls below the water level and a black coating over the top portion of the sand filter bed. When significant levels of dissolved oxygen are present, iron and manganese exist in an oxidized state and normally precipitate into the reservoir bottom sediments. The presence of iron and manganese in water promote the growth of Iron bacteria. Only when a water sample has been acidified then you can perform the analysis beyond the 48 hour holding time. Iron and Manganese in water may be detected by observing the color of the of the filter media. Maintaining a free chlorine residual and regular flushing of water mains may control the growth of iron bacteria in a water distribution system.

**IRON AND MANGANESE:** In water they can usually be detected by observing the color of the inside walls of filters and the filter media. If the raw water is pre-chlorinated, there will be black stains on the walls below the water level and a black coating over the top portion of the sand filter bed. When significant levels of dissolved oxygen are present, iron and manganese exist in an oxidized state and normally precipitate into the reservoir bottom sediments. The presence of iron and manganese in water promote the growth of Iron bacteria. Only when a water sample has been acidified then you can perform the analysis beyond the 48 hour holding time. Iron and Manganese in water may be detected by observing the color of the of the filter media. Maintaining a free chlorine residual and regular flushing of water mains may control the growth of iron bacteria in a water distribution system.

**IRON BACTERIA:** Perhaps the most troublesome consequence of iron and manganese in the water is they promote the growth of a group of microorganism known as Iron Bacteria.

**IRON FOULING:** You should look for an orange color on the resin and backwash water when checking an ion exchange unit for iron fouling

**IRON:** Fe The elements iron and manganese are undesirable in water because they cause stains and promote the growth of iron bacteria.

**IRRUPTION:** A rapid increase in population density often followed by a mass emigration.

**ISOGAMY:** A condition in which male and female gametes are morphologically indistinguishable.

**ISOMER:** Molecules consisting of the same numbers and kinds of atoms, but differing in the way in which the atoms are combined.

**ISOSMOTIC:** Solutions of equal concentration with respect to osmotic pressure.

**ISOTOPE:** An atomic form of an element, containing a different number of neutrons than another isotope. Isotopes vary from one another with respect to atomic mass.

It is also worth noting that the LSI is temperature sensitive. The LSI becomes more positive as the water temperature increases. This has particular implications in situations where well water is used. The temperature of the water when it first exits the well is often significantly lower than the

temperature inside the building served by the well or at the laboratory where the LSI measurement is made.

IUPAC: International Union of Pure and Applied Chemistry

## J

JODIUM: Latin name of the halogen element iodine.

JOULE: The SI unit of energy, defined as a newton-meter.

JUXTAGLOMERULAR APPARATUS (JGA): Specialized tissue located near the afferent arteriole that supplies blood to the kidney glomerulus; JGA raises blood pressure by producing renin, which activates angiotensin.

## K

K- SELECTION: The concept that life history of the population is centered upon producing relatively few offspring that have a good chance of survival.

KARYOGAMY: The fusion of nuclei of two cells, as part of syngamy.

KARYOTYPE: A method of classifying the chromosomes of a cell in relation to number, size and type.

KEYSTONE PREDATOR: A species that maintains species richness in a community through predation of the best competitors in the community, thereby maintaining populations of less competitive species.

KILL = C X T: Where other factors are constant, the disinfecting action may be represented by: Kill=C x T. Kill=C x T. C= Chlorine T= Contact time.

KILOCALORIE: A thousand calories; the amount of heat energy required to raise the temperature of 1 kilogram of water by primary C.

KIN SELECTION: A phenomenon of inclusive fitness, used to explain altruistic behavior between related individuals.

KINESIS: A change in activity rate in response to a stimulus.

KINETIC ENERGY: The ability of an object to do work by virtue of its motion. The energy terms that are used to describe the operation of a pump are pressure and head. The energy of motion. Moving matter does work by transferring some of its kinetic energy to other matter.

KINETICS: A sub-field of chemistry specializing in reaction rates.

KINETOCHORE: A specialized region on the centromere that links each sister chromatid to the mitotic spindle.

KINGDOM: A taxonomic category, the second broadest after domain.

KREBS CYCLE: A chemical cycle involving eight steps that completes the metabolic breakdown of glucose molecules to carbon dioxide; occurs within the mitochondrion; the second major stage in cellular respiration. Also called citric acid cycle or tricarboxylic acid (TCA) cycle.

## L

L.O.T.O.: If a piece of equipment is locked out, the key to the lock-out device the key should be held by the person who is working on the equipment. The tag is an identification device and the lock is a physical restraint.

LABORATORY BLANK: See Method blank

LABORATORY CONTROL SAMPLE (LCS): See Ongoing precision and recovery (OPR) standard

LACRIMATION: The secretion of tears, esp. in abnormal abundance Also, lachrymation, lachrimation.

LACTEAL: A tiny lymph vessel extending into the core of the intestinal villus and serving as the destination for absorbed chylomicrons.

LACTIC ACID: Gram-positive, anaerobic; produce lactic acid through fermentation; include Lactobacillus, essential in dairy product formation, and Streptococcus, common in humans.

LAGGING STRAND: A discontinuously synthesized DNA strand that elongates in a direction away from the replication fork.

LAMARCK: Proposed, in the early 1800s, that evolutionary change may occur via the inheritance of acquired characteristics. This idea, which has since been discredited, holds that the changes in characteristics which occur during an individual's life can be passed on to its offspring.

**LAND APPLICATION:** The disposal of wastewater or municipal solids onto land under controlled conditions.

**LAND DISPOSAL:** Application of municipal wastewater solids to the soil without production of usable agricultural products.

**LANDFILL:** A land disposal site that employs an engineering method of solid waste disposal to minimize environmental hazards and protect the quality of surface and subsurface waters.

**LANGELIER INDEX:** A measurement of Corrosivity. The water is becoming corrosive in the distribution system causing rusty water if the Langelier index indicates that the pH has decreased from the equilibrium point. Mathematically derived factor obtained from the values of calcium hardness, total alkalinity, and pH at a given temperature. A Langelier index of zero indicates perfect water balance (i.e., neither corroding nor scaling). The Langelier Saturation Index (sometimes Langelier Stability Index) is a calculated number used to predict the calcium carbonate stability of water. It indicates whether the water will precipitate, dissolve, or be in equilibrium with calcium carbonate. Langelier developed a method for predicting the pH at which water is saturated in calcium carbonate (called pHs). The LSI is expressed as the difference between the actual system pH and the saturation pH.

**LANTHANIDES:** Elements 57 through 71.

**LARVA** (pl. larvae): A free-living, sexually immature form in some animal life cycles that may differ from the adult in morphology, nutrition, and habitat.

**LATERAL LINE SYSTEM:** A mechanoreceptor system consisting of a series of pores and receptor units (neuromasts) along the sides of the body of fishes and aquatic amphibians; detects water movements made by an animal itself and by other moving objects.

**LATERAL MERISTEMS:** The vascular and cork cambia, cylinders of dividing cells that run most of the length of stems and roots and are responsible for secondary growth.

**LATTICE:** Unique arrangement of atoms or molecules in a crystalline liquid or solid.

**LAW OF INDEPENDENT ASSORTMENT:** Mendel's second law, stating that each allele pair segregates independently during gamete formation; applies when genes for two traits are located on different pairs of homologous chromosomes.

**LAW OF MOTION:** An object in motion stay in motion an object in rest stays in rest unless an unbalanced force acts on it.

**LAW OF SEGREGATION:** Mendel's first law, stating that allele pairs separate during gamete formation, and then randomly re-form pairs during the fusion of gametes at fertilization.

**LEACHATE:** Fluid that trickles through solid materials or wastes and contains suspended or dissolved materials or products of the solids.

**LEACHING:** A chemical reaction between water and metals that allows for removal of soluble materials.

**LEAD AND COPPER:** Initial tap water monitoring for lead and copper must be conducted during 2 consecutive 6-month periods.

**LEADING STRAND:** The new continuously complementary DNA strand synthesized along the template strand in the 5' --- > 3' direction.

**LEUKOCYTE:** A white blood cell; typically functions in immunity, such as phagocytosis or antibody production.

**LEVELS OF ORGANIZATION:** A basic concept in biology is that organization is based on a hierarchy of structural levels, with each level building on the levels below it.

**LICHEN:** An organism formed by the symbiotic association between a fungus and a photosynthetic alga.

**LIFE:** (table) A table of data summarizing mortality in a population.

**LIGAMENT:** A type of fibrous connective tissue that joins bones together at joints.

**LIGAND:** A ligand is a molecule that binds specifically to a receptor site of another molecule. A ligase is an enzyme which catalyzes such a reaction. For example, a DNA ligase is an enzyme which catalyzes the covalent bonding of the 3' end of a new DNA fragment to the 5' end of a growing chain.

**LIGASE:** Ligases are enzymes that catalyze the "stitching together" of polymer fragments. DNA ligase, for example, catalyzes phosphodiester bond formation between two DNA fragments, and

this enzyme is involved in normal DNA replication, repair of damaged chromosomes, and various in vitro techniques in genetic engineering that involve linking DNA fragments.

**LIGHT:** Portion of the electromagnetic spectrum which is visible to the naked eye. Also called "visible light."

**LIGNIN:** A hard material embedded in the cellulose matrix of vascular plant cell walls that functions as an important adaptation for support in terrestrial species.

**LIMBIC SYSTEM:** A group of nuclei (clusters of nerve cell bodies) in the lower part of the mammalian forebrain that interact with the cerebral cortex in determining emotions; includes the hippocampus and the amygdala.

**LIME SODA SOFTENING:** In a lime soda softening process, the pH of the water is raised to 11.0. In a lime softening process, excess lime is frequently added to remove Calcium and Magnesium Bicarbonate. The minimum hardness which can be achieved by the lime-soda ash process is 30 to 40 mg/L as calcium carbonate. The hardness due to noncarbonate hardness is most likely to determine the choice between lime softening and ion exchange to remove hardness.

**LIME SOFTENING:** Lime softening is primarily used to "soften" water—that is to remove calcium and magnesium mineral salts. But it also removes harmful toxins like radon and arsenic. Though there is no consensus, some studies have even suggested that lime softening is effective at removal of Giardia. Hard water is a common condition responsible for numerous problems. Users often recognize hard water because it prevents their soap from lathering properly. However, it can also cause buildup ("scale") in hot water heaters, boilers, and hot water pipes. Because of these inconveniences, many treatment facilities use lime softening to soften hard water for consumer use. Before lime softening can be used, managers must determine the softening chemistry required. This is a relatively easy task for groundwater sources, which remain more constant in their composition. Surface waters, however, fluctuate widely in quality and may require frequent changes to the softening chemical mix. In lime softening, lime and sometimes sodium carbonate are added to the water as it enters a combination solids contact clarifier. This raises the pH (i.e., increases alkalinity) and leads to the precipitation of calcium carbonate. Later, the pH of the effluent from the clarifier is reduced again, and the water is then filtered through a granular media filter. The water chemistry requirements of these systems require knowledgeable operators, which may make lime softening an economic challenge for some very small systems.

**LIME STABILIZATION:** The addition of lime to untreated sludge to raise the pH to 12 for a minimum of 2 hours to chemically inactivate microorganisms.

**LIME:** Is a chemical that may be added to water to reduce the corrosivity. When an operator adds lime to water, Calcium and magnesium become less soluble. The term generally used to describe ground limestone (calcium carbonate), hydrated lime (calcium hydroxide), or burned lime (calcium oxide).

**LINKED GENES:** Genes that are located on the same chromosomes.

**LIPID:** One of a family of compounds, including fats, phospholipids, and steroids, that are insoluble in water.

**LIPOPROTEIN:** A protein bonded to a lipid; includes the low-density lipoproteins (LDLS) and high-density lipoproteins (HDLs) that transport fats and cholesterol in the blood.

**LIPOSOME:** Liposomes are vesicles (spherules) in which the lipid molecules are spontaneously arranged into bilayers with hydrophilic groups exposed to water molecules both outside the vesicle and in the core.

**LIQUID:** A state of matter which takes the shape of its container.

**LISTED HAZARDOUS WASTE:** The designation for a waste material that appears on an EPA list of specific hazardous wastes or hazardous waste categories.

**LOCUS:** A particular place along the length of a certain chromosome where a specified allele is located.

**LOGISTIC POPULATION GROWTH:** A model describing population growth that levels off as population size approaches carrying capacity.

**LONDON DISPERSION FORCES:** A weak intermolecular force.

**LSI = pH - pHs**

**LSI = pH (measured) - pHs**

**LYMPHOCYTE:** Lymphocytes (lymph cells, lympho- leukocytes) are a type of leukocyte (white blood cell) responsible for the immune response. There are two classes of lymphocytes: 1) the B-cells, when presented with a foreign chemical entity (antigen), change into antibody producing plasma cells; and, 2) the T- cells interact directly with foreign invaders such as bacteria and viruses. The T- cells express various surface marker macromolecules. For example, CD4+ is the notation for a specific expressed T- cell surface marker that can be identified by assay.

**LYSIS:** The destruction of a cell by rupture of the plasma membrane.

**LYSOGENIC CYCLE:** A type of viral replication cycle in which the viral genome becomes incorporated into the bacterial host chromosome as a prophage.

**LYSOSOME:** A membrane-bounded organelle found in eukaryotic cells (other than plants). Lysosomes contain a mixture of enzymes that can digest most of the macromolecules found in the rest of the cell. An enzyme in perspiration, tears, and saliva that attacks bacterial cell walls.

**LYTIC CYCLE:** A type of viral replication cycle resulting in the release of new phages by death or lysis of the host cell.

## M

**M PHASE:** The mitotic phase of the cell cycle, which includes mitosis and cytokinesis.

**M.S.D.S.:** Material Safety Data Sheet, now S.D.S. (Safety Data Sheet). A safety document must an employer provide to an operator upon request.

**MACROEVOLUTION:** Evolutionary change on a grand scale, encompassing the origin of novel designs, evolutionary trends, adaptive radiation, and mass extinction.

**MACROMOLECULE:** A giant molecule of living matter formed by the joining of smaller molecules, usually by condensation synthesis. Polysaccharides, proteins, and nucleic acids are macromolecules.

**MACROPHAGE:** An amoeboid cell that moves through tissue fibers, engulfing bacteria and dead cells by phagocytosis.

**MAGNESIUM HARDNESS:** Measure of the magnesium salts dissolved in water – it is not a factor in water balance.

**MAJOR HISTOCOMPATIBILITY COMPLEX:** A large set of cell surface antigens encoded by a family of genes. Foreign MHC markers trigger T-cell responses that may lead to rejection of transplanted tissues and organs.

**MAKEUP WATER:** Fluid introduced in a recirculating stream to maintain an equilibrium of temperature, solids concentration or other parameters. Also refers to the quantity of water required to make a solution.

**MALIGNANT TUMOR:** A cancerous growth; an abnormal growth whose cells multiply excessively, have altered surfaces, and may have unusual numbers of chromosomes and/or aberrant metabolic processes.

**MALPIGHIAN TUBULE:** A unique excretory organ of insects that empties into the digestive tract, removes nitrogenous wastes from the blood, and functions in osmoregulation.

**MANTLE:** A heavy fold of tissue in mollusks that drapes over the visceral mass and may secrete a shell.

**MARBLE AND LANGELETT TESTS:** Are used to measure or determine the corrosiveness of a water source.

**MASS NUMBER:** The sum of the number of protons plus the number of neutrons in the nucleus of an atom; unique for each element and designated by a superscript to the left of the elemental symbol.

**MATRIX SPIKE (MS):** A sample prepared by adding a known quantity of organisms to a specified amount of sample matrix for which an independent estimate of target analyte concentration is available. A matrix spike is used to determine the effect of the matrix on a method's recovery efficiency.

**MATRIX:** The nonliving component of connective tissue, consisting of a web of fibers embedded in homogeneous ground substance that may be liquid, jellylike, or solid.

**MATTER:** Anything that takes up space and has mass.

**MAXIMUM CONTAMINANT LEVEL (MCLs):** The maximum allowable level of a contaminant that federal or state regulations allow in a public water system. If the MCL is exceeded, the water system must treat the water so that it meets the MCL.

**MAXIMUM CONTAMINANT LEVEL GOAL (MCLG):** The level of a contaminant at which there would be no risk to human health. This goal is not always economically or technologically feasible, and the goal is not legally enforceable.

**MCL for TURBIDITY:** Turbidity is undesirable because it causes health hazards. An MCL for turbidity was established by the EPA because turbidity does not allow for proper disinfection.

**MEASURE CORROSION DAMAGE:** A coupon such as a strip of metal and is placed to measure corrosion damage in the distribution system in a water main.

**MECHANICAL SEAL:** A mechanical device used to control leakage from the stuffing box of a pump. Usually made of two flat surfaces, one of which rotates on the shaft. The two flat surfaces are of such tolerances as to prevent the passage of water between them. Held in place with spring pressure.

**MECHANORECEPTOR:** A sensory receptor that detects physical deformations in the body environment associated with pressure, touch, stretch, motion, and sound.

**MEDIAN BODIES:** Prominent, dark-staining, paired organelles consisting of microtubules and found in the posterior half of *Giardia*. In *G. intestinalis* (from humans), these structures often have a claw-hammer shape, while in *G. muris* (from mice), the median bodies are round.

**MEDIUM WATER SYSTEM:** More than 3,300 persons and 50,000 or fewer persons.

**MEDULLA OBLONGATA:** The lowest part of the vertebrate brain; a swelling of the hindbrain dorsal to the anterior spinal cord that controls autonomic, homeostatic functions, including breathing, heart and blood vessel activity, swallowing, digestion, and vomiting.

**MEDUSA:** The floating, flattened, mouth-down version of the cnidarian body plan. The alternate form is the polyp.

**MEGAPASCAL:** A unit of pressure equivalent to 10 atmospheres of pressure.

**MEGGER:** Used to test the insulation resistance on a motor.

**MEIOSIS:** A two-stage type of cell division in sexually reproducing organisms that results in gametes with half the chromosome number of the original cell.

**MELTING:** The phase change from a solid to a liquid.

**MEMBRANE POTENTIAL:** The charge difference between the cytoplasm and extracellular fluid in all cells, due to the differential distribution of ions. Membrane potential affects the activity of excitable cells and the transmembrane movement of all charged substances.

**MEMBRANE:** A thin barrier that permits passage of particles of a certain size or of particular physical or chemical properties.

**M-ENDO BROTH:** The coliform group are used as indicators of fecal pollution in water, for assessing the effectiveness of water treatment and disinfection, and for monitoring water quality. m-Endo Broth is used for selectively isolating coliform bacteria from water and other specimens using the membrane filtration technique. m-Endo Broth is prepared according to the formula of Fifield and Schaufus.<sup>1</sup> It is recommended by the American Public Health Association in standard total coliform membrane filtration procedure for testing water, wastewater, and foods.<sup>2,3</sup> The US EPA specifies using m-Endo Broth in the total coliform methods for testing water using single-step, two-step, and delayed incubation membrane filtration methods.

**M-ENDO BROTH:** The coliform group is used as indicators of fecal pollution in water, for assessing the effectiveness of water treatment and disinfection, and for monitoring water quality. m-Endo Broth is used for selectively isolating coliform bacteria from water and other specimens using the membrane filtration technique. m-Endo Broth is prepared according to the formula of Fifield and Schaufus.<sup>1</sup> It is recommended by the American Public Health Association in standard total coliform membrane filtration procedure for testing water, wastewater, and foods.<sup>2,3</sup> The US EPA specifies using m-Endo Broth in the total coliform methods for testing water using single-step, two-step, and delayed incubation membrane filtration methods.: The media shall be brought to the boiling point when preparing M-Endo broth to be used in the membrane filter test for total coliform.

**MESENTERIES:** Membranes that suspend many of the organs of vertebrates inside fluid-filled body cavities.



**MESODERM:** The middle primary germ layer of an early embryo that develops into the notochord, the lining of the coelom, muscles, skeleton, gonads, kidneys and most of the circulatory system.

**MESOSOME:** A localized infolding of the plasma membrane of a bacterium.

**MESSANGER:** (RNA) A type of RNA synthesized from DNA in the genetic material that attaches to ribosomes in the cytoplasm and specifies the primary structure of a protein.

**METABOLISM:** The sum total of the chemical and physical changes constantly taking place in living substances.

**METAL:** Chemical element that is a good conductor of both electricity and heat and forms cations and ionic bonds with non-metals.

**METALIMNION:** Thermocline, middle layer of a thermally stratified lake which is characterized by a rapid decrease in temperature in proportion to depth.

**METALLOID:** Metalloid is a term used in chemistry when classifying the chemical elements. On the basis of their general physical and chemical properties, nearly every element in the periodic table can be termed either a metal or a nonmetal. A few elements with intermediate properties are, however, referred to as metalloids. (In Greek metallon = metal and eidos = sort)

**METAMORPHOSIS:** The resurgence of development in an animal larva that transforms it into a sexually mature adult.

**METANEPHRIDIUM:** A type of excretory tubule in annelid worms that has internal openings called nephrostomes that collect body fluids and external openings called nephridiopores.

**METASTASIS:** The spread of cancer cells beyond their original site.

**METAZOAN:** A multicellular animal. Among important distinguishing characteristics of Metazoa are cell differentiation and intercellular communication. For certain multicellular colonial entities such as sponges, some biologists prefer the term "parazoa".

**METHANE:** Methane is a chemical compound with the molecular formula CH<sub>4</sub>. It is the simplest alkane, and the principal component of natural gas. Methane's bond angles are 109.5 degrees. Burning methane in the presence of oxygen produces carbon dioxide and water. The relative abundance of methane and its clean burning process makes it a very attractive fuel. However, because it is a gas at normal temperature and pressure, methane is difficult to transport from its source. In its natural gas form, it is generally transported in bulk by pipeline or LNG carriers; few countries still transport it by truck.

**METHYLENE BLUE:** A heterocyclic aromatic chemical compound with the molecular formula C<sub>16</sub>H<sub>18</sub>N<sub>3</sub>SCl.

**METHOD BLANK:** An aliquot of reagent water that is treated exactly as a sample, including exposure to all glassware, equipment, solvents, and procedures that are used with samples. The method blank is used to determine if analytes or interferences are present in the laboratory environment, the reagents, or the apparatus.

**Mg/L:** Stands for "milligrams per liter." A common unit of chemical concentration. It expresses the mass of a chemical that is present in a given volume of water. A milligram (one one-thousandth of a gram) is equivalent to about 18 grains of table salt. A liter is equivalent to about one quart.

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**MICROBE OR MICROBIAL:** Any minute, simple, single-celled form of life, especially one that causes disease.

**MICROBIAL CONTAMINANTS:** Microscopic organisms present in untreated water that can cause waterborne diseases.

**MICROBE OR MICROBIAL:** Any minute, simple, single-celled form of life, especially one that causes disease.

**MICROBIOLOGICAL:** Is a type of analysis in which a composite sample unacceptable.

**MICROBODY:** A small organelle, bounded by a single membrane and possessing a granular interior. Peroxisomes and glyoxysomes are types of microbodies.

**MICROCENTRIFUGE:** A small plastic container that is used to store small amounts of liquid.

**MICROEVOLUTION:** A change in the gene pool of a population over a succession of generations.

**MICROFILAMENT:** Minute fibrous structure generally composed of actin found in the cytoplasm of eukaryotic cells. They play a role in motion within cells.

**MICROFILTRATION:** A low pressure membrane filtration process that removes suspended solids and colloids generally larger than 0.1 micron diameter.

**MICROORGANISMS:** Very small animals and plants that are too small to be seen by the naked eye and must be observed using a microscope. Microorganisms in water include algae, bacteria, viruses, and protozoa. Algae growing in surface waters can cause off-taste and odor by producing the chemicals MIB and geosmin. Certain types of bacteria, viruses, and protozoa can cause disease in humans. Bacteria are the most common microorganisms found in treated drinking water. The great majority of bacteria are not harmful. In fact, humans would not be able to live without the bacteria that inhabit the intestines. However, certain types of bacteria called coliform bacteria can signal the presence of possible drinking water contamination.

**MICROSCOPE:** An instrument which magnifies images either by using lenses in an optical system to bend light (light microscope) or electromagnets to direct the movement of electrons (electron microscope).

**MICROTUBULE:** A minute tubular structure found in centrioles, spindle apparatus, cilia, flagella, and other places in the cytoplasm of eukaryotic cells. Microtubules play a role in movement and maintenance of shape.

**MICROVILLUS:** Collectively, fine, fingerlike projections of the epithelial cells in the lumen of the small intestine that increase its surface area.

**MILLIGRAMS PER LITER:** (mg/L) A common unit of measurement of the concentration of a material in solution.

**MILLILITER:** One one-thousandth of a liter. A liter is a little more than a quart. A milliliter is about two drops from an eye dropper.

**MIMICRY:** A phenomenon in which one species benefits by a superficial resemblance to an unrelated species. A predator or species of prey may gain a significant advantage through mimicry.

**MISCIBLE:** Capable of being mixed together.

**MISSENSE:** (mutation) The most common type of mutation involving a base-pair substitution within a gene that changes a codon, but the new codon makes sense, in that it still codes for an amino acid.

**MITOCHONDRIAL MATRIX:** The compartment of the mitochondrion enclosed by the inner membrane and containing enzymes and substrates for the Krebs cycle.

**MITOCHONDRION:** An organelle that occurs in eukaryotic cells and contains the enzymes of the citric acid cycle, the respiratory chain, and oxidative phosphorylation. A mitochondrion is bounded by a double membrane.

**MITOSIS:** A process of cell division in eukaryotic cells conventionally divided into the growth period (interphase) and four stages: prophase, metaphase, anaphase, and telophase. The stages conserve chromosome number by equally allocating replicated chromosomes to each of the daughter cells.

**MIXED LIQUOR SUSPENDED SOLIDS:** Suspended solids in the mixture of wastewater and activated sludge undergoing aeration in the aeration basin.

**MODEM SYNTHESIS:** A comprehensive theory of evolution emphasizing natural selection, gradualism, and populations as the fundamental units of evolutionary change; also called Neo-Darwinism.

**MOISTURE AND POTASSIUM PERMANGANATE:** The combination of moisture and potassium permanganate produces heat.

**MOISTURE:** If a material is hygroscopic, it must be protected from water.

**MOLARITY:** A common measure of solute concentration, referring to the number of moles of solute in 1 L of solution.

**MOLD:** A rapidly growing, asexually reproducing fungus.

**MOLE:** Abbreviated mol : a measurement of an amount of substance; a single mole contains approximately  $6.022 \times 10^{23}$  units or entities. A mole of water contains  $6.022 \times 10^{23}$  H<sub>2</sub>O molecules.

**MOLE:** The number of grams of a substance that equals its molecular weight in daltons and contains Avogadro's number of molecules.

**MOLECULAR FORMULA:** A type of molecular notation indicating only the quantity of the constituent atoms.

**MOLECULAR ORBITAL:** Region where an electron can be found in a molecule (as opposed to an atom).

**MOLECULAR WEIGHT:** The molecular mass (abbreviated Mr) of a substance, formerly also called molecular weight and abbreviated as MW, is the mass of one molecule of that substance, relative to the unified atomic mass unit u (equal to 1/12 the mass of one atom of carbon-12). This is distinct from the relative molecular mass of a molecule, which is the ratio of the mass of that molecule to 1/12 of the mass of carbon 12 and is a dimensionless number. Relative molecular mass is abbreviated to Mr.

**MOLECULE:** Two or more atoms of one or more elements held together by ionic or covalent chemical bonds. A chemically bonded number of atoms that are electrically neutral.

**MOLTING:** A process in arthropods in which the exoskeleton is shed at intervals to allow growth by secretion of a larger exoskeleton.

**MONERA:** The kingdom of life forms that includes all of the bacteria.

**MONOCLONAL ANTIBODY:** A defensive protein produced by cells descended from a single cell; an antibody that is secreted by a clone of cells and, consequently, is specific for a single antigenic determinant.

**MONOECIOUS:** Referring to an organism having the capacity of producing both sperm and eggs.

**MONOHYBRID CROSS:** A breeding experiment that employs parental varieties differing in a single character.

**MONOMER:** A small molecule, two or more of which can be combined to form oligomers (consisting of a few monomers) or polymers (consisting of many monomers).

**MONOPHYLETIC:** A term used to describe any taxon derived from a single ancestral form that gave rise to no species in other taxa.

**MONOSACCHARIDE:** A simple sugar; a monomer.

**MONOZYGOTIC TWINS:** Monozygotic twins are genetically identical, derived from the division and autonomous development of a single zygote (fertilized egg).

**MORPHOGENESIS:** The development of body shape and organization during ontogeny.

**MORPHOSPECIES:** Species defined by their anatomical features.

**MOSAIC EVOLUTION:** The evolution of different features of an organism at different rates.

**MOSAIC:** A pattern of development, such as that of a mollusk, in which the early blastomeres each give rise to a specific part of the embryo. In some animals, the fate of the blastomeres is established in the zygote.

**MOTOR NERVOUS SYSTEM:** In vertebrates, the component of the peripheral nervous system that transmits signals from the central nervous system to effector cells.

**MOTTLING:** High levels of fluoride may stain the teeth of humans.

**MPF:** M: phase promoting factor: A protein complex required for a cell to progress from late interphase to mitosis; the active form consists of cyclin and cdc2, a protein kinase.

**MUCOSA:** Refers to the mucous tissue lining various tubular structures in the body.

**MUD BALLS IN FILTER MEDIA:** Is a possible result of an ineffective or inadequate filter backwash.

**MULLERIAN MIMICRY:** A mutual mimicry by two unpalatable species.

**MULTIGENE FAMILY:** A collection of genes with similar or identical sequences, presumably of common origin.

**MUNICIPAL WASTE:** The combined solid and liquid waste from residential, commercial and industrial sources.

**MUNICIPAL WASTEWATER TREATMENT PLANT (MWTP):** Treatment works designed to treat municipal wastewater.

**MURIATIC ACID:** An acid used to reduce pH and alkalinity. Also used to remove stain and scale.

**MUST:** This action, activity, or procedural step is required.

**MUTAGEN:** A chemical or physical agent that interacts with DNA and causes a mutation.

**MUTAGENESIS:** The creation of mutations.

**MUTATION:** A spontaneous or induced change in a gene's or chromosome's structure or number. The resulting individual is termed a mutant.

**MUTUALISM:** A symbiotic relationship in which both the host and the symbiont benefit.

**MYCELIUM:** The densely branched network of hyphae in a fungus.

**MYCOBACTERIUM:** Pleomorphic spherical or rod-shaped, frequently branching, no gram stain, aerobic; commonly form yellow pigments; include *Mycobacterium tuberculosis*, cause of tuberculosis.

**MYCOPLASMA:** Spherical, commonly forming branching chains, no gram stain, aerobic but can live in certain anaerobic conditions; without cell walls yet structurally resistant to lysis; among smallest of bacteria; named for superficial resemblance to fungal hyphae (myco-means "fungus").

**MYCOTOXIN:** A toxin produced by a fungus.

**MYELIN SHEATH:** An insulating coat of cell membrane from Schwann cells that is interrupted by nodes of Ranvier where saltatory conduction occurs.

**MYOFIBRILS:** Fibrils arranged in longitudinal bundles in muscle cells (fibers); composed of thin filaments of actin and a regulatory protein and thick filaments of myosin.

**MYOGLOBIN:** An oxygen-storing, pigmented protein in muscle cells.

**MYOSIN:** A type of protein filament that interacts with actin filaments to cause cell movement, such as contraction in muscle cells.

## N

**NAD<sup>+</sup>:** Nicotinamide adenine dinucleotide (oxidized); a coenzyme present in all cells that assists enzymes in transferring electrons during the redox reactions of metabolism.

**NANO-FILTRATION:** A specialty membrane filtration process that rejects solutes larger than approximately one nanometer (10 angstroms) in size.

**NANOMETER:** A unit of measure (length). 1 nm is equal to  $1 \times 10^{-9}$  m, or 1/1,000,000 mm.

**NaOCl:** Is the molecular formula of Sodium hypochlorite.

**NaOH:** Is the molecular formula of Sodium hydroxide.

**NASCENT:** Coming into existence; emerging.

**NATURAL ORGANIC MATTER:** Organic matter present in natural waters.

**NEAT:** Conditions with a liquid reagent or gas performed with no added solvent or co-solvent.

**NEGATIVE CONTROL:** See Method blank.

**NEGATIVE FEEDBACK:** A primary mechanism of homeostasis, whereby a change in a physiological variable that is being monitored triggers a response that counteracts the initial fluctuation.

**NEURAMINIDASE:** A surface enzyme possessed by some influenza viruses which help the virus penetrate the mucus layer protecting the respiratory epithelium and also plays a role in budding of new virus particles from infected cells.

**NEURON:** A nerve cell; the fundamental unit of the nervous system, having structure and properties that allow it to conduct signals by taking advantage of the electrical charge across its cell membrane.

**NEUROSECRETORY CELLS:** Cells that receive signals from other nerve cells, but instead of signaling to an adjacent nerve cell or muscle, release hormones into the blood stream.

**NEUROTRANSMITTER:** The chemical messenger released from the synaptic terminals of a neuron at a chemical synapse that diffuses across the synaptic cleft and binds to and stimulates the postsynaptic cell.

**NEUTRAL VARIATION:** Genetic diversity that confers no apparent selective advantage.

**NEUTRALIZATION REACTIONS:** Chemical reactions between acids and bases where water is an end product.

**NEUTRALIZATION:** The chemical process that produces a solution that is neither acidic nor alkaline. Usually with a pH between 6 and 8.

**NEUTRINO:** A particle that can travel at speeds close to the speed of light and are created as a result of radioactive decay.

**NEUTRON:** An uncharged subatomic particle of about the same size and mass as a proton.

**NH<sub>4</sub><sup>+</sup>:** The molecular formula of the Ammonium ion.

**NITRATES:** A dissolved form of nitrogen found in fertilizers and sewage by-products that may leach into groundwater and other water sources. Nitrates may also occur naturally in some waters. Over time, nitrates can accumulate in aquifers and contaminate groundwater.

**NITROGEN AND PHOSPHORUS:** Pairs of elements and major plant nutrients that cause algae to grow.

**NITROGEN:** Nitrogen is a nonmetal, with an electronegativity of 3.0. It has five electrons in its outer shell and is therefore trivalent in most compounds. The triple bond in molecular nitrogen ( $N_2$ ) is one of the strongest in nature. The resulting difficulty of converting ( $N_2$ ) into other compounds, and the ease (and associated high energy release) of converting nitrogen compounds into elemental  $N_2$ , have dominated the role of nitrogen in both nature and human economic activities. At atmospheric pressure molecular nitrogen condenses (liquefies) at 77 K (-195.8 °C) and freezes at 63 K (-210.0 °C) into the beta hexagonal close-packed crystal allotropic form. Below 35.4 K (-237.6 °C) nitrogen assumes the alpha cubic crystal allotropic form. Liquid nitrogen, a fluid resembling water, but with 80.8% of the density, is a common cryogen. Unstable allotropes of nitrogen consisting of more than two nitrogen atoms have been produced in the laboratory, like  $N_3$  and  $N_4$ .<sup>[1]</sup> Under extremely high pressures (1.1 million atm) and high temperatures (2000 K), as produced under diamond anvil conditions, nitrogen polymerizes into the single bonded diamond crystal structure, an allotrope nicknamed "nitrogen diamond."

**NITROGEN-FIXING:** Rod-shaped, gram-negative, aerobic; convert atmospheric nitrogen gas to ammonium in soil; include *Azotobacter*, a common genus.

**NO<sub>3</sub>-:** The molecular formula of the Nitrate ion.

**NOBLE GASES:** Group 18 elements, those whose outer electron shell is filled.

**NOMENCLATURE:** The method of assigning names in the classification of organisms.

**NON-CARBONATE HARDNESS:** The portion of the total hardness in excess of the alkalinity.

**NON-CARBONATE IONS:** Water contains non-carbonate ions if it cannot be softened to a desired level through the use of lime only.

**NONCOMPETITIVE INHIBITOR:** A substance that reduces the activity of an enzyme by binding to a location remote from the active site, changing its conformation so that it no longer binds to the substrate.

**NONCYCLIC ELECTRON FLOW:** A route of electron flow during the light reactions of photosynthesis that involves both photosystems and produces ATP, NADPH, and oxygen; the net electron flow is from water to NADP<sup>+</sup>.

**NONCYCLIC PHOTOPHOSPHORYLATION:** The production of ATP by noncyclic electron flow.

**NONDISJUNCTION:** An accident of meiosis or mitosis, in which both members of a pair of homologous chromosomes or both sister chromatids fail to separate normally.

**NON-METAL:** An element which is not metallic.

**NON-POINT SOURCE POLLUTION:** Air pollution may leave contaminants on highway surfaces. This non-point source pollution adversely impacts reservoir water and groundwater quality.

**NON-POINT SOURCE POLLUTION:** Air pollution may leave contaminants on highway surfaces. This non-point source pollution adversely impacts reservoir water and groundwater quality.

**NONPOLAR:** Electrically symmetrical. For example, in many molecules with covalent bonds, the electrons are shared equally; the poles are electrically neutral.

**NONSENSE MUTATION:** A mutation that changes an amino acid codon to one of the three stop codons, resulting in a shorter and usually nonfunctional protein.

**NON-TRANSIENT, NON-COMMUNITY WATER SYSTEM:** A water system which supplies water to 25 or more of the same people at least six months per year in places other than their residences. Some examples are schools, factories, office buildings, and hospitals which have their own water systems.

**NORM OF REACTION:** The range of phenotypic possibilities for a single genotype, as influenced by the environment.

**NORMALITY:** It is the number of equivalent weights of solute per liter of solution. Normality highlights the chemical nature of salts: in solution, salts dissociate into distinct reactive species (ions such as  $H^+$ ,  $Fe^{3+}$ , or  $Cl^-$ ). Normality accounts for any discrepancy between the concentrations of the various ionic species in a solution. For example, in a salt such as  $MgCl_2$ , there are two moles of  $Cl^-$  for every mole of  $Mg^{2+}$ , so the concentration of  $Cl^-$  as well as of  $Mg^{2+}$  is said to be 2 N (read: "two normal"). Further examples are given below. A normal is one gram equivalent of a solute per liter of solution. The definition of a gram equivalent varies depending on the type of chemical reaction that is discussed - it can refer to acids, bases, redox species, and ions that will precipitate. It is critical to note that normality measures a single ion which takes part in an overall solute. For example, one could determine the normality of hydroxide or sodium in an

aqueous solution of sodium hydroxide, but the normality of sodium hydroxide itself has no meaning. Nevertheless it is often used to describe solutions of acids or bases, in those cases it is implied that the normality refers to the H<sup>+</sup> or OH<sup>-</sup> ion. For example, 2 Normal sulfuric acid (H<sub>2</sub>SO<sub>4</sub>), means that the normality of H<sup>+</sup> ions is 2, or that the molarity of the sulfuric acid is 1. Similarly for 1 Molar H<sub>3</sub>PO<sub>4</sub> the normality is 3 as it contains three H<sup>+</sup> ions.

NTNCWS: Non-transient non-community water system.

NTU (Nephelometric turbidity unit): A measure of the clarity or cloudiness of water.

NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY: Technique that exploits the magnetic properties of certain nuclei, useful for identifying unknown compounds.

NTU: (Nephelometric turbidity unit): A measure of the clarity or cloudiness of water.

NUCLEAR: 1) (envelope) The surface, consisting of two layers of membrane, that encloses the nucleus of eukaryotic cells. 2) (pore) An opening of the nuclear envelope which allows for the movement of materials between the nucleus and surrounding cytoplasm.

NUCLEAR: Of or pertaining to the atomic nucleus.

NUCLEASE: This term refers to any enzyme that acts on nucleic acids, e.g., Dnase, Rnase, endonuclease, etc.

NUCLEIC: (acid) A polymer composed of nucleotides that are joined by covalent bonds (phosphodiester linkages) between the phosphate of one nucleotide and the sugar of the next nucleotide.

NUCLELUS: A small, generally spherical body found within the nucleus of eukaryotic cells. The site of ribosomal RNA synthesis.

NUCLEOID: The region that harbors the chromosome of a prokaryotic cell. Unlike the eukaryotic nucleus, it is not bounded by a membrane.

NUCLEOLUS (pl. nucleoli): A specialized structure in the nucleus, formed from various chromosomes and active in the synthesis of ribosomes.

NUCLEOSIDE: An organic molecule consisting of a nitrogenous base joined to a five- carbon sugar.

NUCLEOSOME: The basic, beadlike unit of DNA packaging in eukaryotes, consisting of a segment of DNA wound around a protein core composed of two copies of each of four types of histone.

NUCLEOTIDE: The basic chemical unit (monomer) of a nucleic acid. A nucleotide in RNA consists of one of four nitrogenous bases linked to ribose, which in turn is linked to phosphate. In DNA, deoxyribose is present instead of ribose.

NUCLEUS: A membrane-bound organelle containing genetic material. Nuclei are a prominent internal structure seen both in *Cryptosporidium* oocysts and *Giardia* cysts. In *Cryptosporidium* oocysts, there is one nucleus per sporozoite. One to four nuclei can be seen in *Giardia* cysts.

NUCLEUS: The membrane bound organelle of eukaryotic cells that contains the cell's genetic material. Also the central region of an atom composed of protons and neutrons.

NUCLEUS: The center of an atom made up of neutrons and protons, with a net positive charge.

NULL: In the scientific method, the hypothesis which one attempts to falsify.

NUMBER DENSITY: A measure of concentration of countable objects (atoms, molecules, etc.) in space; number per volume.

## O

O<sub>3</sub>: The molecular formula of ozone.

OLIGOTROPHIC: A reservoir that is nutrient-poor and contains little plant or animal life. An oligotrophic ecosystem or environment is one that offers little to sustain life. The term is commonly utilized to describe bodies of water or soils with very low nutrient levels. It derives etymologically from the Greek oligo (small, little, few) and trophe (nutrients, food). Oligotrophic environments are of special interest for the alternative energy sources and survival strategies upon which life could rely.

ONGOING PRECISION AND RECOVERY (OPR) STANDARD: A method blank spiked with known quantities of analytes. The OPR is analyzed exactly like a sample. Its purpose is to assure that the results produced by the laboratory remain within the limits specified in this method for precision and recovery.

OOCYST AND CYST STOCK SUSPENSION: See Stock suspension.

OOCYST: The encysted zygote of some sporozoa; e.g., *Cryptosporidium*. The oocyst is a phase or form of the organism produced as a normal part of the life cycle of the organism. It is characterized by a thick and environmentally resistant outer wall.

ORBITAL: May refer to either an atomic orbital or a molecular orbital.

ORGANIC CHEMISTRY: A part of chemistry concerned with organic compounds.

ORGANIC COMPOUND: Compounds that contain carbon.

ORGANIC MATTER: Substances containing carbon compounds, usually of animal or vegetable origin.

ORGANIC PRECURSORS: Natural or man-made compounds with chemical structures based upon carbon that, upon combination with chlorine, leading to trihalomethane formation.

ORGANIC: Relating to, or derived from, a living thing. A description of a substance that contains carbon atoms linked together by carbon-carbon bonds.

OSMOSIS: Osmosis is the process by which water moves across a semi permeable membrane from a low concentration solute to a high concentration solute to satisfy the pressure differences caused by the solute.

OVER-RANGE PROTECTION DEVICES: Mechanical dampers, snubbers and an air cushion chamber are examples of surging and over range protection devices.

OXIDE: An oxide is a chemical compound containing at least one oxygen atom as well as at least one other element. Most of the Earth's crust consists of oxides. Oxides result when elements are oxidized by oxygen in air. Combustion of hydrocarbons affords the two principal oxides of carbon, carbon monoxide and carbon dioxide. Even materials that are considered to be pure elements often contain a coating of oxides. For example, aluminum foil has a thin skin of  $Al_2O_3$  that protects the foil from further corrosion.

OXIDIZING: The process of breaking down organic wastes into simpler elemental forms or by products. Also used to separate combined chlorine and convert it into free chlorine.

OXYGEN DEFICIENT ENVIRONMENT: One of the most dangerous threats to an operator upon entering a manhole.

OZONE DOES NOT PROVIDE A RESIDUAL: One of the major drawbacks to using ozone as a disinfectant.

OZONE: Ozone or trioxygen ( $O_3$ ) is a triatomic molecule, consisting of three oxygen atoms. It is an allotrope of oxygen that is much less stable than the diatomic  $O_2$ . Ground-level ozone is an air pollutant with harmful effects on the respiratory systems of animals. Ozone in the upper atmosphere filters potentially damaging ultraviolet light from reaching the Earth's surface. It is present in low concentrations throughout the Earth's atmosphere. It has many industrial and consumer applications. Ozone, the first allotrope of a chemical element to be recognized by science, was proposed as a distinct chemical compound by Christian Friedrich Schönbein in 1840, who named it after the Greek word for smell (ozein), from the peculiar odor in lightning storms. The formula for ozone,  $O_3$ , was not determined until 1865 by Jacques-Louis Soret and confirmed by Schönbein in 1867. Ozone is a powerful oxidizing agent, far better than dioxygen. It is also unstable at high concentrations, decaying to ordinary diatomic oxygen (in about half an hour in atmospheric conditions):  $2 O_3 = 3 O_2$ .

## P

PAC: A disadvantage of using PAC is it is very abrasive and requires careful maintenance of equipment. One precaution that should be taken in storing PAC is that bags of carbon should not be stored near bags of HTH. Removes tastes and odors by adsorption only. Powdered activated carbon frequently used for taste and odor control because PAC is non-specific and removes a broad range of compounds. Jar tests and threshold odor number testing determines the application rate for powdered activated carbon. Powdered activated carbon, or PAC, commonly used for in a water treatment plant for taste and odor control. Powdered activated carbon may be used with some success in removing the precursors of THMs.

PARAMECIUM: Paramecia are a group of unicellular ciliate protozoa formerly known as slipper animalcules from their slipper shape. They are commonly studied as a representative of the ciliate group. Simple cilia cover the body which allows the cell to move with a synchronous motion (like a caterpillar). There is also a deep oral groove containing inconspicuous compound



oral cilia (as found in other peniculids) that is used to draw food inside. They generally feed upon bacteria and other small cells. Osmoregulation is carried out by a pair of contractile vacuoles, which actively expel water absorbed by osmosis from their surroundings. Paramecia are widespread in freshwater environments, and are especially common in scums. Paramecia are attracted by acidic conditions. Certain single-celled eukaryotes, such as Paramecium, are examples for exceptions to the universality of the genetic code (translation systems where a few codons differ from the standard ones).

**PARTS PER MILLION (PPM):** A common unit of measure used to express the number of parts of a substance contained within a million parts of a liquid, solid, or gas.

**PASTEURIZATION:** A process for killing pathogenic organisms by applying heat for a specific period of time.

**PATHOGENS:** Disease-causing pathogens; waterborne pathogens A pathogen may contaminate water and cause waterborne disease.

**Pb:** The chemical symbol of Lead.

**PCE:** abbr. perchloroethylene. Known also as perc or tetrachloroethylene, perchloroethylene is a clear, colorless liquid with a distinctive, somewhat ether-like odor. It is non-flammable, having no measurable flashpoint or flammable limits in air. Effective over a wide range of applications, perchloroethylene is supported by closed loop transfer systems, stabilizers and employee exposure monitoring.

**PERKINESIS:** The aggregation resulting from random thermal motion of fluid molecules.

**pCi/L:** Picocuries per liter A curie is the amount of radiation released by a set amount of a certain compound. A picocurie is one quadrillionth of a curie.

**PEAK DEMAND:** The maximum momentary load placed on a water treatment plant, pumping station or distribution system.

**PEPTIDOGLYCAN:** A polymer found in the cell walls of prokaryotes that consists of polysaccharide and peptide chains in a strong molecular network. Also called mucopeptide, murein.

**PERKINESIS:** The aggregation resulting from random thermal motion of fluid molecules.

**PERMEATE:** The term for water which has passed through the membrane of a reverse osmosis unit.

**PERMEATE:** The term for water which has passed through the membrane of a reverse osmosis unit. The liquid that passes through a membrane.

**pH OF SATURATION:** The ideal pH for perfect water balance in relation to a particular total alkalinity level and a particular calcium hardness level, at a particular temperature. The pH where the Langelier Index equals zero.

**pH:** A unit of measure which describes the degree of acidity or alkalinity of a solution. The pH scale runs from 0 to 14 with 7 being the mid-point or neutral. A pH of less than 7 is on the acid side of the scale with 0 as the point of greatest acid activity. A pH of more than 7 is on the basic (alkaline) side of the scale with 14 as the point of greatest basic activity. The term pH is derived from "p", the mathematical symbol of the negative logarithm, and "H", the chemical symbol of Hydrogen. The definition of pH is the negative logarithm of the Hydrogen ion activity.  $\text{pH} = -\log[\text{H}^+]$ .

**PHENOL RED:** Chemical reagent used for testing pH in the range of 6.8 - 8.4.

**PHENOLPHTHALEIN/TOTAL ALKALINITY:** The relationship between the alkalinity constituent's bicarbonate, carbonate, and hydroxide can be based on the P and T alkalinity measurement.

**PHOSPHATE, NITRATE AND ORGANIC NITROGEN:** Nutrients in a domestic water supply reservoir may cause water quality problems if they occur in moderate or large quantities.

**PHOTON:** A carrier of electromagnetic radiation of all wavelength (such as gamma rays and radio waves).

**PHYSICAL CHEMICAL TREATMENT:** Treatment processes that are non-biological in nature.

**PHYSISORPTION:** (Or physical adsorption) Is adsorption in which the forces involved are intermolecular forces (van der Waals forces) of the same kind as those responsible for the imperfection of real gases and the condensation of vapors, and which do not involve a significant change in the electronic orbital patterns of the species involved. The term van der Waals adsorption is synonymous with physical adsorption, but its use is not recommended.

**PICOCURIE:** A unit of radioactivity. "Pico" is a metric prefix that means one one-millionth of one one-millionth. A picocurie is one one-millionth of one one-millionth of a Curie. A Curie is that quantity of any radioactive substance that undergoes 37 billion nuclear disintegrations per second. Thus a picocurie is that quantity of any radioactive substance that undergoes 0.037 nuclear disintegrations per second.

**PIEZOMETRIC SURFACE:** See potentiometric surface.

**PIN FLOC:** Small flocculated particle size.

**PLANKTON:** The aggregate of passively floating, drifting, or somewhat motile organisms occurring in a body of water, primarily comprising microscopic algae and protozoa.

**PLASMA:** State of matter similar to gas in which a certain portion of the particles are ionized.

**PLUNGER:** See Surge-block.

**POINT OF ENTRY:** POE.

**POINT SOURCE DISCHARGE:** A pipe, ditch, channel or other container from which pollutants may be discharged.

**POLLUTANT:** A substance, organism or energy form present in amounts that impair or threaten an ecosystem to the extent that its current or future uses are prevented.

**POLLUTION:** To make something unclean or impure. See Contaminated.

**POLYMER:** A type of chemical when combined with other types of coagulants aid in binding small suspended particles to larger particles to help in the settling and filtering processes. Chemical used for flocculation in dewatering. Also known as a "polyelectrolyte" which is a substance made of giant molecules formed by the union of simple smaller molecules.

**POLYPHOSPHATES:** Chemicals that may be added to remove low levels of iron and manganese.

**POSITIVE CONTROL:** See Ongoing precision and recovery standard.

**POST TREATMENT:** Treatment of finished water or wastewater to further enhance its quality.

**POST-CHLORINE:** Where the water is chlorinated to make sure it holds a residual in the distribution system.

**POST-CHLORINE:** Where the water is chlorinated to make sure it holds a residual in the distribution system.

**POTABLE:** Good water which is safe for drinking or cooking purposes. Non-Potable: A liquid or water that is not approved for drinking.

**POTENTIAL ENERGY:** The energy that a body has by virtue of its position or state enabling it to do work.

**PPM:** Abbreviation for parts per million.

**PRE-CHLORINE:** Where the raw water is dosed with a large concentration of chlorine.

**PRECIPITATE:** A solid that separates from a solution.

**PRECIPTATION:** The phenomenon that occurs when a substance held in solution passes out of solution into a solid form.

**PRELIMINARY TREATMENT:** Treatment steps including comminution, screening, grit removal, pre-aeration, and/or flow equalization that prepares wastewater influent for further treatment.

**PRESIPATATE:** Formation of a solid in a solution or inside another solid during a chemical reaction or by diffusion in a solid.

**PRESSURE FILTER:** Filter unit enclosed in a vessel that may be operated under pressure.

**PRESSURE HEAD:** The height of a column of water capable of being maintained by pressure. See also Total Head, Total Dynamic Head.

**PRESSURE MEASUREMENT:** Bourdon tube, Bellows gauge and Diaphragm are commonly used to measure pressure in waterworks systems. A Bellows-type sensor reacts to a change in pressure.

**PRESSURE:** Pressure is defined as force per unit area. It is usually more convenient to use pressure rather than force to describe the influences upon fluid behavior. The standard unit for pressure is the Pascal, which is a Newton per square meter. For an object sitting on a surface, the force pressing on the surface is the weight of the object, but in different orientations it might have a different area in contact with the surface and therefore exert a different pressure.

**PREVENTION:** To take action. Stop something before it happens.

**PRIMARY CLARIFIER:** Sedimentation basin that precedes secondary wastewater treatment.

**PRIMARY SLUDGE:** Sludge produced in a primary waste treatment unit.

**PRIMARY TREATMENT:** Treatment steps including sedimentation and/or fine screening to produce an effluent suitable for biological treatment.

**PROCESS WASTEWATER:** Wastewater generated during manufacture or production processes.

**PROCESS WATER:** Water that is used for, or comes in contact with an end product or the materials used in an end product.

**PROPIONIC ACID:** Rod-shaped, pleomorphic, gram-positive, anaerobic; ferment lactic acid; fermentation produces holes in Swiss cheese from the production of carbon dioxide.

**PROTIST:** Any of a group of eukaryotic organisms belonging to the kingdom Protista according to some widely used modern taxonomic systems. The protists include a variety of unicellular, coenocytic, colonial, and multicellular organisms, such as the protozoans, slime molds, brown algae, and red algae. A unicellular protist in taxonomic systems in which the protists are considered to form a kingdom.

**PROTOCTIST:** Any of various unicellular eukaryotic organisms and their multicellular, coenocytic, or colonial descendants that belong to the kingdom Protoctista according to some taxonomic systems. The protists include the protozoans, slime molds, various algae, and other groups. In many new classification systems, all protists are considered to be protists.

**PROTON, NEUTRON AND ELECTRON:** Are the 3 fundamental particles of an atom.

**PROTON:** A positive unit or subatomic particle that has a positive charge.

**PROTONATION:** The addition of a proton ( $H^+$ ) to an atom, molecule, or ion.

**PROTOZOA:** Microscopic animals that occur as single cells. Some protozoa can cause disease in humans. Protozoa form cysts, which are specialized cells like eggs that are very resistant to chlorine. Cysts can survive the disinfection process, then "hatch" into normal cells that can cause disease. Protozoa must be removed from drinking water by filtration, because they cannot be effectively killed by chlorine.

**PSEUDOMONAD:** Rod-shaped (straight or curved ) with polar flagella, gram-negative, aerobic; can use up to 100 different compounds for carbon and energy.

**PTFE:** Polytetrafluoroethylene.

**PUBLIC NOTIFICATION:** An advisory that EPA requires a water system to distribute to affected consumers when the system has violated MCLs or other regulations. The notice advises consumers what precautions, if any, they should take to protect their health.

**PUBLIC WATER SYSTEM (PWS):** Any water system which provides water to at least 25 people for at least 60 days annually. There are more than 170,000 PWSs providing water from wells, rivers and other sources to about 250 million Americans. The others drink water from private wells. There are differing standards for PWSs of different sizes and types.

**PUMPING LIFT:** The height to which water must be pumped or lifted to, feet of head.

**PWS:** 3 types of public water systems. Community water system, non-transient non-community water system, transient non-community water system.

## Q

**QUANTA:** It is the minimum amount of bundle of energy.

**QUANTITATIVE TRANSFER:** The process of transferring a solution from one container to another using a pipette in which as much solution as possible is transferred, followed by rinsing of the walls of the source container with a small volume of rinsing solution (e.g., reagent water, buffer, etc.), followed by transfer of the rinsing solution, followed by a second rinse and transfer.

**QUANTUM MECHANICS:** The study of how atoms, molecules, subatomic particles, etc. behave and are structured.

**QUARKS:** Elementary particle and a fundamental constituent of matter.

**QUICKLIME:** A calcium oxide material produced by calcining limestone to liberate carbon dioxide, also called "calcined lime" or "pebble lime", commonly used for pH adjustment. Chemical formula is  $CaO$ .

## R

**RADIATION:** Energy in the form of waves or subatomic particles when there is a change from high energy to low energy states.

**RADIOACTIVE DECAY:** The process of an unstable atomic nucleus losing energy by emitting radiation.

**RADIOCHEMICALS:** (Or radioactive chemicals) Occur in natural waters. Naturally radioactive ores are particularly common in the Southwestern United States, and some streams and wells can have dangerously high levels of radioactivity. Total alpha and beta radioactivity and isotopes of radium and strontium are the major tests performed for radiochemicals. The federal drinking water standard for gross alpha radioactivity is set at 5 picocuries per liter.

**RAW SEWAGE:** Untreated wastewater and its contents.

**RAW SLUDGE:** Undigested sludge recently removed from a sedimentation basin.

**RAW TURBIDITY:** The turbidity of the water coming to the treatment plant from the raw water source.

**RAW WATER:** Water that has not been treated in any way; it is generally considered to be unsafe to drink.

**REAGENT:** A substance used in a chemical reaction to measure, detect, examine, or produce other substances.

**REAGENT WATER BLANK:** see Method blank.

**REAGENT WATER:** Water demonstrated to be free from the analytes of interest and potentially interfering substances at the method detection limit for the analyte.

**REAGENT:** A substance used in a chemical reaction to measure, detect, examine, or produce other substances.

**RECHARGE:** The infiltration component of the hydrologic cycle. Often used in the context of referring to: The infiltration of water back into an aquifer, resulting in the restoration of lost storage and water levels which had been decreased due to pumping and/or natural discharges from the aquifer.

**RECLAIMED WATER:** Wastewater that has been treated to a level that allows for its reuse for a beneficial purpose.

**RECLAMATION:** The process of improving or restoring the condition of land or other material to a better or more useful state.

**RECORDER, FLOW:** A flow recorder that measures flow is most likely to be located anywhere in the plant where a flow must be measured and in a central location.

**RECYCLING:** The process by which recovered materials are transformed into new products.

**RED WATER AND SLIME:** Iron bacteria are undesirable in a water distribution system because of red water and slime complaints.

**REDOX POTENTIAL:** Reduction potential (also known as redox potential, oxidation / reduction potential or ORP) is the tendency of a chemical species to acquire electrons and thereby be reduced. Each species has its own intrinsic reduction potential; the more positive the potential, the greater the species' affinity for electrons and tendency to be reduced. In aqueous solutions, the reduction potential is the tendency of the solution to either gain or lose electrons when it is subject to change by introduction of a new species. A solution with a higher (more positive) reduction potential than the new species will have a tendency to gain electrons from the new species (i.e. to be reduced by oxidizing the new species) and a solution with a lower (more negative) reduction potential will have a tendency to lose electrons to the new species (i.e. to be oxidized by reducing the new species).

**RELATIVE STANDARD DEVIATION (RSD):** The standard deviation divided by the mean times 100.

**RELAY LOGIC:** The name of a popular method of automatically controlling a pump, valve, chemical feeder, and other devices.

**RESERVOIR:** An impoundment used to store water.

**RESIDENCE TIME:** The period of time that a volume of liquid remains in a tank or system.

**RESIDUAL DISINFECTION PROTECTION:** A required level of disinfectant that remains in treated water to ensure disinfection protection and prevent recontamination throughout the distribution system (i.e., pipes).

**RESPIRATION:** Intake of oxygen and discharge of carbon dioxide as a result of biological oxidation.

**RETURN ACTIVATED SLUDGE:** Settled activated sludge that is returned to mix with raw or primary settled wastewater.

**REVERSE OSMOSIS:** Forces water through membranes that contain holes so small that even salts cannot pass through. Reverse osmosis removes microorganisms, organic chemicals, and inorganic chemicals, producing very pure water. For some people, drinking highly purified water exclusively can upset the natural balance of salts in the body. Reverse osmosis units require regular maintenance or they can become a health hazard.

**RICKETTSIA:** Spherical or rod-shaped, gram-negative, aerobic; cause Rocky Mountain spotted fever and typhus; closely related to Agrobacterium, a common gall-causing plant bacterium.

**ROBERT HOOKE:** Coined the term "cell" to describe the structures he saw while examining a piece of cork using a microscope.

**ROTAMETER:** The name of transparent tube with a tapered bore containing a ball is often used to measure the rate of flow of a gas or liquid.

**ROTARY DRUM SCREEN:** Cylindrical screen used to remove floatable and suspended solids.

**ROTIFER:** Rotifers get their name (derived from Greek and meaning "wheel-bearer"; they have also been called wheel animalcules) from the corona, which is composed of several ciliated tufts around the mouth that in motion resemble a wheel. These create a current that sweeps food into the mouth, where it is chewed up by a characteristic pharynx (called the mastax) containing a tiny, calcified, jaw-like structure called the trophi. The cilia also pull the animal, when unattached, through the water. Most free-living forms have pairs of posterior toes to anchor themselves while feeding. Rotifers have bilateral symmetry and a variety of different shapes. There is a well-developed cuticle which may be thick and rigid, giving the animal a box-like shape, or flexible, giving the animal a worm-like shape; such rotifers are respectively called loricate and illoricate.

**RSD:** See Relative standard deviation.

## S

**S-BLOCK ELEMENTS:** Group 1 and 2 elements (alkali and alkaline metals), which includes Hydrogen and Helium.

**S.T.P.:** Standard temperature and pressure standard temperature and pressure the temperature of 0°C and pressure of 1 atmosphere, usually taken as the conditions when stating properties of gases.

**SAFE YIELD:** A possible consequence when the "safe yield" of a well is exceeded and water continues to be pumped from a well, is land subsidence around the well will occur. Safe yield refers to a long-term balance between the water that is naturally and artificially recharged to an aquifer and the groundwater that is pumped out. When more water is removed than is recharged, the aquifer is described as being out of safe yield. When the water level in the aquifer then drops, we are said to be mining groundwater.

**SALINE SOLUTION:** General term for NaCl in water.

**SALT BRIDGE:** Devices used to connection reduction with oxidation half-cells in an electrochemical cell.

**SALTS ARE ABSENT:** Is a strange characteristic that is unique to water vapor in the atmosphere.

**SALTS:** Ionic compounds composed of anions and cations.

**SAMPLE:** The water that is analyzed for the presence of EPA-regulated drinking water contaminants. Depending on the regulation, EPA requires water systems and states to take samples from source water, from water leaving the treatment facility, or from the taps of selected consumers. **Sampling Location:** A location where soil or cuttings samples may be readily and accurately collected.

**SANITARY SURVEY:** Persons trained in public health engineering and the epidemiology of waterborne diseases should conduct the sanitary survey. The importance of a detailed sanitary survey of a new water source cannot be overemphasized. An on-site review of the water sources, facilities, equipment, operation, and maintenance of a public water systems for the purpose of evaluating the adequacy of the facilities for producing and distributing safe drinking water. The

purpose of a non-regulatory sanitary survey is to identify possible biological and chemical pollutants which might affect a water supply.

**SANITIZER:** A disinfectant or chemical which disinfects (kills bacteria), kills algae and oxidizes organic matter.

**SATURATED ZONE:** Where an unconfined aquifer becomes saturated beneath the capillary fringe.

**SATURATION INDEX:** See Langelier's Index.

**SATURATOR:** A device which produces a fluoride solution for the fluoride process. Crystal-grade types of sodium fluoride should be fed with a saturator. Overfeeding must be prevented to protect public health when using a fluoridation system.

**SCADA:** A remote method of monitoring pumps and equipment. 130 degrees F is the maximum temperature that transmitting equipment is able to with stand. If the level controller may be set with too close a tolerance 45 could be the cause of a control system that is frequently turning a pump on and off.

**SCALE:** Crust of calcium carbonate, the result of unbalanced water. Hard insoluble minerals deposited (usually calcium bicarbonate) which forms on pool and spa surfaces and clog filters, heaters and pumps. Scale is caused by high calcium hardness and/or high pH. The regular use of stain prevention chemicals can prevent scale.

**SCHMUTZDECKE:** German, "grime or filth cover", sometimes spelt schmutzedecke) is a complex biological layer formed on the surface of a slow sand filter. The schmutzdecke is the layer that provides the effective purification in potable water treatment, the underlying sand providing the support medium for this biological treatment layer. The composition of any particular schmutzdecke varies, but will typically consist of a gelatinous biofilm matrix of bacteria, fungi, protozoa, rotifera and a range of aquatic insect larvae. As a schmutzdecke ages, more algae tend to develop, and larger aquatic organisms may be present including some bryozoan, snails and annelid worms.

**SCHRODINGER EQUATION:** Quantum state equation which represents the behavior of an electron around an atom.

**SCREENINGS PRESS:** A mechanical press used to compact and/or dewater material removed from mechanical screening equipment.

**SCROLL AND BASKET:** The two basic types of centrifuges used in water treatment.

**SCRUBBER:** A device used to removal particulates or pollutant gases from combustion or chemical process exhaust streams.

**SCUM:** Floatable materials found on the surface of primary and secondary settling tanks consisting of food wastes, grease, fats, paper, foam, and similar matter.

**SEAL:** For wells: to abandon a well by filling up the well with approved seal material including cementing with grout from a required depth to the land surface.

**SECONDARY CLARIFIER:** A clarifier following a secondary treatment process, designed for gravity removal of suspended matter.

**SECONDARY DRINKING WATER STANDARDS:** Non-enforceable federal guidelines regarding cosmetic effects (such as tooth or skin discoloration) or aesthetic effects (such as taste, odor, or color) of drinking water.

**SECONDARY SLUDGE:** The sludge from the secondary clarifier in a wastewater treatment plant.

**SECONDARY TREATMENT:** The treatment of wastewater through biological oxidation after primary treatment.

**SEDIMENT:** Grains of soil, sand, gravel, or rock deposited by and generated by water movement.

**SEDIMENTATION BASIN:** A quiescent tank used to remove suspended solids by gravity settling. Also called clarifiers or settling tanks, they are usually equipped with a motor driven rake mechanism to collect settled sludge and move it to a central discharge point.

**SEDIMENTATION BASIN:** Where the thickest and greatest concentration of sludge will be found. Twice a year sedimentation tanks should be drained and cleaned if the sludge buildup interferes with the treatment process.

**SEDIMENTATION:** The process of suspended solid particles settling out (going to the bottom of the vessel) in water. The removal of settleable suspended solids from water or wastewater by gravity in a quiescent basin or clarifier.

**SEMICONDUCTOR:** An electrically conductive solid that is between a conductor and an insulator.

**SENSOR:** A float and cable system are commonly found instruments that may be used as a sensor to control the level of liquid in a tank or basin.

**SEPTIC:** Condition characterized by bacterial decomposition under anaerobic conditions.

**SESSILE:** Botany. attached by the base, or without any distinct projecting support, as a leaf issuing directly from the stem. Zoology. permanently attached; not freely moving.

**SETTLEABILITY:** The tendency of suspended solids to settle.

**SETTLEABLE SOLIDS:** That portion of suspended solids which are of a sufficient size and weight to settle to the bottom of an Imhoff cone in one hour.

**SETTLED SLUDGE VOLUME:** Volume of settled sludge measured at predetermined time increments for use in process control calculations.

**SETTLED SOLIDS:** Solids that have been removed from the raw water by the coagulation and settling processes.

**SEWAGE:** Liquid or waterborne wastes polluted or fouled from households, commercial or industrial operations, along with any surface water, storm water or groundwater infiltration.

**SEWER GAS:** A gas mixture produced by anaerobic decomposition of organic matter usually containing high percentages of methane and hydrogen sulfide.

**SHEATHED:** Filamentous, gram-negative, aerobic; "swarmer" (colonizing) cells form and break out of a sheath; sometimes coated with metals from environment.

**SHOCK LOAD:** A sudden hydraulic or organic load to a treatment plant, also descriptive of a change in the material being treated.

**SHOCK:** Also known as superchlorination or break point chlorination. Ridding a water of organic waste through oxidization by the addition of significant quantities of a halogen.

**SHORT-CIRCUITING:** Short Circuiting is a condition that occurs in tanks or basins when some of the water travels faster than the rest of the flowing water. This is usually undesirable since it may result in shorter contact, reaction or settling times in comparison with the presumed detention times.

**SHOULD:** This action, activity, or procedural step is suggested but not required.

**SINGLE BOND:** Sharing of one pair of electrons.

**SINGLE PHASE POWER:** The type of power used for lighting systems, small motors, appliances, portable power tools and in homes.

**SINUSOID:** A curve described by the equation  $y = a \sin x$ , the ordinate being proportional to the sine of the abscissa.

**SINUSOIDAL:** Mathematics. Of or pertaining to a sinusoid. Having a magnitude that varies as the sine of an independent variable: a sinusoidal current.

**SLOP OIL:** Separator skimmings and tramp oil generated during refinery startup, shutdown or abnormal operation.

**SLUDGE BASINS:** After cleaning sludge basins and before returning the tanks into service the tanks should be inspected, repaired if necessary, and disinfected.

**SLUDGE BLANKET:** The accumulated sludge suspended in a clarifier or other enclosed body of water.

**SLUDGE DEWATERING:** The removal of a portion or majority of the water contained in sludge by means of a filter press, centrifuge or other mechanism.

**SLUDGE DRYING BED:** A closed area consisting of sand or other porous material upon which sludge is dewatered by gravity drainage and evaporation.

**SLUDGE REDUCTION:** Organic polymers are used to reduce the quantity of sludge. If a plant produces a large volume of sludge, the sludge could be dewatered, thickened, or conditioned to decrease the volume of sludge. Turbidity of source water, dosage, and type of coagulant used are the most important factors which determine the amount of sludge produced in a treatment of water.



SLUDGE: Accumulated and concentrated solids generated within a treatment process that have not undergone a stabilization process.

SLURRY: A mixture of a solid and a liquid that facilitates the transfer of the solid into a treatment solution.

SMALL WATER SYSTEM: 3,300 or fewer persons.

SOC: A common way for a synthetic organic chemical such as dioxin to be introduced to a surface water supply is from an industrial discharge, agricultural drainage, or a spill.

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SODA ASH: Chemical used to raise pH and total alkalinity (sodium carbonate).

SODIUM BICARBONATE: Commonly used to increase alkalinity of water and stabilize pH.

SODIUM BISULFATE: Chemical used to lower pH and total alkalinity (dry acid).

SODIUM HYDROXIDE: Also known as caustic soda, a by-product chlorine generation and often used to raise pH.

SOFTENING WATER: When the water has a low alkalinity it is advantageous to use soda ash instead of caustic soda for softening water.

SOFTENING: The process that removes the ions which cause hardness in water.

SOL: A suspension of solid particles in liquid. Artificial examples include sol-gels.

SOLAR DRYING BEDS OR LAGOONS: Are shallow, small-volume storage pond where sludge is concentrated and stored for an extended periods.

SOLAR DRYING BEDS, CENTRIFUGES AND FILTER PRESSES: Are procedures used in the dewatering of sludge.

SOLDER: A fusible alloy used to join metallic parts.

SOLID: One of the states of matter, where the molecules are packed close together, there is a resistance of movement/deformation and volume change; see Young's modulus.

SOLID WASTE: Garbage, refuse, sludge and other discarded material resulting from community activities or commercial or industrial operations.

SOLID, LIQUID AND VAPOR: 3 forms of matter.

SOLUBILITY: The amount of a substance that can dissolve in a solution under a given set of conditions.

SOLUTE: The part of the solution that is mixed into the solvent (NaCl in saline water).

SOLUTION: Homogeneous mixture made up of multiple substances. It is made up of solutes and solvents.

SOLVENT: The part of the solution that dissolves the solute (H<sub>2</sub>O in saline water).

SPADNS: The lab reagent called SPADNS solution is used in performing the Fluoride test.

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SPECTROSCOPY: Study of radiation and matter, such as X-ray absorption and emission spectroscopy.

SPEED OF LIGHT: The speed of anything that has zero rest mass ( $E_{\text{rest}} = mc^2$  where m is the mass and c is the speed of light).

SPIKING SUSPENSION: Diluted stock suspension containing the organism(s) of interest at a concentration appropriate for spiking samples.

SPIRILLUM: Spiral-shaped, gram-negative, aerobic; include *Bdellovibrio*, predatory on other bacteria.

SPIRIT OF HARTSHORN: A colorless, pungent, suffocating, aqueous solution of about 28.5 percent ammonia gas: used chiefly as a detergent, for removing stains and extracting certain vegetable coloring agents, and in the manufacture of ammonium salts.

SPIROCHETE: Spiral-shaped, gram-negative, mostly anaerobic; common in moist environments, from mammalian gums to coastal mudflats; complex internal structures convey rapid movement; include *Treponemapallidum*, cause of syphilis.

SPLIT FLOW CONTROL SYSTEM: This type of control system is to control the flow to each filter influent which is divided by a weir.

SPOROZOITE: A motile, infective stage of certain protozoans; e.g., *Cryptosporidium*. There are four sporozoites in each *Cryptosporidium* oocyst, and they are generally banana-shaped.

**SPRAY BOTTLE OF AMMONIA:** An operator should use ammonia to test for a chlorine leak around a valve or pipe. You will see white smoke if there is a leak.

**SPRING PRESSURE:** Is what maintains contact between the two surfaces of a mechanical seal.

**STABILIZATION POND:** A large shallow basin used for wastewater treatment by natural processes involving the use of algae and bacteria to accomplish biological oxidation of organic matter.

**STANDARD CONDITIONS FOR TEMPERATURE AND PRESSURE or SATP :** A standardization used in order compare experimental results (25 °C and 100.000 kPa).

**STANDPIPE:** A water tank that is taller than it is wide. Should not be found in low point.

**STATE OF MATTER:** Matter having a homogeneous, macroscopic phase; gas, plasma, liquid, and solid are the most well-known (in increasing concentration).

**STERILIZED GLASSWARE:** The only type of glassware that should be used in testing for coliform bacteria.

**STOCK SUSPENSION:** A concentrated suspension containing the organism(s) of interest that is obtained from a source that will attest to the host source, purity, authenticity, and viability of the organism(s).

**STORAGE TANKS:** Three types of water usage that determine the volume of a storage tank are fire suppression storage, equalization storage, and emergency storage. Equalization storage is the volume of water needed to supply the system for periods when demand exceeds supply. Generally, a water storage tank's interior coating (paint) protects the interior about 3-5 years.

**STUFFING BOX:** That portion of the pump that houses the packing or mechanical seal.

**SUBATOMIC PARTICLES:** Particles that are smaller than an atom; examples are protons, neutrons and electrons.

**SUBLIMATION:** A phase transition from solid to limewater fuel or gas.

**SUBNATANT:** Liquid remaining beneath the surface of floating solids.

**SUBSTANCE:** Material with definite chemical composition.

**SUCCESSION:** Transition in the species composition of a biological community, often following ecological disturbance of the community; the establishment of a biological community in an area virtually barren of life.

**SULFATE- AND SULFUR- REDUCING:** Commonly rod-shaped, mostly gram-negative, anaerobic; include *Desulfovibrio*, ecologically important in marshes.

**SULFATE:** Will readily dissolve in water to form an anion. Sulfate is a substance that occurs naturally in drinking water. Health concerns regarding sulfate in drinking water have been raised because of reports that diarrhea may be associated with the ingestion of water containing high levels of sulfate. Of particular concern are groups within the general population that may be at greater risk from the laxative effects of sulfate when they experience an abrupt change from drinking water with low sulfate concentrations to drinking water with high sulfate concentrations.

**SULFIDE:** The term sulfide refers to several types of chemical compounds containing sulfur in its lowest oxidation number of -2. Formally, "sulfide" is the dianion, S<sup>2-</sup>, which exists in strongly alkaline aqueous solutions formed from H<sub>2</sub>S or alkali metal salts such as Li<sub>2</sub>S, Na<sub>2</sub>S, and K<sub>2</sub>S. Sulfide is exceptionally basic and, with a pK<sub>a</sub> > 14, it does not exist in appreciable concentrations even in highly alkaline water, being undetectable at pH < ~15 (8 M NaOH). Instead, sulfide combines with electrons in hydrogen to form HS<sup>-</sup>, which is variously called hydrogen sulfide ion, hydrosulfide ion, sulfhydryl ion, or bisulfide ion. At still lower pH's (<7), HS<sup>-</sup> converts to H<sub>2</sub>S, hydrogen sulfide. Thus, the exact sulfur species obtained upon dissolving sulfide salts depends on the pH of the final solution. Aqueous solutions of transition metals cations react with sulfide sources (H<sub>2</sub>S, NaSH, Na<sub>2</sub>S) to precipitate solid sulfides. Such inorganic sulfides typically have very low solubility in water and many are related to minerals. One famous example is the bright yellow species CdS or "cadmium yellow". The black tarnish formed on sterling silver is Ag<sub>2</sub>S. Such species are sometimes referred to as salts. In fact, the bonding in transition metal sulfides is highly covalent, which gives rise to their semiconductor properties, which in turn is related to the practical applications of many sulfide materials.

**SULFUR- AND IRON- OXIDIZING:** Commonly rod-shaped, frequently with polar flagella, gram-negative, mostly anaerobic; most live in neutral (nonacidic) environment.

**SUPERNATANT:** The liquid layer which forms above the sludge in a settling basin.

**SURFACE SEAL:** The upper portion of a wells construction where surface contaminants are adequately prevented from entering the well, normally consisting of surface casing and neat cement grout.

**SURFACE WATER SOURCES:** Surface water sources such as a river or lake are primarily the result of Runoff.

**SURFACE WATER:** Water that is open to the atmosphere and subject to surface runoff; generally, lakes, streams, rivers.

**SURFACTANT:** Surfactants reduce the surface tension of water by adsorbing at the liquid-gas interface. They also reduce the interfacial tension between oil and water by adsorbing at the liquid-liquid interface. Many surfactants can also assemble in the bulk solution into aggregates. Examples of such aggregates are vesicles and micelles. The concentration at which surfactants begin to form micelles is known as the critical micelle concentration or CMC. When micelles form in water, their tails form a core that can encapsulate an oil droplet, and their (ionic/polar) heads form an outer shell that maintains favorable contact with water. When surfactants assemble in oil, the aggregate is referred to as a reverse micelle. In a reverse micelle, the heads are in the core and the tails maintain favorable contact with oil. Surfactants are also often classified into four primary groups; anionic, cationic, non-ionic, and zwitterionic (dual charge).

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**SUSCEPTIBILITY WAIVER:** A waiver that is granted based upon the results of a vulnerability assessment.

**SUSPENDED SOLIDS:** Solids captured by filtration through a 0.45 micron filter membrane.

**SYNCHRONY:** Simultaneous occurrence; synchronism.

## T

**TALC:** A mineral representing the one on the Mohs Scale and composed of hydrated magnesium silicate with the chemical formula  $H_2Mg_3(SiO_3)_4$  or  $Mg_3Si_4O_{10}(OH)_2$ .

**TASTE AND ODORS:** The primary purpose to use potassium permanganate in water treatment is to control taste and odors. Anaerobic water undesirable for drinking water purposes because of color and odor problems are more likely to occur under these conditions. Taste and odor problems in the water may happen if sludge and other debris are allowed to accumulate in a water treatment plant.

**TCE, trichloroethylene:** A solvent and degreaser used for many purposes; for example dry cleaning, it is a common groundwater contaminant. Trichloroethylene is a colorless liquid which is used as a solvent for cleaning metal parts. Drinking or breathing high levels of trichloroethylene may cause nervous system effects, liver and lung damage, abnormal heartbeat, coma, and possibly death. Trichloroethylene has been found in at least 852 of the 1,430 National Priorities List sites identified by the Environmental Protection Agency (EPA).

**TDS:** Ion exchange is an effective treatment process used to remove iron and manganese in a water supply. This process is ideal as long as the water does not contain a large amount of TDS. When determining the total dissolved solids, a sample should be filtered before being poured into an evaporating dish and dried. Demineralization may be necessary in a treatment process if the water has a very high value Total Dissolved Solids.

**TDS-TOTAL DISSOLVED SOLIDS:** An expression for the combined content of all inorganic and organic substances contained in a liquid which are present in a molecular, ionized or micro-granular (colloidal sol) suspended form. Generally, the operational definition is that the solids (often abbreviated TDS) must be small enough to survive filtration through a sieve size of two

micrometers. Total dissolved solids are normally only discussed for freshwater systems, since salinity comprises some of the ions constituting the definition of TDS. The principal application of TDS is in the study of water quality for streams, rivers and lakes, although TDS is generally considered not as a primary pollutant (e.g. it is not deemed to be associated with health effects), but it is rather used as an indication of aesthetic characteristics of drinking water and as an aggregate indicator of presence of a broad array of chemical contaminants. Ion exchange is an effective treatment process used to remove iron and manganese in a water supply. This process is ideal as long as the water does not contain a large amount of TDS. When determining the total dissolved solids, a sample should be filtered before being poured into an evaporating dish and dried. Demineralization may be necessary in a treatment process if the water has a very high value Total Dissolved Solids.

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**TELEMETERING:** The use of a transmission line with remote signaling to monitor a pumping station or motors. Can be used to accomplish accurate and reliable remote monitoring and control over a long distribution system.

**TEMPERATURE SAMPLE:** This test should be performed immediately in the field, this is a grab sample.

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**TEMPERATURE:** The average energy of microscopic motions of particles.

**TERTIARY TREATMENT:** The use of physical, chemical, or biological means to improve secondary wastewater effluent quality.

**THE RATE DECREASES:** In general, when the temperature decreases, the chemical reaction rate decreases also.

**THEORY:** A model describing the nature of a phenomenon.

**THERMAL CONDUCTIVITY:** A property of a material to conduct heat (often noted as  $k$ ).

**THERMOCHEMISTRY:** The study of absorption/release of heat within a chemical reaction.

**THERMODYNAMIC STABILITY:** When a system is in its lowest energy state with its environment (equilibrium).

**THERMODYNAMICS:** The study of the effects of changing temperature, volume or pressure (or work, heat, and energy) on a macroscopic scale.

**THERMOMETER:** Device that measures the average energy of a system.

**THICKENING, CONDITIONING AND DEWATERING:** Common processes that are utilized to reduce the volume of sludge.

**THICKENING:** A procedure used to increase the solids content of sludge by removing a portion of the liquid.

**THOMAS MALTHUS:** Formulated the concept that population growth proceeds at a geometric rate.

**TIME FOR TURBIDITY BREAKTHROUGH AND MAXIMUM HEADLOSS:** Are the two factors which determine whether or not a change in filter media size should be made.

**TITRATION:** A method of testing by adding a reagent of known strength to a water sample until a specific color change indicates the completion of the reaction.

**TITRATION:** The process of titrating one solution with another, also called volumetric analysis. A method of testing by adding a reagent of known strength to a water sample until a specific color change indicates the completion of the reaction.

**TITRIMETRIC:** Chemistry. Using or obtained by titration. Titrimetrically, adverb.

**TOROID:** A surface generated by the revolution of any closed plane curve or contour about an axis lying in its plane. The solid enclosed by such a surface.

**TORR:** A unit to measure pressure (1 Torr is equivalent to 133.322 Pa or  $1.3158 \times 10^{-3}$  atm).

**TOTAL ALKALINITY:** A measure of the acid-neutralizing capacity of water which indicates its buffering ability, i.e. measure of its resistance to a change in pH. Generally, the higher the total alkalinity, the greater the resistance to pH change.

**TOTAL COLIFORM:** Total coliform, fecal coliform, and E. coli are all indicators of drinking water quality. The total coliform group is a large collection of different kinds of bacteria. Fecal coliforms are types of total coliform that mostly exist in feces. E. coli is a sub-group of fecal coliform. When a water sample is sent to a lab, it is tested for total coliform. If total coliform is present, the sample will also be tested for either fecal coliform or E. coli, depending on the lab testing method.

**TOTAL DISSOLVED SOLIDS (TDS):** The accumulated total of all solids that might be dissolved in water. The weight per unit volume of all volatile and non-volatile solids dissolved in a water or wastewater after a sample has been filtered to remove colloidal and suspended solids.

**TOTAL DYNAMIC HEAD:** The pressure (psi) or equivalent feet of water, required for a pump to lift water to its point of storage overcoming elevation head, friction loss, line pressure, drawdown and pumping lift.

**TOTAL SOLIDS:** The sum of dissolved and suspended solids in a water or wastewater.

**TOTAL SUSPENDED SOLIDS:** The measure of particulate matter suspended in a sample of water or wastewater.

**TOXIC:** Capable of causing an adverse effect on biological tissue following physical contact or absorption.

**TRANSIENT, NON-COMMUNITY WATER SYSTEM: TNCWS** A water system which provides water in a place such as a gas station or campground where people do not remain for long periods of time. These systems do not have to test or treat their water for contaminants which pose long-term health risks because fewer than 25 people drink the water over a long period. They still must test their water for microbes and several chemicals. A Transient Non-community Water System: Is not required to sample for VOC's.

**TRANSITION METAL:** Elements that have incomplete d sub-shells, but also may be referred to as the d-block elements.

**TRANSURANIC ELEMENT:** Element with atomic number greater than 92; none of the transuranic elements are stable.

**TREATABILITY STUDY:** A study in which a waste is subjected to a treatment process to determine treatment and/or to determine the treatment efficiency or optimal process conditions for treatment.

**TREATED WATER:** Disinfected and/or filtered water served to water system customers. It must meet or surpass all drinking water standards to be considered safe to drink.

**TRihalOMETHANES (THM):** Four separate compounds including chloroform, dichlorobromomethane, dibromochloromethane, and bromoform. The most common class of disinfection by-products created when chemical disinfectants react with organic matter in water during the disinfection process. See Disinfectant Byproducts.

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**TRIPLE BOND:** The sharing of three pairs of electrons within a covalent bond (example N<sub>2</sub>).

**TRIPLE POINT:** The place where temperature and pressure of three phases are the same (Water has a special phase diagram).

**TUBE SETTLERS:** This modification of the conventional process contains many metal tubes that are placed in the sedimentation basin, or clarifier. These tubes are approximately 1 inch deep and 36 inches long, split-hexagonal shape and installed at an angle of 60 degrees or less. These tubes provide for a very large surface area upon which particles may settle as the water flows upward. The slope of the tubes facilitates gravity settling of the solids to the bottom of the basin, where they can be collected and removed. The large surface settling area also means that adequate clarification can be obtained with detention times of 15 minutes or less. As with conventional treatment, this sedimentation step is followed by filtration through mixed media.

**TUBERCLES:** The creation of this condition is of the most concern regarding corrosive water effects on a water system. Tubercles are formed due to joining dissimilar metals, causing electro-chemical reactions. Like iron to copper pipe. We have all seen these little rust mounds inside cast iron pipe.

**TUNDALL EFFECT:** The effect of light scattering by colloidal (mixture where one substance is dispersed evenly through another) or suspended particles.

**TURBIDIMETER:** Monitoring the filter effluent turbidity on a continuous basis with an in-line instrument is a recommended practice. Turbidimeter is best suited to perform this measurement.

**TURBIDITY:** A measure of the cloudiness of water caused by suspended particles. A qualitative measurement of water clarity which results from suspended matter that scatters or otherwise interferes with the passage of light through the water.

## U

**U.S. ENVIRONMENTAL PROTECTION AGENCY:** In the United States, this agency responsible for setting drinking water standards and for ensuring their enforcement. This agency sets federal regulations which all state and local agencies must enforce.

**ULTRAFILTRATION:** A low pressure membrane filtration process which separates solutes up to 0.1 micron size range.

**UN NUMBER:** A four digit code used to note hazardous and flammable substances.

**UNCERTAINTY PRINCIPLE:** Knowing the location of a particle makes the momentum uncertain, while knowing the momentum of a particle makes the location uncertain.

**UNCERTAINTY:** A characteristic that any measurement that involves estimation of any amount cannot be exactly reproducible.

**UNDER PRESSURE IN STEEL CONTAINERS:** After chlorine gas is manufactured, it is primarily transported in steel containers.

**UNIT CELL:** The smallest repeating unit of a lattice.

**UNIT FACTOR:** Statements used in converting between units.

**UNIT FILTER RUN VOLUME (UFRV):** One of the most popular ways to compare filter runs. This technique is the best way to compare water treatment filter runs.

**UNIVERSAL OR IDEAL GAS CONSTANT:** Proportionality constant in the ideal gas law ( $0.08206 \text{ L} \cdot \text{atm}/(\text{K} \cdot \text{mol})$ ).

**UP FLOW CLARIFIER:** Clarifier where flocculated water flows upward through a sludge blanket to obtain floc removal by contact with flocculated solids in the blanket.

## V

**VALENCE BOND THEORY:** A theory explaining the chemical bonding within molecules by discussing valencies, the number of chemical bonds formed by an atom.

**VALENCE ELECTRON:** The outermost electrons of an atom, which are located in electron shells.

**VAN DER WAALS FORCE:** One of the forces (attraction/repulsion) between molecules.

**VAN'T HOFF FACTOR:** Ratio of moles of particles in solution to moles of solute dissolved.

**VAPOR PRESSURE:** Pressure of vapor over a liquid at equilibrium.

**VAPOR:** The gaseous phase of a material that is in the solid or liquid state at standard temperature and pressure.

**VAPOR:** When a substance is below the critical temperature while in the gas phase.

**VAPORIZATION:** Phase change from liquid to gas.

**VELOCITY HEAD:** The vertical distance a liquid must fall to acquire the velocity with which it flows through the piping system. For a given quantity of flow, the velocity head will vary indirectly as the pipe diameter varies.

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**VENTURI:** If water flows through a pipeline at a high velocity, the pressure in the pipeline is reduced. Velocities can be increased to a point that a partial vacuum is created.

**VIBRIO:** Rod- or comma-shaped, gram-negative, aerobic; commonly with a single flagellum; include *Vibrio cholerae*, cause of cholera, and luminescent forms symbiotic with deep-water fishes and squids.

**VIRION:** A complete viral particle, consisting of RNA or DNA surrounded by a protein shell and constituting the infective form of a virus.

**VIRUSES:** Very small disease-causing microorganisms that are too small to be seen even with microscopes. Viruses cannot multiply or produce disease outside of a living cell.

**VISCOSITY:** The resistance of a liquid to flow (oil).

**VITRIFICATION:** Vitrification is a process of converting a material into a glass-like amorphous solid that is free from any crystalline structure, either by the quick removal or addition of heat, or by mixing with an additive. Solidification of a vitreous solid occurs at the glass transition temperature (which is lower than melting temperature,  $T_m$ , due to super cooling). When the starting material is solid, vitrification usually involves heating the substances to very high temperatures. Many ceramics are produced in such a manner. Vitrification may also occur naturally when lightning strikes sand, where the extreme and immediate heat can create hollow, branching rootlike structures of glass, called fulgurite. When applied to whiteware ceramics, vitreous means the material has an extremely low permeability to liquids, often but not always water, when determined by a specified test regime. The microstructure of whiteware ceramics frequently contain both amorphous and crystalline phases.

**VOC WAIVER:** The longest term VOC waiver that a public water system using groundwater could receive is 9 years.

**VOID:** An opening, gap, or space within rock or sedimentary formations formed at the time of origin or deposition.

**VOLATILE ORGANIC COMPOUNDS (VOCs):** Solvents used as degreasers or cleaning agents. Improper disposal of VOCs can lead to contamination of natural waters. VOCs tend to evaporate very easily. This characteristic gives VOCs very distinct chemical odors like gasoline, kerosene, lighter fluid, or dry cleaning fluid. Some VOCs are suspected cancer-causing agents. Volatile organic compounds (VOCs) are organic chemical compounds that have high enough vapor pressures under normal conditions to significantly vaporize and enter the atmosphere. A wide range of carbon-based molecules, such as aldehydes, ketones, and other light hydrocarbons are VOCs. The term often is used in a legal or regulatory context and in such cases the precise definition is a matter of law. These definitions can be contradictory and may contain "loopholes"; e.g. exceptions, exemptions, and exclusions. The United States Environmental Protection Agency defines a VOC as any organic compound that participates in a photoreaction; others believe this definition is very broad and vague as organics that are not volatile in the sense that they vaporize under normal conditions can be considered volatile by this EPA definition. The term may refer both to well characterized organic compounds and to mixtures of variable composition.

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**VOLATILE:** A substance that evaporates or vaporizes at a relatively low temperature.

**VOLT:** One joule of work per coulomb - the unit of electrical potential transferred.

**VOLTAGE:** Voltage (sometimes also called electric or electrical tension) is the difference of electrical potential between two points of an electrical or electronic circuit, expressed in volts.[1] It

measures the potential energy of an electric field to cause an electric current in an electrical conductor. Depending on the difference of electrical potential it is called extra low voltage, low voltage, high voltage or extra high voltage. Specifically Voltage is equal to energy per unit charge.

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**VOLTIMETER:** Instrument that measures the cell potential.

**VOLUMETRIC ANALYSIS:** See titration.

**VOLUTE:** The spiral-shaped casing surrounding a pump impeller that collects the liquid discharge by the impeller.

**VORTEX:** The helical swirling of water moving towards a pump.

**VORTICELLA:** Vorticella is a genus of protozoa, with over 100 known species. They are stalked inverted bell-shaped ciliates, placed among the peritrichs. Each cell has a separate stalk anchored onto the substrate, which contains a contractile fibril called a myoneme. When stimulated this shortens, causing the stalk to coil like a spring. Reproduction is by budding, where the cell undergoes longitudinal fission and only one daughter keeps the stalk. Vorticella mainly lives in freshwater ponds and streams - generally anywhere protists are plentiful. Other genera such as Carchesium resemble Vorticella but are branched or colonial.

**VULNERABILITY ASSESSMENT:** An evaluation of drinking water source quality and its vulnerability to contamination by pathogens and toxic chemicals.

## W

**WAIVERS:** Monitoring waivers for nitrate and nitrite are prohibited.

**WASTE ACTIVATED SLUDGE:** Excess activated sludge that is discharged from an activated sludge treatment process.

**WASTEWATER:** Liquid or waterborne wastes polluted or fouled from households, commercial or industrial operations, along with any surface water, storm water or groundwater infiltration.

**WATER H<sub>2</sub>O:** A chemical substance, a major part of cells and Earth, and covalently bonded.

**WATER HAMMER:** A surge in a pipeline resulting from the rapid increase or decrease in water flow. Water hammer exerts tremendous force on a system and can be highly destructive.

**WATER PURVEYOR:** The individuals or organization responsible to help provide, supply, and furnish quality water to a community.

**WATER QUALITY CRITERIA:** Comprised of both numeric and narrative criteria. Numeric criteria are scientifically derived ambient concentrations developed by EPA or States for various pollutants of concern to protect human health and aquatic life. Narrative criteria are statements that describe the desired water quality goal.

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**WATER QUALITY STANDARD:** A statute or regulation that consists of the beneficial designated use or uses of a waterbody, the numeric and narrative water quality criteria that are necessary to protect the use or uses of that particular waterbody, and an antidegradation statement.

**WATER QUALITY:** The 4 broad categories of water quality are: Physical, chemical, biological, radiological. Pathogens are disease causing organisms such as bacteria and viruses. A positive bacteriological sample indicates the presence of bacteriological contamination. Source water monitoring for lead and copper be performed when a public water system exceeds an action level for lead or copper.

**WATER RECLAMATION:** The restoration of wastewater to a state that will allow its beneficial reuse.

**WATER VAPOR:** A characteristic that is unique to water vapor in the atmosphere is that water does not contain any salts.



**WATERBORNE DISEASE:** A disease, caused by a virus, bacterium, protozoan, or other microorganism, capable of being transmitted by water (e.g., typhoid fever, cholera, amoebic dysentery, gastroenteritis).

**WATERSHED:** An area that drains all of its water to a particular water course or body of water. The land area from which water drains into a stream, river, or reservoir.

**WAVE FUNCTION:** A function describing the electron's position in a three-dimensional space.

**Weathered:** The existence of rock or formation in a chemically or physically broken down or decomposed state. Weathered material is in an unstable state.

**WHOLE EFFLUENT TOXICITY:** The total toxic effect of an effluent measured directly with a toxicity test.

**WORK:** The amount of force over distance and is in terms of joules (energy).

**WPCF:** Water Pollution Control Facility

**WTP:** Water Treatment Plant

**WWTP:** Wastewater Treatment Plant

## X

**X-RAY DIFFRACTION:** A method for establishing structures of crystalline solids using single wavelength X-rays and looking at diffraction pattern.

**X-RAY PHOTOELECTRON SPECTROSCOPY:** A spectroscopic technique to measure composition of a material.

**X-RAY:** Form of ionizing, electromagnetic radiation, between gamma and UV rays.

## Y

**YIELD:** The amount of product produced during a chemical reaction.



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