Illicit Discharge Detection and Elimination

Regulatory Text

- You must develop, implement and enforce a program to detect and eliminate illicit discharges (as defined at Sec. 122.26(b)(2)) into your small MS4.

(ii) You must:

- Develop, if not already completed, a storm sewer system map, showing the location of all outfalls and the names and location of all waters of the United States that receive discharges from those outfalls;

- To the extent allowable under State, Tribal or local law, effectively prohibit, through ordinance, or other regulatory mechanism, non-storm water discharges into your storm sewer system and implement appropriate enforcement procedures and actions;

(C) Develop and implement a plan to detect and address non-storm water discharges, including illegal dumping, to your system; and

(D) Inform public employees, businesses, and the general public of hazards associated with illegal discharges and improper disposal of waste.

(iii) You need address the following categories of non-storm water discharges or flows (i.e., illicit discharges) only if you identify them as significant contributors of pollutants to your small MS4: water line flushing, landscape irrigation, diverted stream flows, rising ground waters, uncontaminated ground water infiltration (as defined at 40 CFR 35.2005(20)), uncontaminated pumped ground water, discharges from potable water sources, foundation drains, air conditioning condensation, irrigation water, springs, water from crawl space pumps, footing drains, lawn watering, individual residential car washing, flows from riparian habitats and wetlands, dechlorinated swimming pool discharges, and street wash water (discharges or flows from fire fighting activities are excluded from the effective prohibition against non-storm water and need only be addressed where they are identified as significant sources of pollutants to waters of the United States).

Guidance

EPA recommends that the plan to detect and address illicit discharges include the following four components: procedures for locating priority areas likely to have illicit discharges; procedures for tracing the source of an illicit discharge; procedures for removing the source of the discharge; and procedures for program evaluation and assessment. EPA recommends visually screening outfalls during dry weather and conducting field tests of selected pollutants as part of the procedures for locating priority areas. Illicit discharge education actions may include storm drain stenciling; a program to promote, publicize, and facilitate public reporting of illicit connections or discharges; and distribution of outreach materials.

BMP Fact Sheets

Failing septic systems

Industrial/business connections

Recreational sewage

Sanitary sewer overflows

Identifying illicit connections

Wastewater connections to the storm drain system

Illegal dumping

Additional Fact Sheets

Non-Storm Water Discharges

Failing Septic Systems

Illicit Discharge Detection and Elimination

Description

Many times an aged or failing septic system requires tank replacement (Source: Texas A&M University, 1995)

Septic systems provide a means of treating household waste in those areas that do not have access to public sewers or where sewering is not feasible. For example, more than 80 percent of the land developed in the state of Maryland in the last decade has been outside the sewer and water "envelope" (MOP, 1991). Currently, it is estimated that 25 percent of the population of the United States rely on onsite wastewater systems to treat and dispose of their household waste. Of that number, about 95 percent of the disposal systems are septic tank systems. The goal of this fact sheet is to prevent new septic systems from failing and to detect and correct existing systems that have been failing.

A failing septic system is considered to be one that discharges effluent with pollutant concentrations exceeding established water quality standards. Failure rates for septic systems typically range between 1 and 5 percent each year (De Walle, 1981) but can be much higher in some regions (Schueler, 1999). Failure of on-site disposal systems can be due to a number of causes, including unsuitable soil conditions, improper design and installation, or inadequate maintenance practices. Improperly functioning septic systems are recognized as a significant contributor of pollutants (especially nitrogen) and microbiological pathogens; these systems discharge more than one trillion gallons of waste each year to subsurface and surface waters (NSFC, 1995). Identifying and eliminating failing septic systems will help control contamination of ground and surface water supplies from untreated wastewater discharges.

Applicability

Conventional septic systems are used throughout the United States and are the wastewater treatment method mostly commonly selected for those areas without public sewer systems and treatment plants. In areas without sewer systems, there are a number of factors that should be examined to determine if conventional septic systems are the right treatment choice. The first is the size of the lot where the system is installed. Conventional septic systems have a relatively large lot size requirement to allow for even effluent distribution across the drainfield. A second factor is the soil type within a region, which influences the ability of the soil to purify effluent and allow the effluent to percolate. Other conditions that can affect septic system applicability include separation distance from the water table and bedrock, topography, flooding frequency, density of development, and distance to streams or shorelines.

Siting and Design Considerations

The best way to prevent septic system failure is to ensure that a new system is sited and sized properly and to employ appropriate treatment technology. Septic systems should be located to ensure a horizontal distance from surface waters and vertical separation from ground water. Setback requirements are determined by each state or region regarding the vertical and horizontal distances that soil absorption fields must be located from building foundations, property boundaries, water supply wells, and other surface waters. The distances between septic system components and man-made and natural water supplies will vary according to local site factors, such as soil percolation rate, grain size, and depth to water table. The most effective siting distances for efficient on-site wastewater disposal are determined by doing individual site assessments prior to installation.

The proper sizing of a system is necessary to avoid hydraulic overloading. Overloading a system can cause the system to back up or can force waste through the septic tank before it receives adequate treatment (Perkins, 1989). Overloading can result in anaerobic conditions in the drainfield and might not give solids time to settle out before being pushed through the system.

In some cases, modifications to septic systems may be necessary in order to ensure proper treatment of wastewater discharges. The size of the septic drainfield must be enlarged in cases where soil permeability is low or steep slopes are present, or where increases in daily sewage flow are expected. Limiting factors such as inadequate lot size, limited separation distances, and the presence of problem pollutants such as nitrogen may require the use of alternative on-site disposal systems, such as mound or recirculating sand filters. Selecting the right system to handle site-specific problems often decreases the likelihood of septic failure. Systems can be designed to control pollutants such as nitrogen and phosphorus (denitrification systems or aquaculture system) or as retrofits for conventional systems that were inadequately sited or sized (alternating bed system, mound system, pressure distribution [low-pressure pipe] system, sand filter system, or constructed wetlands).

Proper siting and postconstruction inspection will work to prevent new systems from failing, but planning for existing systems is needed as well. A septic system management program of scheduled pumpouts and regular maintenance is the best way to reduce the possibility of failure for currently operating systems. A number of agencies have taken on the responsibility for managing septic systems. Table 1 provides some examples of programs and how they seek to control system failures.

Table 1: Examples of septic system management programs (Sources: CWP, 1995; USEPA, 1993)

Georgetown Divide Public Utilities (CA) • Approximately 10% of agency's resources are allocated to septic system management • Provides comprehensive site evaluation and septic system design, and makes inspections during construction • Conducts scheduled post-construction inspections • Homeowners pay $12.50 per month for services
Stinson Beach County Water District (CA) • Monitors septic system operation to identify failures • Detects contamination of ground water, streams, and sensitive aquatic systems from septic systems • Homeowners pay $12.90 per month, plus cost of construction or repair
Puget Sound Water Quality Authority (WA) • Member jurisdictions have established revolving loan funds to provide low-interest loans for repair of failing septic systems
Chesterfield County (VA) • Private pumpers submit form to county, and county maintains database of tracking pumpout • Every 5 years county sends residents notification for pumpout requirement • County contracts to have pumpout performed if owner does not comply and can fine or back-charge to owner.

Programs which seek to address failing septic systems should considered, using field screening to pinpoint areas where more detailed on-site inspection surveys are warranted. There are several references available discussing field screening techniques for identifying sources of contamination (Lalor and Pitt, 1999; Center for Watershed Protection, 1999). Unfortunately, there is not as much information available dealing with specific techniques for identifying existing individual septic systems that might be failing.

Some of the most common indicators of failing septic systems are odors and visual observances like surface pooling and patches of very green grass, particularly in the off-season or in an isolated pocket Simple field tests can also provide insight into the location of illicit discharge. For example, excess ammonia is an indication of anaerobic conditions, and fecal coliform and excess chemicals from laundry detergents indicate inadequate or failing systems (Cox, personal communication, 2000).

Two field screening techniques that have been used with success at identifying possible locations of failing septic systems are the brightener test and color infrared (CIR) aerial photography. The first involves the use of specific phosphorus-based elements found in many laundry products, often called brighteners, as an indicator of the presence of failing on-site wastewater systems. The second technique uses color infrared (CIR) aerial photography to characterize the performance of septic systems. This method has been found to be a quick and cost-effective method for assessing the potential impacts of failing systems and uses variations in vegetative growth or stress patterns over septic system field lines to identify those systems that may potentially be malfunctioning. Then a more detailed on-site visual and physical inspection will confirm whether the system has truly failed and the extent of the repairs needed. These inspections may be carried out by county health departments or other authorized personnel.

Limitations

Septic systems can have numerous impacts on the quality of ground and surface water supplies. Improperly located or failing systems can discharge inadequately treated sewage, which may pond on the ground and run off into surface waters. Inappropriate vertical distances from ground water can result in contamination of water supply wells. The wastewater and sewage that may be discharged from failing on-site systems will contain bacteria and viruses that present problems for the health of both humans and aquatic organisms. In addition, excess nitrogen and phosphorus can cause algal blooms that reduce the level of available oxygen in the water and prevent sunlight from reaching desirable submerged aquatic vegetation.

There are also economic impacts associated with failing or overtaxed systems. Beach and shellfish bed closures affect tourism and the vitality of local businesses that rely on fishing and seafood. In addition, economic factors affect corrections of failing systems because their replacement might be limited by septic owners not having the funding to pay for new systems.

Reliance on individual on-site inspection to detect failed systems is another major limitation. The individual on-site inspection is very labor-intensive and requires access to private property to pinpoint the exact location of the failing system. Property owners might be reluctant to provide this access, and an ordinance mandating inspection authority might be required. A number of communities have dealt with access issues by using an ordinance requiring inspection at time of property transfer to pinpoint systems requiring repairs. An example of this type of ordinance is available at the Center for Watershed Protection web site (*http://www.cwp.org*) in the illicit discharge category.

Perhaps the biggest limitation to correcting failing septic systems is the lack of techniques for detecting individual failed systems. While visual inspections and dye testing can locate a malfunctioning system, they require access to private property and demand staff time. Dealing with failing septic systems requires a stronger emphasis on developing screening techniques for local governments to use to detect and correct improperly operating systems.

In many urbanized areas, replacement of septic systems is not possible due to site limitations. Municipalities should consider eliminating the discharge from septic systems to the MS4 sanitary sewers.

Maintenance Considerations

Periodic maintenance of on-site systems is necessary to ensure their proper functioning. Since many homeowners do not employ these routine maintenance practices, it may be necessary for agencies to establish programs to track pumpout and maintenance requirements. The programs in Table 1 include maintenance tracking as part of their plans.

Effectiveness

The effectiveness of septic systems at removing pollutants from wastewater depends on the type of system used and the conditions at the site. Even a properly operating septic system can release more than 10 pounds of nitrogen per person per year to the ground water (Matuszeski, 1997). Table 2 provides an overview of the average effectiveness for seven types of on-site systems for removing total suspended solids (TSS), biological oxygen demand (BOD), total nitrogen (TN), and total phosphorus (TP). Table 2 shows even properly operating conventional septic systems can have relatively low nutrient removal capability and can be a cause of eutrophication in lakes and coastal areas. Communities may elect to require new septic systems to use more advanced treatment technologies to address concerns regarding pollutant loads from improperly functioning systems.

Table 2. Average effectiveness of on-site disposal systems (total system reductions) (Source: USEPA, 1993)

Disposal practice	TSS (%)	BOD (%)	TN (%)	TP (%)	Pathogens (Logs)
Conventional System	72	45	28	57	3.5
Mound System	NA	NA	44	NA	NA
Anaerobic Upflow Filter	44	62	59	NA	NA
Intermittent Sand Filter	92	92	55	80	3.2
Recirculating Sand Filter	90	92	64	80	2.9
Water Separation System	60	42	83	30	3.0
Constructed Wetlands	80	81	90	NA	4.0

Cost Considerations

Once a septic system has been identified as failing, procedures must be in place to replace that system. The cost to replace a septic system typically ranges between $3,000 and $7,000 per unit (NSFC, 1999), but costs vary significantly depending on site conditions and geographic location. Various methods have been used to finance septic system replacement, including money from state revolving funds or from local utilities through user fees.

The costs associated with detecting and correcting septic system failures are subject to a number of factors, including availability of trained personnel, cost of materials, and the level of follow-up required to fix the system problems. The Mason County, Washington, Department of Health Services has conducted on-site sewage inspections for a number of years and has found that dye tests, while reasonably affordable, were too costly to conduct on a regular basis. The estimated cost for each dye test survey conducted was $290 dollars, and the cost for each visual inspection was $95 (Glasoe and Tompkins, 1996). Most of the causes of system failure were found to be relatively easy and inexpensive to repair, and the cost to oversee the repairs was estimated to be $285.

There are also significant cost differences between the various technologies available for on-site wastewater treatment. Table 3 provides both capital and maintenance costs for seven different on-site disposal systems. The installation cost for alternative systems may be higher due to variables such as requirements for additional system equipment and the cost of permit approval for the system. Differences in maintenance costs may be due to factors such as increased demand for replacement of treatment media and the lack of available personnel with training in maintenance of alternative systems.

Table 3. Cost of on-site disposal systems (Source: USEPA, 1993)

Disposal Practice	Capital Cost ($/House)	Maintenance ($/Year)
Conventional System	4,500	
Mound System	8,300	180
Anaerobic Upflow Filter	5,550	NA
Intermittent Sand Filter	5,400	275
Recirculating Sand Filter	3,900	
Water Separation System	8,000	300
Constructed Wetlands	710	25

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Industrial/Business Connections

Illicit Discharge Detection and Elimination

Description

A common source of pollution from businesses is a floor drain that is improperly connected to a storm drain (Source: Petro-Marine Company, Inc., no date)

This management practice involves the identification and elimination of illegal or inappropriate connections of industrial and business wastewater sources to the storm drain system. Illicit connection detection and elimination programs attempt to prevent contamination of ground and surface water supplies by regulation, inspection, and removal of these connections. Any industrial discharge not composed entirely of storm water that is conveyed to the storm drainage system or a water body is considered to be an illicit discharge. These discharges may contain a variety of pollutants that can affect both public safety and the aquatic environment.

Many of these discharges are a result of connections to the storm drain that are unknown to the business owner and may not be evident in architectural plans. The large amount of storm and sanitary sewer pipes in a community creates a complex and often confusing system of utilities, so it is not unusual for improper connections to occur. For example, nearly 10 percent of all businesses in Wayne County, Michigan, had illicit connections, with an average of 2.6 found at each detected business (Johnson, 1998). A 1986 study found a 38-percent rate of illicit connections for businesses in Washtenaw County, Michigan, mostly in automobile-related and manufacturing businesses (Schmidt and Spencer, 1986).

Applicability

Illicit industrial connections can arise in a number of ways, including cross connections with sanitary sewers and floor drains improperly attached to storm drainage pipes. These connections may be accidental or planned, and may occur in new developments as well as in existing developments. For new businesses, preventative practices such as thorough inspection and verification during the entire construction phase can avoid the need for more extensive detection techniques and disconnection. For existing industries, improper connections are located by using field screening procedures, source testing protocols, and visual inspection.

Design Considerations

Discharges from industry and business may come from a variety of sources including process wastewater, wash waters, and sanitary wastewater. The following methods are often used for identifying improper industrial discharges to the storm drain system:

- *Field Testing of Dry Weather Discharges*. Storm drain outfalls are monitored to identify those areas where discharges are occurring that exceed water quality standards. This monitoring includes both visual inspection and chemical analysis to aid in identifying potential discharge sources.

- *Visual Inspection*. A physical examination of piping connections or analysis by closed circuit camera is used to identify possible illicit connection sites.

- *Piping Schematic Review*. Architectural plans and plumbing details are examined for potential sites where improper connections have occurred.

- *Smoke Testing*. Smoke testing is used to locate connections by injecting a non-toxic vapor (smoke) into the system and following its path of travel.

- *Dye Testing*. Colored dye is added to the drain water in suspect piping. Dyed water appearing in the storm drain system indicates an illegal connection, possibly between the sanitary sewer system and the storm drain.

Facilities that receive NPDES storm water permits are usually required to include documentation that the storm water collection system has been tested or evaluated for the presence of non-storm water discharges. To ensure that only storm water is being discharged into the storm drain system from an industry, communities may wish to institute a program that includes the following:

- Locating of industrial discharges to the municipal storm sewer system or local waters using storm drain monitoring, visual observation, and pipeline schematics

- Locating and evaluating the on-site industrial storm sewer system using field screening techniques, dye tests, smoke tests, and closed circuit television

Developing plans to eliminate improper connections and exploring alternative disposal options for discharges that cannot be sent to the storm sewer system, such as using the sanitary sewer system or collecting and disposing of discharges off-site at an approved disposal facility

- Documenting the testing and eliminating of industrial/business illicit connections, including recording the location of the connection, the date of testing, and the method used to remove the connection

- Establishing a citizen complaint hotline to report incidences of illicit discharges

A program for the field screening of dry weather flows at storm drain outfalls can aid in identifying possible locations of industrial illicit connections. These field screening programs monitor for certain chemical and visual tracers that indicate potential sources of non-ground water illegal discharges. The use of these tracers provides a method for prioritizing sections of the storm drain system that require more intensive analysis to accurately pinpoint the specific sources contributing contaminated discharges. The reference section at the end of this fact sheet provides two excellent resources on the methodology for investigating inappropriate discharges and for selecting tracers to identify sources of contamination in dry weather flows.

Limitations

There are a number of factors affecting the ability of detection and elimination programs to remove illicit industry and business connections to the storm drainage system. The first is cost. Illegal connection location techniques are often labor intensive and can require a large commitment of staff to carry out detection tests. If a community hotline is used, staff will be necessary to record complaints. Training will be required for performing field screening tests, and a variety of equipment is necessary for performing the various detection tests. Resource sharing between several departments may help offset equipment costs.

Another limitation to industrial illicit connection control is the issue of access to private property for inspection purposes. An ordinance that ensures "right of entry" is vital in locating potential sources of illegal industrial discharges. Several cities have enacted sewer use ordinances that include language for permitting the entrance of municipal staff onto commercial and industrial sites for detection purposes. An example of a sewer use ordinance for the city of St. Louis, Missouri, is available for review at the Center for Watershed Protection web page at *http://www.cwp.org*.

Despite the difficulty identifying these connections due to budget and staff restraints, it is important to understand that these connections are illegal and should be identified and reported regardless of cost. Jurisdictions can offset some of these costs by encouraging the reporting of illicit discharges by public and municipal employees, thereby saving expense on inspectors and directing resources more efficiently.

Effectiveness

Industrial storm water discharges due to improper connections to the storm sewer system can have considerable impacts on storm water and receiving waters. These discharges may contain heavy metals, oil and grease, nutrients, or raw sewage that pose serious environmental risks. Bacteria from the presence of untreated human waste may contaminate drinking water supplies and lead to outbreaks of disease. Toxic pollutants and heavy metals can destroy habitat and affect aquatic organisms, impacting economic and public health. The detection and correction of illicit discharges can result in significant reductions of these contaminants, improving water quality and meeting effluent requirements.

Illicit connection programs often do not concentrate solely on businesses and industries, so effectiveness data on actual pollutant removal are difficult to locate. However, there are data that demonstrate the effectiveness of illicit connection correction programs at improving water quality. Two examples show how illicit connection elimination can reduce pollutant levels and remove fecal coliform from streams. The first is the Huron River Pollution Abatement Project, in Washtenaw County, Michigan. This program was active from 1987 to 1992 and dye tested over 3,800 facilities. Improper connections to the storm sewer were found in 450 facilities, of which 328 were verified as being removed. As a result, fecal coliform levels in the Huron River dropped approximately 75 percent between 1987 and 1990. The City of Tulsa, Oklahoma, along with several state agencies, has also sought to control the impacts of illicit discharges. Through inspection of possible illicit discharges, dry weather field screening, repairs to storm sewer and sanitary sewer lines, and community involvement, the city was able to demonstrate an improvement in water quality from pre-program levels.

The city compared the average event mean concentration of selected parameters from pre-program levels to results after 4 years of implementation (1994–1998) to show how much reductions had occurred. The results are listed in Table 1.

Table 1. Water quality improvements 1994–1998 in Tulsa, Oklahoma (Source: NRDC, 1999)

Parameter	Average EMC after program implementation (mg/l)	Pre-program average EMC (mg/l)	Percent reduction
Copper	0.013	0.030	56
Zinc	0.097	0.215	55
BOD[a]	7.7	9.4	18
COD[a]	66.5	70.2	5
TP[a]	0.270	0.325	17
TKN[a]	1.354	1.660	18
TSS[a]	117.5	135	13

[a]BOD=biological oxygen demand; COD=chemical oxygen demand; TP=total phosphorus; TKN=total Kjeldhal nitrogen; TSS=total suspended solids

Cost Considerations

The cost for instituting an illicit connection detection and elimination program will vary greatly based on the intensity of the effort. Identification of illicit connections using visual inspections of dry weather flows has an estimated cost of $1,250 to $1,750 per square mile (Claytor and Brown, 1996). Many programs offset some of their cost by encouraging the reporting of illicit discharges by public and municipal employees, thereby saving expense on inspectors and directing resources more efficiently. Programs have also saved money by using student interns to locate and map dry weather flows from outfalls, or contracting with academic institutions to perform outfall monitoring.

Some programs have used funds available from "environmental fees" or special assessment districts to fund their illicit connection elimination programs. The Huron River Pollution Abatement Project used annual assessments of the city of Ann Arbor, Michigan, and a per parcel basis for the rest of the district to fund the costs of illicit connection removal efforts. The project provided Washtenaw County with a total of $1.7 million over the life of the program to finance their efforts. Fort Worth, Texas, charges an "environmental fee" to local residents and businesses to fund storm water-related efforts, including illicit connection detection. Approximately $2.5 million dollars a year is raised through these fees.

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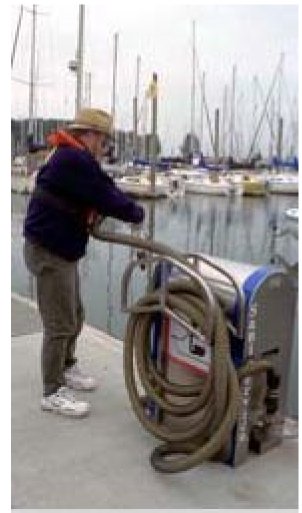
Recreational Sewage

Illicit Discharge Detection and Elimination

Description



Many marinas provide pumpout stations for safe disposal of bilge (Source: Oregon State Marine Board, no date)

Recreational sewage management measures seek to regulate wastewater generated from outdoor activities such as boating or camping by providing alternative methods to waste disposal in place of illegal overboard discharge. Under federal law, it is illegal to discharge marine sewage from boats in navigable U.S. waters, including coastal waters up to 3 miles offshore. The law also specifies that there be "no discharge" by boats operated in lakes and reservoirs or in rivers not capable of interstate navigation. Boats with installed toilets must have an operable Coast Guard approved marine sanitation device (MSD) that either holds sewage for pumpout ashore or for discharge in the ocean beyond the 3-mile limit, or that treats the sewage to Federal standards prior to discharge.

The proper disposal of recreational waste is necessary to avoid the impacts that these activities and their associated developments (i.e., marinas and campgrounds) can have on aquatic environments. Marina and recreational boat sewage can have substantial impact on water quality by introducing bacteria, nutrients, and hazardous chemicals into waterways. It has been reported that a single overboard discharge of human waste can be detected in up to a 1-square-mile area of shallow enclosed water (FL DEP, no date). These human wastes can include *Streptococci*, fecal coliform, and other bacteria which contribute to incidences of human disease, shellfish bed closures, alerts on eating fish, and algal blooms. Boats can be a significant source of fecal coliform bacteria in areas with high boating densities and low hydrologic flushing, and fecal coliform levels become elevated near boats during periods of high occupancy and usage (USEPA, 1993). Holding tanks on boats also concentrate pollutants and use increased levels of oxygen during decomposition. Table 1 shows a comparison of the biological oxygen demand required to break down sewage held by MSD's versus untreated and treated municipal sewage (FL DEP, no date).

Table 1. BOD concentrations according to sewage type

Sewage	BOD concentration
Boat Sewage	1,700–3,500 mg/l
Raw Municipal Sewage	110–400 mg/l
Treated Municipal Sewage	5–100 mg/l

Implementing proper disposal practices and providing services for removal of recreational wastes can alleviate the effects that this source of pollutants has on water quality.

Applicability

Best management practices dealing with recreational sewage sources are most often applied in coastal areas and freshwater bodies of water where boating activity occurs. Physical factors involving the siting of marinas can affect the release of sewage to surface water due to flushing times and circulation patterns. In addition, the use of inadequate marine sanitation devices on boats can cause unintended sewage discharges. Climatic factors such as rainfall and wind also influence the circulation and flushing times for marinas. The proper siting of marina basins and adequate planning for the disposal of boater sewage are important considerations in addressing this form of illicit discharge. The same basic techniques regarding siting and pumpout provision are applicable for sewage generated at campgrounds.

Implementation

Several management practices can reduce the discharge of sewage from vessels at marinas. These practices range from installation of pumpout systems to public education to inspection of marine sanitation devices. The use of the following practices is encouraged to help reduce the incidence of improper discharges from vessels:

- *Pumpout Installation and Operation*—Pumpout stations are an efficient method to control sanitary discharges from boating activities. Pumpout facilities collect waste from on-board MSDs, which are recommended for vessels over 25 feet. EPA Region 1 determined that, in general, one pumpout facility per 300−600 boats with holding tanks (type III MSDs) should be sufficient to meet the demand for pumpout services in most harbor areas (USEPA, 1991b). EPA Region 4 suggested one facility for every 200 to 250 boats with holding tanks (USEPA, 1985a). The State of Michigan has instituted a no-discharge policy and mandates one pumpout facility for every 100 boats with holding tanks (USEPA, 1993).

  There are three types of pumpout stations: a fixed collection system, a mobile/portable system, or a slipside system. All three types of systems provide for the removal of sanitary waste by connecting a flexible hose to the wastewater fitting in the hull of the boat, and pumping or vacuuming the wastewater to an onshore holding tank, sanitary sewer system, or an approved disposal facility. However, there are differences in the cost, location, and use of each of the three collection system types. *Fixed systems* include one or more centrally located sewage pumpout stations. These stations are often located at the end of a pier, typically near fueling docks, so that fueling and pumpout operations are easily accessible. *Portable/mobile collection systems* are similar to fixed-point systems, but are capable of being moved around a marina to provide pumpout services in various locations. This collection system is connected to the deck fitting on the vessel, and wastewater is pumped from the vessel's holding tank to the pumping unit's storage tank. The contents of the storage tank are then discharged into a municipal sewage system or a holding tank for removal by a septic tank pumpout service. Another form of portable pumpout is the radio-dispatched pumpout boat. The pumpout boat goes to a vessel in response to a radio-transmitted request, and eliminates the inconvenience of lines, docking, and maneuvering vessels in high-traffic areas. (USEPA, 1993). *Slipside or remote systems* provide direct hookup and continuous wastewater collection at a slip. EPA recommends that slipside pumpout should be provided to live-aboard vessels

(USEPA, 1993). Marina slips designed to serve transient boating populations can be served by either fixed or mobile pumpout systems.

According to a 1989 American Red Cross Boating Survey, there were approximately 19 million recreational boats in the United States (USCG, 1991). About 95 percent of these boats were less than 26 feet in length. On-board marine sanitation devices are not regularly used on vessels less than 26 feet long. These boats often use only small portable (removable) toilets, requiring planning for sewage disposal for these smaller vessels. A satisfactory disposal facility for this type of device could be a dump station, possibly located at the end of a pier. Given the large percentage of smaller boats, facilities for the dumping of portable toilet waste should be provided at marinas that service significant numbers of these boats (USEPA, 1993).

The operation of pumpout facilities should be tied to times when customers are most likely to use the service. Having services available on weekend mornings and evenings when demand is high will encourage pumpout use. Fees for pumpout use should also be kept at reasonable rates to encourage use. A willingness to-pay-survey conducted by the EPA found that boaters would accept a fee of between $3 and $7 dollars for pumpout service (RI Sea Grant, 1992). Some marinas offer free pumpout service, and build the cost into slip fees or environmental surcharges. Routine inspection of pumpout facilities is also necessary to ensure that the equipment is functioning properly.

- *No-discharge area designations*—No-discharge areas are zones where it is illegal to discharge sanitary waste from vessels, whether it is treated or untreated. Once a specific area has adequate pumpout facilities, states can apply for this designation. The only type of marine sanitation device that can be legally used in these areas are Type III MSDs (holding tanks). The benefit of the no-discharge areas is that they can significantly reduce the amount of bacterial contamination from illegal discharges of vessel waste. In Rhode Island, water quality studies indicate that levels of fecal coliform have declined during the boating season since the establishment of a no-discharge designation (RI Sea Grant, 1992).

- *Education*—Pumpout facilities are of little use if boaters do not use the service. Many boaters are unaware of state and federal regulations requiring the use of marine sanitation devices, or of the location of pumpout services. Like most forms of educational outreach, the use of pamphlets, newsletters, bill inserts, and meetings are often used to inform users of available pumpout services. Offering free inspections of customer MSDs through the Coast Guard Auxiliary Boating Safety Program is another way to control illegal wastewater discharges. Sources can be identified through a number of methods—public complaints, visual screening, water sampling from manholes, outfalls during dry weather, and use of infrared and thermal photograph (USEPA, 2000a).

- *Enforcement*—In some states, laws have been passed granting local harbormasters the authority to enforce MSD requirements and fine violators. Ensuring that local and state laws are passed granting enforcement authority will allow for the inspection and identification of MSDs that are not operating properly.

One method that has been used to enforce illegal discharge controls is by placing dye tablets in holding tanks to discourage illegal disposal. This practice was employed in Avalon Harbor, California, to identify fecal coliform bacteria sources. Upon a vessel entering the harbor, a harbor patrol officer boards and places dye tablets in all sanitary devices. The devices are then flushed to ensure that the holding tanks do not leak. During the first 3 years of implementation, this practice detected 135 violations of the no-discharge policy and was extremely successful at reducing pollution levels (USEPA, 1993). One tablet in approximately 60 gallons of water will give a visible dye concentration of one part per million. The cost of the tablets is approximately $30 per 200 tablets (Forestry Suppliers, 1992, as cited in USEPA, 1993).

- *Signage*—Signs marking pumpout station locations and hours of operation should be placed in prominent places where marina tenants tend to gather. If the pumpout station serves an entire harbor, then signs should be placed in neighboring marinas and mooring areas to direct boaters to the station. Self-service pumpout stations need to include a sign that provides operating guidance. Pumpout signs may be available through either state or federal programs, and marina owners should be encouraged to place these signs near each pumpout station.

Limitations

The management practices for controlling recreational sewage are limited mostly by a lack of pumpout facilities and the need for boater education programs that stress techniques to prevent wastewater discharges. These two factors have been called the most important in successfully preventing sewage discharge (USEPA, 1991b). The cost of pumpout facilities has also been cited as a limitation, but this may be due to a lack of awareness about federal and state grant programs to aid in pumpout station installation.

Maintenance Considerations

In general, marina pumpouts are fairly inexpensive to operate and maintain. Maintenance considerations can include scheduling of inspection and replacement of pumpout equipment, cleaning of hoses and pumpout connections, and hiring of a service to remove sewage that is not discharged into the sanitary sewer.

Effectiveness

Limited data are available on the effectiveness of management practices to reduce water quality impacts from illegal wastewater discharges in marinas. The water quality effects of improper sewage discharges include elevated fecal coliform bacteria levels and reduced oxygen levels in the water. A single weekend boater flushing untreated sewage into our waters produces the same amount of bacterial pollution as 10,000 people whose sewage passes through a treatment plant (CA DBW).

Marine sanitation devices can also introduce harmful chemicals into the aquatic environment. These chemicals are used to disinfect and deodorize the waste, and they include formaldehyde, paraformaldehyde, quaternary ammonium chloride, and zinc sulfate. Some of these chemicals are known carcinogens and have adverse impacts on aquatic organisms.

Cost Considerations

Costs associated with pumpouts vary according to the size of the marina and the type of pumpout system. Table 2 presents EPA cost information for three marina sizes and two types of pumpout systems (USEPA, 1993). The average cost for pumpout installation has been estimated to be $5,323 (RI Sea Grant, 1992). Portable pumpout facilities are believed to be the most logistically feasible, convenient, accessible, and economically affordable way to ensure proper disposal of boat sewage (Natchez, 1991).

Depending on the type of pumpout system installed, maintenance costs can range between $36 and $200 per slip per year. Table 2 contains operation and maintenance figures for three types of sewage pumpout collection system. As the table shows, operation and maintenance is more expensive for marina-wide and portable systems than for slipside systems. This extra expense is balanced by the lower capital cost for system installation for both marina-wide and portable systems.

Table 2. Annual per slip pumpout costs for three collection systems (Source: USEPA 1985 as cited in USEPA, 1993)

Factor	Marina-Wide	Portable/Mobile System	Slipside System
Small Marina (200 slips)			
Capital Cost	15[a]	15[b]	102[a]
O&M Cost	110	200	50
Total Cost (slip/year)	125	215	152
Medium Marina(500 slips)			
Capital Cost	17	10	101
O&M Cost	90	160	40
Total Cost (slip/year)	107	170	141
Large Marina(2,000 slips)			
Capital Cost	16	10	113
O&M Cost	80	140	36
Total Cost (slip/year)	96	150	149

[a]Based on 12% interest, 15 years amortization
[b]12% interest, 15 years on piping, 12% interest, 15 years on portable units

Case studies of best management practices for nonpoint-source pollution related to boating were performed by the University of Rhode Island Sea Grant. The three case studies in Table 3 examined various public education techniques for their cost, educational value, and cost effectiveness. While these public education case studies did not focus exclusively on boat sewage practices, the results can be used as an indicator of expected cost and performance for recreational sewage BMPs.

Table 3. A review of three BMP case studies for marinas (Source: RI Sea Grant, 1992)

BMP	Cost	Educational Value	Cost Effectiveness
Conducting Workshops	Low cost ($16 per facility) but requires considerable investment of time	Ranked last among customer choices for receiving information Low turnout Only 31% of attendees have used BMP's	Low unless attendance is tied to a more popular marina event
Distributing Literature	$52.80 per marina for distribution through display rack ($45 for rack and $7.80 for copies) $45.36 if done through monthly mailing	Ranked as the second most popular way of receiving information 75% reported reading fact sheets and 91% of these readers indicated that they began using practices learned	High if monthly mailing method is used
Posting Signs	$105	Ranked first as the most popular way of receiving information	Very cost effective since signs can be used for several years.

Federal aid is available to states for the construction, renovation, operation, and maintenance of pumpout and dump stations to improve water quality. The Clean Vessel Act Grant Program also provides funds for educational programs about disposing of human waste in an environmentally safe manner. The federal share of any project cannot exceed 75 percent of the total cost, and marina operators agree to the following conditions:

- Pumpout facilities will be operated, maintained, and accessible to all recreation vessels for the full period of their useful life
- The national pumpout symbol shall be installed and must be clearly visible to boaters.
- An informational sign shall be installed at pumpout stations and will specify fees, restrictions, hours of operation, operating instructions, and a contact name and telephone number to call if the facility is inoperable.

The maximum user fee that can be charged for pumpout use is $5 unless a written proposal for a higher fee is submitted. For further information about the Clean Vessel grants program, consult http://fa.r9.fws.gov/cva/cva.html.

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Sanitary Sewer Overflows

Illicit Discharge Detection and Elimination

Description


During large storm events sanitary sewers receive storm water runoff in addition to wastewater, causing them to overflow (Source: USEPA, 2000)

This fact sheet deals with detecting and correcting sanitary sewer overflows in a community. Sanitary sewer overflows (SSOs) involve the release of raw sewage from a separate sanitary sewer system prior to reaching a treatment facility. The raw sewage from these overflows contains bacteria and nutrients that affect both human and environmental health. These overflows occur when the flow into the system exceeds the design capacity of the conveyance system, resulting in discharges into basements, streets, and streams. A common SSO is overflowing sewage manholes that send untreated sewage into a stream. While SSOs can occasionally occur in any system due to factors such as flooding or temporary blockages, chronic overflows are an indicator of a deteriorating system or a system where development has exceeded capacity. Estimates are that about 140 overflows occur per one 1,000 miles of sanitary sewer lines each year (AMSA, 1994). An Association of Metropolitan Sewage Agencies survey also found that 15 to 35 percent of all sewer lines were over capacity and could potentially overflow during a storm.

Applicability

Sanitary sewer overflows occur in urbanized areas where a separate sanitary sewer system has been created to move wastewater from households and businesses to treatment plants. The detection and elimination of SSOs is most important because sanitary sewer collection systems represent a significant investment for urban municipalities. Depending on the their size, the cost of a sanitary sewer system can be in the billions of dollars. Therefore, programs are required not only to identify and eliminate overflows as they occur, but to include preventative maintenance planning.

There are a number of factors that contribute to sanitary sewer systems being more prone to failure and possible overflows. An important factor is the age of the pipe system. If the sewer system is older, deterioration of the main and lateral pipes can create sags in the lines, cracks, holes, and protruding laterals. This deterioration can be due to the type of material used for the pipe system or failure of the material used to seal pipe joints.

Another contributor to sanitary system failure is poor siting or installation techniques. Some sewer lines may be placed in a way that makes them very dependent on the support of the surrounding earth. When movement in the earth surrounding these lines occurs, cracks or misaligned and open pipe joints are the result.

Another factor may be the inadequate size of the existing sewer pipe. New sewer hook-ups, underground water infiltration/inflow, and inputs from roof and/or yard drain connections can cause a system to be overloaded due to the inability of undersized sewer pipe to handle increases in wet weather discharges.

Other factors, both man-made and natural, may also contribute to SSOs. Roots can create stoppages, as well as damaging the structural integrity of the sewer line. Grease from both residential and commercial sources can clog sewer lines. Ground water influences and temperature fluctuations may also contribute to sanitary sewer system failure. Equipment failure and power outages that affect pumping stations and sewage treatment plant operations also contribute to overflows.

Design Considerations

Programs designed to control sanitary sewer overflows need to establish policies for designing, screening and maintaining the sanitary sewer system. Many overflows are the result of inadequate operation and maintenance, improper design and construction, or poor planning that has resulted in new development exceeding the system capacity of an area. Sanitary sewer overflows can often be reduced or eliminated by a number of practices, including the following:

- Sewer system cleaning and maintenance
- Reducing infiltration and inflow through rehabilitation and repair of broken or leaking sewer lines
- Enlarging or upgrading the capacity of sewer lines, pump stations, or sewage treatment plants
- Constructing wet weather storage and treatment facilities to treat excess flows
- Addressing SSOs during sewer system master planning and facilities planning

A number of key elements should be included in programs seeking to control SSOs. Guidance on structuring and organizing operation, maintenance, and remediation of sanitary sewer collection systems suggests that the following measures be incorporated by sewer authorities (USEPA, 1998):

- Identification and tracking of sanitary sewer discharges
- Identification of the causes of any overflow through monitoring and field screening

Many of the same monitoring techniques used to identify other illicit connection sources are also used in sewer system evaluation surveys. These include the following:

Physical inspection. This involves examining the physical condition of manholes and other sewer structures to determine their structural integrity and to identify possible sources of infiltration/inflow.

Flow monitoring/flow isolation. Rainfall gauges are installed to monitor subbasins with overflow problems by collecting and analyzing flow data during normal and storm-related weather events.

Smoke testing. Smoke testing is used to locate defects in sewer mains and laterals that contribute infiltration/inflow to the sewer system. Smoke testing involves injecting a non-toxic vapor (smoke) into the manholes and following its path of travel in the mains and laterals.

Dye water flooding. Colored dye is added to the storm drain water. Dyed water appearing in the sanitary sewer system indicates an existing connection between the sewer and storm drain system.

Closed-circuit television inspection. This is a useful tool in locating specific sources of infiltration as well as in determining the structural condition of the sewer system. This information is necessary for the design of sewer replacement and rehabilitation projects.

Sewer maintenance records. The review of records helps identify areas with frequent maintenance problems and can indicate potential locations of system failure.

- Implementation of both short-and long-term remediation actions and modification of operation and maintenance measures to mitigate the impacts of overflows as quickly as possible and prevent reoccurrence
- Public notification of overflow events and impacts
- Provision of adequate maintenance, both preventative and routine, and updating procedures as problems arise
- Ensuring that maintenance facilities, equipment, and inventory are adequate
- Implementation and enforcement of sewer use ordinances or other legal documents that prohibit new connections from inflow sources, guarantee testing and inspection of all portions of the collection system that handle discharge (including new collector sewers and service laterals which may be owned by another entity), and regulate the discharge of toxics and pollutants that may endanger public safety or the physical integrity of the system or cause the municipality to violate water quality limitations
- Development and tracking of system performance indicators, including hydraulic performance, during wet weather flows.

There are a number of excellent resources in the reference section that explain in greater detail the monitoring techniques and reporting requirements for sewer collection systems and the operation and maintenance procedures for correcting system problems.

Limitations

As with most illicit connection detection, identifying exact causes of sanitary sewer overflow can be time consuming and difficult. The biggest obstacle to identification and correction of sanitary sewer overflows is often the issue of public access to private property. In some areas, significant inflow to the system may be present from improper connections from private sources. In order to correct these connections, an ordinance to ensure the authority for inspection may be necessary. An example of a sewer use ordinance for the city of St. Louis, Missouri, is available for review at the Center for Watershed Protection web page at http://www.cwp.org. Some municipalities have taken the opposite approach and instituted programs that provide homeowners with cash incentives or financial assistance to correct improper connections.

The cost of equipment and staff time for SSO correction may also present a burden for some municipalities. Included in those costs would be inspection equipment, replacement of undersized sewer lines, and upgrading of treatment plants or pumping stations. These system repairs and the materials required could be expensive, and homeowners may be reluctant to pay for a service that they see as having no benefit to them.

Maintenance

A schedule of regular maintenance of the sanitary sewer collection system is a good way to avoid more expensive repairs due to system failure. Preventative maintenance through scheduled inspections and routine cleaning of the sewer system can identify and help eliminate many of the causes of SSOs.

Effectiveness

The elimination of SSO sources can have a significant impact on water quality. Blockages, breaks, and infiltration and inflow in municipal sewer systems create overflows that represent a significant risk to humans and the environment. Because SSOs involve the discharge of raw sewage, there are a number of microorganisms present that can affect the health of the urban population. This untreated sewage enters streams or other water bodies and affects the aquatic habitat and organisms present. Raw sewage often contains pollutants and toxics that impact the aquatic environment by limiting dissolved oxygen levels and promoting algal blooms.

Cost Considerations

Sanitary sewer collection systems are a valuable part of a municipality's infrastructure. EPA estimates that our nation's sewers are worth more than $1 trillion (USEPA, 1996). The collection system of a single large municipality is worth billions of dollars, and that of a smaller city could cost many millions. Reducing or eliminating SSOs can be expensive, but the cost must be weighed against the value of the collection system and the costs of replacing this asset if it is allowed to deteriorate. Ongoing maintenance and rehabilitation add value by maintaining the system's capacity and extending its life. The costs of correcting SSOs can vary widely by community size and sewer system type. Costs will often be highest and ratepayers will pay more in communities that have not put together regular preventive maintenance or remediation programs to deal with system failures. Table 1 gives examples of the cost associated with sanitary sewer remediation to both homeowners and the agency responsible for management of the sanitary sewer collection system.

Table 1. Three case studies of SSO costs.

Location	Cost to Agency or Municipality	Cost to Homeowner
Washington Suburban Sanitary Commission, Maryland	From 1990 to 1994, SSO-related basement backups totaled 2,690, with an average cleanup cost of $700 each Upgrades at pumping stations and sewage treatment plants: $38 million Collection system improvements: $22 million Sewer reconstruction: $6 million (annual) Maintenance program: $10 million (annual)	$50 per household per year
Lynn, Massachusetts	$2.6 million	$10 per household per year
Louisville/Jefferson County, Kentucky	Long-term budget plan for corrective actions totaled $14.6 million	$40 per household per year

SSOs also have significant economic impacts. Shellfish bed closures and bans on fish consumption create economic hardships for associated industries. Water body closures can affect tourism and property values. Basement cleanups due to sewage backup must be done at homeowner and municipal expense.

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