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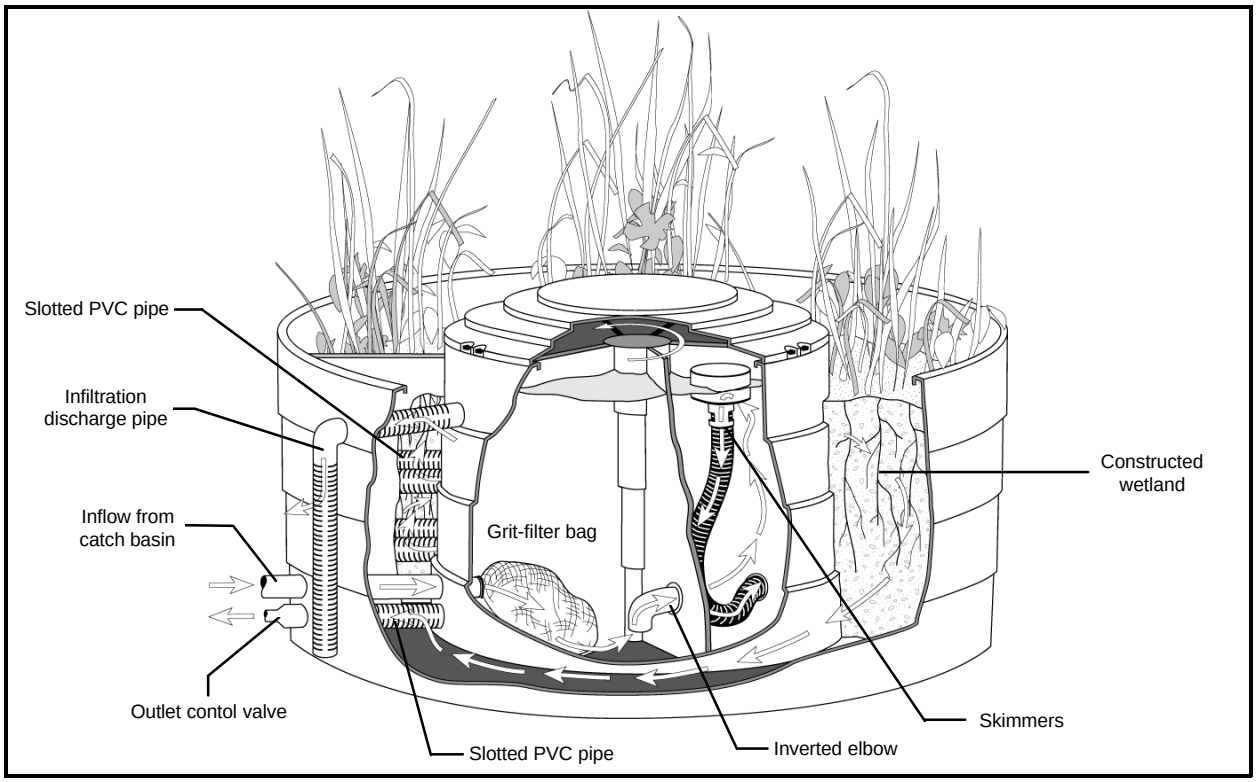
Storm Water Technology Fact Sheet
Modular Treatment Systems

DESCRIPTION

This fact sheet describes modular systems for treating storm water. One of the primary modular storm water treatment systems currently on the market is the StormTreat™ System, or STS. The STS, which was developed in 1994, is a storm water treatment technology consisting of a series of sedimentation chambers and constructed wetlands. These wetlands are contained within a modular, 2.9-meter (9.5 feet) diameter recycled-polyethylene tank. The STS can be applied in many different scenarios, ranging from residential areas to most industrial parks, but should not be used in extremely polluted areas, such as directly in wastewater streams. Figure 1 is a diagram of the STS. The STS works as follows: influent is piped into the unit's sedimentation chambers, where pollutants are removed through sedimentation and filtration. Storm water is then conveyed from the sedimentation chambers to a surrounding constructed wetland. Unlike most constructed wetlands systems, STS conveys the storm water directly into the subsurface of the wetland and through the root zone. Pollutants are then removed through filtration, adsorption, and biochemical reactions. These processes occur at higher rates within the root zone, making STS more efficient in pollutant removal. Storm water is retained in the wetlands for five to ten days prior to discharge.



Source: StormTreat™ Systems, 1998.

FIGURE 1 STORMTREAT™SYSTEM

The STS is suitable for use throughout the U.S.; however, the system may require modification to function in different environments. For example, as an option in dry climates such as in the southwestern U.S., STS has designed a solar-powered water pump to redirect water that is stored in the bottom of the system to the wetland plants. In addition, in arid regions such as these that do not have enough groundwater to support the wetland vegetation, the unit may be altered to release flow at a slower rate, thereby increasing the amount of water retained in the bottom of the unit; or it may be designed with soils that retain water more efficiently. Alternatively, the unit could have a backup water supply to provide for extended dry periods.

The STS design can be modified for areas with high groundwater levels or tidal influence. In areas with high groundwater, the discharge pipework can be modified so that runoff is discharged downgradient to an area with a lower water table. In tidally-influenced areas, a check valve can be installed to prevent flow from re-entering the unit at its discharge point. This will also allow discharge to be released only during mid- to low-tide conditions.

Over 100 STS units have been installed nationwide, including installations in California, Washington, Oregon, Oklahoma, North Carolina, South Carolina, Maryland, New York, Connecticut, New Hampshire, Maine, Rhode Island, and Massachusetts. An STS has been operating in Kingston, Massachusetts, since November 1994. This unit was installed to prevent bacterial contamination from storm runoff from harming shellfish beds in the Jones River. Additional systems have been recently installed in various parts of Massachusetts, as well as in Maine. In Hingham, MA, six STSs were installed in an industrial park bordering a wetland that is a tributary to a drinking water supply. These STSs have been successful in preventing contamination of the water supply. In Ipswich, MA, and Barnstable, MA, several STS tanks were installed to treat road and parking lot drainage to prevent discharges to sensitive receiving waters. Finally, in Manchester, ME, five STSs were installed to help reduce the levels of phosphorus in storm water effluent after new regulations tightened runoff standards for phosphorous.

APPLICABILITY

The STS has applications in a wide range of settings. The system's size and modular configuration make it adaptable to a wide range of site constraints and watershed sizes. Designers of the system indicate that the system can be used to treat runoff from highways, parking lots, airports, marinas, and commercial, industrial, and residential areas. The STS is an appropriate storm water treatment technology for both coastal and inland areas but is not designed to be used directly in wastewater streams.

ADVANTAGES AND DISADVANTAGES

Regulators and environmental groups in Massachusetts are utilizing storm water management practices, including the STS, to improve water quality in the shellfish beds located downstream from potentially contaminated runoff. The STS also protects groundwater by removing pollutants prior to infiltration. The STS has shown high total petroleum hydrocarbons (TPH), Total Phosphorus (TP), metals, and suspended solids removal rates, which improves water quality. An additional benefit of the STS is the system's spill containment feature, which can capture an upstream release and therefore lessen the spill's impact on the environment. However, as previously discussed, the STS is relatively new and remains to be thoroughly tested in different geographical locations. There may be possible limitations in different areas, although soil types and high water tables surrounding the modular unit will not limit the system's effectiveness.

DESIGN CRITERIA

The STS is a modular, 2.9-meter (9.5-foot) diameter recycled-polyethylene tank containing a series of sedimentation chambers and constructed wetlands. The sedimentation chambers are in the inner ring of the tank, which has a diameter of nearly 1.7-meters (5.5 feet). The 2.9-meter diameter outer ring, which surrounds the sedimentation chambers, contains the wetland. The tank walls and bulkheads, which separate the sedimentation chambers, are 1.2-meters (4 feet) high.

STS tanks are designed to withstand the weight of the saturated soils surrounding the tanks. Influent is conveyed from a catch basin (and other preliminary detention structures) through poly-vinyl chloride (PVC) piping to the first of six internal sedimentation chambers. A synthetic woven sack placed at the end of the 10 centimeter (4 inch) diameter inlet pipe traps large particles and debris. Skimmers floating on the water surface within each chamber convey flow to the following chamber through an opening 15 centimeters (6 inches) below the surface. This prevents sediment and floatables from being transported to the subsequent chamber. Sediments that collect in the bottom of the chamber remain there until the unit is cleaned. The bulkhead separating the last two sedimentation chambers is fitted with an inverted elbow, which traps oil and grease. The settling efficiency increases by transferring water from the top of each chamber to the subsequent chamber.

Flow is conveyed from the final sedimentation chamber through four, slotted PVC outlet pipes, each 10 cm (4 inches) in diameter, into the wetland portion of the STS. Partially treated storm water flows beneath the soil through the wetland. The wetland has an approximate storage capacity of 2,880 liters (760 gallons). The entire system has a static holding volume of 5,270 liters (1,390 gallons). However, the system is sized based upon this volume plus associated detention structures.

Vegetation within the wetland will vary depending on the local conditions (climatological). Bulrush and burreeds (which have maximum root depths of 0.8 and 0.6 meters (2.6 and 2 feet), respectively [U.S. EPA, 1993]) have been used in Massachusetts. Mature vegetation in the outer ring should have roots that extend into the permanent 15 cm (6 inches) of water in the bottom of the tank. Insufficient root depth may result in a lack of water supply to the plants during the periods between storm events.

Effluent from the wetland is discharged through a 5 centimeter (2 inch) diameter pipe that is controlled by a valve. Flow rates and holding times can be varied by manipulating the outlet control valve. At the Kingston facility, the control valve is adjusted to provide the recommended discharge rate of 0.1 liters per second (0.2 gallons per minute) and a five day holding time in the wetland. The valve has an added benefit that in the event of an upstream toxic spill, it can be closed, trapping the pollutants in the STS.

Tanks are available in one size, but several tanks can be installed at a site to capture the projected volume of runoff. The determination of the number of tanks needed for a site is based on three factors:

- Area of impervious drainage surfaces.
- Design storm to be treated.
- Detention storage prior to the STS tanks.

Generally 1-2 units are required for each acre of impervious surface. The system is sized based upon the design storm which is determined by state regulations (i.e., Maine requires treatment of first half inch of storm and Washington requires treatment of a six month storm). This first flush storage volume is stored in preliminary storage structures such as underground tanks and large diameter pipes (which can be place under parking areas).

PERFORMANCE

Runoff from the STS installed in Kingston, MA, was analyzed to assess pollutant removal efficiency. Thirty-three samples were collected over eight independent storm events during both winter and summer conditions. Sampling results are shown in Table 1. The results indicate removal rates of 97 percent for fecal coliform bacteria, 99 percent for total suspended solids, and 90 percent for total petroleum hydrocarbons. Nutrient removal rates were 82 percent chemical oxygen demand, 77 percent total dissolved nitrogen, and 90 percent phosphorus. Metal removal rates were 77 percent for lead, 98 percent for chromium, and 90 percent for zinc.

In addition to the study in Kingston, MA, several other studies are currently being conducted in Connecticut, California, and Massachusetts. This

TABLE 1 STORMTREAT™ SAMPLING RESULTS FOR KINGSTON, MA

Pollutant	Percent Removed
Fecal Coliform Bacteria	97
Total Suspended Solids	99
Chemical Oxygen Demand	82
Total Dissolved Nitrogen	77
Phosphorous	90
Total Petroleum Hydrocarbons	90
Lead	77
Chromium	98
Zinc	90

Source: StormTreat™ Systems, Inc., 1998.

data has not been fully developed and is not yet available.

OPERATION AND MAINTENANCE

Anticipated maintenance of the STS is minimal. The system should be observed at least once a year to be sure that it is operating effectively. At that time, the burlap sack that covers the influent line should be replaced. If the installed system uses filters, these should be removed, cleaned, and reinstalled. Sediment should be removed from the system once every three to five years, more often if the system has higher than normal sediment loads. The sediment level may be measured with a probe or even a yard stick. It is recommended that the sediment be removed when 0.3 meters (1 foot) of sediment has accumulated. After six months of operation the unit installed in Kingston, MA was found to have 5 centimeters (2 inches) of accumulated sediment. The sediment can be pumped from the tank by septic haulers or by maintenance personnel responsible for sediment removal from catch basins. It is not anticipated that the sediment will be toxic, and it may be safely landfilled. However, sediment toxicity will depend on the activities in the contributing drainage area and testing of the sediment may be required to determine if it is considered hazardous. Because the STS system is relatively new, there is no definitive data on the lifetime of the plants and gravel in the system. However, it is estimated that these will need to be replaced every 10 to 20 years.

COSTS

The STS is a prefabricated unit that is easily installed in most locations. The cost for one unit is $4,900, and the installation cost is usually between $500 and $1,000 (which is provided by the manufacture). Additional materials required include gravel, PVC piping, and wetland plants, at a total cost of about $350 to $400 per tank. Capital and installation costs per tank decrease as the number of units on a site increases. Installation will cost less if construction on that site is new (not retrofitted) because drainage lines will be more easily accessible. Installation will cost more if there are extra construction costs (for example, retrofit design) or if there are complications. StormTreat™ Systems recommends one STS unit per one acre of impervious surface.

The estimated maintenance cost for removal of sediment from one tank ranges from $80 to $120. This cost is incurred every three to five years, when sediment is removed. Costs have not been determined for an annual site inspection or for removing any debris from the wetland area. However, these costs should be minimal (i.e., one day of labor for one person per year).

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