Designation: E2635 – 14

Standard Practice for Water Conservation in Buildings Through In-Situ Water Reclamation[1]

This standard is issued under the fixed designation E2635; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 In an effort to help meet growing demands being placed on available water supplies and water treatment facilities, many communities throughout the United States and the world are turning to water reclamation and reuse. Water reclamation and reuse offer an effective means of conserving the Earth's limited high-quality freshwater supplies while helping to meet the ever growing demands for water in residential, commercial, and institutional development. This practice sets forth a practice for water reuse in buildings and related construction, encompassing both graywater and blackwater in-situ reclamation.

1.1.1 This practice specifies parameters for substituting reclaimed water in place of potable water supplies where potable water quality is not required.

1.1.2 This practice specifies limitations for use of reclaimed water in-situ. It is not intended for application to the use of reclaimed water delivered from an offsite municipal wastewater treatment facility.

1.1.3 This practice specifies performance requirements for in-situ reclaimed water systems. It does not specify particular technology(ies) that must be used. A variety of technologies may satisfy the performance requirements.

1.1.4 This practice specifies requirements for water stewardship associated with in-situ water reuse. Consistent with Guide E2432 and for purposes of this practice, water stewardship includes both quantity and quality impacts on water used in buildings.

1.2 Implementation of this practice will require professional judgment. Such judgment should be informed by experience with sustainable development, including environmental, economic, and social issues as appropriate to the building use, type, scale, and location.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3.1 *Exception*—Solely SI units are used in Table 1, Table X3.1, and Table X4.1.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D888 Test Methods for Dissolved Oxygen in Water
D1253 Test Method for Residual Chlorine in Water
D4188 Practice for Performing Pressure In-Line Coagulation-Flocculation-Filtration Test in Water
D4840 Guide for Sample Chain-of-Custody Procedures
D5128 Test Method for On-Line pH Measurement of Water of Low Conductivity
D5244 Practice for Recovery of Enteroviruses from Waters (Withdrawn 2013)[3]
D5464 Test Method for pH Measurement of Water of Low Conductivity
D5907 Test Methods for Filterable Matter (Total Dissolved Solids) and Nonfilterable Matter (Total Suspended Solids) in Water
D6238 Test Method for Total Oxygen Demand in Water
D6569 Test Method for On-Line Measurement of pH
D6698 Test Method for On-Line Measurement of Turbidity Below 5 NTU in Water
D6734 Test Method for Low Levels of Coliphages in Water
E631 Terminology of Building Constructions
E2114 Terminology for Sustainability Relative to the Performance of Buildings
E2432 Guide for General Principles of Sustainability Relative to Buildings

[1] This practice is under the jurisdiction of ASTM Committee E60 on Sustainability and is the direct responsibility of Subcommittee E60.07 on Water Use and Conservation.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

2.2 *Other References:*

U.S. EPA Protocols, Monitoring and Assessing Water Quality; Section 5.2, Dissolved Oxygen and Biochemical Oxygen Demand[4]

California Health Laws Related to Recycled Water, "The Purple Book"[5]

3. Terminology

3.1 *Definitions:*

3.1.1 For terms related to building construction, refer to Terminology E631.

3.1.2 For terms related to sustainability relative to the performance of buildings, refer to Terminology E2114.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *blackwater, n*—untreated wastewater from toilets, kitchen sinks, and dishwashers.

3.2.2 *cross-connection, n*—a physical connection between any part of a water system used or intended to supply water for drinking purposes and any source or system containing water or substance that is not or cannot be approved as potable water.

3.2.3 *disinfection, n*—destruction, inactivation, or removal of pathogenic microorganisms by chemical, physical, or biological means.

3.2.4 *dual distribution system, n*—reclaimed water distribution systems that parallels a potable water system.

3.2.5 *filtration, n*—the passing of wastewater through natural undisturbed soils or filter media such as sand or anthracite, or both, filter cloth, or the passing of wastewater through microfilters or other membrane processes.

3.2.6 *graywater, n*—untreated wastewater from bathtubs, showers, bathroom wash basins, clothes washing machines, and laundry tubs.

3.2.6.1 *Discussion*—Graywater is unlikely to contain significant organic contaminants or chemical contaminants more hazardous than detergents, excluding blackwater.

3.2.7 *groundwater, n*—water that is found beneath the surface of the ground, usually in porous rock known as an aquifer.

3.2.7.1 *Discussion*—The top of this groundwater is called the water table.

3.2.8 *nonpotable water, n*—water that has not been treated for human consumption in conformance with applicable drinking water quality regulations.

3.2.9 *osmosis, n*—the movement of water between two solutions, separated by a membrane that permits the free passage of water but prevents or slows down the passage of dissolved substances.

3.2.9.1 *Discussion*—Water moves more rapidly from the less concentrated solution to the solution of a higher concentration than in the opposite direction.

3.2.10 *persistent organic pollutant (POP), n*—a chemical substance that persists in the environment, bioaccumulates through the food web, and poses a risk of causing adverse effects to human health and the environment.

3.2.10.1 *Discussion*—The United Nations Environment Programme (UNEP) Governing Council, at its 19th session in February 1997, identified 12 POPs: Aldrin, Chlordane, Dieldrin, DDT, Endrin, Heptachlor, Hexachlorobenzene, Mirex, Toxaphene, PCBs, Dioxins, and Furans.

3.2.11 *potable water, n*—water that does not endanger the lives or health of human beings and that conforms to applicable regulations for drinking water quality.

3.2.12 *reclaimed water, n*—nonpotable water that is highly treated and used for approved purposes other than drinking water.

3.2.13 *reverse osmosis, n*—a separation process that uses pressure to force a solvent through a membrane that retains the solute on one side and allows the pure solvent to pass to the other side.

3.2.13.1 *Discussion*—Pressure (usually 725.19 to 2900.76 psi (5 to 20 MPa)) is applied on the high concentration side of the membrane, forcing the solvent through a membrane to a solution of lower concentration. Pure solvent is obtained on the other side. The membranes used for reverse osmosis do not have pores: rather, separation takes place in a polymer layer of microscopic thickness.

3.2.14 *water reuse, v*—cycling water one or more times for beneficial use as reclaimed water.

3.2.14.1 *Discussion*—All water is cycled in the hydrologic cycle and so in the broadest sense may be considered to be 'reused.' The term 'water reuse' is utilized in this practice to refer specifically to a man-made intrusion in the hydrologic cycle that diverts water for multiple uses.

4. Significance and Use

4.1 *General*—As the world's population increases, so does the need for water to meet various needs, as well as the need to manage wastewater. Already accepted and endorsed by the public in many urban and agricultural areas, properly implemented nonpotable water reuse projects can help communities meet water demand and supply challenges without any known significant health risks.

4.1.1 Many communities throughout the world are approaching, or have already reached, the limits of their available water supplies; water reuse has become necessary for conserving and extending available water supplies. Where the availability of water limits development, water reuse can facilitate social and economic developmental needs in an environmentally responsible manner.

4.1.2 Many communities are also approaching, or have already reached, the limit of available water treatment facilities. New facilities and infrastructure are costly. In-situ water reuse reduces load on community wastewater facilities.

[4] Available from United States Environmental Protection Agency (EPA), Ariel Rios Bldg., 1200 Pennsylvania Ave., NW, Washington, DC 20460, http://www.epa.gov. Specific reference available as EPA 841-B-97-003, *Volunteer Stream Monitoring: A Methods Manual*, November 1997, Online, http://www.epa.gov/volunteer/stream/stream.pdf, 1 September 2008.

[5] Available from the California Department of Public Health (CDPH), CDHP Headquarters, 1616 Capitol Ave., P.O. Box 997377, MS 7400, Sacramento, CA 95899-7377, http://ww2.cdph.ca.gov. Specific reference available as "The Purple Book," June 2001, Online, http://ww2.cdph.ca.gov/certlic/drinkingwater/Documents/Recharge/Purplebookupdate6-01.pdf, 1 September 2008.

4.1.3 Additionally, many communities face increased security issues in safeguarding water sources and treatment. In-situ systems provide for redundancies and diversified systems that decrease security issues associated with centralized facilities.

4.2 *Sustainable Development*—This practice is consistent with the general principles for sustainability relative to building as identified in Guide E2432. It addresses the environmental, economic, and social principles as follows:

4.2.1 *Environmental*—Water is a natural resource. Sustainable use of natural resources requires that the resource is utilized efficiently and in a manner that preserves or enhances the quality of that resource and does not adversely alter the balance between the renewable resource and the rate of consumption for building-related purposes. Utilization of technologies, such as in-situ water reclamation systems that help conserve water enable more sustainable use of water than standard construction.

4.2.2 *Economic:*

4.2.2.1 *Direct Costs/Benefits*—Direct cost/benefits include first costs/benefits as well as operating costs/benefits such as: utility costs, maintenance and repair costs, and costs associated with replacement of component materials and systems. Utilization of technologies, such as in-situ water reclamation systems that help reduce building demand for potable water can reduce utility costs and prevent moratoriums on new construction.

4.2.2.2 *Indirect Cost/Benefits*—Sustainable building practices seek to identify associated external costs/benefits, minimize associated external costs, and maximize external benefits. Utilization of technologies, such as in-situ water reclamation systems that help reduce the amount of wastewater discharge from a building reduce demands on municipal water infrastructure. This includes costs for centralized treatment and distribution. Significant energy is expended for treatment and distribution of water. For example, in California, an estimated 19 % of electricity, 32 % of natural gas consumption, and 88 billion gallons of diesel fuel annually power the treatment and distribution of water and wastewater.[6]

NOTE 1—The Final Report includes Table 1–2: Range of Energy Intensities for Water Use Cycle Segments, below:[6]

Water-Use Cycle Segments	Range of Energy Intensity, kWh/MG Low	High
Water Supply and Conveyance	0	14 000
Water Treatment	100	16 000
Water Distribution	700	1 200
Wastewater Collection and Treatment	1 100	4 600
Wastewater Discharge	0	400
Recycled Water Treatment and Distribution	400	1 200

4.2.2.3 *Social*—Sustainable buildings protect and enhance the health, safety, and welfare of building occupants. Utilization of technologies, such as in-situ water reclamation systems that help diversify and decentralize critical health, safety, and welfare infrastructure help promote the safety and security of the general public.

4.3 *Continual Improvement*—No specific technology is required by this practice. Utilization of performance requirements rather than prescriptive requirements is intended to promote continued research, development, and improvement of as in-situ water reclamation systems.

5. Allowable Uses for In-Situ Reclaimed Water

5.1 *General*—Water reclamation and nonpotable reuse typically require conventional water and wastewater treatment technologies that are already widely practiced and readily available in many countries throughout the world. When discussing treatment for a reuse system, the overriding concern continues to be whether the quality of the reclaimed water is appropriate for the intended use. Reclaimed water meeting the requirements of this practice is usable in urban and industrial applications as indicated and in such other applications as agencies having jurisdiction may permit.

5.2 *Urban Reuse*—All types of landscape irrigation, toilet flushing, use in fire protection systems and commercial air conditioners, automatic washing equipment, and other uses with similar access or exposure to the water.

5.3 *Industrial Reuse*—Once-through cooling and recirculating cooling towers. Industrial reuse does NOT include process water for manufacturing.

6. Performance Requirements for In-Situ Reclaimed Water Systems

6.1 *Reclaimed Water Quality*—Provide water treatment sufficient to produce reclaimed water with qualities as indicated in Table 1, Treatment Requirements.

6.2 *Setback Distances*—Provide setback distances to protect potable water supply sources from contamination and to protect humans from unreasonable health risks due to exposure to reclaimed water. Setback distances refer to distances between potable water supply sources and reclaimed water collection/holding areas, treatment equipment, and open portions of the system.

6.2.1 *Urban Reuse*—Maintain reclaimed water systems minimum 50 ft (15 m) away from potable water supply wells. Maintain reclaimed water systems piping minimum 200 ft (60 m) from potable water supply wells; and 10 ft (3 m) horizontally and 1.5 ft (0.45 m) vertically from potable water piping.

6.2.2 *Industrial Reuse*—Maintain reclaimed water systems minimum 300 ft (90 m) away from areas accessible to the public. Locate such that windblown spray does not reach areas accessible to the public. Maintain reclaimed water systems piping minimum 200 ft (60 m) from potable water supply wells; and 10 ft (3 m) horizontally and 1.5 ft (0.45 m) vertically from potable water piping.

7. Procedure for Water Reuse in Buildings

7.1 *System Design*—This practice specifies performance requirements for in-situ reclaimed water systems. It does not specify particular technology(ies) that must be used. A variety of technologies may satisfy the performance requirements. Treatment methods include, but are not limited to: biological and or chemical treatment systems with tertiary disinfection

[6] *California Energy Commission; California's Water—Energy Relationship*; prepared in Support of the 2005 Integrated Energy Policy Report Proceeding (04-IEPR-01E), November 2005, CEC-700-2005-011-SF.

TABLE 1 Treatment Requirements

Types of Reuse	Treatment Level	Reclaimed Water Quality	Monitoring
Urban Reuse	Provide: Primary, Secondary, & Tertiary—Filtration & Tertiary—Disinfection	pH = 6–9 ≤10 mg/L BOD ≤2 NTU No detectable fecal coli/100 mL[A] (The number of fecal coliform organisms may not exceed 14 ⁄100 mL in any sample.) 1 mg/L Cl_2 residual minimum Enteroviruses – inactivate or remove, or both, 99.999 % of the polio virus in wastewater	pH—weekly BOD—weekly Turbidity continuous Coliform—daily Cl_2 residual continuous Enteroviruses—daily
Industrial Reuse	Provide: Primary, Secondary, & Tertiary—Disinfection (chemical coagulation and filtration may be needed for recirculating cooling towers)	pH = 6–9 ≤30 mg/L BOD ≤30 mg/L TSS ≤200 fecal coli/100 mL (The number of fecal coliform organisms may not exceed 800 ⁄100 mL in any sample) 1 mg/L Cl_2 residual minimum Enteroviruses—inactivate or remove, or both, 99.999 % of the polio virus in wastewater	pH—weekly BOD—weekly TSS—daily Coliform—daily Cl_2 residual continuous Enteroviruses—daily

[A] Unless otherwise noted, recommended coliform limits are median values determined from the bacteriological results of the last seven days for which analyses have been completed. Either the membrane filter or fermentation-tube technique may be used.

and filtration, distillation, freezing, reverse osmosis, advanced oxidation processes, constructed wetlands, membrane bioreactor (MBR) systems, electrodialysis, and ion exchange.

7.1.1 Water reclamation system shall be designed and implemented to provide for reliability and redundancy. System design shall take into account operations and treatment during normal and peak loading conditions, and periods of shutdown. Peak loading conditions shall include peak hydraulic loading and pollutant loading conditions. Periods of shutdown shall include: power failures, equipment failure, and normal maintenance shutdowns.

7.1.2 System must be capable of easy access for effective monitoring program and for effective maintenance and process control program.

7.2 *Collection*—Collection may include rainwater, snowmelt, stormwater runoff, condensation, graywater and blackwater.

7.2.1 Collection and use of rainwater, snowmelt, and stormwater runoff for water reuse in buildings shall not significantly reduce the amount of runoff that would have occurred from the site in its natural, pre-development state. Harvested rainwater shall not be appropriated in a manner that permanently and significantly alters the natural hydrologic functioning of the site or of adjacent property owners.

7.3 *Treatment*—Reclaimed water shall be processed with primary, secondary, and tertiary treatment levels as indicated in Table 1, Treatment Requirements, and as follows:

7.3.1 *Reclaimed Water Treatment Levels:*

7.3.1.1 *Primary Treatment*—Remove 70 to 85 % of the organic and inorganic solids that settle out and float to the top.

7.3.1.2 *Secondary Treatment*—Produce effluent in which both the BOD and TSS do not exceed 0.004 oz/gal (30 mg/L).

NOTE 2—Conventional Secondary Treatment mixes the remaining suspended waste solids with microorganisms and air. The microorganisms convert the waste solids to biomass that settles out. Secondary treatment processes include but are not limited to: activated sludge processes, trickling filters, rotating biological contractors, and may include stabilization pond systems.

Where in-line coagulation-flocculation is used in reclamation systems, Practice D4188 should be used to determine the effectiveness of flocculants or coagulants, or both, and filter medium(a) in removing suspended and colloidal material from water and wastewater.

It is recommended that filtered wastewater that has been coagulated and has passed through natural undisturbed soils or a bed of filter media, does not exceed a rate of 5 gal/min/ft^2 of surface (18.93 L/min/0.09 m^2) area in mono, dual or mixed media gravity, upflow, or pressure filtration systems; or, does not exceed 2 gal/min/ft^2 (7.57 L/min/0.09 m^2) of surface area in traveling bridge automatic backwash filters.

If the filtered wastewater has passed through a microfiltration, ultrafiltration, nanofiltration, or reverse osmosis membrane, it is recommended that the turbidity of the wastewater does not exceed 0.2 nephelometric turbidity units (NTU) more than five percent of the time within a 24-h period and 0.5 NTU at any time.

7.3.1.3 *Tertiary Treatment*—Provide filtration or disinfection, or both.

(1) Filtration—Filter out remaining solids through a granular media (for example, sand or anthracite coal) or a membrane.

(2) Disinfection—Remove measurable levels of viable pathogens. Disinfection may be accomplished by chlorination, UV radiation, ozonation, other chemical disinfectants, membrane processes, or other processes. The use of chlorine as defining the level of disinfection does not preclude the use of other disinfection processes as an acceptable means of providing disinfection for reclaimed water.

7.4 *Monitoring*—As indicated in Table 1, Treatment Requirements, and as follows:

7.4.1 *Continuous On-Line Monitoring*—Because of the dynamic nature of many water treatment systems and the worldwide need for improved reliability and quality, a high degree of precision is required. On-line measurement is preferred over laboratory measurement to obtain real time, continuous values for automatic control and monitoring purposes. Where laboratory tests are utilized, provide for chain-of-custody of water samples in accordance with Guide D4840.

7.4.2 *Test Methods:*

7.4.2.1 *pH*—pH is a measure of the hydrogen ion activity in water. It is a major parameter affecting the corrosivity and scaling properties of water, biological life in water, and many applications of chemical process control. It is therefore important in water purification, use and waste treatment before release to the environment. Monitor pH in accordance with Test Methods D6569, D5128, or D5464.

7.4.2.2 *Turbidity*—Turbidity is the cloudiness or haziness of a fluid, or of air, caused by individual particles (suspended solids) that are generally invisible to the naked eye, similar to smoke in air. Turbidity is undesirable in drinking water, plant effluent water, water for food and beverage processing, and for a large number of other water-dependent manufacturing process. Monitor NTU in accordance with Test Method D6698. The turbidity limit should be met prior to disinfection. The average turbidity should be based on a 24-h time period. The turbidity may not exceed 5 NTU at any time. If total suspended solids (TSS) is used in lieu of turbidity, the TSS may not exceed 5 mg/L.

7.4.2.3 *Total Suspended Solids (TSS)*—TSS is a water quality parameter that at one time was called non-filterable residue (NFR). It refers to the dry weight of particles trapped by a filter, typically of a specified pore size. Monitor TSS in accordance with Test Method D5907.

7.4.2.4 *Biochemical Oxygen Demand (BOD)*—BOD is a chemical procedure for determining how fast biological organisms use up oxygen in a body of water. It is usually performed over a 5-day period at 20°C (293.15 K). BOD and chemical oxygen demand (COD) analyzers have long time cycles and in the case of COD analyzers use corrosive reagents with the inherent problem of disposal. Total oxygen demand (TOD) analysis is faster, approximately 3 min, and uses no liquid reagents in the analysis. TOD can be correlated to both COD and BOD, providing effective on-line monitoring. Provide BOD monitoring correlated to TOD as tested in accordance with Test Method D6238. Alternately, monitor BOD in accordance with Test Methods D888 or U.S. EPA Protocols, or both.

7.4.2.5 *Coliform*—Coliforms and Coliphages serve as indicators of fecal contamination. The absolute relationship between the number of coliforms and coliphages in natural waters has not been conclusively demonstrated; therefore, for purposes of this practice, use a 1:1 relationship. Coliphages are generally more resistant than coliforms to chlorination and may have some advantage over coliforms as an indicator of treatment efficiency in disinfected waters. Test for fecal contamination in accordance with Test Method D6734.

NOTE 3—California requirements for disinfected tertiary recycled water, in accordance with 'The Purple Book', include the following criteria: "The median concentration of total coliform bacteria measured in the disinfected effluent does not exceed an MPN of 2.2 per [3.38 ounces] 100 millilitres utilizing the bacteriological results of the last seven days for which analyses have been completed and the number of total coliform bacteria does not exceed an MPN of 23 per [3.38 ounces] 100 millilitres in more than one sample in any 30-day period. No sample shall exceed an MPN of 240 total coliform bacteria per [3.38 ounces] 100 millilitres."

7.4.2.6 *Residual Chlorine*—Chlorine is used to destroy or deactivate a variety of unwanted chemicals and microorganisms in water and waste water. An uncontrolled excess of chlorine in water, whether free available or combined, can adversely affect the subsequent use of the water. Monitor residual chlorine in accordance with Test Method D1253 (see Note 4). Total chlorine residual should be met after a minimum contact time of 30 min.

NOTE 4—The enteric virus is a general term describing a virus that can enter by way of the oral route, is capable of multiplying in cells of the alimentary canal, and is found in stool specimens. Included under this general term are agents such as calicivirus, Norwalk virus, adenovirus, and enteroviruses. Enteric viruses are responsible for a wide range of illnesses that include hepatitis and gastroenteritis. Practice D5244 may be used to recover many entericviruses in water.

7.4.2.7 *Enteroviruses*—Enteroviruses are a genus of the family Picornaviridae, and include genus such as: poliovirus, coxsackievirus, and echovirus. Test for the poliovirus in accordance with Practice D5244. Additionally, test for other enteroviruses in accordance with Practice D5244 if conditions warrant.

7.5 *Distribution:*

7.5.1 System installation must conform to the applicable local codes, rules, and regulations as adopted by the authority having jurisdiction.

7.5.2 Provide dual distribution systems to prevent cross-connections of reclaimed water and potable water lines and the misuse of reclaimed water.

7.5.3 Provide backflow prevention devices on reclaimed water lines to preclude the likelihood of incidental human misuse.

7.5.4 Hose bibs on reclaimed water lines are not permitted unless they can be locked and secured from unauthorized use.

7.5.5 *Identification:*

7.5.5.1 Mark or color code all piping, valves, and hydrants to differentiate reclaimed water from potable water. Marking and color coding shall be purple unless otherwise required by agencies having jurisdiction. Marking and color coding shall apply to both exposed and buried pipe.

7.5.5.2 Mark all outlets from the reclaimed water system with "CAUTION—RECLAIMED WATER—DO NOT DRINK" and with the "Do Not Drink" symbol as indicated in Fig. 1.

7.6 *Maintenance*—Develop and implement a preventive maintenance and process control program that includes the following:

7.6.1 Regular inspections conducted of the entire reclaimed water system including: treatment equipment, pumps and

FIG. 1 Do Not Drink Symbol

distribution systems, water closets, sprinkler heads, spray patterns, drip lines, storage facilities, lakes, controllers, signage, etc.

7.6.2 Procedure for periodic recalibration of equipment.

7.6.3 Procedure for identification and prompt correction of problems.

7.6.4 Annual testing of backflow prevention assemblies by a tester certified by the American Backflow Prevention Association (ABPA) or American Water Works Association (AWWA).

7.6.5 Procedure for documentation of maintenance, including records-keeping system of all inspections, testing, modifications, and repairs.

8. Water Stewardship

8.1 *Quantity Impacts*—Water reuse is utilized to reduce the demand on drinking water sources for uses not requiring potable water. Water reuse is utilized to help conserve surface waters by reducing the demand for withdrawing water for potable uses.

8.2 *Quality Impacts*—Water reuse is utilized to improve water quality by reducing discharge of treated effluent to surface waters. Water reclamation processes employed for water reuse should not increase persistent organic pollutants (POPs) in the water.

8.2.1 A chlorine residual of 6.6756×10^{-5} oz/gal (0.5 mg/L) or greater in the distribution system may be utilized to reduce odors, slime, and bacterial regrowth.

9. Reports

9.1 *Engineering Report:*

9.1.1 An Engineering Report shall be prepared prior to occupancy. A copy shall be maintained on site and shall include:

9.1.1.1 Description and diagrams of the design of the proposed reclamation system.

9.1.1.2 Identification of the means for compliance with this practice.

9.1.1.3 Contingency plan to avoid distribution of untreated or inadequately treated wastewater.

9.1.1.4 Any other features specified by the regulatory agency having jurisdiction.

9.1.2 The report shall be prepared by a registered engineer experienced in the field of wastewater treatment.

9.2 *Operating Records and Reports:*

9.2.1 Operating records shall be maintained on site and shall include:

9.2.1.1 Contact information for water reclamation system designer, manufacturer, and installer.

9.2.1.2 Contact information for water reclamation system manager.

9.2.1.3 Contact information for water reclamation system testing laboratory(ies).

9.2.1.4 Schedule for monitoring, inspections and testing.

9.2.1.5 Results of monitoring, inspections and testing, including records of operational problems, equipment breakdowns, diversions to emergency storage or disposal, and all corrective or preventive action taken.

9.2.2 Operating reports shall be prepared monthly. Reports shall contain a monthly summary of operating records.

10. Keywords

10.1 building; green building; reclaimed water; sustainability; sustainable building; water conservation; water reuse; water stewardship

APPENDIXES

(Nonmandatory Information)

X1. WATER IMPURITIES

X1.1 Common soluble and suspended impurities found in water are shown in Table X1.1.

TABLE X1.1 Common Soluble and Suspended Impurities Found in Water

Constituent	Chemical Formula	Difficulties Caused	Examples of Treatment
Turbidity	Non-expressed in analysis as units	Imparts unsightly appearance to water; deposits in water lines, process equipment, etc.; interferes with most process uses	Coagulation, settling, and filtration
Hardness	Calcium and magnesium salts, expressed as $CaCO_3$	Chief source of scale in heat exchange equipment, boilers, pipe lines, etc.; forms curds with soap, interferes with dyeing, etc.	Softening; demineralization; internal boiler water treatment; surface active agents
Alkalinity	Bicarbonate (HCO_3^-), carbonate (CO_3^{2-}), and hydroxide (OH^-), expressed as $CaCO_3$	Foam and carryover of solids with steam; embrittlement of boiler steel; bicarbonate and carbonate produce CO_2 in steam, a source of corrosion in condensate lines	Lime and lime-soda softening; acid treatment; hydrogen zeolite softening; demineralization dealkalization by anion exchange
Free Mineral Acid	H_2SO_4, HCl. etc., expressed as $CaCO_3$	Corrosion	Neutralization with alkalies
Carbon Dioxide	CO_2	Corrosion in water lines, particularly steam and condensate lines	Aeration, deaeration, neutralization with alkalies
pH	Hydrogen ion concentration defined as: $pH = \log\frac{1}{[H^+]}$	pH varies according to acidic or alkaline solids in water; most natural waters have a pH of 6.0-8.0	pH can be increased by alkalies and decreased by acids
Sulfate	SO_4^{2-}	Adds to solids content of water, but in itself is not usually significant, combines with calcium to form calcium sulfate scale	Demineralization, reverse osmosis, electrodialysis, evaporation
Chloride	Cl^-	Adds to solids content and increases corrosive character of water	Demineralization, reverse osmosis, electrodialysis, evaporation
Nitrate	NO_3^-	Adds to solids content, but is not usually significant industrially: high concentrations cause methemoglobinemia in infants; useful for control of boiler metal embrittlement	Demineralization, reverse osmosis, electrodialysis, evaporation, biological reduction (denitrification)
Fluoride	F^-	Cause of mottled enamel in teeth; also used for control of dental decay: not usually significant industrially	Adsorption with magnesium hydroxide, calcium phosphate, or bone black; alum coagulation
Sodium	Na^+	Adds to solids content of water: when combined with OH^-, causes corrosion in boilers under certain conditions	Demineralization, reverse osmosis, electrodialysis, evaporation
Silica	SiO_2	Scale in boilers and cooling water systems; insoluble turbine blade deposits due to silica vaporization	Hot and warm process removal by magnesium salts; adsorption by highly basic anion exchange resins, in conjunction with demineralization, reverse osmosis, evaporation
Iron	Fe^{2+} (ferrous) Fe^{3+} (ferric)	Discolors water on precipitation; source of deposits in water lines, boilers. etc.; interferes with dyeing, tanning, papermaking, etc.	Aeration; coagulation and filtration; lime softening; cation exchange; contact filtration; surface active agents for iron retention
Manganese	Mn^{2+}	Same as iron	Same as iron
Aluminum	Al^{3+}	Usually present as a result of floc carryover from clarifier; can cause deposits in cooling systems and contribute to complex boiler scales	Improved clarifier and filter operation
Oxygen	O_2	Corrosion of water lines, heat exchange equipment, boilers, return lines, etc.	Deaeration; sodium sulfite; corrosion inhibitors
Hydrogen Sulfide	H_2S	Cause of "rotten egg" odor; corrosion	Aeration; chlorination; highly basic anion exchange
Ammonia	NH_3	Corrosion of copper and zinc alloys by formation of complex soluble ion	Cation exchange with hydrogen zeolite; chlorination; deaeration, biological oxidation (denitrification)
Dissolved Solids	None	Refers to total amount of dissolved matter, determined by evaporation; high concentrations are objectionable because of process interference and as a cause of foaming in boilers	Lime softening and cation exchange by hydrogen zeolite; demineralization, reverse osmosis, electrodialysis, evaporation
Suspended Solids	None	Refers to the measure of undissolved matter, determined gravimetrically; deposits in heat exchange equipment, boilers, water lines, etc.	Subsidence; filtration, usually preceded by coagulation and settling
Total Solids	None	Refers to the sum of dissolved and suspended solids, determined gravimetrically	See "Dissolved Solids" and "Suspended Solids"

X2. REUSE REGULATIONS AND GUIDELINES—U.S. EXAMPLES[7]

X2.1 Water reuse in the United States is a large and growing practice. An estimated 1.7 billion gal (6.4 million m^3) per day of wastewater is reused, and reclaimed water use on a volume basis is growing at an estimated 15 % annually. In 2002, Florida reclaimed 584 mgd (2.2×10^6 m^3) of its wastewater and California reclaimed an estimated total of 525 mgd (2.0×10^6 m^3) of wastewater. Florida has an official goal of reclaiming 1 billion gal per day (3.8×10^6 m^3 per day).

X2.2 The U.S. Bureau of Reclamation is developing a program, Water 2025, to focus attention on the emerging need for water. Explosive population growth in urban areas of the western United States, along with a growing demand for available water supplies for environmental and recreational uses, is conflicting with the national dependence on water for the production of food and fiber from western farms and ranches (Department of the Interior/Bureau of Reclamation, 2003).

X2.3 A majority of the states have published treatment standards or guidelines for one or more types of water reuse. Some of these states require specific treatment processes; others impose effluent quality criteria, and some require both. Many states also include requirements for treatment reliability to prevent the distribution of any reclaimed water that may not be adequately treated because of a process upset, power outage, or equipment failure.

X2.4 Table X2.1 summarizes water reuse regulations in the United States on a state-by-state basis.

[7] *Guidelines for Water Reuse*; EPA/625/R-04/108; U.S. Environmental Protection Agency Municipal Support Division Office of Wastewater Management Office of Water Washington, DC, September 2004.

TABLE X2.1 Summary of Water Reuse Regulations in the United States

State	Regulations	Guidelines	No Regulations or Guidelines[A]	Change from 1992 Guidelines for Water Reuse[B]	Unrestricted Urban Reuse	Restricted Urban Reuse	Agricultural Reuse Food Crops	Agricultural Reuse Non-Food Crops	Unrestricted Recreational Reuse	Restricted Recreational Reuse	Environmental Reuse	Industrial Reuse	Groundwater Recharge	Indirect Potable Reuse
Alabama		•		N		•		•						
Alaska	•			NR				•						
Arizona	•			U	•	•	•	•		•				
Arkansas		•		N	•	•	•	•						
California[C]	•			U	•	•	•	•	•	•		•	•	•
Colorado	•			GR	•	•	•	•	•	•				
Connecticut			•	N										
Delaware	•			GR	•	•		•						
Florida	•			U	•	•	•	•			•	•	•	•
Georgia		•		U	•	•		•						
Hawaii		•		U	•	•	•	•		•		•	•	•
Idaho	•			N	•	•	•	•						
Illinois	•			U	•	•		•						
Indiana	•			U	•	•	•	•						
Iowa	•			NR		•		•						
Kansas		•		N	•	•	•	•						
Kentucky			•	N										
Louisiana			•	N										
Maine			•	N										
Maryland		•		N		•		•						
Massachusetts		•		NG	•	•		•					•	•
Michigan	•			N			•	•						
Minnesota			•	N										
Mississippi			•	N										
Missouri	•			N		•		•						
Montana	•			GR	•	•	•	•						
Nebraska	•			GR		•		•						
Nevada	•			GR	•	•	•	•	•	•				
New Hampshire			•	N										
New Jersey		•		RG	•	•	•	•				•		
New Mexico		•		N	•	•	•	•						
New York		•		N				•						
North Carolina	•			U	•	•						•		
North Dakota		•		U	•	•		•						
Ohio		•		NG	•	•		•						
Oklahoma	•			GR		•	•	•						
Oregon	•			N	•	•	•	•	•	•		•		
Pennsylvania		•		NG				•						
Rhode Island			•	N										
South Carolina	•			GR	•	•		•						
South Dakota		•		N	•	•		•			•			
Tennessee	•			N	•	•		•						
Texas	•			U	•	•	•	•	•	•		•		
Utah	•			U	•	•	•	•	•	•		•		
Vermont	•			N				•						
Virginia			•	N										
Washington		•		U	•	•	•	•	•	•	•	•	•	•
West Virginia	•			N			•	•						
Wisconsin	•			N				•						
Wyoming	•			U	•	•	•	•						

[A] Specific regulations on reuse not adopted: however, reclamation may be approved on a case-by-case basis.
[B] N–no change; NR–no guidelines or regulations to regulations; U–updated guidelines or regulations; NG–no guidelines or regulations to guidelines; GR–guidelines to regulations; RG–regulations to guidelines.
[C] Has regulations for landscape irrigation excluding residential irrigation; guidelines cover all other uses.

X3. UNRESTRICTED URBAN REUSE—U.S. EXAMPLES[7]

X3.1 Unrestricted urban reuse involves the use of reclaimed water where public exposure is likely in the reuse application, thereby necessitating a high degree of treatment. See Table X3.1.

TABLE X3.1 Unrestricted Urban Reuse—U.S. Examples

	Arizona	California	Florida	Hawaii	Nevada	Texas	Washington
Treatment	Secondary treatment, filtration, and disinfection	Oxidized, coagulated, filtered, and disinfected	Secondary treatment, filtration, and high-level disinfection	Oxidized, filtered, and disinfected	Secondary treatment and disinfection	NS[A]	Oxidized, coagulated, filtered, and disinfected
BOD_5	NS	NS	20 mg/L $CBOD_5$	NS	30 mg/L	5 mg/L	30 mg/L
TSS	NS	NS	5.0 mg/L	NS	NS	NS	30 mg/L
Turbidity	2 NTU (Avg) 5 NTU (Max)	2 NTU (Avg) 5 NTU (Max)	NS	2 NTU (Max)	NS	3 NTU	2 NTU (Avg) 5 NTU (Max)
Coliform	Fecal None detectable (Avg) 23/100 mL (Max)	Total 2.2/100 mL (Avg) 23/100 mL (Max in 30 days)	Fecal 75 % of samples below detection 25/100 mL (Max)	Fecal 2.2/100 mL (Avg) 23/100 mL (Max in 30 days)	Fecal 2.2/100 mL (Avg) 23/100 mL (Max)	Fecal 20/100 mL (Avg) 75/100 mL (Max)	Total 2.2/100 mL (Avg) 23/100 mL (Max)

[A] NS—Not specified by state regulations.

X4. SOURCES OF WATER—INTERNATIONAL EXAMPLES[8]

X4.1 See Table X4.1.

[8] Sources: Adapted from World Bank, 2001, with updates from Hamdallah, 2000, and published in *Guidelines for Water Reuse*; EPA/625/R-04/108; U.S. Environmental Protection Agency Municipal Support Division Office of Wastewater Management Office of Water Washington, DC, September 2004.

TABLE X4.1 Sources of Water—International Examples

Country	Total Annual Water Withdrawal			Annual Reclaimed Water Usage			Reclaimed Water as Percent of Total
	Year	Mm^3	MG	Year	Mm^3	MG	
Algeria	1990	4 500	1 188 900	–[A]	–	–	–
Bahrain	1991	239	63 144	1991	15	3 963	6 %
Cyprus	1993	211	55 746	1997	23	6 077	11 %
Egypt	1993	55 100	14 557 420	2000	700	184 940	1 %
Iran	2001	81 000	21 400 200	1999	154	40 687	0.20 %
Iraq	1990	42 800	11 307 760	–	–	–	–
Israel	1995	2 000	528 400	1995	200	52 840	10 %
Jordan	1993	984	259 973	1997	58	15 324	6 %
Kuwait	1994	538	142 140	1997	80	21 136	15 %
Kyrgyzstan	1990	11 036	2 915 711	1994	0.14	37	0 %
Lebanon	1994	1 293	341 611	1997	2	528	0.20 %
Libya	1994	4600	1 215 320	1999	40	10 568	1 %
Morocco	1991	11 045	2 918 089	1994	38	10 040	0.30 %
Oman	1991	1 223	323 117	1995	26	6 869	2 %
Qatar	1994	285	75 297	1994	25	6 605	9 %
Saudi Arabia	1992	17 018	4 496 156	2000	217	57 331	1 %
Syria	1993	14 410	3 807 122	2000	370	97 754	3 %
Tajikistan	1989	12 600	3 328 920	–	–	–	–
Tunisia	1990	3 075	812 415	1998	28	7 398	1 %
Turkey	1992	31 600	8 348 720	2000	50	13 210	0 %
Turkmenistan	1989	22 800	6 023 760	–	–	–	–
U. A. Emirates	1995	2 108	556 934	1999	185	48 877	9 %
Yemen	1990	2 932	774 634	2000	6	1 585	0 %

[A] (–) indicates that data was not available.