

Advanced Water Purification Facility Study Report

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CITY OF SAN DIEGO

Indirect Potable Reuse/Reservoir Augmentation Demonstration Project
Advanced Water Purification Facility



THE CITY OF SAN DIEGO



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AWP Facility Study Report

Acknowledgements

This Advanced Water Purification (AWP) Facility Study Final Report summarizes the results of the City of San Diego's AWP Facility Study, conducted as part of the City's multi-faceted Water Purification Demonstration Project (Demonstration Project) to evaluate the feasibility of indirect potable reuse through reservoir augmentation to provide safe and reliable water for San Diego. The combined contributions of the project team, regulatory agency representatives, Independent Advisory Panel members, and local stakeholders were invaluable completing this project. This page recognizes the efforts of participants that contributed substantially to this effort.

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Abbreviations, Acronyms, and Glossary

Abbreviations and Acronyms

Ace-K	acesulfame-k
ADI	acceptable daily intake
AWP	advanced water purification
AWP Facility	advanced water purification facility
Basin Plan	Water Quality Control Plan for the San Diego Basin
Bay-Delta	Sacramento-San Joaquin Bay-Delta
BDCM	bromodichloromethane
CDPH	California Department of Public Health
CEC	constituent of emerging concern
CIP	clean in place
City	City of San Diego
cm	centimeter
CTR	California Toxics Rule
CWA	Clean Water Act
DBCM	dibromochloromethane
DCS	distributed control system
DEET	N,N-diethyl-meta-toluamide
C	Celsius
Demonstration Project	Water Purification Demonstration Project
DLR	CDPH detection limit for reporting
DP	distribution panel
DWEL	Drinking Water Equivalent Level
DWR	California Department of Water Resources
EDR	electrodialysis reversal
EEO	electrical energy per order
ENR	Engineering News Record
EPA	U. S. Environmental Protection Agency
ft ²	square feet
gfd	gallons per day per square foot
gpm	gallons per minute
H ₂ O ₂	hydrogen peroxide
HAA5, Total	Haloacetic Acids
HMI	human machine interface
HP	horsepower
HVAC	heating, ventilating, and air conditioning
I&C	instrumentation and controls
IAP	Independent Advisory Panel
in ²	square inches
IPR	indirect potable reuse
IPR/RA	indirect potable reuse/reservoir augmentation
IRWM	Integrated Regional Water Management
KV	kilovolts
KVA	kilovolts-amperes
kW	kilowatt
kWh	kilowatt-hours
kWh/d	kilowatt-hours per day
kWh/yr	kilowatt-hours per year

L	liter
LPHO	low pressure high output
LRL	laboratory reporting level
LSI	Langelier Saturation Index
MCL	maximum contaminant level
MDL	method detection limit
MF	microfiltration
m	meter
MCC	motor control center
MG	million gallons
mg/L	milligrams per liter
mg/L-N	milligrams per liter as nitrogen
mg/L-P	milligrams per liter as phosphorus
mgd	million gallons per day
mL	milliliter
mL/min	milliliters per minute
min	minute
mJ/cm ²	millijoules per square centimeter
MPN	most probable number
mV	millivolt
µg/L	micrograms per liter
µg/L-P	micrograms per liter as phosphorus
µS/cm	microsiemens per centimeter
N/A	not applicable
North City	North City Water Reclamation Plant
ND	not detectable or not quantifiable
NDEA	N-Nitrosodiethylamine
NDMA	N-Nitrosodimethylamine
ng/L	nanograms per liter
NL	notification level
NPDES	National Pollution Discharge Elimination System
NR&C	Natural Resources and Culture Committee
NTU	Nephelometric Turbidity Units
O&M	operation and maintenance
ORP	oxidation reduction potential
pCi/L	picocuries per liter
PLC	programmable logic controller
Point Loma	Point Loma Wastewater Treatment Plant
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
psi	pounds per square inch
PVC	polyvinyl chloride
PVDF	polyvinylidene fluoride
Q1	Quarter 1
Q2	Quarter 2
Q3	Quarter 3
Q4	Quarter 4
QA/QC	quality assurance/quality control
RA	Reservoir Augmentation
Regional Board	San Diego Regional Water Quality Control Board
RfDs	Reference Doses

RO	reverse osmosis
SDG&E	San Diego Gas & Electric
SDI	silt density index
SIP	State Board Policy for Implementation of Toxics Standards for Inland Surface Water, Enclosed Bays, and Estuaries of California
South Bay	South Bay Water Reclamation Plant
State Board	State Water Resources Control Board
STD	standard deviation
T&M Plan	Testing and Monitoring Plan
TCEP	tris (2-chloroethyl) phosphate
TCPP	tris (1-chlor-2-propyl) phosphate
TDI	tolerable daily intake
TDS	total dissolved solids
THMs	trihalomethanes
Title 22	Title 22 of California Code of Regulations
TOC	total organic carbon
UCMR	Unregulated Contaminant Monitoring Rule
UF	ultrafiltration
UV	ultraviolet light
UV254	UV 254 Absorbance
UVT	ultraviolet light transmittance
VOC	volatile organic compound
Water Authority	San Diego County Water Authority
WSE	water surface elevation

Glossary

1, 4- Dioxane: A chemical contaminant primarily used as an industrial stabilizer to enhance performance of solvents in manufacturing processes. Commonly used in food and food additives or in personal care products such as cosmetics, deodorants, soaps and shampoos. Currently there is not a federal or state MCL; however, the CDPH has established a notification level of 1 ppb. CDPH also specifies in the 2011 Draft Groundwater Recharge Reuse Regulations that AOP systems required for direct injection applications can be designed to achieve 0.5 log removal of 1,4-dioxane. Alternatively, AOP sizing can be based on demonstrated log removals of select indicator compounds from different functional groups.

Advanced Oxidation: A set of chemical treatment processes designed to destroy organic material through the breakdown of their molecular structure. The advanced oxidation process used at the AWP Facility employs ultraviolet light and hydrogen peroxide, which break down into natural elements, such as carbon, hydrogen and nitrogen.

Advanced Water Purification Facility (AWP Facility): A facility that produces purified water by utilizing advanced treatment technologies: membrane filtration (microfiltration [MF] or ultrafiltration [UF]), reverse osmosis (RO), disinfection, and advanced oxidation.

Advanced Water Purification (AWP) Facility Study: One element of the multi-faceted Demonstration Project. The AWP Facility Study included two primary elements: (1) the design, installation, and operation of a one million gallon per day (mgd) Demonstration Facility located at North City and (2) a conceptual design and cost estimate for a potential Full-Scale Facility.

Advanced Water Purification (AWP) Facility Study Report: Final report documenting the observations and findings of the AWP Facility Study.

Analyte: a chemical substance that is the subject of chemical analysis.

Backwash: The process of reversing the direction of flow through a filtration system in order to remove contaminants that had been filtered out in a water purification process, e.g. membrane filtration. The backwash process is necessary in order to maintain the treatment capacity of membrane filtration.

Bacteriophage: Viruses present among coliform bacteria. Have a high presence in wastewater.

Ballast: An electronic device on the UV system designed to generate a constant UV intensity and maximize UV lamp life.

Blending: Mixing or combining one water source with another such as purified water with raw water sources.

California Groundwater Recharge Reuse Draft Regulations: The November 21, 2011 Groundwater Recharge Reuse Draft Regulations, which are used as a guidance document for the conceptual design of the Full-scale Facility since regulations for reservoir augmentation with purified water do not yet exist. Also referred to as the draft groundwater recharge regulations.

Clean in place: The in-situ chemical cleaning of membranes that consists of soaking membranes in one or more chemical solutions (typically acid and caustic solutions) to remove accumulated foulants and restore permeability.

Concentrate: A continuous waste stream, typically containing concentrated dissolved solids, from the membrane process.

Constituent: In water, a constituent is a dissolved chemical element or compound or a suspended material that is carried in the water.

Constituents of Emerging Concerns (CECs): CECs are not regulated and include commonly used pharmaceuticals, personal care products, flame retardants and unregulated pesticides.

Contaminant: An organic or inorganic substance found in the water. Some contaminants have a health effect in people consuming the water, and thus is regulated in drinking water. Not all contaminants are unsafe. Iron and manganese are contaminants, but in excess simply causing staining. See Maximum Contaminant Level.

Critical alert limit: Measurement of a critical limit parameter that requires urgent corrective action in order for the corresponding critical control point to function as intended.

Critical control point: A point or step within the AWP Facility process train at which critical limit parameters can be monitored in order for corrective actions to be taken should critical alert limits be exceeded.

Critical limit parameter: A parameter that indicates whether or not a control measure is within the alert limit or critical alert limit for the corresponding critical control point.

Demonstration Facility: The one-mgd advanced water purification facility that was designed, installed, and operated as part of the City's Water Purification Demonstration Project.

Detection limit for the purposes of reporting (DLR): The DLR is a parameter that is set by regulation for each reportable analyte. It is not laboratory-specific and it is independent of the analytical method used (in cases where several methods are approved). The DLR cannot be changed by the laboratory. It is expected that a laboratory can achieve a reporting limit that is lower than or equal to the DLR set by the California Department of Public Health (CDPH).

Disinfection: The removal, inactivation or destroying of microorganisms present in a water supply that may be harmful to humans. Commonly used disinfectants include chlorine (and its derivatives), ultraviolet (UV) light, and ozone. Chlorine and its derivatives are used to disinfect drinking water because they provide residual disinfection that protects the water as it goes through the pipes to homes and businesses.

Disinfection byproduct: A compound that is formed through the reaction of a disinfectant (chlorine, ozone, chlorine dioxide, hydrogen peroxide) with organic or inorganic material present in the water. Some disinfection byproducts have been found to be harmful to human health and are regulated by the EPA or under consideration for future regulation.

Drinking water: Water that meets federal drinking water standards as well as state and local water quality standards so that it is safe for human consumption. Water treatment facilities that produce drinking water require a state permit. Also referred to as potable water.

Drought: A defined period of time when rainfall and runoff in a geographic area are much less than average.

Endocrine disrupting compounds (EDCs): A chemical substance or mixture that alters the normal hormone functions in humans and animals. These chemicals can come from pharmaceuticals and personal care products such as detergent and synthetic hormones. They may also come from some industrial wastes and pesticides. EDCs are also contained in natural agricultural products such as soybeans, alfalfa, and natural hormones in animals.

Effluent: The water leaving a water or wastewater treatment process or facility. If effluent has been treated to a high enough standard, it may be considered to be recycled water and can be used for beneficial purposes.

EEO-electrical energy per order: The amount of energy required to destroy 1 log order (i.e. 90%) of a given contaminant per 1000 gallons of water treated. EEO values are both reactor and water quality specific and used to baseline differences in reactor configurations and UV lamp intensities to establish comparative removals of a given constituent such as NDMA and 1,4- dioxane.

Environmental Impact Statement / Environmental Impact Report (EIS/EIR): Detailed analysis of impacts of a project on all aspects of the natural and human environment. An EIS is required by the federal National Environmental Policy Act (NEPA) for federal permitting or use of federal funds. An EIR is required by the California Environmental Quality Act (CEQA) for local projects.

Filtrate: A continuous stream of water that passes through a filter.

Filtration: A process that separates small particles from water by using a porous barrier to trap the particles and allow the water to pass through.

Flux: The unit rate at which water passes through the membrane expressed as flow per unit of membrane area (e.g., gallons per square foot per day (gfd)).

Fouling: The accumulation of contaminants on the membrane surface, within membrane pores, or media surface that inhibits the passage of water.

Full-Scale Facility: The proposed AWP Facility for the full-scale IPR/RA project. The Full-Scale Facility will have a capacity of 18 mgd and annual average purified water production of 15 mgd.

Groundwater recharge: Naturally or artificially adding water back into a groundwater basin.

Hydrogen peroxide: Chemical added in the UV disinfection/advanced oxidation step.

Imported water: A water source that originates in one hydrologic region and is transferred to another hydrologic region. In San Diego's case, water is imported from Northern California or the Colorado River and travels to this region in large above ground aqueducts or underground pipelines.

Imported raw aqueduct water: The raw imported water conveyed to the City's three water treatment plants for treatment prior to being introduced into the City's drinking water distribution system. For the AWP Facility Study, imported raw aqueduct water specifically refers to the imported water that was sampled at the Miramar Water Treatment Plant, per the Testing and Monitoring Plan.

Indicator Compounds or Indicator Organisms: A common method to evaluate water or wastewater quality using representative chemicals or organisms that are characteristic of a larger group of related chemicals or organisms. Coliform bacteria are common indicator organisms, and trihalomethanes, benzene, and NDMA are examples of indicator compounds.

Indirect potable reuse (IPR): The process of blending purified water into a natural water source (groundwater basin or reservoir) that can be used as a source of drinking water.

Influent: Flow entering a process.

Inorganic chemicals: Inorganic chemicals are substances that do not contain both carbon and hydrogen. Generally, inorganic chemicals are minerals. Most minerals are not a cause for concern in water. Water contains many natural minerals from the rocks the water has come into contact with on its journey to the water treatment plant. Nutrients, such as phosphorus and nitrogen, and metals, such as calcium, iron, sodium, potassium, and zinc, are inorganic chemicals. Some inorganic chemicals, when they are too abundant, are considered contaminants in water.

Integrity monitoring: Performance evaluation of a treatment process in order to verify that the process meets its intended treatment performance on a continuous basis.

Laboratory reporting level (LRL): The lowest concentration at which an analyte can be quantified and reported with an acceptable degree of accuracy. Laboratory reporting levels can vary based on the analytical method used, the laboratory, and the concentration being tested.

Maximum Contaminant Level (MCL): The highest allowable amount of a contaminant in drinking water mandated by the Safe Drinking Water Act, established by the U.S. Environmental Protection Agency as a regulatory standard.

Membrane filtration: A type of filter used to separate particles from the water. Membrane filters are characterized by the pore openings size from the largest to the smallest pore size: microfiltration, ultrafiltration, and nanofiltration. Membrane filters remove suspended solids, bacteria, protozoa, and other material from water.

Method detection limit (MDL): The lowest concentration at which an analyte can be detected in a sample and reported with greater than 99 percent certainty using a particular analytical method.

Microfiltration (MF): A low-pressure membrane filtration process where tiny, hollow straw-like membranes separate small suspended particles, bacteria and other materials out of the water. MF provides the most efficient preparation of water for reverse osmosis. MF is used in commercial industries to process food, fruit juices and soda beverages; in computer chip manufacturing; and to sterilize medicines that cannot be heated.

Micron: Equal to one-millionth of a meter or 1/25,400 of one inch. The eye can see particles only to about 40 microns. Used to describe the size of bacteria.

Non detectable and non quantifiable (ND): Laboratory sample results of a constituent reported as less than the laboratory reporting level or method detection limit (MDL).

Nitrosodimethylamine (NDMA): A semi-volatile, yellow, oily liquid of low viscosity that has been extensively used in industry for several decades (USEPA, 2001). NDMA is found at low levels in numerous items of human consumption including cured meat, fish, beer, and tobacco smoke. Currently there is not a federal or state MCL; however, the CDPH has established a notification level of 10 ng/L. Until revision of the Draft Groundwater Recharge Reuse Regulations in 2011 CDPH required that AOP systems required for direct injection applications be designed to achieve 0.5 log removal of 1,4-dioxane and 1.2 log removal of NDMA.

Non-potable water: Water that is not suitable for drinking because it has not been treated to drinking water standards.

North City Water Reclamation Plant (North City): Wastewater treatment plant that produces recycled water through a series of processes: primary treatment (screening and sedimentation), secondary treatment (aeration and clarification), and tertiary treatment (filtration and disinfection).

National Pollutant Discharge Elimination System (NPDES): A federal permit authorized by the Clean Water Act, Title IV, which is required for discharge of pollutants to navigable waters of the United States, and includes any discharge to surface waters: lakes, streams, rivers, bays, the ocean, wetlands, storm sewer, or tributary to any surface water body.

Organic chemicals: Chemicals that contain both carbon and hydrogen. There are millions of organic compounds, both naturally occurring and man-made. Naturally occurring organic compounds include amino acids (the building blocks of proteins), sugars, fats, hormones, and vitamins. All living matter is made up of natural organic chemicals. Synthetic (manmade) organic chemicals have been developed because they exhibit features that are valuable to us. These synthetic organic chemicals include herbicides, insecticides, pharmaceuticals, food coloring and flavors, personal care products, dyes, paints, adhesives, detergents, polymers, and plastics.

Osmotic pressure: The amount of pressure that must be applied to stop the natural osmosis-driven flow of water across a semi-permeable membrane.

Oxidation: A treatment step often used in disinfection, where chlorine, hydrogen peroxide, ozone, or another oxidizing agent is added to water to produce a chemical reaction that removes or aids in removal of harmful substances.

Pathogens: Disease-causing organisms. The general groupings of pathogens are viruses, bacteria, protozoa, and fungi.

Permeate: A continuous stream of water that passes through membrane. Typically used for water that passes through a reverse osmosis membrane (i.e., reverse osmosis permeate). Also referred to as filtrate or product.

Personal care product: Products that can be found in wastewater such as shampoos, fragrances, soap, and deodorant.

Pharmaceutically-active compound: Hormone-based compounds found within EDCs. Examples of these compounds include antibiotics, anti-epileptic medications, heart medications, pain medications, and cancer medications, along with veterinary drugs and feed additives used for livestock.

Phenolic Compounds: A class of aromatic organic compounds commonly used in the manufacture of plastics, cosmetics, and antiseptics, and as preservatives for wood and rubber. Several of these compounds are regulated for surface water (11 compounds), drinking water (1 compound), and air (5 compounds), based on observed toxicity. Phenolic compounds are commonly found in bottled water and are sometimes classified as endocrine disrupting compounds.

Point Loma Wastewater Treatment Plant (Point Loma): Advanced primary wastewater treatment plant that discharges treated wastewater into the Pacific Ocean.

Potable water: See drinking water.

Purified water: Recycled water that has been treated to an advanced level beyond tertiary treatment, so that it can be added to water supplies ultimately used for drinking water. The treatment includes membrane filtration with microfiltration (MF) or ultrafiltration (UF), reverse osmosis (RO), and advanced oxidation that consists of disinfection with ultraviolet light (UV) and hydrogen peroxide (H₂O₂). Purified water may be discharged into a groundwater basin or surface water reservoir that supplies water to a drinking water treatment facility.

Quarterly Testing Reports: Four quarterly testing reports were prepared to summarize the testing data collected at the Demonstration Facility. Quarterly Testing Report No. 4 includes all of the data collected at the Demonstration Facility and is included as an appendix to the AWP Facility Study Report.

Raw water: Water that has not been treated for use. Examples of raw water are water in the Colorado River aqueduct, the State Water Project aqueduct, open reservoirs (whether filled with imported water or runoff), rivers, naturally occurring lakes and some well water.

Reactor: A vessel or tank where physical or chemical treatment processes occur.

Reclaimed water: See recycled water.

Recovery: The volumetric percent of feed water that is converted to filtrate or permeate.

Recycled water: Treatment of wastewater beyond secondary treatment using tertiary filtration and chlorination. Water treated to this tertiary level is considered to be recycled water, which is suitable for many beneficial uses including irrigation or industrial processes. Recycled water meets treatment and reliability criteria established by Title 22, Chapter 4, of the California Code of Regulations.

Reservoir: A manmade lake or tank used to collect and store water.

Reservoir augmentation (RA): The process of adding purified water to a surface water reservoir. The purified water undergoes advanced treatment (membrane filtration, reverse osmosis and UV disinfection/advanced oxidation). The purified water is then blended with untreated water in a reservoir. The blended water is then treated and disinfected at a conventional drinking water treatment plant and is distributed into the drinking water delivery system. Also known as surface water augmentation.

Reverse osmosis (RO): A high-pressure membrane process that forces water through the molecular structure of several sheets of thin plastic membranes to filter out minerals and contaminants, including salts, viruses, pesticides, and other materials. The RO membranes are like microscopic strainers -- bacteria and viruses as well as inorganic and most organic molecules cannot pass through the membranes.

Scaling: The precipitation or crystallization of salts on a surface (e.g., on the feed side of a membrane).

Stage: A group of membrane units operating in series. In a two-stage configuration, concentrate from the first stage travels to the second where more water is produced.

Storage: Water held in a reservoir for later use.

Surface water: Water located on the Earth's surface in a river, stream, lake, pond or surface water reservoir.

Surrogate Compounds or Surrogate Parameters: A common method used to evaluate water quality using a compound or parameter viewed as representative of a non-related class of chemicals or organisms. Surrogates are used when the analytes of interest are more difficult to quantify and measure through standard laboratory practices. Examples of surrogate parameters include turbidity, conductivity, UV254, and total organic carbon.

Tertiary effluent prior to chlorination: Tertiary effluent prior to chlorination is wastewater that has undergone primary treatment, secondary treatment, and tertiary filtration, but has not been disinfected with chlorine. This is the feed water to the AWP Facility. Sometimes referred to as recycled water even though it has not been disinfected.

Testing and Monitoring Plan (T&M Plan): This plan was prepared as part of the AWP Facility Study to outline the testing and monitoring that was conducted at the Demonstration Facility. The plan was reviewed and commented on by the Independent Advisory Panel (IAP), the California Department of Public Health (CDPH), and the San Diego Regional Water Quality Control Board (Regional Board). More information about the T&M Plan is included in Section 2 and the plan is included as an appendix.

Total dissolved solids (TDS): The concentration of mineral salts dissolved in water. Salinity may be measured by weight (TDS) or by electrical conductivity. Salinity and TDS are both measures of the amount of salt dissolved in water, and the terms are often used interchangeably. Generally, salinity is used when referring to water with a lot of salt (e.g., seawater), whereas TDS is used to refer to water with little salt (e.g., freshwater).

Total organic carbon (TOC): A measure of the amount of carbon that is bound in organic molecules, including all natural and man made chemicals.

Transmembrane pressure: The difference in pressure from the feed (or feed-concentrate average) to the permeate across the membrane.

Turbidity: A measure of suspended solids in water; cloudiness.

Ultrafiltration (UF): Identical to microfiltration, except membrane pore size is smaller.

Ultraviolet (UV) disinfection and advanced oxidation: During ultraviolet disinfection, water is exposed to ultraviolet (UV) light, just like instruments in medical and dental offices, to provide disinfection. Additionally, ultraviolet light combined with hydrogen peroxide creates an advanced oxidation reaction that eliminates any remaining compounds in water by breaking them down into harmless compounds.

Vessel Array: Physical arrangement of pressure vessels in a reverse osmosis (RO) system. For example, a 10 by 5 by 3 vessel array indicates a three-stage RO system with 18 total vessels: stage one has 10 vessels, stage two has 5 vessels, and stage three has 3 vessels.

Wastewater: Untreated water collected in the sewer system from residences and businesses (e.g., from bathtubs, showers, bathroom sinks, clothes washers, toilets, kitchen sinks, dishwashers, and industrial processes). It consists of mostly water with some impurities. Also known as sewage.

Water Purification Demonstration Project (Demonstration Project): The second phase of the City of San Diego's Water Reuse Program. During this phase the Demonstration Facility will operate for approximately one year and will produce one million gallons of purified water per day. A study of the

San Vicente Reservoir is being conducted to test the key functions of reservoir augmentation and to determine the viability of a full-scale project. No purified water was sent to the reservoir during the demonstration phase.

Water Purification Demonstration Project (Demonstration Project) Report: Final report documenting the findings of the Demonstration Project.

Water purification process: The process of using water purification technology on recycled water to produce a water supply that can be used for reservoir augmentation and ultimately for drinking water purposes. The process of water purification starts with recycled water, which has already been treated to produce a supply of water safe enough for irrigation and industrial purposes. This recycled water is further treated with water purification technology. The resulting purified water can be used to augment local reservoir supplies, which would be treated once more at a potable water treatment plant to produce drinking water.

Water purification technology: The technology used for purifying treated wastewater, including membrane filtration with microfiltration (MF) or ultrafiltration (UF), reverse osmosis (RO), and ultraviolet (UV) disinfection and advanced oxidation.

Water reuse: The planned use of recycled water that would otherwise return to the natural hydrologic (water) system for a specific beneficial purpose.

Water Measurement Terms

Milligrams per liter (mg/L) also known as parts per million (ppm): A measurement describing the amount of a substance (such as a mineral, chemical or contaminant) in a liter of water; a unit used to measure water concentrations (parts of something per million parts of water). One part per million is equal to one milligram per liter. (This term is becoming obsolete as instruments measure smaller particles.) This is equivalent to one drop of water diluted into 50 liters (roughly the fuel tank capacity of a compact car) or about thirty seconds out of a year.

Micrograms per liter ($\mu\text{g/L}$) also known as parts per billion (ppb): A frequently used measurement for water concentration (parts of something per billion parts of water). One part per billion is equivalent to one second of time in 32 years or one drop of water in a typical backyard swimming pool (a typical residential swimming pool is 30 feet by 15 feet with an average depth of 6 feet or 60 cubic meters). One thousand parts per billion is equal to one part per million.

Nanograms per liter (ng/L) also known as parts per trillion (ppt): A very high level of measurement for water concentration (parts of a constituent per trillion parts of water). This is equivalent to one drop of water diluted into 20 London Olympics swimming pools (2,500 cubic meters times 20 = 50,000 cubic meters) or about three seconds out of every 100,000 years.

Million gallons per day (mgd): This term is used to describe the volume of water treated and distributed from a treatment plant daily.

Acre foot (AF): A unit of water commonly used in the water industry to measure large volumes of water. It equals the volume of water required to cover one acre to a depth of one foot. An acre-foot is 325,851 gallons and is considered enough water to meet the needs of two families of four with a house and yard for one year.

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