Following the Flow

An Inside Look at Wastewater Treatment

Water Environment Federation®
the water quality people®

Following the Flow

An Inside Look at Wastewater Treatment

Water Environment Federation®
the water quality people®

601 Wythe Street
Alexandria, Virginia
22314-1994 USA

Formed in 1928, the Water Environment Federation (WEF; Alexandria, Va.) is a not-for-profit technical and educational organization with more than 35,000 individual members and 81 affiliated Member Associations representing an additional 50,000 water quality professionals throughout the world. WEF and its member associations proudly work to achieve our mission of preserving and enhancing the global water environment.

WEF's mission is the basis for all of its programs and activities. WEF is governed by a member-appointed board of trustees acting on behalf of its membership to advance its mission of providing information, education, and resources to water quality professionals and the public. Visit WEF online at www.wef.org.

Photographs on pages 1, 3, 5, 7, 8, and 9 provided by Paul Cockrell.

Wastewater Treatment: The Cornerstone of Clean Water

Clean water is critical for sustaining life and our most basic sanitary needs, yet many people take for granted the flow of water in and out of their homes. Where does it all go after we flush the toilet or pull the plug on the drain, and what's more, how does it safely find its way back into the environment?

There are many fronts in the campaign to restore and protect our nation's water, and one of the most active and least understood is the process of wastewater treatment. Few people realize how complex the treatment processes are, how useful the byproducts can be, or what an amazing bargain this public service has become.

Treatment of wastewater is a relatively modern practice. While sewers to carry away foul-smelling water were common in ancient Rome, it was not until the 19th century that cities began to understand the need to reduce the pollutants in the used water they were sending back into the environment.

Since that time, the practice of clean water collection and treatment has made substantial engineering improvements, and many state and federal regulations have been put in place. Touring a wastewater treatment plant is a short course in environmental engineering, chemistry, biology, microbiology, and public policy. Each plant is a collection of our best efforts to control water pollution, and the cycle that occurs each day at these facilities is a vivid illustration of the Clean Water Act in motion. As a result, public health, water quality, and our water environment are all enhanced and protected better today than ever before.

Key Dates in Clean Water History

1850s Dr. John Snow, a London physician, convinces local authorities that bacteria in the waste carried by sewers is causing cholera and typhoid epidemics that are sweeping through urban centers and killing thousands in England and France.

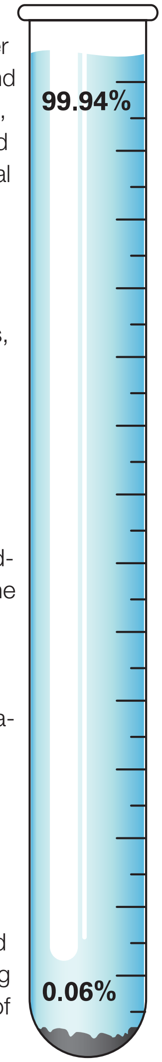
1913 Experiments conducted in the United States and England lead to the development of the activated sludge process, which uses bacteria to feed on nutrients and pathogens in wastewater. Biological treatment is found to reduce bacterial content in water by as much as 90% and is considered the most promising treatment technique of the time.

1920 Sheffield, England, becomes the first city to treat all of its wastewater using the activated sludge process. Several cities in the United States follow shortly after, including Houston, Des Plaines, Milwaukee, Indianapolis, and Chicago.

1948 Congress passes the first comprehensive law governing the pollution of the nation's surface waters—the Federal Water Pollution Control Act. This law is established to eliminate or reduce pollution of interstate waters and tributaries and to improve sanitary conditions of surface and ground water.

1977 A series of major amendments beginning in 1972 helps shape the Federal Water Pollution Act into today's Clean Water Act. This legislation puts in place the basic structure for regulating the discharge of pollutants into U.S. water bodies and creates a permit system for dischargers.

What Is Wastewater?



Basically, wastewater is the flow of used water from a community or city. While most people think of it as only sanitary sewage, wastewater comes from many sources, including homes, businesses, schools, and industries. This flow includes water from showers, sinks, dishwashers, laundries, car washes, hospitals, and food processing operations, and this is just scratching the surface. According to the U.S. Environmental Protection Agency (U.S. EPA), the average American produces 100 gallons of wastewater each day—that's nearly 1600 glasses of water or almost two full bathtubs!

Sometimes wastewater can even come from nature. In some cases, water from storm drains or groundwater that seeps into cracked pipes is also added to the wastewater stream.

As its name implies, "wastewater" is mostly water. In fact, wastewater typically averages 99.94% water by weight; only a small 0.06% is actually waste material. So what makes up this other small percentage? It is material that is either dissolved or suspended in the water, and it too can come in many forms. Aside from the most obvious human waste, our daily activities contribute many other water pollutants, including food particles, paper products, dirt, oil and grease, proteins, organic materials such as sugars, inorganic materials such as salts, personal care products, pharmaceuticals, cleaning chemicals, and hundreds of other chemicals.

Concentrations of these substances are usually referred to in milligrams of pollutants per liter of water (mg/l) or parts per million (ppm). To put these terms in perspective, one ppm is equivalent to one minute of time in 1.9 years or one inch in 16 miles. These statistics emphasize that wastewater treatment processes designed to remove a few milligrams per liter of a pollutant are similar to sifting through a haystack to remove a tiny needle; however, the balance of nature depends on the ability to do just that—and our wastewater treatment plants accomplish this continuously 24 hours a day, 365 days a year.

Wastewater Treatment: Perfecting the Natural Process

From the outside, a wastewater treatment facility can appear to be a complicated arrangement of concrete, machines, pumps, pipelines, tanks, and towers. But for all of their complexities, treatment plants are designed to accomplish one basic goal: to produce a stream of clean water that is safe to return to the environment.

What happens in a wastewater treatment plant is essentially the same process that occurs naturally in a stream or lake. A treatment plant simply helps speed up water's natural process. In a typical stream or lake, bacteria and other small organisms living in the water body feed on waste. While consuming this food, the organisms eliminate waste and produce new bacterial cells, carbon dioxide, and other products in a natural cycle.

However, as the bacteria consume the wastewater, they also consume oxygen. In order to support aquatic life, a water body must maintain a certain level of dissolved oxygen, which is typically absorbed from the air and aquatic plants. If only a small amount of untreated wastewater enters a steam, bacteria can consume the waste along with the necessary oxygen, and then the water body will naturally replenish its lost oxygen.

Trouble begins if the amount of wastewater discharged into a stream is so great that bacteria consuming the waste deplete the available supply of dissolved oxygen that fish and other aquatic organisms need for survival. Growing human populations can cause the volume of wastewater to increase beyond a level that the natural process can absorb and purify by itself. To help maintain an effective balance, wastewater treatment facilities are employed to supplement nature's work. In a wastewater treatment plant, bacteria and other organisms are also used to consume waste, but in a much more controlled process.

Occasionally, wastewater can also contain substances that cannot be completely removed by microorganisms in wastewater treatment. For example pesticides, heavy metals, nutrients, and pharmaceuticals may not be totally removed in the standard treatment time available. Because these substances may have adverse health or environmental effects on downstream water supplies, wastewater treatment plants must go above and beyond the natural process and use complex, auxiliary treatment processes to remove what the bacteria cannot consume. Additionally, some wastewater could contain potentially harmful bacteria, viruses, and other microorganisms, which are different from the beneficial bacteria feeding on the waste. Therefore an important process after treatment is the removal of disease-producing pathogenic bacteria and organisms through disinfection before the water is discharged.

1980s Membrane bioreactors become widely applied for treatment of industrial wastewater. The technology combines the activated sludge process with membranes that are used to filter out substances and effectively separate liquids and solids.

1987 In response to new research indicating that stormwater runoff contributes largely to poor water quality, amendments to the Clean Water Act now require permits for stormwater dischargers.

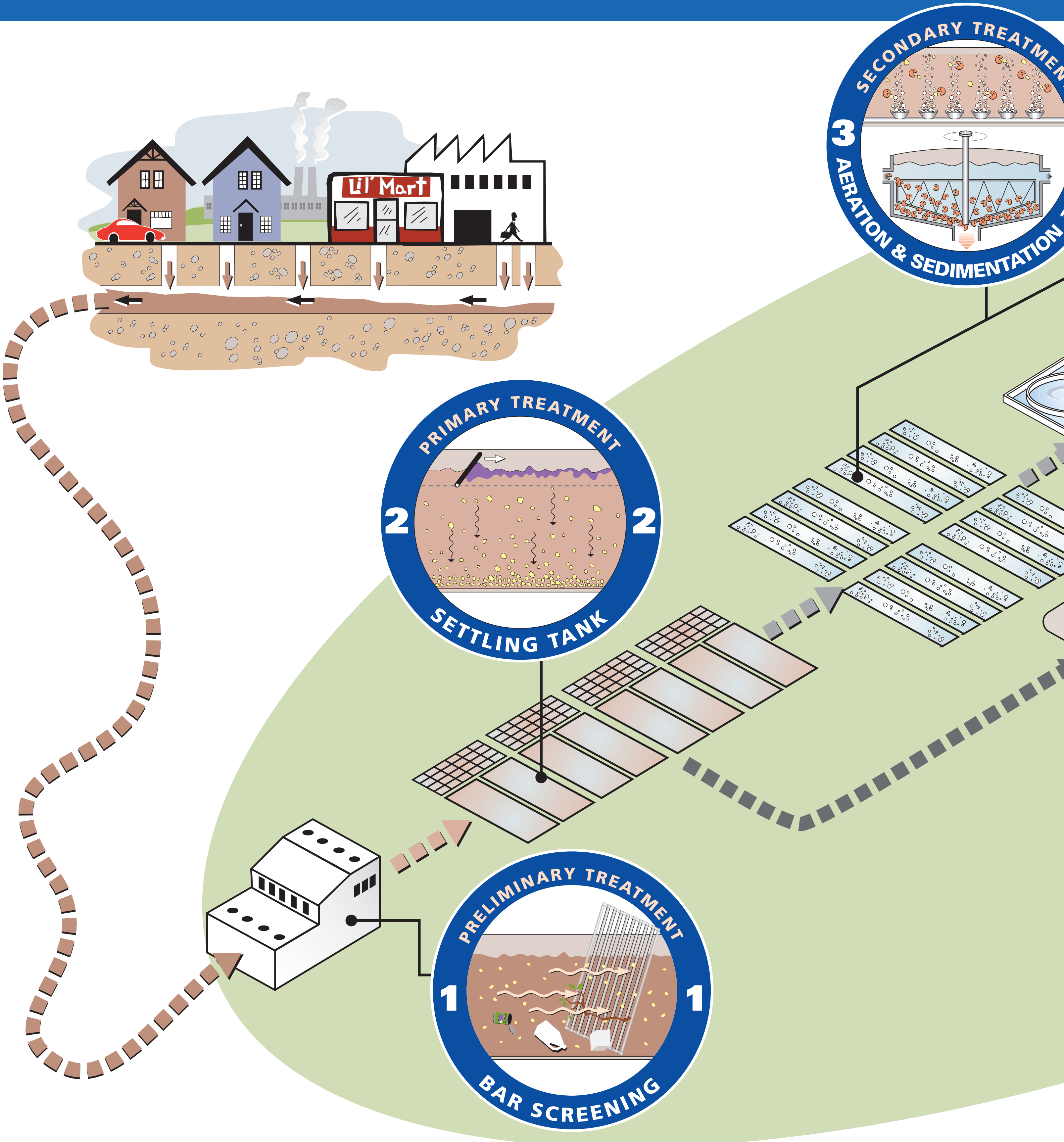
1993 Standards are adopted for treatment and use of biosolids, the material resulting from treated sewage sludge. These standards establish strict regulations to help protect public and environmental health, including management practices, pollutant limits, and monitoring guidelines.

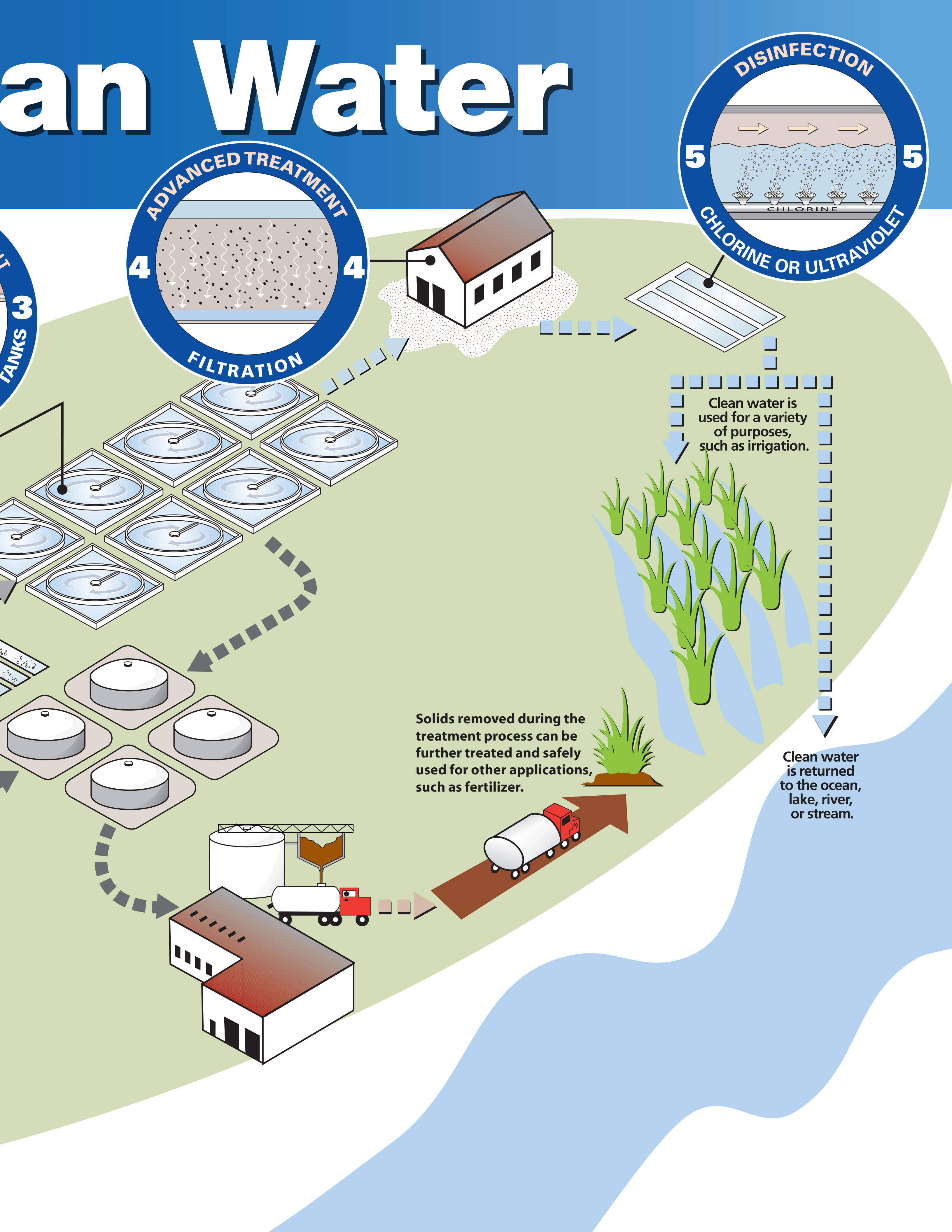
1999 Ultraviolet light becomes a widely accepted technology as a viable method for disinfecting wastewater before it is discharged into rivers and lakes.

2000 World leaders meet at the United Nations Millennium Summit and establish eight developmental goals, one of which focuses on significantly reducing the number of people without access to safe drinking water.

2003 Wastewater from sewage is recycled into drinking water. Although the technology has existed since the early 1990s, public opinion and shortages of water have just begun to make this an attractive option.

5 Steps to Cle

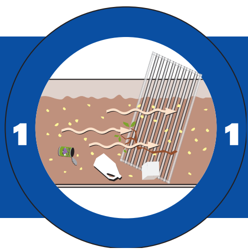



an Water
ADVANCED TREATMENT
4
FILTRATION
4
DISINFECTION
5
CHLORINE
5
CHLORINE OR ULTRAVIOLET
3
TANKS
Clean water is used for a variety of purposes, such as irrigation.
Solids removed during the treatment process can be further treated and safely used for other applications, such as fertilizer.
Clean water is returned to the ocean, lake, river, or stream.

A Typical Treatment Plant: Clean Water Step by Step

Most homes, businesses, and institutions throughout the modern world are connected to a network of belowground pipes that carry their wastewater to a treatment plant. Sanitary sewer systems carry only domestic and industrial wastewater, while a combined sewer also carries stormwater runoff. Wastewater in these systems either flows by gravity or is pumped into the treatment plant, and in some cases a combination of both methods is used.

Once it arrives at the plant, wastewater is typically treated through a series of five major steps: preliminary treatment, primary treatment, secondary treatment, tertiary treatment, and disinfection, along with processes to reuse or to dispose of the remaining products. Keeping all of these steps functioning effectively is an intricate balance of physical, biological, and chemical processes—not to mention a lot of work for plant operators, managers, and engineers.



Step 1: Preliminary Treatment

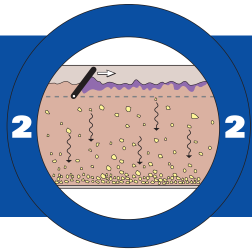
Wastewater entering a treatment plant is also known as influent, and the first stop for this incoming water is preliminary treatment. This step helps remove many of the solids that could clog pipes and disable treatment plant pumps down the line.

Screening removes large objects, such as sticks, rags, leaves, plastics, sanitary products, rocks, toys, or trash. Treatment plant screens are built to withstand the flow of untreated wastewater for years at a time and are typically made of steel or iron bars set in parallel about one-half inch apart. Some treatment plants use devices that combine the function of a screen with that of a grinder to further reduce the impact of large solids on downstream processes.

The sand, grit, and gravel that make it through the screens are picked up in the next stage of pretreatment—the grit chamber. Grit chambers are large tanks designed to slow down wastewater just long enough for the grit to drop to the bottom. Sometimes the grit is washed after its removal from the chamber and disposed of, which could mean being buried in a landfill or incinerated.

After the flow passes out of the grit chamber, it is ready for the primary treatment process.

Large screens, like those shown here, are typically used to remove larger debris and other solid materials from wastewater as it enters a treatment plant.



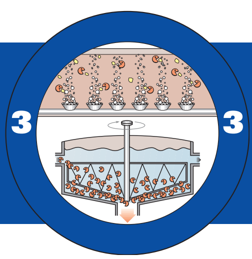
Step 2: Primary Treatment

Primary treatment involves a more sophisticated settling tank, also called a sedimentation tank or clarifier. In this phase, a series of operations removes most of the solids that will float or settle, a process that can remove up to 50% of pollutants.

Sedimentation removes the solids that are too light to fall out in the grit chamber. These tanks are designed to hold wastewater for several hours. During that time, floating material, such as oil and grease, can be skimmed off the top, and suspended solids can drift to the bottom of the tank, where they are collected by mechanical scrapers and pumped out of the bottom of the tank.

The solids removed at this point are called primary solids, and they are usually pumped along for further treatment or solids thickening. We'll learn more about these later. The floatable substances collected are either sent on with the primary solids for treatment, disposed of, or incinerated.

This is the end of the primary stage of treatment. Most of the solids in the stream that can be removed by the purely physical processes of screening, skimming, and settling have been collected, and secondary treatment using biological processes is next in line.

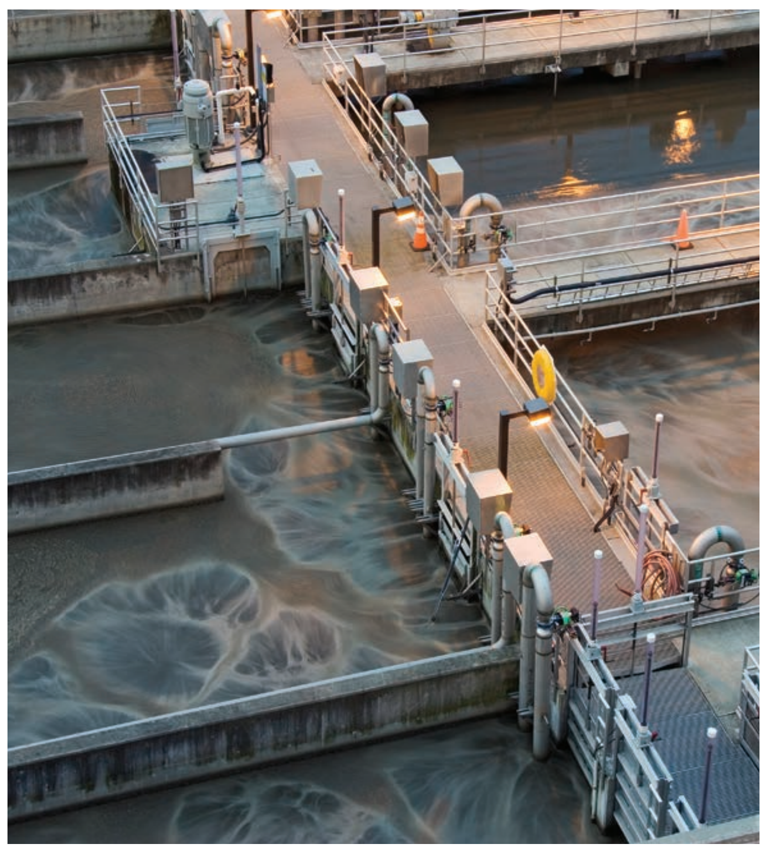


Step 3: Secondary Treatment

Wastewater flowing out of primary treatment still contains solid materials, either floating on the surface, dissolved in the water, or both. In a natural stream, these substances would be a source of food for hungry protozoa, fungi, algae, and hundreds of varieties of bacteria and microorganisms. This is also the case in wastewater treatment plants.

The secondary treatment process is a highly controlled artificial environment where the ideal conditions are created for microscopic organisms to work as fast and efficiently as they can. Care is taken to create an environment with the appropriate temperature, oxygen level, and contact time to support rapid and complete consumption of dissolved wastes. Feeding on waste just as they would in nature, the microorganisms biologically convert the dissolved solids in the wastewater into

Settling tanks, big basins that hold wastewater, remove pollutants by collecting materials that naturally fall to the bottom and skimming off those that float to the top.



Aeration tanks use bubbling air to help suspend microorganisms in the wastewater. These microorganisms can then break down waste materials into carbon dioxide and clean water.

suspended solids, which can then physically settle out. The final products are carbon dioxide, cleaner water…and more microorganisms.

There are several methods available to help treatment plants control microorganisms in order to filter or settle out the resulting solids. However, one of the most common forms of secondary treatment is the activated sludge process. In this method, incoming wastewater and microorganisms are mixed in a large tank using constant aeration and agitation for a period of anywhere from a couple hours to an entire day. The microorganisms are essentially "activated" by bubbling oxygen through the mixture.

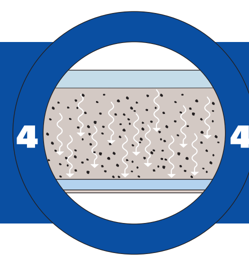
Activated sludge is a continuous process, meaning a portion of the settled solids containing active microorganisms, also known as return activated sludge, is circulated back to the beginning of the process to continue working. The portion that does not go back into circulation is called waste activated sludge, and it is piped on for further treatment, which we'll catch up with later in the process. The mixture of water and microorganisms flows on to a sedimentation tank, similar to the one used in primary treatment, where the microorganisms and other solids settle to the bottom.

Additional filtration is sometimes employed by treatment plants that need to remove a greater level of solids from wastewater than is possible with standard methods. Plants may use this step or a combination of processes to meet the specific needs of their water.

There are several variations on the activated sludge process. The typical process is called suspended-growth activated sludge, because microorganisms are suspended in and moving around a tank. Another process, fixed-growth activated sludge, involves inserting various media into the tank to encourage the growth of additional microorganisms that will help treat the wastewater. Yet another activated sludge process called membrane bioreactors involves using a membrane at the end of the tank to draw clean water through the membrane filtering equipment while leaving solids in the tank. One advantage to membrane bioreactors is that a sedimentation tank is not needed.

Some communities also use aerated basins or lagoons for secondary treatment. This form of treatment relies heavily on the interaction of sunlight, algae, and oxygen, and since these interactions are relatively slow, the wastewater is aerated to speed up the process. As with membrane bioreactors, this process usually operates without the use of a sedimentation tank. Suspended solids settle to the bottom of the lagoon where they remain or are removed every few years. Generally speaking, lagoons are simpler to operate than other forms of secondary treatment, but can be less efficient.

At the end of most secondary treatment processes, 85% to 90% of the waste has been removed from the flow of water. Now, the water continues on to tertiary treatment.



Step 4: Tertiary Treatment
(or Advanced Treatment)

The next stage in the treatment process, tertiary treatment, is used to improve the quality of water even more. In certain cases, these systems are designed to remove specific toxic substances that may be present in the water stream, but generally the most common systems remove suspended solids and nutrients. One treatment plant can use a variety of tertiary processes to remove materials that remain in the wastewater after secondary treatment.

Nutrient Removal

All domestic and some industrial wastewater contains nutrients. Discharging too many nutrients into water can over stimulate the growth of algae and other aquatic vegetation, since nutrients produce a fertilizer-like effect. If this happens, excessive plant growth can use so much dissolved oxygen that an insufficient amount remains for fish and other aquatic life. To prevent this result, many treatment plants employ processes to remove nutrients, and the two primary targets are phosphorus and nitrogen.

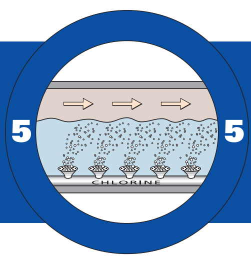
Typically, phosphorus is removed by adding aluminum-based chemicals to separate it from the wastewater and allowing it to settle out. Other processes force bacteria to consume and remove phosphorus, which can be done by varying the amount of oxygen available to the bacteria. This is known as biological phosphorus removal, or BPR for short.

Nitrogen, which is present in the form of urea in urine and also as ammonia in domestic wastewater, can be converted to another compound—nitrate. This conversion is called nitrification, and it consists of using special bacteria to change ammonia to nitrates, compounds that are less harmful to receiving waters since they do not require oxygen from the stream. In some cases a stream is so sensitive to nitrogen that almost all of the nitrogen must be removed from the wastewater to maintain acceptable water quality. An additional biological process after nitrification, known as denitrification, is employed. Denitrification further converts the nitrogen in the nitrates to nitrogen gas, a gas that is then released into the atmosphere.

Filtration

Sometimes it is necessary to achieve a higher level of suspended solids removal than is possible through primary and secondary screening and sedimentation. This can be accomplished using filtration. In this process, wastewater passes through granular material, such as sand and coal. Usually, several types and sizes of filtering materials are mixed together in what is known as a multimedia filter. Eventually, the filter becomes clogged with material removed from the wastewater, and it is cleaned by reversing the wastewater flow in a process called backwashing. Removed solids are then recycled back into the wastewater plant for further processing. Occasionally membrane filters are used in place of granular filters to produce a very high-quality effluent.

After the water makes its way through one or more tertiary processes, it is on to the last leg of its journey—the disinfection process.



Step 5: Disinfection

In many plants disinfection is the final stop in the treatment process before water is released back into the environment. Disinfection significantly reduces any remaining bacteria and viruses and helps protect the public from exposure to potentially pathogenic microorganisms. Although for years many plants relied on methods involving chlorination to do the job, alternative methods, such as ultraviolet and ozone disinfection, are becoming more widespread.

In the traditional process, a chlorine solution is added to wastewater to disinfect or kill pathogens that are present in the flow. However, since chlorine gas can be hazardous, many plants are moving to sodium hypochlorite solutions, which are similar to the chlorine found in swimming pools, or bleach. Because chlorine can remain in the water after disinfection is complete, it can also be carried into the stream. Some sensitive water bodies require the removal of this remaining chlorine, because it can be toxic to the aquatic organisms living in the stream. The removal process, called dechlorination, is usually performed by adding sulfur compounds (sulfur dioxide) to absorb the chlorine.

Disinfection through ultraviolet (UV) light is being used more often because it does not produce the toxic byproducts that are associated with chlorine. In this process, wastewater flows over submerged light bulbs, much like fluorescent lights, that generate UV light. This light kills the pathogenic bacteria, disinfecting the wastewater quickly.

Ozone disinfection is another option that some treatment plants are implementing. This alternative uses ozone to oxidize organic matter, killing any present pathogens. This method is also considered to be relatively safer than traditional chlorine because ozone can be created onsite and does not need to be stored in large volumes, lessening the opportunity for hazardous accidents.

Once the water has been properly disinfected through any one of a number of methods, it has completed its trip through the wastewater treatment process. Now, the clean water can be safely sent on its way—back to the oceans, rivers, lakes, or streams in our communities or on for other uses.

As a final step in the treatment process, water can be disinfected through exposure to UV light. Running the water over these lights can quickly kill any remaining pathogenic bacteria.

Solids Processing and Handling

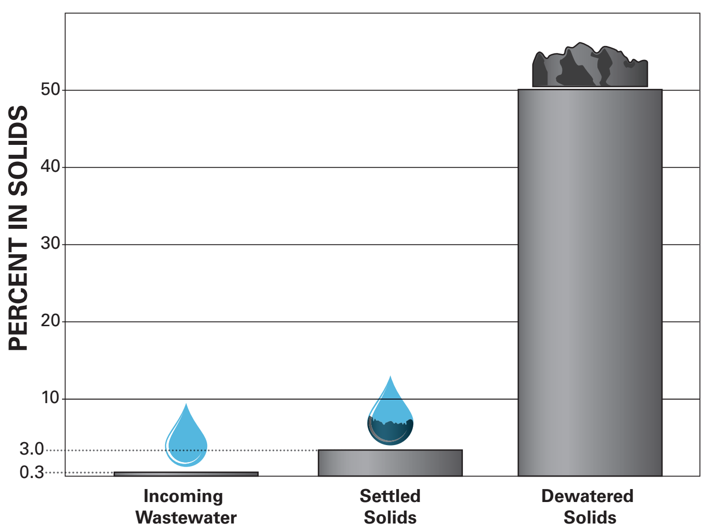
By now, you may have figured out that wastewater treatment processes not only create clean water, they also leave behind solids. Remember all those solids that were sent along for further processing? Well, they also need to be treated, and handling these solids can often be more expensive and complex than the actual process of purifying the water.

Untreated solids are often referred to as sludge, and treated solids are known as biosolids. However, these mixtures of solids and wastewater are not the thick, molasses-like substances that most people think of when they hear the word sludge. They are slurries of water and solids that are roughly 100 times more concentrated than the wastewater that first enters a plant, which is still only about 3% to 6% solids.

Because these mixtures contain so much water, and more mass equates to higher processing and handling costs, it is logical for plants to try to dispose of or recycle as much liquid as possible. Solids-handling processes are designed to help make that happen. The spectrum of handling techniques is divided into processes that condition, thicken, stabilize, and dewater solids.

Conditioning and thickening are usually the first steps in handling solids. Conditioning operations generally rely on chemicals or heat to encourage the release of water, while thickening techniques use gravity, flotation, and chemicals to separate water from the solids.

Next, stabilization processes are used to further treat the sludge by reducing odors and pathogen levels, so that the product can be beneficially used or disposed of without posing a hazard in the environment. Stabilization can occur with oxygen (aerobic) or without oxygen (anaerobic) in special tanks called digesters. Sometimes chemicals, such as lime, are used to raise the pH level and eliminate odors. Anaerobic digesters are becoming more favored because they can also generate methane gas. This gas can be used as fuel or to help heat the digester, which can reduce the time needed for the process as well as the size of the digester's components.



As wastewater moves through the treatment process, solids are removed, cleaning the water and producing byproducts that must follow their own treatment course.

The last step in the process, dewatering, is typically accomplished by mechanical means. Filters, centrifuges, and sludge presses remove even more water from the biosolids. Other techniques such as drying beds can also be used to dewater, producing up to 50% solids—about the consistency of dry soil. Federal and state biosolids regulations provide options for how local treatment plants can manage the resulting treated product. At the end of the process, the concentrated solids can be beneficially used through land application, composted for use as a soil conditioner, incinerated for thermal or energy recovery, or placed in landfills.

Products of the Treatment Process

So far, you've learned about all the steps that go into the wastewater treatment process and the two primary results of all of this work: clean water and biosolids. But what happens to these products when they leave the treatment plant? Where do they go and how can they be used in a community?

After wastewater has been treated, it can be returned to the lakes, rivers, or streams from which it came. Treated wastewater can also be used for a variety of beneficial purposes, such as irrigation.

Water Reuse

While most treated water is returned to the environment, water scarcity is causing people in many areas to rethink how they handle this valuable commodity. The same amount of water that was on the Earth billions of years ago is still here today, and we can't get any more. Increasing populations and a changing climate are creating water shortages around the world, and the newly cleaned water flowing out of treatment plants is one resource that communities are taking advantage of.

Treated water can be recycled and used again in many different ways. Some communities are using this water for toilets, golf course and landscape irrigation, or even groundwater recharge programs where highly treated plant water is replaced in the soil to replenish the supply. Beyond these uses, Singapore was the first country to begin bottling very highly treated recycled water for public consumption.

Biosolids

The oldest and most common method of biosolids disposal has typically been burial in a landfill, and many plants have incinerators that can change the solids into ash, making disposal even easier. Energy recovery from these incinerators and thermal processes is also gaining broader use by generating steam and methane gas that can be recaptured and ultimately help to reduce a facility's energy use.

However, instead of disposing of these products, some plants are choosing to use biosolids in other ways. One of the foremost beneficial uses for this product is land application. In this alternative, the organic matter is recycled into the soil. It adds bulk to thin soil, improves water retention, reduces acidity, and stops erosion—making biosolids ideal for land reclamation projects. Other biosolids with enough nutrients in them can be used to improve the yields of agricultural lands. Still other methods involve mixing biosolids with wood chips, leaves, or shredded paper in a composting operation that creates a product that can be used on lawns, parks, and golf courses.

Implementing any one of these uses requires an effective biosolids management program, which allows biosolids to be safely reused without environmental damage.

Permits and Monitoring

With so many steps along the treatment process, it is necessary for plants to constantly monitor the water to make sure that everything is running smoothly. When we want to check a person's health, we may do nothing more complicated than check their temperature or pulse. However, in a typical treatment plant, numerous sampling points and laboratory tests are used to monitor the health of the water. Some sampling is done by hand: bottles are lowered into the flow to collect samples for analysis at a laboratory. Some is automatic: devices measure the various properties of the flow, reporting electronically to a computer. Each step in the treatment process has its own sampling and monitoring requirements, and each is important to protecting public health.

Treatment operators must know what is happening at each stage so they can adjust the controls to compensate for changes in the composition and behavior of the water and its contents. Many treatment plants have their own laboratories, and in large treatment operations these centers are as sophisticated as any used in the medical profession. Computers store, retrieve, and evaluate the data obtained throughout the treatment process, and some plants even automate adjustments in processes based on the concentrations detected in the wastewater. Some instruments are advanced enough to detect traces of substances down to one part of pollutant per billion parts of water or even lower.

In the United States, many of a plant's monitoring requirements are laid out in what is called a discharge permit. These permits also specify the plant's pollutant discharge limits. Since 1972, every treatment plant that discharges directly into a body of water has been required to have a permit issued by an approved state agency or by the U.S. EPA. The authority for issuing these permits comes from the Federal Clean Water Act. Although many states exercise this authority directly, some allow the U.S. EPA to maintain this responsibility. The system under which the permits are administered is called the National Pollutant Discharge Elimination System or NPDES for short.

NPDES permits tell the plant how often they need to sample and report on the quality of the water they are discharging back into the environment. Permits are based on each particular wastewater treatment plant and its processes, with the minimum being set at secondary treatment plus any additional treatment required to meet the water quality standards of the receiving water body. Although permits are valid for a specific period of time (generally 5 years), they can be re-opened at any time if national or state requirements change or if the nature of the plant's waste stream changes significantly. Each state or local authority can also establish more stringent permit requirements than those applied by the federal EPA. This could be based on the concern for an individual water body or water quality improvement goals.

The People Behind the Plant

The success of any wastewater treatment plant, large or small, requires the support of a large number of people working together. Each facility is responsible for treating an incoming flow of water with characteristics that can change daily or even hourly, depending on the weather or industrial activities. There are no holidays for wastewater treatment, and most plants must operate 24 hours a day, seven days a week. To meet clean water standards on a continuous basis, a wastewater treatment plant needs to be well managed and skillfully operated.

In addition to producing clean water, proper management of a wastewater treatment facility also includes ensuring cost-efficient operations. This means making the best use of funds generated through local user charges. In addition to operation and maintenance costs, sufficient revenue is needed to finance the facility's mortgage. Wastewater treatment plants are complex facilities, requiring substantial sums of money to construct. Few local governments can afford to pay cash outright for construction, even if they benefit from federal or state construction grants. In some cases, it is necessary to sell bonds or arrange private financing to raise the required local capital, which will all need to be paid back.

It is the plant manager's job to bring together money, staff, and materials to ensure that a treatment plant meets its goals—wastewater collection, treatment, and ultimate disposal in a safe and efficient manner. The basic functions required to carry out those objectives are identical from plant to plant, but vary in scope depending on the size, location, complexity, and condition of each facility.

In a small town, a wastewater plant manager may have direct access to the mayor and may supervise only one or two employees. In a large metropolitan area, a plant manager may report to a hierarchy of individuals that includes a mayor, public works director, special board or commission, or other officials, and in turn, another hierarchy including foremen, operators, and maintenance workers may report to the plant manager.

A successful plant manager must be a master of many skills, including planning and budgeting, purchasing equipment, recruiting and managing personnel, communicating with the public, and initiating government procedures. Operators must also be skilled in areas such as mechanics, chemistry, hydraulics, biology, and computer science.

Adequate training of personnel is critical. Generally, on-site training is provided initially by the engineering firm that designs the plant and by equipment manufacturers. Subsequent training becomes the responsibility of the treatment facility staff. In a large facility, a separate training department may be established. In almost all states, certification or licensure is required for individuals who operate wastewater treatment facilities, and these licenses can be earned only through hands-on experience, formal training, and passage of a comprehensive exam.

Because the collection and treatment of wastewater can be a relatively hazardous occupation, safety consciousness must also be an essential part of every properly managed plant. A proper safety program includes regular training in safety and emergency procedures, as well as necessary safety equipment for all plant and collection systems personnel.

All treatment plants require the support of many people working together to keep them functioning and to continuously clean our water.

The Important Role of Infrastructure

In an ideal model—with all the right processes, pumps, and people in working together—treating the wastewater that comes into a plant is challenging enough. But sewer systems aren't that simple. Pipes corrode, equipment breaks down, and brick and mortar crumble. And, what's more, wastewater treatment doesn't start at the plant—water must be delivered through a system of equally vulnerable pipelines that stretches for hundreds, even thousands of miles, connecting each domestic and industrial customer to the treatment plant at the end of the network.

Most of us are unaware of the vast network of reservoirs, sewers, basins, and pipes—the infrastructure—that provides and treats our water. But, for hundreds of years, we have relied on this infrastructure to protect the wellbeing of our communities and the environment. It is all around and below us, quietly working to get the job done. When it comes to infrastructure, the old saying "out of sight, out of mind" rings true. Although much of the water infrastructure in the United States was built over a century ago, our investment in maintaining these systems has been dramatically low. And age isn't the only force working against them. Most systems were originally designed for populations half their current size. Since the 1950s the U.S. population has more than doubled, and it only continues to grow, putting even more wear on our aging infrastructure.

If we continue to ignore these valuable assets, we could be headed for a crisis. In fact, the U.S. EPA reports that if we do not reinvest in our water and wastewater infrastructure soon, water pollution levels may increase to those seen in the 1970s. This means we could risk losing decades of progress in public health and environmental protection, not to mention our quality of life.

Working Together for Clean Water

Clean water depends on the participation and support of the entire community—from government agencies to individual citizens. Water is essential to everyone, and we all play a role in wastewater treatment. Public support is critical to providing adequate funds for construction, operation, and maintenance of necessary treatment facilities. Competent personnel are necessary to operate the sophisticated treatment processes. And state and federal legislators must ensure that water quality goals are attainable through workable, cost-effective regulations.

With a clear understanding of the value and needs of adequate wastewater treatment, we can all work together to ensure we meet our clean water and environmental goals.

Glossary

Activated Sludge is produced by mixing primary effluent with bacteria-laden sludge in a process that is activated using aeration and agitation to promote biological treatment.

Advanced Waste Treatment is wastewater treatment beyond the secondary or biological stage of treatment. It includes the removal of nutrients such as phosphorus and nitrogen and a high percentage of suspended solids. It is also often called tertiary treatment.

Aerobic refers to life or processes that require the presence of free elemental oxygen.

Aeration is the process of exposing something to circulating air.

Anaerobic refers to life or processes that require the absence of free elemental oxygen.

Bacteria are single-cell microscopic organisms that grow in nearly every environment on Earth. In wastewater treatment, they can perform a variety of biological treatment processes, including biological oxidation, sludge digestion, nitrification, and denitrification.

Biochemical Oxygen Demand (BOD) is the measure of the amount of oxygen consumed in the biological processes that break down organic matter in water. The greater the BOD, the greater the degree of pollution.

Biosolids are the primarily organic solid product of wastewater treatment processes and can be beneficially recycled or appropriately disposed of via landfilling or incineration.

Combined Sewer is a sewer system that carries both sanitary sewage and stormwater runoff.

Denitrification is the reduction of nitrate nitrogen to nitrogen gas.

Effluent is wastewater, treated or untreated, that flows out of a treatment plant, sewer, or industrial outfall

I and I (I/I) is short for infiltration and inflow (see below).

Infiltration is entry of water into a sewer system through such sources as defective pipes, pipe joints, connections, or manhole walls.

Inflow is entry of water into a sewer system from sources other than infiltration, such as basement drains, storm drains, and street washing.

Influent is water, wastewater, or other liquid flowing into a reservoir, basin, treatment plant, or treatment process.

Infrastructure in the wastewater treatment industry refers to the expansive network of reservoirs, plants, and pipes above and below ground that provides, processes, and treats our water.

Land Application is the treatment or disposal of wastewater or wastewater solids by spreading it on land under controlled conditions.

Membranes are soft, pliable sheets or layers that can be used in filtration processes.

Membrane Bioreactors combine activated sludge treatment processes and membrane filtration equipment to separate liquids and solids.

Microconstituents are trace complex organic compounds, generally from industrial, medicinal, pharmaceutical, and personnel care products, but may also be naturally occurring. They are sometimes called compounds of emerging concern (CECs) or endocrine disrupting compounds (EDCs).

Microorganisms are microscopic organisms, either plant or animal, invisible or barely visible to the naked eye, for example, bacteria, fungi, protozoa, and viruses.

National Pollution Discharge Elimination System (NPDES) is the permit process established under the Clean Water Act that requires municipal and industrial wastewater treatment facilities to obtain permits that specify the types and amounts of pollutants that may be discharged into water bodies.

Nitrification is the oxidation of ammonia nitrogen to nitrate nitrogen in wastewater by biological chemical reactions.

Nutrients are elements or compounds, such as nitrogen, phosphorus, and potassium, that are necessary for plant growth.

Operations and Maintenance (O&M) is the organized procedure for causing a piece of equipment or a treatment plant to perform its intended function and for keeping the equipment or plant in such a condition that it is able to continually and reliably perform its intended function.

Permit is a legal document issued by a government agency. In wastewater treatment, a discharge permit requires that the plant operator achieve specific water quality standards and discharge limits and also establishes monitoring and reporting requirements.

Preliminary Treatment is the initial treatment process within a treatment plant where solids from the incoming influent are removed to enhance further treatment processes and future prevent damage to equipment.

Primary Treatment is the stage in wastewater treatment where screens and sedimentation tanks are used to remove most material that floats or will settle. Primary treatment results in the removal of a substantial amount of suspended matter but little or no dissolved matter.

Receiving Stream is a river, lake, ocean, or other watercourse into which wastewater or treated effluent is discharged.

Sanitary Sewer is a sewage system that carries only household, commercial, and industrial wastewater.

Secondary Treatment is the phase in the wastewater treatment process where bacteria are used to digest organic matter in the wastewater. Sometimes the term is used interchangeably with the concepts of biological wastewater treatment.

Sludge is solid matter that settles to the bottom of septic tanks or the material that results from wastewater treatment plant sedimentation.

Suspended Solids are solid pollutants that either float on the surface of or are suspended in wastewater primarily due to their small size. They can also be called total suspended solids (TSS).

Ultraviolet Disinfection is the process of using ultraviolet light to kill disease-causing bacteria and viruses.

User Charges are charges billed to users of water and wastewater systems for services supplied.

Wastewater is used water from a community or industry that contains dissolved or suspended matter.

Water Environment Federation®
the water quality people™

601 Wythe Street
Alexandria, Virginia
22314-1994 USA