After The Flush
Teacher Viewing Guide:

The general principle in wastewater treatment is to remove pollutants from the water by getting them either to settle or to float and then removing this material. Some pollutants are easily removable. Others must be converted to a settleable form before they can be removed. Treatment facilities are designed in stages. Each stage either removes particles from the wastewater or changes dissolved and suspended material to a form that can be removed.

Primary Treatment
Bar Screens/ Grit Chamber/ Primary Clarifier

1. What is raw sewage called when it enters the treatment facility?
   Wastewater or influent

2. Give examples of some inorganic and organic contaminants found in wastewater.
   Organic: *urine, feces, hair, skin, wood or plant material*

   Inorganic: *plastic bags, condoms, plastic tampon applicators, wipes*

3. During filtration in the first stage of primary treatment, *large inorganic*
   Solids are removed by fine screens and transported to a landfill.

4. The grit chambers allow sand and dirt to settle to the bottom where it can be pumped out and transported to a *landfill.*

5. In the primary clarifier, contaminants that are heavier than water (dissolved feces, food, hair etc.) settle to the bottom while lighter substances like fat and oil rise to the *top* where it is separated and transported to the *solid digesters*.

For Clarification or Further Discussion: The simplest form of wastewater treatment, primary treatment involves filtration and settling. Raw wastewater entering a treatment facility (*influent*) will first pass through mechanically raked ***bar screens*** to remove large debris such as rags, plastic, sticks, cans, condoms and wipes. Smaller inorganic material such as sand and gravel is removed by a ***grit removal system*** while lighter organic solids remain suspended in the water and flow into large tanks, called ***primary clarifiers***. There the heavier organic solids settle by gravity. The settled solids, called ***primary sludge*** are removed along with floating scum and grease and pumped to ***anaerobic digesters*** for further treatment. Forty five to 50 percent of pollutants are removed utilizing primary techniques.

The total solids in sewage consist of suspended solids and dissolved solids. These total solids represent 0.1% of the material entering the wastewater treatment plant, the other 00.9% being water. Part of the suspended solids will have a specific gravity greater than the water and will settle out of the water. All of the solids may be either organic or inorganic.

Organic matter has either been alive or is still alive. Organic material would include bacteria, algae, foodstuffs, and fecal matter. Organics may be either suspended or dissolved. The organics cause the greatest problems for the operator

because of their degradation and possible purification. The organic fraction may be approximated by running suspended solids test and then burning the residue off at 550°C (Volatile suspended solids). The organic material burns off, or volatilizes and may be determined by calculation.

Sand, silt, clay and minerals are considered inorganic. Carbonates, bicarbonates, sulfates, and other such compounds are inorganic. Inorganic materials have never had life. Inorganics may be either suspended or dissolved. Suspended inorganic materials (grit) in the wastewater can cause damage as a result of abrasion.

The inorganic fraction may be approximated by the volatile solids test mentioned about. The fraction that does not volatilize represents the inorganic material in the sample and is termed "ash."

Secondary Treatment

Aeration Basin/ Final Clarifier

1. What is the first step of secondary treatment? *Aeration basin*
2. Aerobic microorganisms in wastewater require oxygen to metabolize organic waste.
3. What are the byproducts of aerobic cellular respiration? *Carbon dioxide and water*
4. In the final clarifier, wastewater is slowed so that suspended solids settle to the bottom. Called *activated sludge* at this point, it is removed and sent to the solid digesters. Some is also recycled back to the aeration basins to replenish the microorganisms there.

For Clarification or Further Discussion: After primary clarification the water is then transferred to the biological or secondary stage where it is mixed with a controlled population of bacteria and an ample supply of oxygen in the ***aeration basins***. Microorganisms, like all living things, require food for growth. Domestic wastewater and many industrial wastes contain organic materials that are a rich source of food. Called ***aerobic digestion***, this is a natural biological degradation and purification process in which microorganisms (colloquially called "bugs") that thrive in oxygen-rich environments break down and digest the waste. In other words, the microorganisms digest the fine suspended and soluble organic materials, thereby removing them from the wastewater. Aeration provides oxygen for the microorganisms, brings them into contact with food and keeps the solids in suspension. This digestion process produces carbon dioxide and water, substances favorable to the environment. The aerobic microorganisms essential to this stage of treatment include bacteria, protozoans, fungi, algae and viruses.

Supplemental Video:
https://www.youtube.com/watch?v=epAh6hHOq3c

Dissolved oxygen (DO) represents the amount of oxygen dissolved in the water and is vital to all aerobic wastewater treatment systems. Aerobic bacteria are dependent upon sufficient DO to survive. All living organisms are dependent upon oxygen in one form or another to maintain the metabolic process that produces energy and for growth and reproduction. Generally, wastewater will contain no DO unless the wastewater is very fresh or very weak.

The more waste there is in water the more oxygen is required In order to aerobically digest it. Therefore, from knowing how much oxygen is needed to break down the waste dissolved in some water using aerobic bacteria, we can tell how much waste there is (or was) dissolved in the water. This measure of how much waste there is dissolved in the water is called BOD, which stands for ***Biochemical Oxygen Demand (BOD).*** It represents the amount of oxygen required to break down the dissolved water in a given volume of water. A higher BOD means more dissolved waste or dirtier water. Water with a high BOD is water of poor quality.

Ammonia is a significant component in wastewater, originating from urine. Humans and other mammals excrete a compound called ***urea*** in urine. Urea, made in the liver, consists of 2 ammonia molecules and 1 carbon dioxide molecule. The urea molecules can dissociate in the wastewater, creating ammonia and carbon dioxide (Co_2) Ammonia must be removed from the water before the water is released back to the environment because it is toxic to many aquatic organisms at low concentrations. Because ammonia does not float or settle, but instead dissolves, it cannot be removed with the primary treatment. But can be removed by biological treatment. Ammonia oxidizing bacteria are used in wastewater treatment plants to break down organic material, and are essential to the nitrification process.

Nitrification is a two-step aerobic process that occurs during secondary treatment. Ammonia (NH3) is oxidized to nitrite, which is subsequently oxidized to nitrate. Ammonia oxidizing bacteria are responsible for converting ammonia to nitrite, which is the first step of the process. Since nitrates are more environmentally friendly than ammonia, nitrification is essential to the health of the receiving stream. Several types of bacteria are able to convert ammonia into nitrate during ***nitrification***. The bacteria also use some of the ammonia to make more bacteria cells.

Supplemental Video:
https://www.youtube.com/watch?v=BosHU4ARR9w

Once the microorganisms have done their work you need to remove them. The water is transferred to the secondary or final clarifiers, where the biological solids or ***activated sludge*** settles to the bottom and is pumped to biosolids (anaerobic) digesters.

Tertiary Treatment

Filtration/ Chlorination/ Dechlorination

1. During final filtration, *any remaining solids* are removed from the wastewater.
2. *Chlorine* is injected into the water in a reaction chamber to kill microorganisms. It takes about 20 minutes to effectively kill all microorganisms.
3. *Sulfur dioxide* is added to neutralize the chlorine. Why is this a necessary step? *To prevent killing things living in the receiving stream.*
4. A portion of the effluent is used in the recycled water system. List some uses of recycled water mentioned in the film. *San Antonio River Walk,*
5. How much wastewater is treated each day?
6. What is the wastewater called after it has completed the treatment? *Effluent*
7. What is the treated wastewater discharged into? *A river. (Medina River)*
8. Is there a water quality problem caused by the discharge? No, the water quality has increased downstream of the discharge point.
9. Does the treatment facility operate under state and or federal regulations? *Yes* What federal law dictates the water quality standards of water being discharged into the environment must be? *Clean Water Act*

For Clarification or Further Discussion: In this stage any remaining suspended and dissolved substances remaining are removed through filtering and the water is disinfected to reduce the ***pathogenic or disease-causing microorganisms*** that remain in it. The most common processes use ***chlorine gas*** or a chlorine-based disinfectant such as ***sodium hypochlorite***. To avoid excess chlorine escaping to the environment, the water called ***effluent*** at this point may be dechlorinated using ***sulfur dioxide*** prior to discharge into the receiving stream. Other disinfection options include ultraviolet light and ozone.

Wastewater may contain high levels of the nutrients nitrogen and phosphorus. Excessive release to the environment can lead to a buildup of nutrients, called ***eutrophication***, which can encourage the overgrowth of weeds, algae, and cyanobacteria (blue-green algae). This may cause an algal bloom, a rapid growth in the population of algae. The algae numbers are unsustainable and eventually most of them die. The decomposition of the algae by bacteria uses up so much of the oxygen in the water that most or all of the animals die, which creates more organic matter for the bacteria to decompose. In addition to causing deoxygenation, some algal species produce toxins that contaminate drinking water supplies. Different treatment processes are required to remove nitrogen and phosphorus.

Biosolids Treatment

1. After treatment the wastewater is called effluent.
2. What type of bacteria consumes waste in the solid digesters? anaerobic
3. A byproduct of this process is natural gas, which is processed and sold on the natural gas market.

4. The sludge is dewatered through mechanical belt filter presses or natural evaporation in san drying beds. The resulting biosolids material is mixed with wood chips and sold as compost.

For Clarification or Further Discussion: The solid by-product of wastewater treatment is called ***sludge or biosolids.*** The term “solids” is generally used when referring to any material suspended or dissolved in wastewater that can be physically isolated either through filtration or through evaporation. Solids can be classified as either filterable or nonfilterable, settleable or nonsettleable and also as organic or inorganic.

Filterable solids are so small that they will pass through a standard laboratory filter while ***nonfilterable*** solids are large enough to be capturde on a standard filter pad. The nonfilterable solids are termed settleable if the solids settle out in a standard settling container within a specified period of time. They are called non-settleable if they fail to settle out with that time period. If solids are ***organic*** the material is carbon-based and will burn. ***Inorganic*** solids on the other hand are mineral based and generally will not burn. Any material that was at one time living (body wastes, starches, sugars, wood, bacteria and cotton) are all organic while limestone, iron and calcium are inorganic.

BONUS:

What is the SAWS Environmental Trifecta? *Recycled water, biogas and biosolids*

For Clarification and Further Discussion: Wastewater was once considered something best quickly disposed of. But in San Antonio we have learned to turn wastewater into valuable resources. We call it our environmental "trifecta" of recycled water, organic biosolids and methane gas. San Antonio is the only U.S. city to reuse all three wastewater treatment process byproducts.

Recycled Water
San Antonio boasts the largest direct recycled water delivery system in the nation. More than 130 miles of pipeline delivers high-quality recycled water for use by golf courses, parks, commercial and industrial customers, as well as San Antonio's famous River Walk.

Compost
Biosolids, another byproduct of treating wastewater, are used in generating compost for improving soil quality in landscaping and gardening. The compost is sold commercially through local retailers and nurseries.

Biogas
Biogas (mostly composed of methane) generated during the treatment process is the newest addition to our environmental trifecta. Biogas is refined and compressed for the open market.SAWS has partnered with Ameresco, Inc. – a national energy company focusing on renewable energy – to treat and transfer at least 900,000 cubic feet of gas per day to a nearby commercial pipeline to sell on the open market, making San Antonio the first city to utilize biogas in this unique renewable energy strategy.

Harnessing these valuable byproducts of the wastewater treatment process is beneficial for the environment – another demonstration of SAWS mission of providing sustainable, affordable water services.