

DEMONSTRATION 2

SEWAGE/WASTEWATER TREATMENT

LEARNING OBJECTIVES

☒ *At the conclusion of Demonstration 2, participants will be able to:*

1. State the primary purpose of the Wastewater Treatment Plant.
2. Explain how sewage travels from homes and industries to Wastewater Treatment Plants.
3. Explain the four basic treatment steps: Preliminary, Primary, Secondary and Disinfection.
4. Explain the difference in treatment of wastewater from urban areas, rural areas and industries.
5. Explain the harmful effects of too many nutrients in a waterbody.
6. List some uses of treated wastewater.
7. List ways to reduce waste.
8. Explain how storm systems function.

☒ *Terms to be familiar with:*

- | | |
|---|------------------|
| • Sewage | • Sludge |
| • Effluent | • Clarification |
| • National Pollutant Discharge Elimination System (NPDES) | • Eutrophication |
| • Certificate of Approval (C of A) | • Outfall |
| • Screening | • Grey water |
| • Settling | • Septic system |
| | • Wetland |

☒ *Before you begin:*

1. Find the location of your local Wastewater Treatment Plant. You can obtain this information from municipal or regional public works agencies and departments of environmental protection.

INTRODUCE PARTICIPANTS TO DEMONSTRATION 2

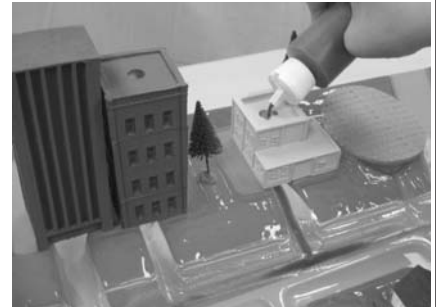
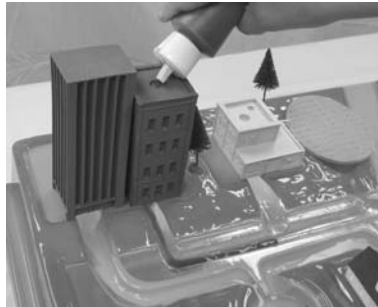
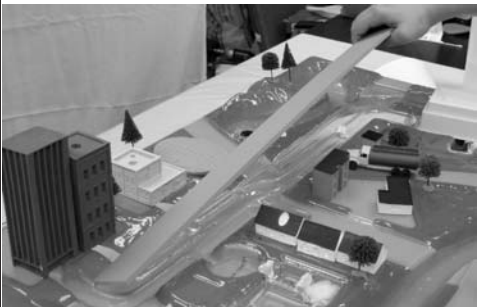
In Demonstration 1 we saw how water for drinking, home, community and industrial uses is collected, treated, stored and distributed throughout our community.

We use water in a lot of ways — we use it to flush our toilets, to wash our dishes, clothes, bodies and cars; we drink it, cook with it and water our lawns and grounds with it. Industry uses it for production and cooling in factories.

But have you ever thought about what happens to the water after we use it? Where do you think it goes? (Solicit answers.) Yes, it goes to another treatment plant — this time, a Wastewater Treatment Plant. And that's what Demonstration 2 is about.

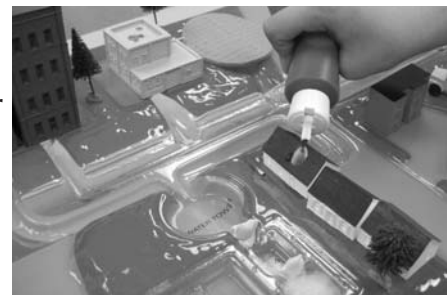
✓1. **REMOVE BOTH ROAD PIECES. Shake your sewage/waste bottle and then carefully squirt waste (about $\frac{3}{4}$ of the bottle) in:**

- CITY BUILDING w/hole
- **Large** hole in FACTORY
- HOUSE by the water tower (reservoir)



ASK *What is happening to the sewage?*

Answer: It is running through the main sewer pipe to the Wastewater Treatment Plant.



DEMONSTRATION 2: SEWAGE/WASTEWATER TREATMENT

DISCUSS This main sewer pipe is different and completely separate from the pipe that brought clean water to our homes and industries.

This pipe moves the dirty water out of our homes, places of work and recreation areas to a bigger pipe that leads to the Wastewater Treatment Plant.

See the large pipe (represented by trenches in the model) where the sewage from the house, the city building and factory is flowing? This is our main sewer pipe (or line). All of the houses and businesses connected to the sewage/Wastewater Treatment Plant have small sewage/wastewater pipes that connect to this main sewer line.

The sewers are designed to keep the sewage moving quickly to avoid things settling in the pipes and blocking them.

ASK *Who can define “sewage”? What are some examples of sewage?*

DISCUSS The water that runs down our drains in our homes and businesses, or is flushed down our toilets, becomes sewage or wastewater. Whenever you flush the toilet or open the drain in your sink or bath, you are releasing sewage.

Sewage is mostly dirty water that contains solids and dissolved material such as dirt, toilet waste, grease, food, soap, sand, nutrients and other liquid waste products from homes, businesses and the community — anything that is flushed down the toilet and rinsed down our drains, including much that should not go down the drain, such as cigarettes, paper, plastic, grease and chemicals.

ASK *Think of all the people that live in your city. How many bathtubs do you think there are? And what about all the factories that make things for us? What types of sewage or wastewater leave their operations?*

DISCUSS The main sewer pipes are usually put in the ground at a slope so gravity can help carry the sewage to the Wastewater Treatment plant. The Wastewater Treatment Plant for a community is usually built on the lowest land available. This allows gravity to help transport the sewage to the Treatment Plant, although if the pull of gravity isn't enough, pumps are sometimes installed.

DEMONSTRATION 2: SEWAGE/WASTEWATER TREATMENT

ASK *Where is your treatment plant? You can obtain this information from municipal or regional public works agencies and departments of environmental protection.*

DISCUSS Your WASTEWATER TREATMENT PLANT is where your sewage – and that of your neighbors and everybody else in your town – is treated to remove as many pollutants (including excess nutrients) as possible before the remaining water (called effluent) is discharged back to the environment – like your nearby river.

A Note on Excess Nutrients: Although nutrients are essential to life, too many of them can harm fish and plant life in the water. Excess nutrients such as too much nitrogen and phosphorus can speed up the aging process of the lake (eutrophication) by causing sudden and excessive growth of algae and aquatic plants. Excessive growth of algae and plants can crowd the waterbody, suffocating aquatic plant life. When these plants die and decay, they take away the oxygen needed by the fish and other aquatic life. This lack of oxygen can kill the fish. So, too many nutrients are potential pollutants.

☒ *Now, we're going to talk about four treatment steps, which are:*

- Step 1. Preliminary Treatment
- Step 2. Primary Treatment
- Step 3. Secondary Treatment
- Step 4. Final Treatment — Disinfection

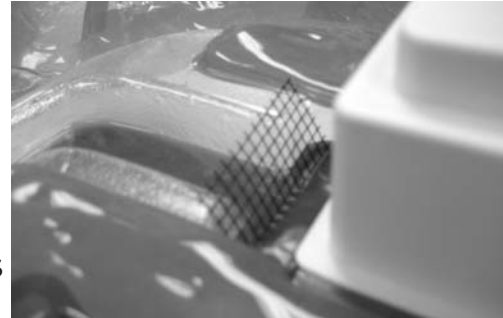
DEMONSTRATION 2: SEWAGE/WASTEWATER TREATMENT

STEP 1. PRELIMINARY TREATMENT

☒ *LOOK at SCREEN/Grid at the WWTP*

DISCUSS Preliminary treatment screens out, grinds up or separates debris.

When the main sewage line reaches the Wastewater Treatment Plant, large screens or grates remove the large solid objects such as wood, paper, rags, large food particles, toys and plastic.



This process is called screening. This debris is then cleaned off the screens and put in a dumpster, which is usually taken to a landfill. Screening is the first step in the sewage treatment process. Removing the debris protects pumps and other equipment in the treatment plant.

After screening, the sewage flow slows down enough so heavy grit and sand can settle to the bottom of special tanks where it is collected and removed.

The sewage/wastewater continues to flow to the next step at the Wastewater Treatment Plant.

STEP 2: PRIMARY TREATMENT

☒ *LIFT OFF Wastewater Treatment Plant (WWTP) COVER and set aside. The first rectangular section is called the primary clarifier.*

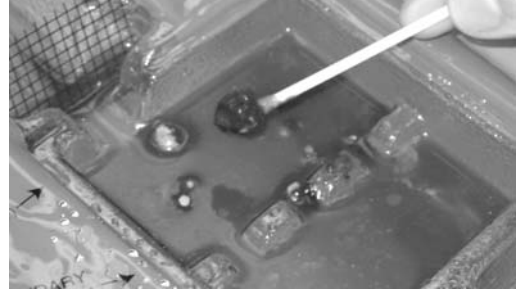
DISCUSS Primary treatment removes the solid content of sewage which is called sludge.



DEMONSTRATION 2: SEWAGE/WASTEWATER TREATMENT

- ⊗ **USE COTTON SWAB** to lift some of the settled solids from the primary clarifier tank.

ASK See how the solids have begun to settle in the tank?



This process is sometimes referred to as Primary Clarification. In this stage, sewage is slowed down in even larger tanks. The tanks allow small solids to fall and clump together at the bottom, creating sludge. The sludge consists of mostly organic material.

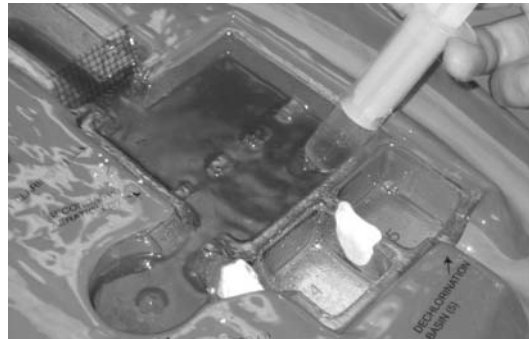
The clarified wastewater flows on to the next stage of wastewater treatment.

STEP 3: SECONDARY TREATMENT (BIOLOGICAL)

- ⊗ **USE SYRINGE (or pipette if preferred), to SQUEEZE AIR** into the liquid in the Aeration Basin (the second rectangular tank), creating bubbles.

DISCUSS Aerators then pump air into the water to provide oxygen, which creates an ideal home for small

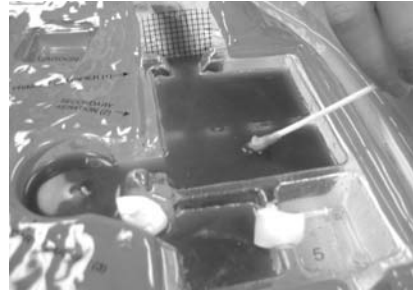
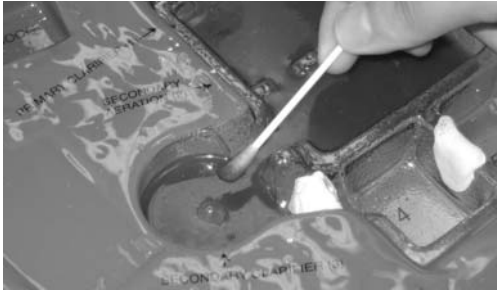
microorganisms such as bacteria. These organisms eat much of the organic matter in the water, which helps clean the water. The bacteria grab hold of even the tiniest pieces of organic matter and clump them together into large "floc" particles to eat later. These larger particles can settle much faster than the bacteria or organic matter would alone.



The partially treated sewage now flows out of the aeration basin and into the secondary clarifier (circular tank). Here, more solids settle to the bottom of the tank.

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- ☒ **DIP COTTON SWAB** into the round secondary clarifier tank and remove some sludge and dip it back into the rectangular aeration basin.



DISCUSS Some of the solids that settle in the secondary clarifier are returned to the aeration basin to increase the rate of organic decomposition, because the solids that are returned to the aeration tank contain some of the micro-organisms that eat the pollutants. It's like recycling pollution-eating bugs.

There are different approaches used to accomplish secondary treatment – all achieving the same goal through different methods.

In some areas this treatment process provides wastewater that is clean enough to be returned to the environment. In other instances, additional treatment may be required to further reduce the amount of nitrogen or phosphorus (called Tertiary Treatment).

ASK *The wastewater moves on to the next step. But what happens to the settled solids or “sludge”?*

- ☒ **USE COTTON SWAB** to **SCOOP** some sludge out of the primary and secondary clarifiers and point to the orange incinerator building.



DISCUSS These solids are sent off to a separate Solids Treatment System. Part of the sludge is disposed of through incineration (burning) or placed in a landfill. Or, at some facilities it may be processed further into a treated sludge called biosolids. For more information on Biosolids, see Demonstration 3.

DEMONSTRATION 2: SEWAGE/WASTEWATER TREATMENT

Let's follow the treated wastewater to the last step.

STEP 4: FINAL TREATMENT — DISINFECTION

- ⊗ **LIFT & REPLACE adhesive tack plug from the secondary clarifier to the adjoining Chlorination Basin and allow the water to move into the basin. If more wastewater is needed, squirt more waste into home and city building.**



- ⊗ **ADD CHLORINE to Square Chlorination Basin until full.**

DISCUSS After the biological treatment process completes, the wastewater is disinfected, usually with chlorine, to kill any remaining disease-causing organisms. (Some treatment plants are using ultraviolet and other forms of disinfection.)



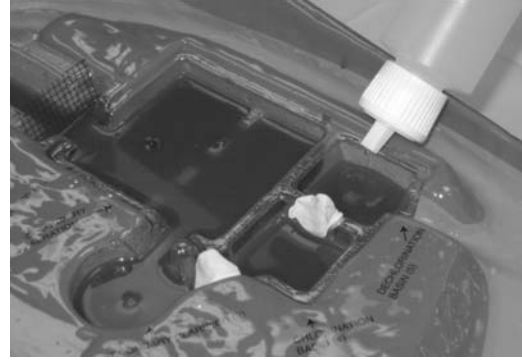
- ⊗ **LIFT AND REPLACE the adhesive tack plug between the chlorination basin and dechlorination basin to allow the water to flow through.**



DEMONSTRATION 2: SEWAGE/WASTEWATER TREATMENT

- ⊗ **ADD DECHLORINATION AGENTS** (*specialized salts/chemicals*) to the *dechlorination basin and watch the wastewater become clean.*

DISCUSS The treated wastewater, now called effluent, is treated to remove any excess chlorine.



- ⊗ **Continue adding DECHLORINATION AGENTS until effluent discharge begins.**
- ⊗ **WATCH THE EFFLUENT discharge area and see how it releases treated wastewater into the stream**

DISCUSS The treated wastewater (“effluent”) is then released into the ocean, lake, river or stream. The area where the treated effluent is discharged from the treatment plant is called the Outfall. The water released here has gone through the entire wastewater treatment process. At this point the water is monitored at the outfall to verify that it meets or exceeds the quality established in its discharge permit.

Each sewage treatment plant is permitted to discharge a certain level of pollutants. In the U.S., the discharge permits are called NPDES, which stands for the National Pollutant Discharge Elimination System. In Ontario, Canada, the discharge permits are called C of A’s, which stands for Certificate of Approvals.

DISCUSS Once the water is discharged to the receiving waterbody, the water molecules are again subject to the influence of the natural global water cycle (they may evaporate into the atmosphere or they may stay put in the receiving water and eventually get pumped to another water treatment plant). As our population increases, so does the human demand for water. Some are moving away from discharging all the treated wastewater to a receiving stream, and instead have begun direct re-use of some of the water. People refer to this water as "reclaimed wastewater" or "reclaimed water" and it may be used for landscape irrigation — watering golf courses and landscaping along public roads.

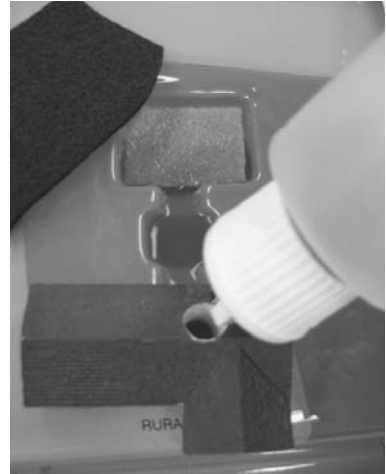
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It's also possible to reuse untreated wastewater from some sources, called grey water. For example, a lot of water is needed to cool power generation equipment. This water is typically recycled without leaving the site (i.e., it doesn't go to the wastewater treatment plant). Similarly, some residential users may recycle bath water to water their lawns.

ASK So where does the waste in the rural community go?

⊗ **LIFT GRASS FELT PIECE over the septic drain field & squirt sewage in hole in the rural home until small tank is filled and begins to flow into the drain field.**

DISCUSS Most rural and some suburban homes are not connected to public or private sewer systems because houses are spaced so far apart a sewer system would be too expensive to install. Instead they install their own private sewage treatment plants called septic systems in their yards to handle the wastes from their homes.



Here you can see the wastes generated in the home (from bathrooms, kitchen sinks, washing machines and dishwashers – all plumbing inside the home) entering the septic system. In the septic tank the solids settle and bacteria help break down the waste. The liquid then flows into the septic field (also known as a drain field) where the liquid waste is broken down by bacteria and soil microbes. These wastes are very high in nutrients. Bright green sections in a yard may indicate the septic system is not functioning properly and emitting too many nutrients to the surface of the yard.

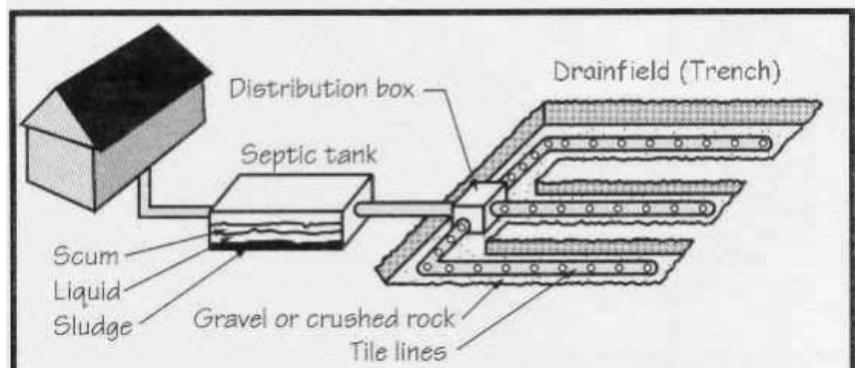


Image courtesy of U.S. Environmental Protection Agency.

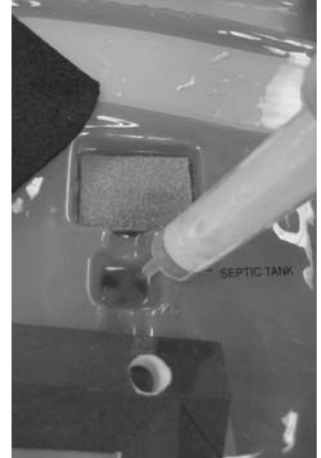
Schematic of Drain Field

DEMONSTRATION 2: SEWAGE/WASTEWATER TREATMENT

- ☒ **USE SYRINGE TO DRAW SOLIDS AND WASTEWATER from septic tank and put into cup.**

DISCUSS When not installed correctly or properly maintained by pumping solids out of the tank every couple of years, a septic system can malfunction. This can pollute groundwater or cause the sewage to come out on the surface of the land.

Lakes and bays are especially vulnerable to poor private septic system practices. In these areas, the water tables become higher than normal at times, which can cause septic systems to stop functioning properly. Homes or cottages near lakes and bays often unknowingly discharge sewage into lakes through the groundwater. One popular test is to float a packet of dye in the septic tank and watch for the colored dye to emerge in the lake.

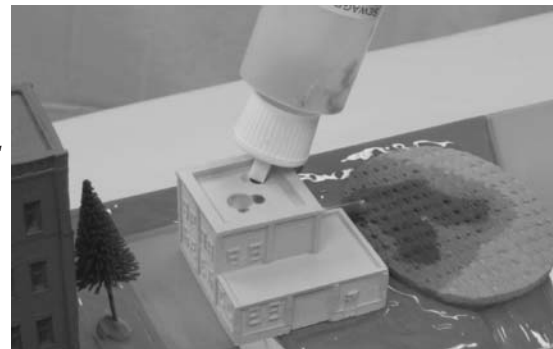


LET'S GO TO THE FACTORY AND SEE HOW THEY MIGHT HANDLE THEIR WASTE DIFFERENTLY.

- ☒ **SQUIRT WASTE INTO THE "SMALL" HOLE IN FACTORY and see how the waste moves to the constructed wetland and then eventually onto the main sewer line.**

DISCUSS Because industrial waste contains many chemicals and other substances unsuitable for the Wastewater Treatment Plant, many factories are required to pre-treat their wastes before discharging to the main sewer line for treatment.

This factory has already pre-treated its waste and as a "finishing treatment" has constructed a wetland to serve as a natural filter to help further remove pollutants before discharging to the main sewer.



DEMONSTRATION 2: SEWAGE/WASTEWATER TREATMENT

It's well known that wetlands can serve as natural filters, capable of removing many common pollutants while providing habitat for a variety of species. Therefore, when adjacent land is available and environmental conditions are suitable, constructed wetlands are becoming a popular method of some level of pre-treatment. They are often used to treat wastewater in roadside parks, rest stops, campgrounds and recreational areas.

Many manufacturing facilities, however, lack the space to construct wetlands for such use and rely on eliminating sources of pollution and/or engineering a solution that does not include wetlands.

Pre-treatment procedures vary in accordance with the composition of the wastewater, often involving some combination of physical and chemical treatment techniques.

ASK We've learned where wastewater comes from and where it goes for treatment before being released back into the environment. Are there ways we can help reduce the quantity or improve the quality of waste and/or help the waste treatment process?

DISCUSS Yes, we can use fewer goods and reuse products and goods and also recycle. And always remember not to treat your toilets and sink drains as "garbage cans." You now understand that everything that goes down the drain enters an underground collection system that takes it to the wastewater treatment plant. Fats, grease and oils can lead to blockages that disrupt this operation. Other contaminants can also harm the collection system, or the actual treatment process.

Putting greasy materials down a sink can lead to sewer clogs and clogs can lead to wastewater backing up into your home or business, spilling out onto the streets and even finding its way into storm drains. In some areas, restaurants are required to store fats, oils and grease in containers that are picked up by permitted recycling and rendering facilities. And residents are asked to mix fats, oils and grease with absorbent waste such as paper towels, kitty litter, coffee grounds or shredded newspaper before discarding in the trash.

DEMONSTRATION 2: SEWAGE/WASTEWATER TREATMENT

NOW LET'S TAKE A MOMENT TO UNDERSTAND THE DIFFERENCE BETWEEN A STORM SEWER PIPE AND A WASTEWATER SEWER PIPE.

⊗ *First, REPLACE BOTH ROADS on the model.*



⊗ *SQUIRT OIL DOWN THE STORM DRAIN located at road intersection. (Squirt until you see some enter the waterway). You might also place pollutants on the ground and make it rain and see them flow into the storm drain... showing potential effects of runoff.*

IMPORTANT: This is for demonstration purposes only and is an example of how pollution occurs. OIL SHOULD NEVER BE DUMPED INTO A STORM DRAIN.



DISCUSS Watch what we dump in the storm drain go directly to the stream. The stream carries what we dump down the storm drains as well as the runoff from the land and takes it directly to the water body.

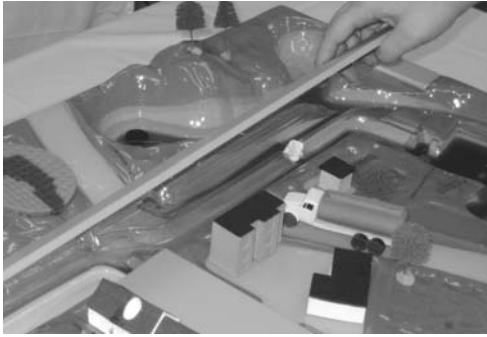
Most stormwater systems were originally built to move water to the nearest water body as quickly as possible with no treatment.

In towns and cities, the rainwater that washes streets and roofs becomes dirty and, in some instances, may need to be treated before being discharged into the environment.

ASK *Do you have any suggestions for solving this?*

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- ☒ **REMOVE** Long Road piece and **REMOVE** adhesive tack/putty (clay) between storm pipe and sewer pipe.



- ☒ **SQUIRT MORE OIL MIXTURE** down the storm drain.



DISCUSS From the late 1800s to early 1900s, many storm drain systems were combined with the sewage/wastewater systems (sewers carried both sewage and stormwater runoff in a single pipe) to the nearest receiving body of water.

Around the 1950s, most newer systems were built as separated systems (sewage in one pipe and stormwater in another pipe), with the sewage/wastewater sent to treatment plants and stormwater to the nearest receiving body of water. To correct combined systems from the earlier days, special pipes were installed to move sewage/wastewater to a treatment plant.

Combined sewers still exist in many parts of older cities. During heavy or long storms, the volume of stormwater may become too much for the combined sewers and treatment plants to handle; overflow is released into nearby bodies of water to alleviate sewer backups in homes and businesses and to protect treatment plants (combined sewer overflow).

