

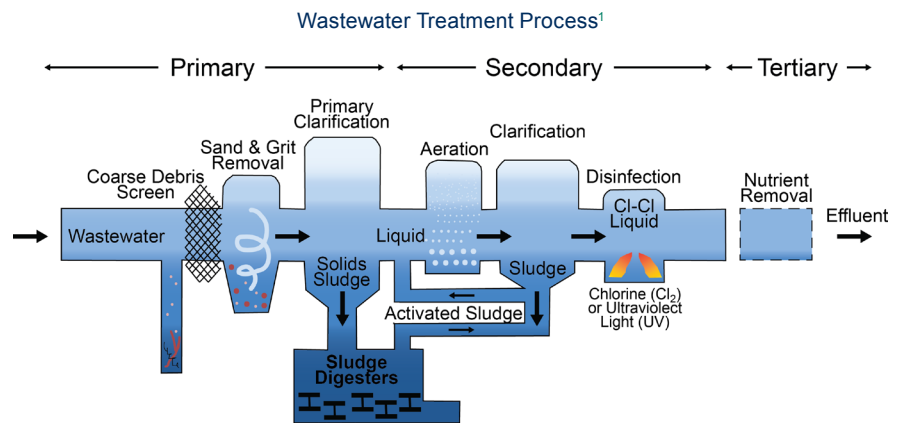
# U.S. Wastewater Treatment

## Patterns of Use

For many years, humans have treated wastewater to protect human and ecological health from waterborne diseases. Since the early 1970s, effluent water quality has been improved at Publicly Owned Treatment Works (POTWs) and other point source discharges through major public and private investments prescribed by the Clean Water Act (CWA). Despite the improvement in effluent quality, point source discharges continue to be a significant contributor to the degradation of surface water quality. In addition, much of the existing wastewater infrastructure, including collection systems, treatment plants, and equipment, has deteriorated and is in need of repair or replacement.

## Contamination and Impacts

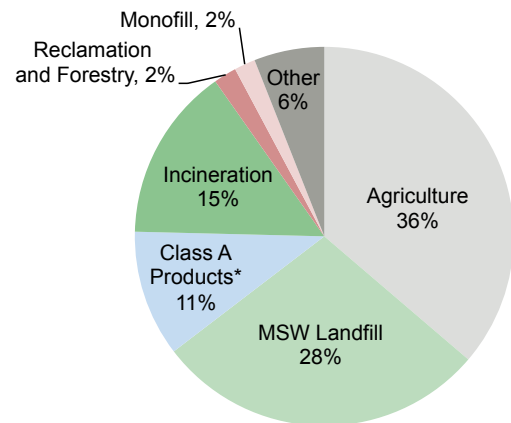
- Pollutants contaminate receiving water via many pathways: point sources, non-point sources (e.g., air deposition, agriculture), sanitary sewer overflows, stormwater runoff, combined sewer overflows, and hydrologic modifications (e.g., channelization and dredging).
- 55% of river and stream miles, 70% of lake acres, 78% of estuarine square miles, and 98% of Great Lakes shoreline miles that have been assessed are classified as impaired (unacceptable for at least one designated use) by the EPA.<sup>2</sup>
- 19% of households are not served by public sewers and usually depend on septic tanks to treat and dispose of wastewater.<sup>3</sup> Failing septic systems may contaminate surface and groundwater.<sup>4</sup>



## Treatment of Municipal Wastewater

- An estimated 14,748 POTWs provide wastewater collection, treatment, and disposal service to 238.2 million people.<sup>6</sup> Use of reclaimed water for consumption is becoming more common, particularly in the fast-growing southwest region of the U.S.<sup>7</sup>
- In 2010, California recycled roughly 650,000 acre-feet of water per year (ac-ft/yr). They have set ambitious goals to increase water recycling, with at least 1 million ac-ft/yr recycled by 2020, and 2 million ac-ft/yr by 2030.<sup>8</sup>
- POTWs generate over 8 million tons (dry weight) of sludge annually.<sup>9</sup> Sludge requires significant energy to treat—about one-third of total electricity use by a wastewater treatment system.<sup>10</sup>
- In the U.S., chlorination is the most common means of disinfection. Chlorination may be followed by dechlorination with sulfur dioxide to avoid deteriorating ecological health of the receiving stream and the production of carcinogenic by-products.<sup>11</sup>
- Ultraviolet (UV) disinfection is the most common alternative to chlorination and has comparable energy consumption.<sup>12</sup>
- Chemical additions of ferric salts and lime enhance coagulation and sedimentation processes for improved solids removal as well as removal of toxic pollutants. However, their production and transport have life cycle impacts.<sup>13</sup>
- Classes of unregulated compounds known as “contaminants of emerging concern” (CECs) are a concern for water treatment engineers, particularly pharmaceuticals, personal care products, and perfluorinated compounds.<sup>14</sup> In the past decade, polybrominated diphenyl ethers (PBDEs) and perfluorinated compounds (PFCs) have become CECs due to their wide distribution and persistence in the environment.<sup>14</sup> Some of these chemicals are endocrine disruptors, a class of compounds that alter the normal functioning of endocrine systems, including those that affect growth, reproduction, and behavior.<sup>15</sup> Many of these chemicals are not removed by POTWs.<sup>16</sup>

Biosolids Use and Disposal<sup>5</sup>



\*(e.g., treated for horticulture use)

## Biosolids (Sludge) End-of-Life

- Qualified biosolids can be beneficially used after “stabilization,” which kills pathogens and decomposing vector attractive substances.<sup>17</sup>
- 54% of biosolids are beneficially used. Most of this is applied to agricultural sites, with minor amounts applied to forestry and reclamation sites (e.g., Superfund and Brownfield lands) and urban area (e.g., maintaining park land).<sup>18</sup>

## Life Cycle Impacts

Wastewater treatment systems reduce environmental impacts in the receiving water but create other life cycle impacts mainly through energy consumption. Greenhouse gas (GHG) emissions are associated with both the energy and chemicals used in wastewater treatment and the degradation of organic materials in the POTW.

### Electricity Consumption and Emissions

- 2% of total U.S. electricity use goes towards moving and treating water and wastewater.<sup>10</sup>
- In 2000, energy-related emissions resulting from POTW operations, excluding organic sludge degradation, led to total emissions of 15.5 teragrams (Tg) CO<sub>2</sub>-equivalents (CO<sub>2</sub>-eq.), an acidification potential of 145 gigagrams (Gg) SO<sub>2</sub> equivalents, and eutrophication potential of 4 Gg PO<sub>4</sub><sup>3-</sup> equivalents.<sup>19</sup>
- CH<sub>4</sub> and N<sub>2</sub>O are mainly emitted during organic sludge degradation by anaerobic bacteria in the soil, wastewater treatment plant and receiving water body.<sup>20</sup> In 2014, an estimated 14.7 and 4.8 Tg CO<sub>2</sub>-eq. of CH<sub>4</sub> and N<sub>2</sub>O, respectively, resulted from organic sludge degradation in wastewater treatment systems, about 0.5% of total U.S. GHG emissions.<sup>20</sup>

### Social and Economic Impacts

- Population growth and urban sprawl increase the collection (sewer) system needed.
- Although the 50-year life expectancy of a sewer system is longer than treatment equipment (15 to 20 years), renovation needs of a sewer system can be more costly. If there is no renewal or replacement of existing 600,000 miles of sewer systems, the amount of deteriorated pipe will increase from 10% to 44% of the total network from 1980 to 2020.<sup>21</sup> In 2012, U.S. clean water needs for building new and updating existing wastewater treatment plants, pipe repair and new pipes, and combined sewer overflow corrections were \$102.0, \$95.7, and \$48.0 billion, respectively.<sup>6</sup>

## Solutions and Sustainable Alternatives

### Administrative Strategy

- Investment in wastewater treatment systems is shifting from new construction projects to maintenance of original capacity and function of facilities (asset management). Life cycle costing should be embedded in capital budgeting, and combined sewer overflow, sanitary sewer overflow, and stormwater management programs need to be conducted continuously.<sup>23</sup>
- In order to meet ambient water standards, total maximum daily loads (TMDLs) considering both point and non-point source pollutant loadings can be developed to achieve fishable and swimmable water quality. Watershed-based management of clean water is expected to facilitate establishment of these TMDLs.<sup>24</sup>

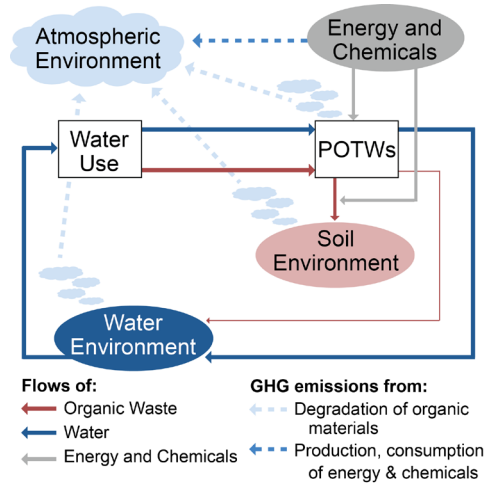
### Reduce Loading

- Examples of projects to reduce or divert wastewater flow include disconnecting household rainwater drainage from sanitary sewers, installing green roofs, and replacing impervious surfaces with porous pavement, swales, or French drains.
- Toilets, showers, and faucets represent 64% of all indoor water use.<sup>25</sup> Install high-efficiency toilets, composting toilets, low-flow shower heads, faucet aerators, and rain barrels. One study found water-efficient appliances contributed to a 10% decline in household water use since 1990.<sup>25</sup>
- Graywater—wash water from kitchen sinks, tubs, clothes washers, and laundry tubs—can be used by homeowners for gardening, lawn maintenance, landscaping, and other uses.<sup>26</sup>

### Technological Improvements and System Design

- The aeration process, which facilitates microbial degradation of organic matter, can account for 25% to 60% of the energy use in wastewater treatment plants. Flexible designs allow the system to meet oxygen demands as they fluctuate with time of day and season.<sup>27</sup>
- Pumping systems, typically consuming 10-15% of energy at wastewater treatment plants, can lead to inefficient energy consumption when pumps, flow control, and motors are mismatched to treatment plant needs.<sup>10</sup>
- A number of treatment plants are considering using methane generated from anaerobic digestion of biosolids as an energy resource.<sup>10</sup>
- Water reuse can significantly decrease system energy usage.<sup>10</sup>

### Life Cycle Impact of Wastewater Treatment Systems<sup>1</sup>



City Hall Green Roof, Chicago, Illinois<sup>22</sup>



1. Adapted from Arkansas Watershed Advisory Group.
2. U.S. Environmental Protection Agency (EPA) (2016) "National Summary of State Information: Assessed Waters of United States."
3. U.S. Census Bureau (2015) 2013 Housing Profile Factsheet: United States.
4. U.S. EPA (2015) "Why Maintain Your Septic System."
5. North East Biosolids & Residuals Association (NEBRA) (2007) A National Biosolids Regulation, Quality, End Use & Disposal Survey.
6. U.S. EPA (2016) Clean Watersheds Needs Survey 2012-Report to Congress.
7. National Water Research Institute (2012) Direct Potable Reuse: Benefits for Public Water Supplies, Agriculture, the Environment, and Energy Conservation.
8. Tchobanoglous, G., et al. (2011) Direct Potable Reuse: A Path Forward. Water Reuse Association.
9. US EPA (2006) Emerging Technologies for Biosolids Management.
10. Electric Power Research Institute (2013) Electricity Use and Management in the Municipal Water Supply and Wastewater Industries.
11. U.S. EPA (1999) Wastewater Technology Factsheet: Chlorine Disinfection.
12. SBW Consulting, Inc. (2002) Energy Benchmarking Secondary Wastewater Treatment and Ultraviolet Disinfection Processes at Various Municipal Wastewater Treatment Facilities. Pacific Gas and Electric Company.
13. U.S. EPA (2000) Wastewater Technology Factsheet: Chemical Precipitation.
14. U.S. EPA (2014) "Contaminants of Emerging Concern."
15. U.S. EPA (2011) "Endocrine Disruptor Screening Program (EDSP): Endocrine Primer."
16. U.S. EPA (2009) Occurrence of Contaminants of Emerging Concern in Wastewater From Nine Publicly Owned Treatment Works.
17. U.S. EPA (2003) Environmental Regulations and Technology: Control of Pathogens and Vector Attraction in Sewage Sludge.
18. National Biosolids Partnership (2013) Potential Uses of Biosolids.
19. CSS calculations using EPRI (2000) water data, and Franklin Associates (2000) 1996 average U.S. fuel mix for energy.
20. U.S. EPA (2016) Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 - 2014.
21. U.S. EPA (2002) The Clean Water and Drinking Water Infrastructure Gap Analysis.
22. Photo by Katrin Scholz-Barth, courtesy of National Renewable Energy Laboratory, NREL-13397.
23. U.S. EPA (1998) Cost Accounting and Budgeting for Improved Wastewater Treatment.
24. U.S. EPA (2013) "What is a TMDL?"
25. Water Research Foundation (2016) Residential End Uses of Water, Version 2 Executive Report.
26. Sharvelle, S., et al. (2012) Long-Term Study on Landscape Irrigation Using Household Graywater. Water Environment Research Fund.
27. U.S. EPA (2010) Evaluation of Energy Conservation Measures for Wastewater Treatment Facilities.