BSR/ASHRAE/ASPE/AWWA Standard 191P

Public Review Draft

Standard for the Efficient Use of Water in Building Mechanical Systems

Third Public Review (July 2020)
(Draft Shows Complete Proposed New Standard)

This draft has been recommended for public review by the responsible project committee. To submit a comment on this proposed standard, go to the ASHRAE website at www.ashrae.org/standards-research--technology/public-review-drafts and access the online comment database. The draft is subject to modification until it is approved for publication by the Board of Directors and ANSI. Until this time, the current edition of the standard (as modified by any published addenda on the ASHRAE website) remains in effect. The current edition of any standard may be purchased from the ASHRAE Online Store at www.ashrae.org/bookstore or by calling 404-636-8400 or 1-800-727-4723 (for orders in the U.S. or Canada).

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ASHRAE, 1791 Tullie Circle, NE, Atlanta GA 30329-2305

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(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

FOREWORD

In 2007, ASHRAE, USGBC, ASPE, and AWWA entered into an agreement to jointly sponsor Standard 191 and any subsequent addenda. (The USGBC subsequently withdrew from sponsorship.) By mutual agreement, ASHRAE is the lead organization responsible for the administration and maintenance of the joint standard. Although SPC 191 is the consensus body developing the proposed standard, the procedures of the individual organizations have been followed with regard to approval of this public review draft.

- *ASPE - the American Society of Plumbing Engineers. An international professional society serving the plumbing engineer and designer community by providing education, credentialing, research, standards, and technical publications with the ultimate purpose of protecting public health and safety through adequate plumbing system design*.

- *AWWA – the American Water Works Association. An international nonprofit educational association dedicated to safe water. Founded in 1881 as a forum for water professionals to share information and learn from each other for the common good, AWWA is the authoritative resource for knowledge, information, and advocacy for improving the quality and supply of water in North America and beyond.*

Water efficiency and conservation are critical factors in the design and operation of buildings. Buildings consume 20% of the world's available water, a resource that becomes scarcer each year, according to the United Nations Environmental Program. Efficient practices and products provide opportunities to save significant amounts of water. The reduction of energy use and operating costs and the expectation of increased government regulation will continue to drive faster adoption of water-efficient products and methods.

Over the past several decades, regulations have been implemented to encourage improved fixture performance and irrigation practices. Regulations governing the water performance of Mechanical systems and Process equipment have lagged, creating a gap. Standard 191 attempts to fill this gap by focusing on both Mechanical and Process systems. Furthermore, Standard 191 sets requirements for whole building water balances that will enable authorities having jurisdiction to account for water performance similar to the energy cost budget and performance rating methods found in ASHRAE Standards 90.1 and 90.2.

No additional plumbing or irrigation regulations are included in this standard as standards already exist to address these. Additional regulations have the potential for creating conflicts among codes and standards, which creates hardships for design professionals. Plumbing fixture flow rates and consumption values and irrigation are included following project-specified codes and standards in the water balance to ensure all water uses are accounted for in the analysis.

Buildings use water in many ways; sometimes too subtle for building occupants to notice. Regulations on fixtures and irrigation have been out in front as it is water that users see and interact with at home and at work. However, for many water intense facilities, Mechanical or Process systems may account for most of the water consumption. For example, in water-cooled data centers, over 99% of all water consumed is for heat rejection. In a hospital, less than 20% of water is consumed in fixtures with the bulk going towards heat rejection and process equipment such as sterilizers and cart washers. Still, there are other facilities where nearly 100% of the water is consumed in fixtures that building occupants interact with daily. To identify where water is *consumed, Standard 191 begins with a water balance so that intelligent design decisions can be made as to where water is most likely consumed. The figure below shows how variable the typical water balance may be from building to building, which is why completing a balance is a critical first step.*

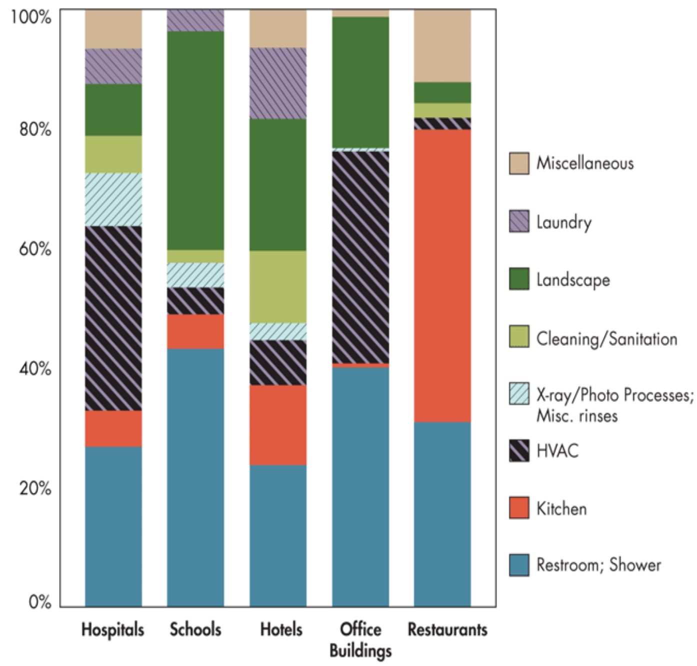

Figure I: Water Use in Buildings.

Maximizing the water efficiency of buildings is, by definition, an interdisciplinary process as no one discipline is always the largest water consumer. To optimize water efficiency in buildings, plumbing, fire protection, and HVAC&R engineers must work closely with civil engineers and landscape architects in putting together a functional building mechanical system. This new standard will rely heavily on the latest detailed design guidelines and information published by the National Fire Protection Association (NFPA), the American Water Works Association (AWWA), the American Society for Plumbing Engineers (ASPE), and the Irrigation Association.

Water:Energy Nexus

The continued security and economic health of the population depends on a sustainable supply of both water and energy. These two critical resources are inextricably and reciprocally linked. A nation's ability to continue providing both clean, affordable energy and water is being seriously challenged by a number of emerging issues.

Energy production requires a reliable, abundant, and predictable source of water, a resource that is already in short supply throughout much of the U.S. and the world. The electricity industry is second only to agriculture as the largest user of water in the United States. Electricity production from fossil fuels and nuclear energy requires 190,000 million gallons of water per day, accounting for 39% of all freshwater withdrawals in the nation, with 71% of that going to fossil-fuel electricity generation alone[1].

[1] Estimated Use of Water in the United States in 2005. Circular 1344. U.S. Department of the Interior, U.S. Geological Survey. 2009.

According to the World Health Organization, approximately 2.4 billion people live in highly water-stressed areas. Two primary solutions—shipping in water over long distances or cleaning nearby, but dirty, supplies—both require large amounts of energy. Therefore, there is a significant amount of embedded energy in the water we use to drink, cook, flush toilets, and bathe.

Figure II: US Water Availability Map.[2]

[2] Water Stress in the U.S. https://www.globalchange.gov/browse/multimedia/water-stress-us

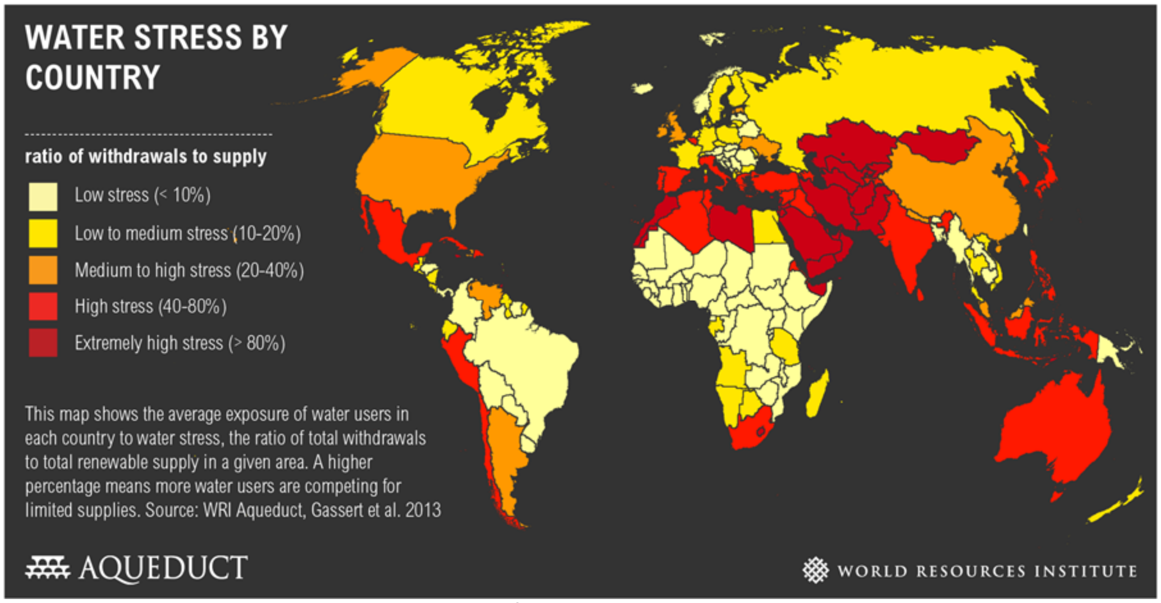

Figure III: World Water Availability Map. [3]

In areas where water supply is not plentiful, a design engineer should consider taking into account the total energy required to operate a cooling plant, including the embedded energy of the water. For example, if a life cycle analysis is performed to compare an air-cooled chilled water plant to a water-cooled chilled water plant, the total energy of the air-cooled plant may end up being approximately the same as the total energy that would be used by a water-cooled plant. In addition, the best available technology in evaporative heat rejection equipment (hybrid closed circuit coolers and evaporative condensers) utilizing wet/dry or all dry designs should be considered as standard in order to maximize water savings while conserving energy.

Therefore, when evaluating predicted energy (and carbon) loads for alternative building system design options, it is important to look at the embedded energy of the water. Additional reference material:
Sandia National Laboratories- The Energy Water Nexus: http://www.sandia.gov/energy-water/

Energy versus Water: Solving Both Crises Together*, Michael E. Webber, Scientific American Special Editions - October 22, 2008*
http://www.sehn.org/tccenergyversuswater.html

Reference CTI Paper No: TP10-16 Water/Energy Nexus, Comparing the Relative Value of Water versus Energy Resources.

Water Supply & Cost

This basic resource is obviously essential at every building site, but what has changed over the last several decades is the realization that it is fast becoming a precious resource. While the total amount of water in its various forms on the planet is finite, the amount of fresh water, of a quality suitable for the purposes for which it may be used, is not uniformly distributed (e.g., 20% of the world's fresh water is in the United States' Great Lakes); elsewhere, it is often nonexistent or in very meager supply. Nevertheless, water must be allocated somehow to the world's populated lands, many of which are undergoing rapid development. In short, it is becoming more and more difficult to provide for the adequate and equitable distribution of the world's water supply to those users for whom it is essential.

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[3] Water Stress by Country: http://www.wri.org/resources/charts-graphs/water-stress-country

This trend has implications for not only how prudently we use the water we have, but also what we do to avoid contaminating water supplies. While many of the measures to protect and preserve the world's freshwater supplies are beyond ASHRAE's purview, the purpose of this standard is to make sure that the building designers and operators address the appropriate measures relating to building sites that will have a significant impact on the availability of clean water for the local and global citizens.

The cost of water and sewer is rising at an average rate of 6% per year and as high as 30% per year in many locations (ref). The drivers for this are many and are almost always local: population growth, aging infrastructure, climate change, declining water quality, and accounting practices are the common causes. Furthermore, water prices are local and are not always driven by scarcity. Designers are encouraged to review utility rates for all projects on a case-by-case basis as the prices may vary widely even a few miles down the road.

Water Quality

The intent of this standard is in no way to compromise health and safety of building occupants or occupants outside the building. Design engineers are encouraged to investigate technologies not only from efficiency perspectives but also water quality to ensure safety and long-term functionality of equipment.

Codes and Standards Alignment

There are numerous other codes and standards that address water efficiency on a variety of levels. Standard 191 is meant to fill a gap that exists in the water efficiency industry at the building and systems level for mechanical systems and process equipment. Everywhere in the United States is already covered by plumbing efficiency codes, and many jurisdictions have irrigation ordinances. However, most jurisdictions do not have codes or standards around mechanical systems or process equipment. Standard 191 is meant to address these missing pieces.

Furthermore, most jurisdictions in the United States have energy codes that do impact water efficiency, mostly through heat rejection. This standard is intended to work with energy codes and standards and should not make a building less energy efficient.

1. PURPOSE

The purpose of this standard is to provide baseline requirements for the design of mechanical systems that minimize the volume of water required to operate HVAC systems.

1.1. Balance environmental responsibility, resource efficiency, process efficacy, and community sensitivity.

1.2. Support the goal of the development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

2. SCOPE

2.1. This standard provides baseline criteria that:

1. Applies to new buildings and renovation projects (new portions of buildings and their systems) and the surrounding site: a building or group of buildings that utilize a single submittal for a construction permit or which are within the boundary of a contiguous area under single ownership.

2. Addresses water use through the concept of water use efficiency implemented during design and construction of residential, commercial, institutional, and industrial projects.

2.2. The provisions of this standard do not apply to:

1. Storm or building wastewater management, except as a means of reducing potable water use.

2. Industrial process systems.

2.3. This standard shall not be used to circumvent any safety, health, or environmental requirements.

2.4. This standard shall not be used to circumvent local or state water rights laws or any other local, municipal, and/ or state statutes.

3. DEFINITIONS, ABBREVIATIONS, ACRONYMS

Addition: an extension or increase in floor area or height of a building outside of the existing building envelope.

***AHJ*: ** Authority (Authorities) Having Jurisdiction. The organization, office, or individual responsible for approving equipment, materials, an installation, or a procedure.

Air Washer: unit for the purpose of removing particulate matter from the airstream by spraying or atomizing clean water into an air supply system; capable of heating, cooling, humidifying, or dehumidifying the air depending on whether the water is heated or chilled.

ASHRAE: Originally founded as the American Society of Heating, Refrigerating and Air-Conditioning Engineers. An international technical society organized to advance the arts and sciences of heating, ventilation, air-conditioning, and refrigeration

ASME: Originally founded as the American Society of Mechanical Engineers. A nonprofit organization that enables collaboration, knowledge sharing, career enrichment, and skills development across all engineering disciplines.

AWWA: the American Water Works Association. An international nonprofit scientific and educational society dedicated to the improvement of drinking water quality and supply.

Alteration: a replacement or addition to a building or its systems and equipment; routine maintenance, repair, and service or a change in the building's use classification or category shall not constitute an alteration.

Alternate On-Site Sources of Non-Potable Water: water from on-site sources (i.e., air conditioning condensate, stormwater, etc.), that is collected and treated to acceptable levels for non-potable uses.

Approved: Acceptable to the *code official* or *AHJ*.

Approved Agency: an established and recognized agency regularly engaged in conducting tests or furnishing commissioning services, where such agency has been approved*.*

Aquifer: an underground layer of water-bearing permeable rock, rock fractures, or unconsolidated materials (gravel, sand, or silt) from which groundwater can be extracted.

Approved Source**:** an independent person, firm, or corporation, approved by the code official, who is competent and experienced in the application of engineering principles to materials, methods, or systems analyses.

Backwash Water: the water used to flush accumulated particulate matter and impurities from a treatment system by reversing the flow through the filtration medium.

Baseline Building Design: a computer representation of a hypothetical design based on the proposed building project. This representation is used as the basis for calculating the baseline building performance for rating above-standard design.

Blackwater: Blackwater is water originating from water closets, urinals, kitchen sinks with and without garbage disposals, medical sinks, laboratory sinks, and other sanitary fixtures designed for carrying human waste.

Blowdown/Bleed: Blowdown or Bleed is the amount of water removed from the cooling system circulating water in order to prevent build-up of minerals that can foul the system.

Boilers: an enclosed mechanical device for transferring heat energy to a medium (generally water) generally resulting from combustion of a fuel.

Building: any structure used or intended for supporting or sheltering any use or occupancy, including the water using systems and site sub-systems powered through the building's electrical service.

Building Commissioning (BCx): a process that verifies and documents that the selected building systems have been designed, installed, and function according to the owner's project requirements and construction documents and to minimum code requirements except as noted herein.

Building Site: a lot, or a combination of adjoining lots, that are being developed and maintained subject to the provisions of this standard. A building site shall be permitted to include public ways, private roadways, bikeways, and pedestrian ways that are developed as an element of the total development.

Closed Loop: a control system for an operation or process that provides feedback to the processes being controlled/executed, and/or a system by which the medium, resource, or entity conveyed within the system remains constant in net measure despite differential in energy level, form, or concentration at various points in the loop.

Code Official: the appointed or officiating agent of the jurisdiction, charged with the oversight and/or enforcement of the applicable codes and regulations.

Condensate: liquid formed by condensation of a vapor. In steam heating, water condensed from steam; in air conditioning, water extracted from air, as by condensation on the cooling coil..

Conductivity: the measurement of the level of dissolved solids in water, using the ability of an electric current to pass through water. Because it is affected by temperature, conductivity is measured at 25°C for standardization.

Control: to manage the conditions of an operation in order to maintain compliance with established criteria..

Cooling Towers, Closed Circuit: a heat rejection device, which extracts waste heat to the atmosphere via a specialized heat exchanger that uses two separate fluid circuits, a process circuit and an external circuit, to extract waste heat via an evaporative cooling process. Closed loop systems involve no direct contact between the process fluid (typically water or glycol) and the atmosphere or the recirculated external water. Also known as an “indirect” cooling tower.

Cooling Towers, Open Circuit: a heat rejection device, which extracts waste heat to the atmosphere via a specialized heat exchanger in which two fluids (air & water) are brought into direct contact to affect transfer of heat energy. Cooling is achieved through evaporation of a percentage of the circulating water.

Counter flow cooling towers: one in which air, drawn in through air inlets at the tower perimeter (induced draft) or forced in (forced draft) at the base by the fan flows up through the fill material in a direction opposite to the falling hot water.

Crossflow cooling towers: one in which air, drawn or forced in through the air intakes by a fan, flows horizontally across the fill section perpendicular to the falling hot water

Cycles of Concentration (COCs): Cycles of Concentration are defined as the ratio of the makeup rate to the sum of the blowdown and *drift* rate. The COCs can also be monitored by calculating the ratio of the chloride ion, which is highly soluble, in the system water to that in the makeup water. The number of COCs is dependent on the composition of the makeup water, particularly minerals and their quantity contained in the makeup water supply.

Demand: the highest amount of water (average gal/hr over an interval) recorded for a building or facility in a selected timeframe.

Detention: the short-term storage of stormwater on a site in order to regulate the runoff from a given rainfall event and to control discharge rates to reduce the impact on downstream stormwater systems.

Drift: in a cooling tower, water lost as liquid droplets entrained in the exhaust air. It is independent of water lost by evaporation.

Efficiency: the ratio of the effective or useful output to the total input in any system; the ratio of the energy delivered by a machine to the energy supplied for its operation.

EPA: the U.S. Environmental Protection Agency. A federal agency established to protect the health of all Americans and the environment from significant risk based on the best available scientific information, through the support and information of the legislative process and enforcement of laws and regulations relative to environmental policy.

EPA Water Sense: a program established by the EPA to identify/label products and fixtures that achieve at least 20 percent greater water use efficiency than industry standard, without sacrificing performance.

Energy Star: a joint program of the EPA and the U.S. Department of Energy (DOE) designed to identify and promote energy-efficient products and practices.

Evapotranspiration: the water that is evaporated and transpired by plant material. Expressed as a volume in inches (or in centimeters).

Evaporative Condenser: condenser in which the removal of heat from the refrigerant is achieved by the evaporation of water from the exterior of the condensing surface, induced by the forced circulation of air and sensible cooling by the air.

Evaporative Coolers: a cooler that cools indoor air by moisture evaporation, thereby lowering its dry-bulb temperature and raising its wet-bulb temperature, all at a constant energy (adiabatic) level

Existing buildings: a building or portion thereof that has been in operation and normal use for at least 12 consecutive months following the date of initial occupancy, the date of the certificate of occupancy, or occupancy class change, whichever is later.

Filter Backwash Water: see Backwash Water.

Fixtures: A device that receives water, waste matter, or both and directs these substances into a drainage system.

Graywater: untreated wastewater that originates from a variety of domestic uses, including, but not limited to: bathtubs, showers, lavatories, and clothes washers.

Ground Source Heat Pump: an electrically-powered system that utilizes the earth's relatively constant temperature to provide heating, cooling, and hot water for homes and commercial buildings. Systems can be categorized as closed or open loop and are installed horizontally, vertically, or in a pond/lake. The type of system selected depends on the available land area, proximity to a viable water body, and/or the soil and rock type at the installation site.

Hybrid Wet/Dry Closed Circuit Coolers and Evaporative Condensers: hybrid heat rejection equipment offers the benefits of saving water with dry operation and saving energy while operating in the evaporative mode.

Hydrozone: an irrigated area of landscape in which the plants have similar water needs and are irrigated by the same type of emission devices.

Improved Landscape Area: any disturbed area of the site where new plant and/or grass materials are to be used, including green roofs, plantings for stormwater controls, planting boxes, and similar vegetative use. Improved landscape shall not include hardscape areas such as sidewalks, driveways, other paved areas, and swimming pools or decking.

Irrigation Association: a non-governmental professional association dedicated to promoting efficient irrigation through improved industry proficiency, advocacy for sound water management, and increased demand for improvement in water-efficient products and services.

Irrigation Systems: a system by which water can be made available or more available to plants to foster and/or increase biotic production for agricultural, functional, or aesthetic purposes.

Label: an identification applied on a product by the manufacturer that contains the name of the manufacturer, the function and performance characteristics of the product or material, and the name and identification of an *approved* agency that indicates that the representative sample of the product or material has been tested and evaluated by an *approved* agency.

Labeled: equipment or materials to which a label, symbol, or other identifying mark of an organization, acceptable to the authority having jurisdiction, has been attached. This organization is concerned with product evaluation and maintains periodic inspection of the production of labeled equipment or materials. By labeling the equipment or materials, the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

Landscape: referring to the aggregate of elements or unified result of improving the aesthetic appearance or function of an area by changing its contour, character, and/or adding improved landscape features and plantings.

Landscape Establishment Period: a time period, beginning on the date of completion of permanent plantings and not exceeding 18 months, intended to allow the permanent landscape to become sufficiently established to remain viable.

Langelier Saturation Index (LSI): a measure of a solution's ability to dissolve or deposit calcium carbonate that is often used as an indicator of the corrosivity of water, calculated using the following formula:

$$LSI = pH - pH_s$$

where

pH is the measured water pH
pH_s is the pH at saturation in calcium carbonate

Medical and Health Care: Medical facilities (e.g., clinics, hospitals, medical centers, physician and dental offices, and medical laboratories of all types):

Meter: a water volume measuring device used to collect data and indicate water usage abnormalities. Such devices are provided by the water purveyor or the building owner.

Meter data management system: a system for collecting, storing, and retrieving metered data for analysis and/or visualization.

Municipal Water: see potable water

Municipally-reclaimed Water: non-potable water that has been derived from the treatment of wastewater by the municipally contracted utility provider, to achieve acceptable levels of filtration, disinfection, pH, turbidity, and chemical toxicity (including nitrogen, heavy metals, benzene, and others) for use in designated building processes, fixtures, or landscape functions as defined by the level of human contact. Applicable codes and regulations shall designate the appropriate levels of treatment as it correlates to designated use.

Nanofiltration: a membrane filtration process for water treatment that is more rigorous than ultra filtration but removes less particulate matter than reverse osmosis.

Non-Residential: all occupancies other than residential. (See residential.)

On-site Wastewater: non-potable water produced from use in mechanical and/or domestic processes on-site. Typically, wastewater is classified as graywater or blackwater.

Once through cooling: the use of water as a cooling medium where the water is passed through a heat exchanger one time and is then discharged to the drainage system. This also includes the use of water to reduce the temperature of condensate or process water before discharging it to the drainage system.

Open Loop: a control system for an operation or process that does not provide feedback on the processes being controlled/executed, and/or a system by which the medium, resource, or entity conveyed within the system is exhausted after the desired exchange, transfer, or reaction is performed.

Operations: a facility is operational during the time when the primary activity that facility is designed for is taking place. For Group A and Group M occupancies, this is the time during which the facility is open to the public.

Permeate, Concentrate: that portion of the feed water that passes through the membrane to become product water.

Performance Rating Method: a calculation procedure that generates an index of merit for the performance of building designs that exceeds the water efficiency levels required by this standard.

Permit: an official document or certificate issued by the jurisdiction that authorizes performance of a specified activity.

Plumbing Fixtures and Fittings: (1) a device that is part of a system to deliver and drain away water and waste but is also configured to enable a particular use. (2) end-use equipment such as sinks, lavatories, toilets, showers, drinking fountains, etc.

Potable Water: a building water distribution system that provides hot or cold water intended for direct and indirect human contact or consumption.

Process equipment: equipment used in support of a manufacturing, industrial, or commercial process other than conditioning spaces and maintaining comfort and amenities for the occupants of a building.

Proposed building performance: the annual water cost calculated for a proposed design.

Rainwater: water from natural precipitation prior to treatment or use.

Rainwater Collection and Conveyance System: rainwater collection system components extending between the collection surface and the storage tank that convey collected rainwater, usually through a gravity system.

Rating authority: the organization or agency that adopts or sanctions use of this rating methodology.

Reclaimed Water: nonpotable water derived from the treatment of waste water by a facility or system licensed or permitted to produce water meeting the jurisdiction's water requirements for its intended uses, including but not limited to above-surface landscape irrigation.

Registered Design Professional: an individual who is registered or licensed to practice their respective design profession as defined by the statutory requirements of the professional registration laws of the state or jurisdiction in which the project is to be constructed.

Registered Design Professional in Responsible Charge: a registered design professional engaged by the owner to review and coordinate certain aspects of the project, as determined by the building official, for compatibility with the design of the building or structure, including submittal documents prepared by others, deferred submittal documents, and phased submittal documents.

Reject Water: a term used in distillation, reverse osmosis, and ultrafiltration to describe that portion of the incoming feed water that has passed across the membrane but has not been converted to product water and is being sent to drain or other use.

Residential: spaces in buildings used primarily for living and sleeping. Residential spaces include, but are not limited to, dwelling units, hotel/motel guest rooms, dormitories, nursing homes, patient rooms in hospitals, lodging houses, fraternity/sorority houses, hostels, prisons, and fire stations.

Retention (Stormwater): the permanent holding of stormwater on a site, preventing the water from leaving the site as surface drainage and allowing for use of the water on site, or loss of the water through percolation, evaporation, or absorption by vegetation.

Reverse Osmosis: a water desalinization and/or purification process by which a pressurized volume of water is passed through a semi-permeable membrane to remove impurities (include salts) and contaminant solids.

Roof Rain Water: Rain water falling onto a *building* roof prior to treatment or use.

Salt Water: Saline waters above 1,000 mg per liter.

Secondary Standards: standards, practices, or policies that ensure that wastewater has been treated to achieve a level of quality that is safe for release into the environment, such as, but not limited to, release into seas, rivers, lakes, and the ground.

Stormwater: water originating from rain, snow melt, or other precipitation, as well as incidental run-off from uncaptured outdoor use (e.g., washing cars, overwatering lawns, etc.), which is transferred via surface conveyance or man-made systems on the *building site* to lakes, rivers, streams, and reservoirs.

Systems: a combination of equipment and auxiliary devices (e.g., controls, accessories, interconnecting means, and terminal elements) by which water is conveyed so it performs a specific function, such as HVAC, service water heating, or irrigation.

Tertiary Standards: standards, practices, or policies that ensure that wastewater has been treated to achieve a level of quality that is safe for limited reuse and release into the environment, such as, but not limited to, release into seas, rivers, lakes, but not for ground water replenishment.

Vegetative Roof: an assembly of interacting components designed to waterproof and normally insulate a building's top surface that includes, by design, vegetation and related landscaping elements.

Vivarium: a laboratory or controlled area within a building for keeping and raising living organisms (plants and/or animals) for the purposes of observation or research.

Water Treatment Professional: The term "water treatment professional" means any person, either employed by the owner or an outside firm contracted to provide water treatment services for the owner, knowledgeable on the requirements for implementing a water management program for the applicable water system(s) including, but not limited to the control of scale, corrosion, fouling, and biological growth while minimizing the use of water.

4. WATER BALANCE

4.1 Scope

This section contains requirements for the calculation of water sources and end-uses within the *building site* and systems. It covers the mandatory quantification of available sources and end-uses, lists potential uses of *alternate sources of non-potable water*, and provides guidance for the minimum treatment requirements for various end uses.

4.2 Compliance

Water balance and accounting shall comply with Section 4.3, "Mandatory Provisions," and either:

1. Section 4.4, "Prescriptive Option," or
2. Section 4.5, "Performance Option."

4.3 Mandatory Provisions

4.3.1 Water Quality

4.3.1.1 A *registered design professional* shall determine the water quality needed for each end use and compare it to that expected from the alternate sources to determine applicability.

4.3.1.2 All alternate sources utilized shall meet the water quality requirements of the *AHJ* and applicable manufacturer.

4.3.1.3 The use of *alternate on-site sources of water* shall comply with 2015 IAPMO Green Plumbing and Mechanical Code Supplement, Chapters 5 and 6, or 2015 ICC Green Construction Code, Chapter 7, and meet the 2012 ANSI/NSF 350 or 350-1 standard for water quality or the standards set by the *AHJ*.

4.3.2 Public Non-Potable Water
If municipally *reclaimed water* is available within 1,000 feet of the property boundary, it shall be used for all landscape irrigation water requirements and for cooling tower makeup unless on-site non-potable sources are used or prohibited by *AHJ*.

Exception:

If *municipal* non-potable sources do not meet cooling tower equipment manufacturers' recommended water chemistry guidelines per Section 5.3.1, then usage is not required in cooling tower equipment.

4.3.3 Alternate On-Site Sources of Non-Potable Water

Quantify on-site sources of non-potable water for potential reuse in the building on a monthly basis to reflect changes in climatic and operational factors. At a minimum, the availability of *alternate on-site sources of water* evaluated shall include:

a) Rainwater
b) Air-conditioning condensate
c) Foundation drain system water
d) Reject water from *reverse osmosis* treatment systems and similar devices
e) *Graywater*
f) Pool drain water
g) Filter backwash water
h) On-site treated wastewater
i) Stormwater
j) Cooling tower blowdown
k) Any other available source.

4.3.4 End-Uses

All end-uses within the project shall be identified and monthly water volume consumption quantified based on climatic and operational factors; potential uses for the alternate sources of water shall be quantified on a daily basis based on monthly climatic and operational factors. All applicable end-uses that shall be quantified shall include, but are not limited to:

1. Cooling tower makeup (evaporation, blowdown, and drift).
2. Humidification
3. Landscape irrigation, including irrigation of vegetative roofs.
4. Plumbing fixtures
5. Process water
6. Any other end-uses.

4.4 Prescriptive Option

4.4.1 If the prescriptive option is followed, a document describing how the water quality of the alternate source meets the water quality needs of the intended use or a document that describes the treatment implemented to make the water usable for that purpose shall be provided to the *AHJ*.
4.4.2 Document the water quantity available per month from all alternate sources identified in 5.3.3.
4.4.3 Document the water quantity available per month for all end-uses identified in 5.3.4.
4.4.4 Correlate the results between available non-potable water calculated in 5.3.3 with end-uses identified in 5.3.4.
4.4.5 Quantification of end-uses shall be based on benchmark data provided in Appendix A or equivalent as *approved* by *AHJ*.

4.5 Performance Option

4.5.1 If the performance option is followed, a document describing how the water quality of the alternate source meets the water quality needs of the intended use or a document that describes the treatment implemented to make the water usable for that purpose shall be submitted to the *AHJ*.
4.5.2 Document the water quantity available per month from all alternate sources identified in 5.3.3.
4.5.3 Document the water quantity available per month for all end-uses identified in 5.3.4.
4.5.4 Correlate the results between available non-potable water calculated in 5.3.3 with end-uses identified in 5.3.4.
4.5.5 Quantification of end-uses shall be based on performance modeling based on guidance provided in Appendix B or equivalent as *approved* by *AHJ*.

4.6 Submittals

The applicant shall submit a document that contains all of the information mandated in Section 4.3 (Mandatory Provisions) and documentation clearly describing how alternate non-potable water is being quantified and used so that either the prescriptive or performance criteria in Sections 4.4 and 4.5 is met.

5. HVAC SYSTEMS AND EQUIPMENT

5.1 Scope

This section covers water efficiency requirements for *evaporative heat rejection equipment, hydronic closed systems, ground source heat pump systems, humidification systems, evaporative coolers, steam and hot water systems, and air washers*.

5.2 Compliance

HVAC Systems and Equipment shall comply with Section 4.3, "Mandatory Provisions," and either:

3. Section 5.4, "Prescriptive Option," or
4. Section 55, "Performance Option."

5.3 Mandatory Provisions

5.3.1 *Once-through cooling* with potable water is prohibited.

5.3.2 An analysis of the *municipal* and/or *municipally reclaimed waste-water* makeup water supplied to the *HVAC systems* and equipment shall be conducted prior to design completion. Analysis *of Alternate On-Site Sources of Non-Potable Water* shall be completed within the first year of operation. A written report that includes the values for the attributes listed in the chart below shall be generated and incorporated into the system design and equipment selection requirements.[4]

Langelier Stability Index
Ca as CaCO3 (ppm)
Total (M) Alkalinity (ppm)
SiO2 (ppm)
Cl (ppm)
Sulfates (ppm)
Conductivity (micro-Ohms)
Phosphate (ppm)

5.3.3 Meters

5.3.3.1 The *potable* and *non-potable* water supply entering the *building* project shall be metered.

5.3.3.2 *Cooling towers*, *evaporative heat rejection equipment, evaporative coolers, air washers*, and steam and hot water *boilers* shall be equipped with makeup *meters* and *conductivity* controllers if they are sized for the water quantities stated in Table 5-1.

Table 5-1 Subsystem Water Measurement Thresholds

Subsystem	Threshold Values for Sub-Metering Requirement
Cooling Towers and *evaporative heat rejection equipment* (*meter* on makeup water and blowdown)	*Cooling tower* recirculation rate (system flow) through tower >500 gpm (30 l/s)
Evaporative Coolers, air washers	30,000 CFM
Steam and Hot Water *Boilers*	>5,000,000 Btu/h (1,465 kW) input

5.3.3.3 Meter Data Collection. All building *meters* and sub-*meters* installed to comply with the threshold limits in 5.3.3.2 shall be configured to communicate water consumption data to a *meter data management system*. *Meters* shall provide data a minimum of daily and shall record a minimum of hourly consumption of water.

5.3.3.4 Data Storage and Retrieval. The *meter data management system* shall be capable of electronically storing water *meter* and sub-*meter* data and creating user reports showing calculated hourly, daily, monthly, and annual water consumption for each *meter* and sub-*meter* and provide alarming notification capabilities. Data shall be saved for a period of no less than three years.

5.3.4 Open Towers shall be equipped with efficient *drift* eliminators that achieve *drift* reduction to a maximum of 0.002% of the recirculated water volume for *counterflow cooling towers* and 0.005% of the recirculated water volume for *crossflow cooling towers*.

5.3.5 The water treatment program for systems containing open circuit cooling towers for air conditioning systems shall be designed, built, and operated for maximum water conservation by maintaining at least one of the limiting parameters at 90% or more of the maximum value shown in Table 5-2. The pH value of the recirculating water shall fall within a value of 6.0 to 9.2.

[4] Potable and non-potable water systems may have fluctuating quality throughout the year as water sources change. Ongoing water quality testing may be required to optimize water consumption.

Table 5-2 Recirculating Water Properties for Various Open Circuit Cooling Tower Materials of Construction

Maximum Value for the Property of Recirculating Water*	Open Circuit Cooling Tower
Conductivity (micromhos)	2,400
Total Dissolved Solids (ppm)	1,500
Total Alkalinity as CaCO3 (ppm)	500
Calcium Hardness as CaCO3 (ppm)	500
Chlorides as Cl (ppm)	300
Sulfates (ppm)	250
Silica (ppm)	150
LSI (Langelier Saturation Index)	+2.8

* Based on typical recirculating water temperatures for condenser loops in air conditioning systems

5.3.6 **The materials of construction** for the water system, including heat exchangers, piping, and valves, shall be evaluated and the recirculating water properties shall be maintained within the range recommended by manufacturer. If galvanized steel is used in the cooling loop, the limits in Table 5-2 are applicable only after the initial passivation period has been completed.

5.3.7 **General.** Baseline Minimum Energy Efficiency Requirements – equipment shall comply with *ASHRAE* 90.1-2016, Efficiencies – Standard Rating and Operating Conditions.

5.4 Prescriptive Option

5.4.1 *Evaporative Heat Rejection Equipment-Cooling Towers, closed circuit coolers*, and *evaporative condensers*, including hybrid designs, shall include the following:

5.4.1.1 **Water Treatment Plan:** A comprehensive water treatment plan shall be implemented based on the water analysis obtained in Section 5.3.2 and a sustainable design. The water treatment plan shall include:

a. Documented Minimum *COCs* based on local water quality conditions, equipment materials of construction, and system metallurgy.

b. Owner's training and *commissioning*.

5.4.1.2 **Cooling Equipment Designed for Non-Potable Water Makeup:** *Evaporative-cooled* heat rejection equipment shall be designed to accommodate makeup water from non-potable sources, including rainwater, stormwater, air handler condensate, recycled treated wastewater foundation drain, or reclaimed municipal water.

a. Makeup water from non-potable sources shall meet evaporative heat rejection equipment manufacturer's recommended water chemistry guidelines.

5.4.2 Hydronic Closed Systems

5.4.2.1 Hot Water *Boilers* shall incorporate a leak detection system with an alarm or positive displacement *meter* on water makeup points to prevent fluctuation in the internal system pressure.

5.4.2.2 Chilled Water Systems shall incorporate a leak detection system with an alarm or positive displacement *meter* on water makeup points to prevent fluctuation in the internal system pressure.

5.4.2.3 Dual Temperature Water Systems shall incorporate a leak detection system with an alarm or positive displacement *meter* on water makeup points to prevent fluctuation in the internal system pressure.

5.4.3 Ground Source Heat Pump Systems

5.4.3.1 Ground Water Heat Pump Systems (Open Loop)

1. *Ground water heat pump* (GWHP) systems shall conform to all regulatory requirements applicable to the site at which the system is installed. 100% of water drawn from an aquifer shall be injected (re-injected to the *aquifer* from which it was withdrawn. The ground water shall be returned to the producing aquifer unchanged with the exception of temperature.

   Exception: Surface disposal of ground water withdrawn from an aquifer for use in a GWHP system shall be permitted only in those *non-residential* applications in which:

   a. Aquifer testing and analysis by a registered hydrology consultant demonstrates that surface disposal from the GWHP system does not result in aquifer decline over the expected life of the system, or

   b. All of the surface disposal flow from the GWHP system is subsequently delivered to a beneficial use (irrigation, industrial use, stock water).

3. Any *non-residential* GWHP system employing surface disposal for any portion of the ground water shall be equipped with a totalizing water *meter* to record the total flow diverted to surface disposal. Annual total ground water use shall be recorded by the owner and these records maintained in such a manner as to be available to the responsible regulatory agency.

4. The building loop piping of the GWHP system shall be subject to the same makeup water *metering* requirements for hydronic systems found in Section 5.3.3 of this standard.

   a. Microclimate requirement for plentiful water.

      i. Regional Design Recommendation: design shall take into consideration the natural rise and fall of pond/lake/aquifer water levels when considering an open loop ground source heat pump system.

   b. *Salt water* option: shall select a heat exchanger capable of operating on *salt water*.

5.4.3.2 Ground Coupled Heat Pump Systems (Closed Loop)

1. *Ground coupled heat pump* (GCHP) systems shall not be designed or installed incorporating a water supply system (“soaker system”) intended to artificially re-hydrate the soil in the ground loop zone using anything other than *reclaimed water*.

2. GCHP systems involving the use of a *cooling tower* (aka Hybrid systems) shall conform to all requirements associated with cooling tower operation as provided in Section 4.3 of this standard.

3. Loop piping for GCHP systems shall be subject to the same makeup water *metering* requirements for hydronic systems found in Section 4.4.3 of this standard.

4. Leak detection: shall incorporate a leak detection system with an alarm or positive displacement *meter* on water makeup points to prevent fluctuation in the internal system pressure.

5.4.4 Humidification Systems

Use humidification systems only when required to meet the operational program for a building.

5.4.5 Evaporative Coolers

Direct and indirect evaporative coolers greater than 30,000 cfm of supply air shall be designed to conserve water. Their design shall include:

1. Positive closing water makeup valves.

2. Overflow located in quiescent area of sump, away from makeup valve and return water.

3. Positively closing sump drain located in the lowest area of sump.

4. Fully drainable sump.

5. Sumps shall be sized to hold all returned water when pumps are shut off.

6. No water carry over.

7. When mist eliminators are used, the captured water shall be returned to the evaporative cooler sump.

8. Bleed off shall be controlled by conductivity controllers.

9. Temperature or humidity shall be controlled with a thermostat or humidistat.

5.4.6 Steam Systems

5.4.6.1 *Metering*/leak detection requirements for closed piping AND vent systems.

1. Shall develop a maintenance operation procedure to physically and visually inspect every steam trap in a facility. Ensure steam is not bypassed if not needed. Use a non-contact infrared thermometer to *meter* steam temperatures.

5.4.6.2 Requirements for dealing with vented systems when they are blowing off steam. 85% of condensate shall be returned to the boiler feed water system Exceptions:

1. Humidification steam

2. Contaminated process steam

5.4.6.3 Incorporate measures to capture condensate from flash prior to venting to atmosphere and return to steam condensate system.

5.4.6.4 *Metering* of makeup water to the boiler shall comply with 4.3.3. Bleed off shall be controlled by conductivity controllers.

5.4.6.5 **Condensate Coolers/Tempering:** *Potable* water shall not be used as tempering water for sanitary discharge where the tempering water volume requirement for the application exceeds 200 gallons per day (757 liters per day) per Normative Appendix A thresholds.

5.4.6.6 **Boilers**

1. *Meter* requirements – makeup water shall be metered and combined with the *meter data management system*.
2. Boiler blowdown – the system shall be equipped with a water tempering device which operates only when the discharge temperature to the sanitary system exceeds 140°F or recover the heat off the discharge water.
3. Potable water shall not be used as tempering water for sanitary discharge where the tempering water volume requirement for the application exceeds 200 gallons per day (757 liters per day) per Normative Appendix A thresholds.
4. Boiler *blowdown* shall be controlled by *conductivity controllers*.

5.5 Performance Path

5.5.1 For projects using energy models; the water-energy nexus shall be accounted for through both an energy and water model. The water model shall follow Section 4 criteria. Savings and losses for both energy and water must be accounted for and offsets applied through efficiency measures. Energy models shall be based on ASHRAE 90.1-2016 requirements. [5]

5.5.1.1 Water saved via energy savings shall be accounted for when calculated using an energy model to comply with section 4.

5.5.1.2 Additional water savings may be obtained through systems that increase energy consumption. The energy consumption increase shall be accounted for in the energy model used for code compliance and other rating systems.

5.6 Submittals

The applicant shall submit a document which contains all of the information mandated in Section 5.3 (Mandatory Provisions) and documentation clearly describing how water efficient HVAC systems and equipment are being used so that either the prescriptive or performance criteria in Sections 5.4 and 5.5 are met.

6. APPLIANCES AND EQUIPMENT

[5] There are numerous technologies applied in whole building energy models that may save energy and water. For example; reduced lighting energy requires less cooling and therefore less heat rejection. Similarly, alternate heat rejection technologies such as hybrid wet/dry coolers and condensers and ground source heat pump cooling may offer both energy and water savings. Review Normative References for additional context on the water-energy nexus and it’s link to whole building energy modeling.

6.1 Scope

This section contains water efficiency requirements for appliances and equipment for different applications, including commercial food service *operations*, medical and health care systems, laundering systems, laboratory facilities, and residential appliances.

6.2 Compliance

All appliances and equipment shall comply with Section 6.3, "Mandatory Provisions" and those listed below.

1. Section 6.4, "Prescriptive Path."
2. Section 6.5, "Performance Path."

6.3 Mandatory Provisions

6.3.1 Commercial Food Service Operations

6.3.1.1 *Once through cooling* with *potable* water is prohibited for all refrigeration/freezer equipment.

6.3.1.2 *Once through cooling* with *potable* water is prohibited for all Commercial Ice Machines equipment.

6.3.2 Medical and Health Care Systems

6.3.2.1 *Once through cooling* with *potable* water is prohibited for all medical equipment.

6.3.2.2 Makeup water and pure water or reject water shall be monitored and metered to maintain performance and prevent fouling or corrosion via excessive pure water production.

6.3.3 Laundering System

1. **Laundering appliances (e.g., clothes washers):** Shall use clothes washers that have an ENERGY STAR label for residential or commercial washers for applicable clothes washer types.

6.3.4 Laboratory Facilities (e.g., biomedical, chemical, animal, *vivarium*)

6.3.4.1 *Once through cooling* with *potable* water is prohibited for all laboratory equipment and shall use one of the following:

1. Cooling tank
2. Closed loop chilled water cooling
3. Non-potable water cooling with tempering system
4. Dry Heat.

6.3.4.2 Makeup water and pure water or reject water shall be monitored and metered to maintain performance and prevent fouling or corrosion via excessive pure water production.

6.4 Prescriptive Path

6.4.1 **Commercial Food Service Operations** (e.g., restaurants, cafeterias, food preparation kitchens, caterers, etc.):

6.4.1.1 **Combination Ovens**. Shall use no water in the convection mode and no more than 1.5 gallons per pan per hour in the steam mode.

Exception: Where moisturizing water is used in the convection mode, total use shall not exceed 0.5 gallons per hour per oven cavity.

6.4.1.2 **Dipper Well Faucets**. Where dipper wells are installed, the water supply to a dipper well shall have a shutoff valve and flow *control*. The flow of water into a dipper well shall be limited by at least one of the following methods:

a. Maximum continuous flow. Water flow shall not exceed the water capacity of the dipper well in one minute at supply pressure of 60 psi (414 kPa), and the maximum flow shall not exceed 0.25 gpm (0.063 L/s) at a supply pressure of 60 psi (414 kPa).

   The water capacity of a dipper well shall be the maximum amount of water that the fixture can hold before water flows into the drain.

b. *Metered* flow. The volume of water dispensed into a dipper well in each activation cycle of a self-closing fixture fitting shall not exceed the water capacity of the dipper well, and the maximum flow shall not exceed 0.25 gpm (0.063 L/s) at a supply pressure of 60 psi (414 kPa).

6.4.1.3 **Pre-Rinse Spray Valves**: Shall use pre-rinse spray valves (i.e., valves that function at a maximum of 4.9 L (1.28 gal) per minute and comply with the performance criteria of the U.S. EPA Water Sense High-Efficiency Pre-Rinse Spray Valve Specification.

6.4.1.4 **Dishwashers**. Shall use dishwashers that comply with the requirements of the U.S. EPA Energy Star Program for Commercial Dishwashers

6.4.1.5 **Food Steamers**. Shall use food steamers that comply with the requirements of the U.S. EPA Energy Star Program for Commercial food steamers.

6.4.2 Medical and Health Care Systems

6.4.2.1 **Digital Imaging and Radiography Systems**. Shall use digital imaging and radiography systems or shall use water recycling units for large frame x-ray films of more than 150mm (6in) in either length or width.

6.4.2.2 **Wet Hood Scrubber Systems**. shall be equipped with a water recirculation system or use a dry-hood scrubber system. For perchlorate hoods and other applications where a hood wash-down system is required, the hood shall be equipped with self-closing valves on those wash-down systems

6.4.2.3 **Vacuum Pumps**. Shall use dry vacuum pumps, unless fire and safety codes for explosive, corrosive, or oxidative gasses require liquid ring pumps.

6.4.2.4 **Reverse Osmosis and Nanofiltration**. For *reverse osmosis* and *nanofiltration* equipment, *permeate* water shall exceed 75% of the feed water for systems larger than 2 gpm, and 50% of the feed water for systems smaller than 2 gpm.

6.4.2.5 **Water Treatment Systems.** Shall use water treatment systems that comply with the following criteria:

a. For all filtration processes, pressure gauges shall determine and display when to *backwash* or change cartridges.

b. For all ion exchange and softening processes, recharge cycles shall be set by volume of water treated or based upon *conductivity* or hardness.

6.4.2.6 **Steam Sterilizers**. Shall be designed to the following:

a. Shall use mechanical vacuum equipment

b. Shall be sized for volume and rate, which is needed for specific application.

c. Shall maximize claim recovery rates as prescribed by equipment manufacturer.

d. Shall use equipment with recirculation or which allows flow to be turned off when not in use, or both.

e. Shall be set to the minimum flow rates as recommended by the manufacturer.

f. Shall be equipped with manual or automatic shut off features. Exception: Sterilizers used to sterilize FDA regulated devices and instruments shall not require automatic shut off.

6.4.3 Laundering Systems (not used)

6.4.4 Laboratory Facilities

6.4.4.1 **Lab Faucets.** Faucets connected to non-potable water or connected to lab waste systems shall have a maximum flow rate of 1.5 gpm (x lps)

Exception Lab sink/faucet connected to potable water or sanitary systems are not covered by this standard and shall follow applicable plumbing code.

6.4.4.2 **Undercounter Glassware Washers**. Shall use less than 7 gallons (26 liters) per cycle.

6.4.4.3 **Reverse Osmosis and Nanofiltration**. For *reverse osmosis* and *nanofiltration* equipment, *permeate* water shall exceed 75% of the feed water for systems larger than 2 gpm, and 50% of the feed water for systems smaller than 2 gpm.

6.4.4.4 **Water Treatment Systems.** Shall use water treatment systems that comply with the following criteria:

a. For all filtration processes, pressure gauges shall determine and display when to *backwash* or change cartridges.

b. For all ion exchange and softening processes, recharge cycles shall be set by volume of water treated or based upon *conductivity* or hardness.

6.4.4.5 **Steam Sterilizers**. Shall be designed to the following:

a. Shall use mechanical vacuum equipment

b. Shall be sized for volume and rate, which is needed for specific application.

c. Shall maximize claim recovery rates as prescribed by equipment manufacturer.

d. Shall use equipment with recirculation or which allows flow to be turned off when not in use, or both.

e. Shall be set to the minimum flow rates as recommended by the manufacturer.

f. Shall be equipped with manual or automatic shut off features.

Exception: Sterilizers used to sterilize FDA regulated devices and instruments shall not require automatic shut off.

6.4.4.6 **Trench Flush**. Shall use automated control for set duration to flush trenches based on animal requirements per NIH Publication 86-23, Guide for the Care and User of Laboratory Animals and American Association for Accreditation of Laboratory Animal Care or use non-potable water.

6.4.4.7 **Vivarium Animal Watering Systems.** Shall use efficient water *vivarium* practices that comply with the following criteria:

a. Shall use cage and rack washers with models that recycle water through a counter-current rinsing process.

b. Shall use animal watering systems that incorporate one of the following solutions:
   i. Bottle water
   ii. Recirculated water at the water main and room level, but not rack level shall adjust flush duration to adequately match the pipe volume required to be turned over.
   iii. Hybrid recirculation at main level and flushed at room level shall adjust flush duration to adequately match the pipe volume required to be turned over.
   iv. Complete recirculated water system through rack shall be treated and reused

c. Shall use tunnel washers for small cage washing complying with 6.4.4.5.

6.5 Performance Path

6.5.1 **Water Cost Budget Method.** A project may deviate from the prescriptive requirements in Section 6.4 by demonstrating water savings in other end-uses so that the Proposed design has a lower water and sewer cost than the Prescriptive design.

6.6 Submittals

The applicant shall submit a document which contains all of the information mandated in Section 6.3 (Mandatory Provisions) and documentation clearly describing how water efficient appliances and equipment are being used.

7. NORMATIVE REFERENCES

1. ANSI/ASHRAE/IESNA Standard 90.1-2016 Energy Standard for Buildings Except Low-Rise Residential Buildings
2. NIH publication 86-23, Guide for the Care and Use of Laboratory Animals.
3. U.S. Environmental Protection Agency Green Chemistry Guidelines
4. National Oceanographic and Atmospheric Administration: Hydrometeorological Design Studies Center. Precipitation Frequency Data Server
5. U.S. Energy Information Agency: Commercial Building Energy Consumption Survey 2007 and 2012
6. International Performance Measurement and Verification Protocol: Concepts and Options for Determining Energy and Water Savings, Volume 1. March 2002.
7. United States Environmental Protection Agency: EnergyStar
8. United States Environmental Protection Agency: WaterSense
9. Betz, Fred and Willa Kuh. Simulating Water: Supply and Demand in the Built Environment. ASHRAE/IBPSA-USA Building Simulation Conference. Atlanta, GA. September 10-12, 2014.
10. Betz, Fred and Lyle Keck. Challenges and Opportunities in Whole Building Water Modeling. ASHRAE/IBPSA-USA Building Performance Analysis Conference and SimBuild. Chicago, IL. September 26-28, 2018.
11. 2019 ASHRAE Applications Method Section 6.0, Indoor Swimming Pools
12. United States Green Building Council. Leadership in Energy and Environmental Design
13. Code of Federal Regulations: 21 CFR 173.310 (April 1999), US Dept. of Health and Human Services, Food and Drug Administration.
14. 2015 International Association of Plumbing and Mechanical Officials (IAPMO) Green Plumbing and Mechanical Code Supplement, Chapter 5 and 6,
15. 2018 International Code Council (ICC) Green Construction Code, Chapter 7
16. 2012 ANSI/NSF 350 and 350-1: Onsite Water Reuse
17. Aquacraft, Inc. Embedded Energy in Water Studies, Study 3: End-use Water Demand Profiles April 29, 2011. CALMAC Study ID CPU0052 Volume 1 of 1.
18. ASHRAE Handbook - Fundamentals 30.6 WUI
19. 2012 ANSI/NSF 350 and 350-1 Onsite Water Reuse

Normative Appendix A: Water Benchmark Guideline

A1 General

A1.1 Benchmark Rating Method Scope. This *benchmark rating method* is an allowed compliance path for Chapter 5 Water Balance and is intended for use in rating the water *efficiency* of building and site designs that meet the requirements of this standard. This appendix is provided for those wishing to use the method developed for this standard to quantify performance that meets the requirements of Standard 191. It shall be used for evaluating the performance of all such *proposed designs*, including *alterations* and *additions* to *existing buildings*.

A1.2 Benchmark Sources. The benchmark data source applied to the project shall be a similar building as defined by *owner* and selected from one of the following sources or as approved by *AHJ*.

a. Average of three years of project scope meter data
b. U.S. Environmental Protection Agency Water Sense (https://www3.epa.gov/watersense/)
c. Pacific Institute
d. U.S. Commercial Building Energy Consumption Survey 2007 and 2012
e. Local Municipal water benchmarking data sets
f. EnergyStar Portfolio Manager.

A1.3 Benchmark Modification. A selected benchmark shall be modified to account for end-uses that are not applicable or may require significant modification for building specific requirements. Each modification shall include a narrative describing the cause for the modification along with available supporting data.

A1.4 Non-Potable Water Availability. The identified sources of non-potable water shall be quantified through *calculation* and/or recorded data such as:

- Weather station data
- Bin data analysis
- Nearby measured benchmarks
- Estimates based on selected benchmark data.

A2 Calculation General Requirements

A2.1 Monthly Calculations. The proposed building performance and benchmark building performance shall be calculated using the following:

a. The same *calculation approach*
b. The same weather location as the benchmark data source.

A2.2 Calculation Approach. The *calculation approach* shall be computer based and shall apply the same building function, operating schedules, and climatic data for both the *proposed* and *benchmark* cases.

A2.3 Climatic Data. The *calculation approach* shall utilize the closest possible data set for benchmark comparison. For cities or urban regions with several climatic data entries, and for locations where weather data are not available, the designer shall select available weather data that best represent the climate at the construction site. The selected weather data shall be *approved* by the rating authority.

A3. Calculation of the Proposed and Benchmark Building Performance

A3.1 Monthly Water End-Use Allocation. Allocate water usage to each month evenly per day based on the selected and modified benchmark except as noted below:

a. Process water associated with chilled water, hot water, and steam shall be separated from space heating and cooling loads.

b. Cooling tower water usage for the space cooling system shall be distributed in the months for the applicable season to warmer months. The water end-use shall be distributed based on percentage monthly cooling degree days.

c. Cooling tower evaporation, drift, and blowdown volumes shall be determined in accordance with Sections 5.3.4 and 5.3.5.

d. Boiler blowdown and losses for the space heating system shall be distributed in the months for the applicable heating season. The water end-use shall be distributed based on percentage monthly heating degree days.

e. Irrigation water shall be distributed in the months for the applicable season to warmer months. The water end-use shall be distributed based on average monthly evapotranspiration.

A3.2 Monthly Non-Potable Water Availability. Allocate water availability to each month evenly per day based on the selected data sources except as noted below:

a) Cooling coil condensate shall be calculated based on bin hour analysis.

b) Rainwater and stormwater shall be calculated and distributed as measured by the referenced source.

c) Cooling tower blowdown volumes shall be determined in accordance with Sections 5.3.4 and 5.3.5.

d) Grey water volumes shall be based on Figure A3.2.1.

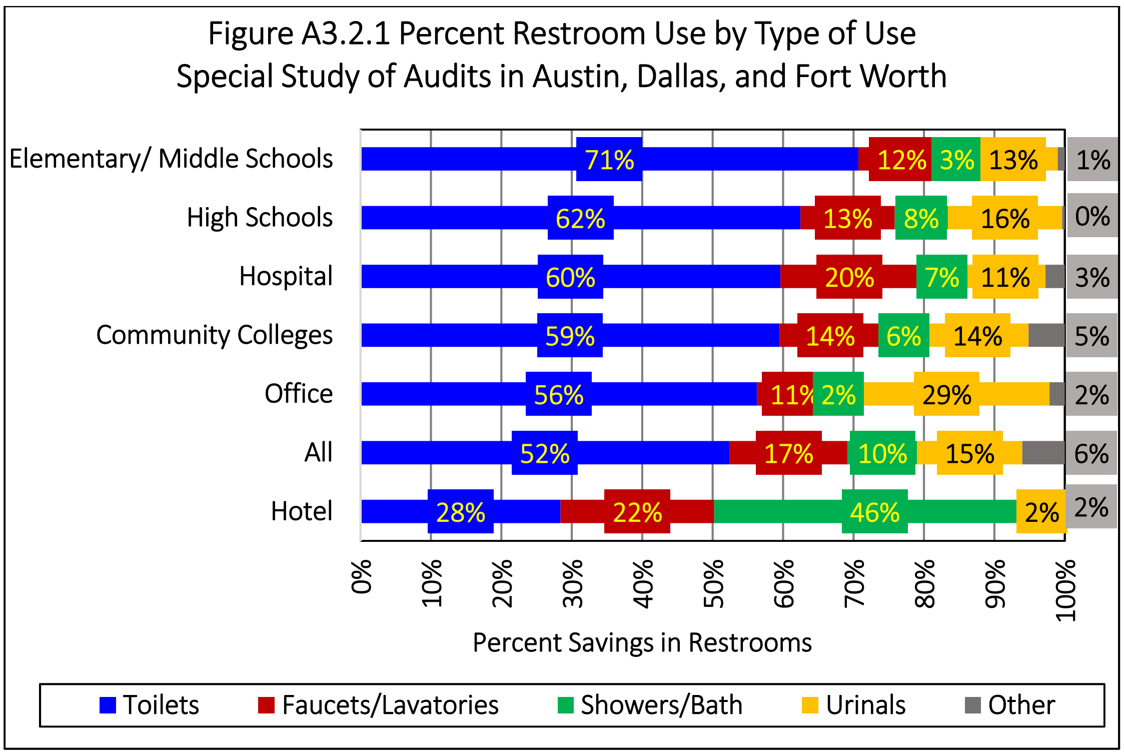

Figure A3.2.1: Fixture Water End-Use Breakdown for Multiple Building Types (H.W.(Bill) Hoffman & Associates, LLC)

A3.3 Water Savings Estimation.

a) Document water quantity saved by end-use through water efficiency strategies.

b) Document water quantity available from non-potable source.

c) Document water quantity captured for reuse.

Informative Appendix B: Water Performance Modeling Guideline

B.1 General

B1.1 Performance Rating Method Scope. This *performance rating method* is an allowed compliance path for Chapter 4 Water Balance and is intended for use in rating the water *efficiency* of building and site designs that exceed the requirements of this standard. This appendix is provided for those wishing to use the method developed for this standard to quantify performance that exceeds the requirements of Standard 191. It shall be used for evaluating the performance of all such *proposed designs*, including *alterations* and *additions* to *existing buildings*.

B1.2 Performance Rating. This *performance rating method* requires conformance with the following provisions:

All requirements of Sections 4.3, 5.3, and 6.3 are met. These sections contain mandatory provisions of the standard and are prerequisites for this rating method. The improved performance of the proposed building design is calculated in accordance with provisions of this appendix using the following formula:

Percentage Improvement = 100 x (Baseline performance – Proposed Performance) / Baseline Performance

Notes:

1. Both the proposed building performance and the baseline building performance shall include all end-use load components, such as kitchen equipment and process loads.

2. Neither the proposed building performance nor the baseline building performance are predictions of actual water consumption or costs for the proposed design after construction. Actual experience will differ from these calculations due to variations such as occupancy, building operation and maintenance, weather, water use not covered by this procedure, changes in water rates between design of the building and occupancy, and the precision of the calculation tool.

B1.3 Trade-Off Limits. When the proposed modifications apply to less than the whole building, only parameters related to the systems to be modified shall be allowed to vary. Parameters relating to unmodified existing conditions or to future building components shall be identical for determining both the baseline building performance and the proposed building performance. Future building components shall meet the prescriptive requirements of Sections 4.5, 5.5, and 6.5.

B1.4 Documentation Requirements. Simulated performance shall be documented, and documentation shall be submitted to the rating authority. The information shall be submitted in a report and shall include the following:

a. A brief description of the project, the key energy efficiency improvements, the simulation program used, the version of the simulation program, and the results of the energy analysis. This summary shall contain the calculated values for the baseline building performance, the proposed building performance, and the percentage improvement.

b. An overview of the project that includes: the number of stories (above and below grade), the typical floor size, the uses in the building (e.g., office, cafeteria, retail, parking, etc.), the gross area of each use, and whether each use is conditioned space.

c. A list of the water-related features that are included in the design and on which the performance rating is based. This list shall document all energy features that differ between the models used in the baseline building performance and proposed building performance calculations.

d. A list showing compliance for the proposed design with all the requirements of 4.3, 5.3, and 6.3 (mandatory provisions).

e. A list identifying those aspects of the proposed design that are less stringent than the requirements of 4.4, 5.4, and 6.4 (prescriptive provisions).

f. A table with a summary by end use of the water volume savings in the proposed building performance.

g. Building elevations and floor plans (schematic is acceptable).

h. An explanation of any significant modeling assumptions.

i. Back-up calculations and material to support data inputs

j. Input and output report(s) from the simulation program or compliance software, including a breakdown of water usage by at least the following components: fixtures, process equipment, service water heating equipment, space heating equipment, space cooling and heat rejection equipment, and irrigation.

k. Purchased water and sewer rates used in the simulations.

l. For any exceptional calculation method(s) employed, document the predicted water and sewer savings by water type, the water and sewer cost savings, a narrative explaining the exceptional calculation method performed, and theoretical or empirical information supporting the accuracy of the method.

B2 SIMULATION GENERAL REQUIREMENTS

B2.1 Performance Calculations. The proposed building performance and baseline building performance shall be calculated using the following:

a. the same simulation program

b. the same weather data

c. the same water and sewer rate structures.

B.2 Simulation Program. The simulation program shall be a computer-based program for the analysis of water consumption in systems effected by weather such as cooling towers and boiler blowdown (a program such as, but not limited to, DOE-2, BLAST, or EnergyPlus). The simulation program shall include calculation methodologies for the building components being modeled. For components that cannot be modeled by the simulation program, the exceptional calculation methods requirements in Section B2.5 shall be used.

B2.2.1 The simulation program shall be *approved* by the rating authority and shall, at a minimum, have the ability to explicitly model all of the following:

a. 8760 hours per year

b. hourly variations in fixtures, irrigation, process load, and HVAC system operation, defined separately for each day of the week and holidays

c. baseline building design characteristics specified in Section B3.

B2.2.2 The simulation program shall have the ability to either (1) directly determine the proposed building performance and baseline building performance or (2) produce hourly reports of water use by a water source suitable for determining the proposed building performance and baseline building performance using a separate calculation engine.

B2.2.4 The simulation program shall be tested according to ASHRAE Standard 140, and the results shall be furnished by the software provider.

B2.3 Climatic Data. The simulation program shall perform the simulation using hourly values of climatic data, such as temperature and humidity from representative climatic data, for the site in which the proposed design is to be located. For cities or urban regions with several climatic data entries, and for locations where weather data are not available, the designer shall select available weather data that best represent the climate at the construction site. The selected weather data shall be *approved* by the rating authority.

B2.4 Water Rates. Annual water and sewer costs shall be determined using either actual rates for purchased water or local average water prices published by the local water provider for commercial building customers, but rates from different sources may not be mixed in the same project. Well water users shall utilize the cost of energy to pump the water out of the ground, and any required treatment energy cost.

Exception: On-site recovered water shall not be considered to be purchased water and shall be included in the proposed building performance. The cost of treating on-site recovered water shall be included. Where only on-site renewable or site recovered sources are used, the baseline building performance shall be based on the water source used as the backup water source or on the use of water if no backup water source has been specified.

B2.5 Exceptional Calculation Methods. When the simulation program does not model a design, material, or device of the proposed design, an Exceptional Calculation Method shall be used if *approved* by the *Rating Authority*. If there are multiple designs, materials, or devices that the simulation program does not model, each shall be calculated separately, and Exceptional Savings determined for each. At no time shall the total Exceptional Savings constitute more than half of the difference between the baseline building performance and the proposed building performance. All applications for approval of an exceptional method shall include:

a. Step-by-step documentation of the Exceptional Calculation Method performed detailed enough to reproduce the results;

b. Copies of all spreadsheets used to perform the calculations;

c. A sensitivity analysis of water consumption when each of the input parameters is varied from half to double the value assumed;

d. The calculations shall be performed on a time step basis consistent with the simulation program used;

e. The Performance Rating calculated with and without the Exceptional Calculation Method.

B3 CALCULATION OF THE PROPOSED BUILDING AND SITE WATER

B3.1 Building Performance Calculations The simulation model for calculating the proposed and baseline building performance shall be developed in accordance with the requirements in Table B3.1.

Table B3.1 Modeling Requirements for Calculating Proposed and Baseline Building Performance

No	Proposed Building Performance	Baseline Building Performance
1.	**Design Model**	
a.	The simulation model of the *proposed design* shall be consistent with the design documents, including proper accounting of *fixtures* quantities, *landscape* areas, *process equipment*; *HVAC system* types and sizes; and controls. All end-use water load components within and associated with the building shall be modeled. Where the *simulation program* does not specifically model the functionality of the installed *system*, spreadsheets or other documentation of the assumptions shall be used to generate the water *demand* and operating schedule of the *systems*.	The baseline building design shall be modeled with the same number of floors and identical conditioned floor area as the proposed design.
b.	When the *performance rating method* is applied to buildings in which energy related features have not yet been designed (e.g., a lab water system), those yet-to-be-designed features shall be described in the *proposed design* exactly as they are defined in the *baseline building design*. Where the space classification for a space is not known, the *space* shall be categorized as an office *space*.	
2.	**Additions & Alterations**	

	It is acceptable to predict performance using building models that exclude parts of the existing building provided that all of the following conditions are met:	Same as Proposed design
a.	Work to be performed in excluded parts of the building shall meet the requirements of Sections 5 and 6.	
b.	Excluded parts of the building are served by piping systems that are entirely separate from those serving parts of the building that are included in the building model.	
c.	Plumbing, landscape, and plant systems operating set points and schedules on either side of the boundary between included and excluded parts of the building are essentially the same.	
d.	If a declining block or similar utility rate is being used in the analysis and the excluded and included parts of the building are on the same utility meter, the rate shall reflect the utility block or rate for the building plus the addition.	
3. **Space Use Classification**		
Usage shall be specified using the building type or space type lighting usage classifications in accordance with ASHRAE 90.1-2016 Section 9.5.1 or 9.6.1. The user shall specify the space use classifications using either the building type or space type categories but shall not combine the two types of categories. More than one building type category may be used in a building if it is a mixed-use facility. If space type categories are used, the user may simplify the placement of the various space types within the building model, provided that building-total areas for each space type are accurate.		Same as Proposed design
4. **Schedules**		
Schedules capable of modeling hourly variations in occupancy, fixture flow, process equipment flow, thermostat set points, and HVAC system operation shall be used. The schedules shall be typical of the proposed building type as determined by the designer and *approved* by the rating authority.		Same as Proposed Design **Exception:** Schedules may be allowed to differ between proposed design and baseline building design when necessary to model nonstandard efficiency measures, provided that the revised schedules have the approval of the *rating authority*. Measures that may warrant use of different schedules include, but are not limited to, automatic irrigation controls, filter backwash schedules, etc. In no case shall schedules differ where the controls are manual (e.g., manual operation of pool covers or manual operation of faucets).
5. **Plumbing Fixtures**		
a.	All fixture water uses within the building shall be accounted for using methods defined in B3.2.1	Same as Proposed design Baseline flow rates shall be based on locally adopted plumbing code.

6. Process Water	
a. All process water uses within the building shall be accounted for except water used for life safety systems such as fire pump tests or back up cooling systems. b. Internal sources of moisture such as occupants and water features shall be accounted for.	Same as Proposed Design
7. Mechanical Systems	
The mechanical system type and all related performance parameters in the proposed design, such as equipment capacities and efficiencies, shall be determined as follows: a. Where a complete mechanical system exists, the model shall reflect the actual system type using actual component capacities and efficiencies. b. Where a mechanical system has been designed, the system model shall be consistent with design documents. Mechanical equipment efficiencies shall be adjusted from actual design conditions to the standard rating conditions specified in Section 5 if required by the simulation model. The proposed building mechanical system shall be modeled using manufacturers' full- and part-load data. c. Where no heating system exists or no heating system has been specified, the system characteristics shall be identical to the system modeled in the baseline building design. d. Where no cooling system exists or no cooling system has been specified, the cooling system shall be identical to the system modeled in the baseline building design. e. Exception to (d): Spaces using ASHRAE 90.1-2016 baseline HVAC system types 9 and 10.	Same as Proposed Design **Exception:** Baseline design shall apply heat rejection strategies as defined in ASHRAE 90.1-2016
8. Irrigation	
a. Evapotranspiration shall be calculated on hourly basis using the equations in B3.2.3 with a site appropriate weather file. b. The total landscaped site area shall be included in the water accounting. Areas that are irrigated with differing irrigation technologies shall be highlighted as different hydrozones as well as areas that are not irrigated. c. Landscape factors such as species factor, density, and microclimate as well as irrigation technology and controller efficiency shall be based on an *AHJ approved* reference code, standard or guideline.	Same as Proposed Design

9. Precipitation	
a. Rain fall data shall be sourced from the National Oceanic and Atmospheric Administration or alternate approved by *AHJ*.	Same as Proposed Design

B3.1.1 Purchased Non-Potable Water. For systems using purchased non-potable water, the water source shall be modeled as purchased non-potable water in both the proposed and baseline building designs for applicable systems. Non-potable water shall be based on actual utility rates.

B3.2 Water Calculation Methods This section defines *approved* methods for calculating water consumption for each end-use and source per Sections 4.3.2 and 4.3.3. Alternate methods shall require the approval of the *AHJ*.

B3.2.1 Plumbing Fixture Calculation. Calculate and document the volume of water consumed by all plumbing fixtures on an hourly basis by multiplying fixture flow rates by hourly fixture schedules defined in B3.2.1.1.

> **Exception:** Emergency usage fixtures such as eye wash stations shall not be included.

B3.2.1.1 Plumbing Fixture Schedule. Apply applicable water fixture schedule found in “Embedded Energy in Water Studies, Study 3: End-use Water Demand Profiles April 29, 2011.”

> **Exception:** Where standard water fixture schedules do not exist; apply space occupancy schedules.

B3.2.1.2 Plumbing Fixture Schedule Modification. Schedule modification shall be based on building operational schedule and applied uniformly to both the *Baseline* and *Proposed* models.

B3.2.1.3 Service Hot Water Calculation. Calculate and document the volume of water consumed by all plumbing fixtures on an hourly basis by multiplying volume the values in Table B3.2.1.2.

B3.2.1.2 Service Hot Water Fraction. Follow Table B3.2.1 to determine the fraction of hot water used by each fixture type.

Table B3.2.1 Service Hot Water Fixture Fractions

Fixture Type	**Percent Hot Water (%) for ASHRAE climate zones 0 to 3**	**Percent Hot Water (%) for ASHRAE climate zones 4 to 8**
Water Closet	0	0
Urinal	0	0
Public Lavatory Faucet	40%	50%
Private Lavatory Faucet	40%	50%
Kitchenette Sink	50%	50%
Janitor’s Closet Sink	75%	75%
Showerhead	65%	75%
Laboratory/Medical Sink	50%	50%

B3.2.2 Process Water Calculations. Calculate the volume of *potable water* consumed by all process *equipment* or *systems* following Sections 6.3 and 6.4.

B3.2.2.1 Process Equipment. Calculate water consumption based on both design flow rates and stand by flow rates applying project specific usage schedules. Consumption shall be based on:

flow rate (per cycle or unit time) x the number of hours operation per year (standby and operation separately)

Informative footnote: Consult with equipment planners or equipment users to determine usage rates and schedules.

B3.2.2.2 Pool Makeup Water. Calculate pool makeup water demand following:

2011 ASHRAE Applications Method section 5.6, Natatoriums.

B3.2.2.2.1 Pool Maintenance. The volume of water consumed by draining and refilling the pool shall be included in the calculation and shall be the same in the baseline and proposed.

B3.2.2.2.2 Pool Covers. Manually operated pool covers shall not be included in the calculation of water savings.

B3.2.3 Irrigation Calculation. Calculate irrigation volume, Vir, based on the plant type, area by plant type, weather patterns, and irrigation equipment.

B3.2.3.1 Evapotranspiration. Calculate the amount of water needed by plants through evapotranspiration and landscape factors using an appropriate evapotranspiration equation and a site appropriate weather file with hourly data.

B3.2.3.2 Plant Water Demand. Calculate hourly water demand by plant area, PW, by multiplying species factor (ks), density factor (kd), and microclimate factor (kmc) and the hourly evapotranspiration value from B3.2.3.1.

B3.2.3.3 Irrigation Efficiency. Determine an irrigation efficiency, IE, value that accounts for water loss to atmosphere by dividing PW by IE to calculate irrigation demand, ID. Document ID by differing irrigation zones as appropriate.

B3.2.3.4 Controller Efficiency. Calculate the impact of irrigation controls by multiplying ID by controller efficiency, CE, to determine total irrigation demand, TID.

B3.2.3.5 Rain Fall. Calculate the hourly reduction in irrigation demand by subtracting rain fall, RF, from TID and document the results per plant type and irrigation zone.

B3.2.4 Mechanical Calculations. Mechanical system equipment water consumption and generation calculations shall be based on an hourly energy model.

B3.2.4.1 Air Handling Unit Water.

B3.2.4.1.1 Humidification. Calculate the hourly volume of water used by the HVAC to condition supply or exhaust air for comfort and/or cooling per *2013 ASHRAE Fundamentals* and the scheduled humidity set point.

B3.2.4.1.2 Air Handling Unit Condensation. Calculate the hourly volume of water generated by cooling coils due to condensation per *2013 ASHRAE Fundamentals* based on the scheduled supply temperature and/or humidity.

B3.2.4.2 Cooling Tower Water Consumption. Calculate the total hourly cooling tower water demand based on modeled heat rejection and hourly weather data.

B3.2.4.2.1 Cooling Tower Evaporation. Calculate the hourly volume of water evaporated by the cooling tower due to rejected heat using equations (4-6).

$$\dot{Q}_{water} = \dot{m}_{water} \times c_P \times (T_{water,i} - T_{water,o}) \qquad (4)$$

Where,

$\dot{Q}_{water}$ is the heat transfer across the condenser side of the cooling tower (W)

$\dot{m}_{water}$is the condenser water mass flow rate to the cooling tower (kg/sec)

c_P is the condenser water specific heat (W/kg-K)

$T_{water,i}$ is the condenser water inlet temperature (°C)

$T_{water,o}$ is the condenser water outlet temperature (°C)

On the air-side of the cooling tower, equation (5) applies:

$$h_{air-sat,o} = h_{air,i} + \left(\frac{\dot{Q}_{water}}{\dot{m}_{air}}\right) \quad (5)$$

Where,

$h_{air-sat,o}$ is the saturated outlet air enthalpy (J/kg)

$h_{air,i}$ is the inlet air enthalpy (J/kg)

$\dot{m}_{air}$ is the outdoor air mass flow rate (kg/sec)

A psychrometric calculation is done to calculate the air-side outlet conditions of the cooling tower to determine temperature and humidity ratio, $\omega_{air-sat,o}$. The humidity ratio is then used in equation (6) to determine the amount of water evaporated.

$$\dot{V}_{Evap} = \frac{\dot{m}_{air} \times (\omega_{air-sat,o} - \omega_{air,i})}{\rho_{water}} \quad (6)$$

Where,

$\dot{V}_{Evap}$ is the evaporation water volume (m3/sec)

$\omega_{air-sat,o}$ is the tower outlet air humidity ratio (kgWater/kgDryAir)

$\omega_{air,i}$ is the tower inlet air humidity ratio (kgWater/kgDryAir)

ρ_{water} is the density of water (kg/m3)

B3.2.4.2.2 Cooling Tower Drift. Calculate the volume of water for drift, Vdrift, per Table B3.2.4.2.2 by multiplying the hourly evaporation volume, Vevap, by the % evaporation.

Table B3.2.4.2.2: Percentage Drift

Tower Type	Baseline % of Evaporation
Counter flow	0.010%
Counter flow with drift eliminator	0.002%
Cross flow	0.050%
Cross flow with drift eliminator	0.005%

B3.2.4.2.3 Cooling Tower Blowdown. Calculate cooling tower blowdown using equations (10-13)

$$Cycles\ of\ Concentration = \frac{V_{MAKEUP}}{V_{BLOWDOWN} + V_{DRIFT}} \quad (10)$$

$$V_{MAKEUP} = V_{EVAPORATION} + V_{DRIFT} + V_{BLOWDOWN} \quad (11)$$

Combining these equations yields:

$$Cycles\ of\ Concentration = \frac{V_{EVAPORATION}+V_{DRIFT}+V_{BLOWDOWN}}{V_{BLOWDOWN}+V_{DRIFT}} \quad (12)$$

Rearranging and simplifying equation (12) yields:

$$V_{BLOWDOWN} = \frac{V_{EVAPORATION}}{Cycles\ of\ Concentration-1} - V_{DRIFT} \quad (13)$$

Baseline cycles of concentration are calculated per 4.3.5.

B3.2.4.3 Steam Boiler Blowdown. Calculate steam boiler blowdown based on the quantity of steam delivered by the steam boiler, and the blowdown fraction per Table B3.2.4

Blowdown Volume Flowrate (lb/hr) = Steam Load (btu/hr) / Steam enthalpy (btu/lb) x Blowdown Fraction

Table B3.2.4 Steam Boiler Blowdown Fraction by Treatment Type

Water Treatment Strategy	Blowdown Fraction
Softener	5%
Dealkalizer	3%
Reverse Osmosis	1%

Informative Note: Ensure to account for the entire steam load, and do not solely rely on energy model outputs. Many energy models do not account for heating makeup water nor the load of the deaerator.

B3.2.4.4 Closed Loop Hydronic Leaks. All closed loop hydronic leaks are assumed negligible for compliance purposes.

B3.2.5 Non-Potable Water Storage.

B3.2.5.1 Available. Calculate available hourly water volume sent to storage by source as defined in Section 4.3.3.

B3.2.5.2 Reuse Water. Calculate hourly water volumes offset by non-potable water withdrawn from storage and note deduction by appropriate end-use calculated in Section B3.2.4.

B3.2.5.3 Storage Losses. Calculate hourly water volume lost to evaporation from storage vessels open to atmosphere (ponds, etc.) based on hourly weather data.

B3.2.5.4 Overflow. Subtract the amount of water consumed per hour and the amount of water currently in the storage from the amount of water available. Document positive values as overflow.