



Designation: ~~E2635--14~~ E2635 – 22

Standard Practice for Water Conservation in Buildings Through In-Situ Water Reclamation¹

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 reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

¹ This practice is under the jurisdiction of ASTM Committee E60 on Sustainability and is the direct responsibility of Subcommittee E60.01 on Buildings and Construction. Current edition approved March 1, 2014; Dec. 1, 2022. Published April 2014; December 2022. Originally approved in 2008. Last previous edition approved in 2008 as E2635-08-14. DOI: [10.1520/E2635-14](https://doi.org/10.1520/E2635-14); [10.1520/E2635-22](https://doi.org/10.1520/E2635-22).

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 (Withdrawn 2015)³
- 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

2.2 Other References:

- U.S. EPA Protocols, Monitoring and Assessing Water Quality; Section 5.2, Dissolved Oxygen and Biochemical Oxygen Demand⁴
- 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.
<https://standards.iteh.ai/catalog/standards/sist/0b8cc80b-8be2-4774-967b-c18b20e66703/astm-e2635-22>
- 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.

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.

⁴ Available from United States Environmental Protection Agency (EPA), Ariel Rios-William Jefferson Clinton 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>, <https://www.epa.gov/wetlands/volunteer-stream-monitoring-methods-manual>, 1 September 2008.

⁵ Available from the California Department of Public Health (CDPH), CDHP Headquarters, 1616 Capitol Ave., P.O. Box 997377, MS 7400, 0500, Sacramento, CA 95899-7377, <http://www2.cdph.ca.gov>, <https://www.cdph.ca.gov>. Specific reference available as “The Purple Book,” June 2001, Online, <http://www2.cdph.ca.gov/certief/drinkingwater/Documents/Recharge/Purplebookupdate6-01.pdf>, https://www.waterboards.ca.gov/drinking_water/certief/drinkingwater/Lawbook.html, 1 September 2008.

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))~~ 725.19 psi to 2900.76 psi (5 MPa 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.

4.1.3 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

<https://standards.iteh.ai/catalog/standards/sist/0b8cc80b-8be2-4774-967b-c18b20e66703/astm-e2635-22>

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.

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.

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) (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 and filtration, distillation, freezing, reverse osmosis, advanced oxidation processes, constructed wetlands, membrane bioreactor (MBR) systems, electro dialysis, 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.

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.

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~~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/ft² of surface (18.93 L/min/0.09 m²) area in mono, dual or mixed media gravity, upflow, or pressure filtration systems; or, does not exceed 2 gal/min/ft² (7.57 L/min/0.09 m²) 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~~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~~**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~~**Methods** **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)~~**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**.

ASTM E2635-22

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.