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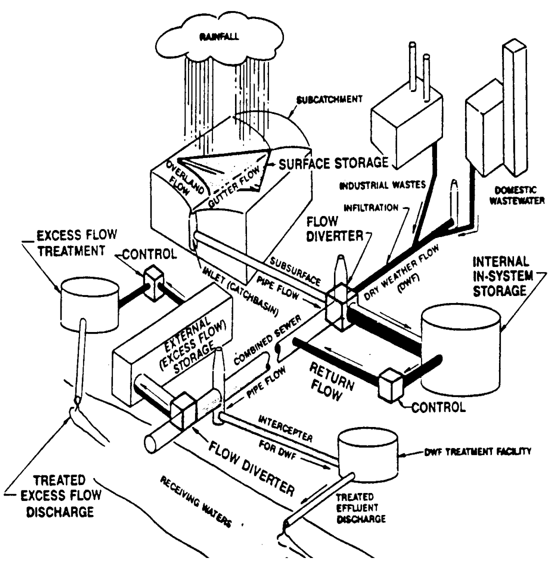
Combined Sewer Overflow O&M Fact Sheet

Proper Operation and Maintenance

DESCRIPTION

Combined sewer systems (CSSs), as shown in Figure 1, are single-pipe sewer systems that convey sanitary wastewaters (domestic, commercial and industrial) and storm water runoff to a publicly owned treatment works. During periods of heavy rainfall, however, the sanitary wastewaters and storm waters can overflow the conveyance system and discharge directly to surface water bodies. This is called a combined sewer overflow (CSO).

CSOs may contain high levels of suspended solids, biochemical oxygen demand (BOD), oil and grease, floatables, toxic pollutants, pathogenic microorganisms and other pollutants. These pollutants can exceed water quality standards and pose risks to human health, threaten aquatic species, and damage the waterways.



Source: U.S. EPA, 1989.

FIGURE 1 COMBINED SEWER SYSTEM

Because of the pollution potential from CSOs, EPA issued the CSO Control Policy on April 19, 1994. This policy states that permittees with CSSs that have CSOs should be able to provide, at a minimum, primary treatment and disinfection, when necessary, to 85 percent of the volume captured in a CSS on an annual average basis. The policy also includes nine minimum control requirements for inclusion in the CSO discharge permit. One of these minimum controls is proper operation and regular maintenance (O&M) programs for the sewer systems with CSOs.

KEY PROGRAM COMPONENTS

Proper O&M of combined sanitary sewers and overflows is not significantly different from that of sanitary sewer systems, with the objective being to maintain maximum flow to the wastewater treatment plant and to maximize either in-line storage capacity or detention upstream of the system inlets. There are several key components of an O&M program that a municipality/authority must provide to ensure proper O&M and to meet the minimum control requirement. These program components include:

- Scheduling routine inspections, maintenance and cleaning of the CSS, regulators and outfalls.

- Developing O&M reporting and record keeping systems with maintenance procedures and inspection reports.

- Providing training for O&M personnel.

- Reviewing the O&M program periodically to up-date and revise procedures as necessary.

These components are further described below.

Operational Review

Prior to developing an O&M program, the municipality should undertake an operational review of its system to inventory and assess existing facilities, operating conditions and maintenance practices. The municipality should have a complete plan of the collection system, showing all sewers and points where CSOs and outfalls are located. This plan should reference streets and other utilities to enable the maintenance crews to locate the structures and CSOs quickly. This plan may also aid in scheduling and planning the inspection and maintenance of the CSS system and overflows; for example, the regions or areas that are prone to flooding or premature overflows should be inspected first after a major storm.

The nine minimum CSO control requirements include conducting a characterization of the CSS. This characterization should include documentation of overflow occurrences and correlation of these events with rainfall patterns (e.g., volume, intensity, duration). The results of the CSS characterization are critical to designing an O&M program that is effective in optimizing system operations. As part of these studies, it is important to measure actual system flows and the response to various operating and wet weather conditions. This information will be critical during the development of specific operation and maintenance procedures that will be part of the O&M program.

Municipalities may eventually be able to use data from their Long-term CSO Control Plans to supplement their O&M programs. As part of these plans, a system may conduct modeling of the integrated system (sewers, regulators, and treatment plant) to analyze operational improvements. These modeling efforts typically identify operational modifications that maximize storage and transport, provide improved treatment in the existing system, and decrease untreated CSO discharges. Because many municipalities will implement their O&M programs before their Long-term CSO Control Plans are completed, the results of the CSS modeling may not be available during the early phase of the O&M program. However, the O&M program should be updated periodically to address this type of additional information.

Record Keeping System

The O&M program should include a record keeping component. The record keeping system should document maintenance procedures through inspection reports. These reports should include information about when the system was inspected, and, if applicable, what maintenance action was taken, including the equipment used and the personnel involved. Geographical information systems (GIS) and desktop mapping may be useful in storing O&M data on the CSO system, as well as in developing a database of problem areas.

System Operating Procedures

Each municipality should have written policies, procedures, or protocols for training O&M personnel and should conduct periodic reviews and revisions of the O&M program. Some municipalities have reported that alternating crews between O&M and other functions has proven beneficial because it reduces the tedium of the work by making it less routine, and it promotes the cross-training of employees. Other municipalities prefer devoting personnel strictly to O&M because it keeps the work assignments simple.

Training

The O&M Program should have established training goals, procedures, and schedules. Training should provide the maintenance personnel with an understanding of the CSS operations and system characteristics. Hands-on training illustrates the specific O&M procedure to those directly responsible for performing these activities. In addition, the nature of the O&M work may require employees to work in confined spaces or to be exposed to dangerous gases. Providing proper safety training, in accordance with Occupational Safety and Health Administration (OSHA) standards, is imperative. Safety programs should be reviewed, and, if necessary, updated periodically. Tide gates that require underwater inspection should only be inspected by a certified diver.

ROUTINE MAINTENANCE ACTIVITIES

Proper operation of the CSO system begins with proper operation and maintenance of the individual components - the regulators, tide gates, pump stations, sewer lines, and catch basins; and implementation of an organized plan that provides regular, consistent, and response-oriented O&M. In addition, operators must develop plans for determining where CSOs occur, and for conducting system-specific repairs to prevent future CSOs.

Regulator/Tide Gate Maintenance

Because of the debris normally present in combined sewage, regulators are particularly susceptible to the accumulation of materials that cause clogging and blockages. Trash blockages at the entrance to the orifice of the interceptor increase the headloss through the orifice and causes the majority of unnecessary overflows in passive regulators. Other causes of unnecessary diversions at regulators include weir plates or dams that are improperly set, damaged, or broken off. Similarly, tide gate failure can often be attributed to trash or debris becoming lodged in the gate, or corrosion of the gate or deterioration of the gate gaskets. Tide gate failure allows the receiving water to enter the CSS, reducing the storage and flow capacity. For more information on solids and floatables control, refer to the EPA's CSO Technology Fact Sheets on Screens (EPA 832-F-99-027) and Floatables Control (EPA 832-F-99-008).

Frequent inspection of CSO regulators and tide gates for the problems outlined above, and subsequent program to implement corrective measures (such as cleaning or repair of the regulator or tide gate) will ensure maximum storage or flow capacity. Inspection of tide gates is most easily performed during dry weather and at low tide, when most installations are above the water level of the receiving water. Tide valves that are below the level of the receiving water at all times may require a diver to perform the inspection. Regulators which have proven to be problematic should be inspected after every rainfall event.

There are many different ways of determining if an overflow has occurred at a regulator or tide gate, how long it lasted, and what volume was discharged. For instance, some municipalities have installed switches on their tide gates that sense when the gate is open; others have installed instrumentation in the discharge line upstream of the tide gate that senses when there is water in the line. In both cases, the signal from the instrumentation is sent to the operating municipality via telemetry to alert the operator of a possible overflow. This type of system may be especially useful if the tide gate is inaccessible or difficult to inspect. These types of systems should be regularly tested to ensure proper operation.

An inexpensive way of passively determining if an overflow occurred at the CSO is to place a small wooden block on the static weir; if the block is not present after a rainfall event, then it was carried off with the overflow. If the wooden block disappears after a period of dry weather flows, then the overflow structure needs to be recalibrated. Base sanitary flows can increase over time as a result of changes in the drainage basin, (e.g., more paved areas), higher sanitary flows, and increased I&I. An increase in base sanitary flow could cause dry weather overflows that need to be identified and eliminated. Another inexpensive method to determine overflows is to install a portable water level or depth gauge (e.g., sonic meter or bubbler) in the combined sewer line and to check dry weather head relative to overflow control structure elevation. This method can quickly determine if the overflow weir or other device needs to be adjusted.

Pump Station Maintenance

Pump stations should be maintained to operate at the design conditions. Wet wells should be routinely cleaned because grit and solids deposition in the wet well can damage or restrict the flow of wastewater into the pump.

Inadequate or improper pump station operation can lead to reduced storage and hydraulic capacity during wet weather, and, if the pumping capacity is severely restricted, dry weather overflows can result. In general, inadequate pumping capacity is caused by:

- Mechanical, electrical, or instrumentation problems.
- Changes in the upstream drainage area that cause storm runoff to exceed the original design basis.
- Changes in the discharge piping (e.g., tying-in or manifolding with another pressure system) that creates more headloss in the discharge system.

If conditions upstream of the pump station (such as development) increase the flow above the design values, steps should be taken to upgrade the station to meet the increased flowrate. Pump station upgrading may include such items as:

- Installing new pumps and motors.
- Changing out impellers.
- Upgrading/changing pump controls to maximize use of all pumps during wet weather.
- Modifying system piping to improve the system
- head curve.
- Installing additional force main piping for wet weather pumping.

Depending on the complexity of the system, changes to the downstream discharge conditions that may affect the system head curve may require extensive study and should be evaluated on a case-by-case basis.

Sewer Line Maintenance

Sewer line maintenance can be broken down into two main components, which include the use of diagnostic methods to identify potential trouble spots in the line; and actual physical inspections of the lines for cracks, breaks, or blockages.

The use of diagnostic methods allows system operators to predict where problems may occur in the lines, thus allowing a more efficient use of O&M resources. Proper maintenance of a sewer system requires a knowledge of the system, including information about the age of the system, the drainage areas served, the elevations of the drainage structures, and slopes of the sewer lines. Adequate knowledge of the age of the sewer system is crucial because many older systems are constructed of weaker materials (such as clay pipe) that are prone to cracking and collapsing. Cracked and collapsed sewers can pose significant problems, such as infiltration of the sewer flow into the groundwater and the introduction of sediment into the system. This may lead to hydraulic restrictions. Knowing which sections of the sewer system are the oldest or identifying sections that are made of less sturdy materials will allow the system operators to track the most likely trouble spots in the system.

Information regarding the elevations of the sewer system is important for determining the likelihood of sediment accumulation in the line. The slope of a sewer line is directly proportional to the line capacity and velocity. When the wastewater velocity in the line is below the self-cleaning velocity of 2 feet per second, solids tend to settle out, creating a flow restriction. Oversized sewers placed on very flat gradients are especially prone to conveying the wastewater at low velocities, and, as a result, filling with sediment. Small- and mid-sized storms are of significant concern because the flow velocity from these storms may be below the self-cleaning velocity. Therefore, areas that are prone to deposition should be inspected frequently. Sewer lines with a history of sediment deposition and blockages should be identified and scheduled for routine cleaning.

Modeling a sewer to evaluate the need for improvements can be especially beneficial in avoiding future problems. For instance, increasing the flow in an upstream sewer can create problems downstream if the downstream sewer does not have the capacity to handle the increased flow. Other problems, such as flow backing up into basements, may appear as a result. In cases where there is concern about back-ups into basements, a backflow preventor may be warranted. Modeling will help to determine how raising a weir will decrease CSOs. Methods of increasing the flow through sewers include increasing the pumping rate from the upstream pumping station and injecting polymer to reduce the sewer roughness coefficient (Field et al., 1994).

Determining whether an overflow occurred in a discharge sewer is important in understanding how the system works and for requirements on reporting. An inexpensive method for determining the maximum depth of flow in the discharge line is to draw a chalk line around the inner circumference of the discharge sewer. The overflow water will dissolve this substance to the maximum depth of flow. More advanced techniques include employing instrumentation that measures the flow in a discharge and relays this information via telemetry to the municipality.

The second part of a sewer line maintenance program is physical inspection of the lines. If possible, CSSs and CSOs should be inspected regularly to ensure peak performance. Sewers are commonly inspected by television cameras, but if the sewers are large enough and flow conditions are low enough, manual inspection may be possible. If manual inspection is the chosen method, the inspector must follow the OSHA confined space entry guidelines.

Inspections should be used to identify blockages, cracks, or other problems in the lines. Blockages are typically the result of sediment and grit accumulating in the sewer system, although dislodged vegetation and debris restrict flow as well. Another common cause of sewer blockages is tree roots, which can grow through cracked sewers. System blockages in sewer systems can decrease both the hydraulic capacity of the sewer and its effective storage capacity. This can cause flow to back up and overflow the sewer system.

Once these problems have been identified, maintenance crews must be dispatched to correct them. Crews should ensure that all lines are cleared of all lodged debris. They should check and empty any in-line grit chambers or flushing stations where sediment routinely causes blockages in the system. Cracked sewers should be repaired and collapsed sewers should be replaced to restore the system capacity and prevent infiltration.

Catch Basin and Grit Chamber Maintenance

Catch basins and grit chambers are inlet chambers that provide sumps for the retention of sediment, grit, and debris. These basins should be cleaned on a routine basis to prevent grit and sediment from filling the structure and passing untreated flow into the CSS. Cleaning methods include utilizing vacuum trucks, jet sprays, submersible pumps that can handle grit and slurry mixtures, and clamshell buckets.

Sediment Control

As sediment is a significant source of the problems in combined sewer systems, control of sediment from the source can prove beneficial. An example of source control includes implementing and maintaining effective erosion control practices for construction in the drainage area. These practices will prevent sediment from being transported to the sewer inlet during a rainfall event. Frequent street sweeping has also proven effective in decreasing the sediment load to the sewer system.

Infiltration & Inflow

Sewer system evaluation studies (SSES), such as smoke testing and television inspection, are effective methods of determining infiltration and inflow of groundwater into the sewer system. This is the result of structural failure of the piping system that allows groundwater into the piping system and is a common problem in older sewer systems. Often, tree roots will grow into the broken piping system, causing more blockage problems in the sewer. This problem is a serious one not only because it introduces additional flow into the sewer system which can lead to surcharges and overflows, but also because it can introduce sediment into the system, which can cause the problems outlined above.

COST

The cost of operating and maintaining CSOs and CSSs is especially difficult to determine because it is a function of many different factors, including the age of the system, the type(s) of overflow structure(s), the size of the system (both in linear footage and in the diameter of combined sewer), and the drainage areas. Cost data for key components of proper O&M of CSO systems is summarized in other EPA Fact Sheets, including "Sewer Cleaning and Inspection" (EPA 832-F-99-018) and "Catch Basin Cleaning" (EPA 832-F-99-011). For example, average costs for catch basin cleaning can range from $8-$16 per catch basin depending on whether the cleaning is done manually or with a vacuum sweeper. Table 1 summarizes average national cost data for cleaning and inspecting sewers, another key component of proper CSO system O&M..

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TABLE 1 NATIONAL SUMMARY OF MAINTENANCE COSTS

Identifier	Range of Costs	Average Cost
Total O&M cost/mile*year	$951-$46,973[1]	$2,823[3]
Labor (cost/mile/year)	$695 -$19,831[1]	$3,626[1]
Fringe Benefits (cost/mile/year)	$192 -$9,033[1]	$1,185[1]
Chemicals (cost/mile/year)	$0.3 -$7,616[1]	$512[1]
Hydroflush Cleaning (cost/mile)	$475 -5,230[2]	$1,700[1]
Television Inspection (cost/mile)	$1,000 -$11,450[2]	$4,600[1]
Preventive Maintenance	63% of Total Maintenance Costs (excludes depreciation)	

Source: 1 Water Environment Research Foundation, 1997.
2 Arbour and Kerri, 1997.
3 Black & Veatch/ASCE, 1998.

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