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Illicit Discharge Detection and Elimination

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This course was adapted from United States Environmental Protection Agency (U.S. EPA) Best Management Practice relating to “Illicit Discharge Detection and Elimination”, which is in the public domain.

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.

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Failing Septic Systems

Illicit Discharge Detection and Elimination

Description

Septic systems provide a means of treating household waste in those areas that do not have access to public sewers or where sewerage 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 be 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

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).



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)

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

^aBOD=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

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).



Many marinas provide pumpout stations for safe disposal of bilge (Source: Oregon State Marine Board, 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

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.



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

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 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	<p>From 1990 to 1994, SSO-related basement backups totaled 2,690, with an average cleanup cost of \$700 each</p> <p>Upgrades at pumping stations and sewage treatment plants: \$38 million</p> <p>Collection system improvements: \$22 million</p> <p>Sewer reconstruction: \$6 million (annual)</p> <p>Maintenance program: \$10 million (annual)</p>	\$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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Identifying Illicit Connections

Illicit Discharge Detection and Elimination

Description

Illicit connections are defined as "illegal and/or improper connections to storm drainage systems and receiving waters" (CWP, 1998). A discharge of industrial wastewater to a storm sewer is "illicit" because it would ordinarily require a permit under the Clean Water Act. Many building owners or operators are not aware that improper connections exist in their facilities. Identifying and removing illicit connections is a measure for reducing storm water pollution. In extreme cases of illicit dumping, legal action is necessary.

From 1987 to 1998, Wayne County, Michigan, investigated 3,851 businesses and industries for illicit connections to the county's storm sewer system. Of those investigated, about 8 percent had illicit connections, and where one illicit connection was found, there was an average of 2.4 improper connects at that business. To prioritize the investigation, the county relied on Standard Industrial Classification (SIC) codes of the businesses. The prioritization system was found to be successful in locating illicit discharges (Johnson and Tuomari, no date; Tuomari, no date). The City of Hialeah, Florida, uses its storm water management plan to emphasize illicit discharge detection and removal as part of its overall monitoring activities. There are at least 252 outfalls in the city, 72 of which drain into city rights-of-way. After considering the costs associated with removing illicit discharges, the city chose a proactive field screening program approach to remove these discharges (City of Hialeah, 1999).



One of the ways to identify illicit connections is by inspecting storm drain system using video equipment (Source: Drain Patrol, no date)

Applicability

Identifying illicit and improper connections are necessary for all sewer systems, especially in areas where pollutants with unknown sources have been detected in receiving waters. The level and types of industrial activities and the surrounding land uses and ordinances will affect the methods used to identify illicit connections.

Implementation

Some practices used to discover and prevent illicit connections are

- Instituting building and plumbing codes to prevent connections of potentially hazardous pollutants to storm drains.
- Organizing structures to be inspected by building age, with older buildings identified as priorities. Buildings whose processes have the potential to affect water quality also should be given priority.

- Mapping each area to be surveyed and indicating the route of the sewer system and the locations of storm drains on the map. This enables planners to estimate the likely locations of illicit connections. A Geographic Information System (GIS) is an appropriate tool for identifying illicit discharges. The location of illicit discharges can be maintained by a geo-coded address. The attributes for illicit discharges are SIC code, owner/occupant information, inspection schedule, inspection dates, and comments (Huey, 2000).

To help municipalities detect illicit connections to storm sewers, the North Central Texas Council of Governments (NCTCOG) used GIS to develop a 1/4-mile grid cell overlay for the entire 16-county NCTCOG region. The initial report suggested that illicit connections were not as prevalent in the North Central Texas area, and sewage material was observed in about 10 percent of the sites (NCTCOG, 2000).

The City of Greensboro, North Carolina, is using GIS technology as part of its storm water management program. This GIS system is used to in conjunction with the program's monitoring aspect to identify illicit connections. More information on this program can be found at www.ci.greensboro.nc.us/stormwater/dynamic%5Fwatershed%5Fmanagement%5Fpro.htm (Bryant et al., 1999 and City of Greensboro, 2000).

- Survey individual buildings to discover where connections to storm drains exist.
- Inspect sewer lines with television equipment to visually identify all physical connections.
- Compare the results of the field tests and the video inspection with the known connections on the map. Suspicious areas should be further investigated.
- Institute mandatory inspections for new developments or remodeling to identify illicit connections to the storm sewer system.
- Remove and test sediment from the catch basins or equivalent structures.
- Inspect connections in question to determine whether they should be connected to the storm drain system or to the sanitary sewer. Use methods of identification such as dye testing, visual inspection, smoke testing, or flow monitoring, as described below.
 - *Dye Testing.* Flushing fluorometric dye into suspicious downspouts can be useful to identify illicit connections. Once the dye has been introduced into the storm system via the connection in question, the water in the collection system is monitored to determine whether an illicit connection is present.
 - *Visual Inspection.* Remotely guiding television cameras through sewer lines is another way to identify physical connections.

- *Smoke Testing.* Smoke testing is another method used to discover illicit connections. Zinc chloride smoke is injected into the sewer line and emerges via vents on connected buildings or through cracks or leaks in the sewer line. Monitoring and recording where the smoke emerges, crews can identify all connections, legal and illegal, to the sewer system. Mechanisms on drains should prevent the smoke from entering buildings; however, in some instances, this will occur. It is important to notify the public that the smoke is non-toxic, though it should be avoided as it can cause irritation of the nose and throat for some people.
- *Flow Monitoring.* Monitoring increases in storm sewer flows during dry periods can also lead investigators to sources of infiltration due to improper connections.
- *Infrared, Aerial, and Thermal Photography.* Researchers are experimenting with the use of aerial, infrared, and thermal photography to locate dischargers by studying the temperature of the stream water in areas where algae might be concentrated and in soils. It also examines land surface moisture and vegetative growth. This technique assumes that a failing OSDS, for example, would have more moisture in the surface soil, the area would be warmer, and the vegetation would grow faster than in the surrounding area (Johnson and Tuomari, no date).

On November 17 and 30, 1999, the Arkansas Department of Health used infrared technology to identify illicit discharges from septic systems into Lake Conway, Arkansas. Lake Conway, located in Faulkner County, Arkansas, is a man-made lake used mostly for recreational fishing. Approximately 90 percent of the residents within 1 mile of the lakefront have onsite wastewater treatment systems. Of the 2,500 to 3,500 residents who living within 300 feet of the shoreline, only 250 are connected to the public sewer system. Most of these systems are more than 30 years old and were installed before state regulations. The inspector used a state policy helicopter that was equipped with a Forward Looking Infrared imaging system, video equipment, and a global positioning system. The results of this two-day survey indicated that there are approximately 380 malfunctioning and improperly constructed septic systems within 300 feet of the lakefront (Eddie, 2000). Facility owners should be required to correct the problem by eliminating the discharge and connecting to the sanitary sewer system

Some agencies use a priority system for identifying illicit discharges. According to the Southeast Michigan Council of Governments (1987, cited in Tuomari, no date), a priority scheme for detecting illicit discharges from businesses should be as follows:

1. Automobile-related businesses/facilities and heavy manufacturing
2. Printers, dry cleaners/laundries, photo processors, utilities, paint stores, water conditioners, chemical laboratories, construction companies, and medium light manufacturing
3. Institutional facilities, private service agencies, retail establishments, and schools

Limitations

There are several limitations to programs to detect illicit connections. First, a local ordinance is necessary to provide investigators with access to private property in order to perform field tests (Ferguson et al. 1997). Second, rain fall can hamper efforts to monitor flows and visual inspections. In addition, smoke testing and dye testing may become more difficult, depending on the severity of the storm event. Smoke testing has roughly the same efficiency as door-to-door investigation, and both smoke and dye testing are more accurate than visual inspection.

Despite the difficulty in 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 employees, thereby saving expense on inspectors and directing resources more efficiently.

Maintenance Considerations

Identifying illicit discharges requires teams of at least two people (volunteers can be used), plus administrative personnel, depending on the complexity of the storm sewer system. To help identify illicit discharges, the City of Raleigh, North Carolina, has illicit discharge regulations and dry weather screening for illicit discharges and connections. By taking baseline samples throughout the city, pollution control efforts can be better established for future identification of illicit discharges. This inventory, combined with the city's mapping effort, will be added to the city's GIS to allow for improved tracking of illicit discharges and spills (City of Raleigh, 1998).

Effectiveness

An illicit discharge detection program can be an effective method to reduce the quantity of industrial or commercial pollutants that enter the storm drain system. For example, the Department of Environmental Protection in Montgomery County, Maryland, has an illicit discharge detection and elimination program called "Pipe Detectives," which uses volunteer monitoring and community hotlines to identify suspicious discharges (MCDEP, 1997). When discharges are reported, DEP consults maps of the surrounding areas and targets those areas for additional monitoring to narrow the search for the illicit connection. In one instance, a "milky white" discharge was reported in an area with many small businesses and large apartment buildings. Businesses were sent informational letters advising them of the illegal discharge and requesting their assistance in identifying it by allowing DEP to survey the properties. Through this cooperative effort, three illicit connections were detected and removed, including a sink that was used to wash paintbrushes (the source of the milky white discharge).

The City of Denver Urban Drainage and Flood Control District (UDFCD) is an independent agency whose functions include master planning, design and construction, maintenance, floodplain management, and management of the South Platte River. The master planning aspect includes major drainageway master planning, outfall systems planning, preparation of drainage criteria manuals for local governments and the district, support of special projects, and wetland projects. The City of Denver has a Storm Drainage Master Plan, which identified \$100 million in necessary drainage improvements. The district uses pollutants and education materials to limit illicit discharges to storm drains (City of Indianapolis and Marion County, 2000).

As part of the Rogue River National Wet Weather Demonstration Project, Wayne County, Michigan, offers training for illicit discharge elimination. Four training courses are offered: Overview, Basic Investigations, Advanced Investigations, and Prevention of Construction-Related Illicit Discharges. More information on these training opportunities can be found at <http://www.wcdoe.org/rougeriver/techtop/index.html>.

EPA's Surf Your Watershed (<http://www.epa.gov/surf>) can help citizens and business/industry owners identify into which watershed their storm drains flow.

The Conservation Technology Information Center (CTIC), a non-profit data and technology information transfer center, has created *Know Your Watershed* (www.ctic.purdue.edu/KYW). This web site allows individuals to learn their watershed address by entering their city, county, or river name, or their ZIP code.

Cost Considerations

The cost of smoke testing, dye testing, visual inspection, and flow monitoring can be significant and time-consuming. Site-specific factors, such as the level of impervious area, the density and ages of buildings, and type of land use will determine the level of investigation necessary. Case studies in Michigan have estimated the cost of two field staff and required support at \$182,000 to \$187,000 annually (Ferguson et al., 1997). Wayne County's budget for illicit detection investigations was \$735,151 from 1996 to 1997 and \$599,041 for 1997 through 1998 (Johnson and Tuomari, no date).

Many programs offset some of their cost by encouraging the reporting of illicit discharges by 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 by 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 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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Wastewater Connections to the Storm Drain System

Illicit Discharge Detection and Elimination

Description

An illicit discharge is considered to be a discharge composed of non-storm water that enters the storm drain system through an unwarranted connection. Storm sewer systems are sometimes employed as an inexpensive or convenient alternative to proper disposal of wastewater to treatment plants. These illegal wastewater discharges can occur as illicit connections from commercial or business establishments or illegal dumping into storm drain inlets. Illicit connection detection and elimination programs seek to prevent contamination of ground and surface water supplies by regulation, inspection, and removal of these illegal sources of wastewater discharge.

Pollutants that may be found in these untreated wastewater discharges include raw sewage, heavy metals, oil and grease, solids, detergents, chlorine, potassium, ammonia and nutrients. These pollutants can have implications for both human health and the aquatic environment. Bacterial contamination from raw sewage can spread disease and close waters to fishing and swimming, and heavy metals are known to be toxic to aquatic organisms. Excessive nutrient loads can lead to eutrophication in lakes, reducing oxygen levels, and affecting aquatic species.



An example of an illicit wastewater connection is a cross-connect of a shop drain to the storm sewer. This type of improper connection often occurs in automobile-related facilities (garage/repair, tire stores, service stations, muffler/transmission shops, car washes, and auto dealerships). The Wayne County, Michigan, illicit connection investigation program found that the majority of illicit connections in nonresidential facilities were drains connected to storm sewers (Johnson, 1998). Many times the connection of the shop drain to the storm drain system is unknown to the business owner, and may not be evident in architectural plans. Shop drains that may potentially be connected to the storm sewer include floor drains, wash sinks, sump pumps and solvent sinks.

Applicability

Illicit connection programs tend to concentrate their efforts on areas where nonresidential facilities are located. The USEPA has estimated that approximately 60 percent of the businesses known to use or store petroleum products were improperly connected to the storm sewers systems (USEPA, 1991, as referenced by the Rouge River National Wet Weather Demonstration Project). These improper connections often happen during new construction activities. Inadequate mapping of the internal plumbing connections for a building can lead to wastewater being discharged incorrectly to storm drains. Sewer maps may also be incorrect, leading to cross connections between the sanitary sewer lines and the storm sewer system.

Thorough inspection and verification by monitoring during the entire construction phase can prevent the illegal connection of wastewater sources during new construction. For existing facilities, the location of improper connections will require the use of field screening procedures, source testing protocols, and visual inspection.

Design Considerations

Programs that address illicit connections, including wastewater connections, typically use a combination of monitoring, inspection, and public outreach to achieve the goal of eliminating improper discharges to the storm drainage system. With many communities facing limited budgets and resources, it is important that investment in an illicit detection program have the greatest return possible.

Field monitoring is an essential component of an illicit detection program and is very valuable for creation of a cost-effective program. Monitoring drains that have dry weather flows will allow program managers to focus their illicit detection investigations on those outfalls that do not meet water quality standards. Once an outfall is identified as having a high priority through visual inspection, there are a few ways to find the source of the problem. Using closed circuit television testing may reveal a connection that is discharging suspicious material. Spot testing at storm drain manholes upstream of the outfall may aid in isolating an area where the problem discharge is coming from. Infrared and thermal photography have also been used to identify suspect discharges.

Once an area is identified as requiring further investigation, a letter should be sent to facility owners or operators in that area to that alert them that their facility has been selected for an illicit connection inspection. An inspection appointment is made, and field crew determines the location of storm and sanitary sewer manholes and the locations of all plumbing fixtures in the facility. Using either a trace dye or smoke test, the facility is monitored for any illicit connection. If the dye is seen in the storm sewers or smoke is seen in the facility, an inspection team identifies the likely source of the illicit connection.

If a plumbing fixture is found to be connected to the storm sewer, or discharging to either surface water or the ground, the facility is informed of the violation. The facility is given a time frame in which to respond to the violation. Following this period, the fixtures are retested. If the connection has not been corrected, further disciplinary action may be taken if the business or property owner has not provided a description of the corrective actions that were taken.

The general housekeeping practices of a facility should also be examined during an inspection. Issues such as proper storage of hazardous materials and where wastewater from cleaning equipment is emptied should be reviewed with facility operators. This check will help eliminate potential sources of pollutants entering the storm sewers system.

An inspection program of existing septic systems to identify failing systems will also prevent wastewater discharges to storm drains or receiving waters. Requiring inspection of on-site wastewater systems at the time of property transfer and developing a database that tracks septic system pumpouts can help this effort. This process could be done in cooperation with the local health department.

Limitations

A number of limitations might occur during the establishment and operation of an illicit connection program. One is the time and effort it takes to inspect each individual site if program managers plan to inspect all the facilities within their community. Many times illicit connection programs are just one aspect of a public works' or environmental department's mission, so the ability to monitor and inspect nonresidential facilities may be limited by staff availability. In some instances, agencies primarily use citizen complaints to identify potential sources of illicit connections due to staff requirements. Citizens can play an important role in monitoring and inspecting the system to save the municipality money. Louisville and Jefferson counties in Kentucky employ students in the summer to conduct dry weather sampling and system inspections. Monterey, California, has trained citizen volunteers to help with outfall sampling (NRDC, 1999).

Another limitation is the issue of public access to private property. Inspectors responsible for illicit discharge detection and elimination must have access to private property to identify and remove the connections that are the source of illegal non-storm water discharges. An ordinance guaranteeing "right of entry" to private property is critical to allowing inspectors to identify and take corrective actions on individual sources of illicit discharges.

A final limitation is the intermittent nature of illicit discharges. Because wastewater discharges from illicit connections do not necessarily happen on a consistent basis, it is difficult to identify areas where these connections exist unless constant monitoring occurs.

Maintenance Considerations

Two-person teams should be capable of performing field investigations and inspections. The number of teams required in a program will be based on the size of the community, the number of nonresidential facilities to be inspected, and the number of storm drain outfalls to be monitored.

Effectiveness

The effectiveness of illicit discharge programs at removing pollutants from storm water has not received extensive study at this time. Some program managers have estimated the amount of pollutants they believe to have been removed by their programs (see the fact sheet on Industrial Connections, as well as below), but percentage estimates for individual pollutant removal effectiveness are currently difficult to locate. Table 1 from the Wayne County Illicit Connection Control Program shows the estimated reduction in pounds of pollutants due to illicit connection elimination for the years 1991–1994.

Table 1. Estimated pounds of pollutants removed by illicit connection control program, 1991–1994 (Source: Wayne County Dept. of Public Health Illicit Connection Investigation Program Quarterly Report)

Pollutant	Pounds Removed
Ammonia	165
Chlorine	54
Potassium	34
Total Phosphorus	148
Biological Oxygen Demand	2,010
Chemical Oxygen Demand	5,800
Flow, Storm Water to Sanitary System	850,000 (gallons/year)
Surfactants as MBAs?	2,554
Suspended Solids	2,010
Total Solids	6,790
Volatile Solids	2,800

Illicit connection elimination programs have been identified by the USEPA as an important tool in protecting urban water quality. EPA's Nationwide Urban Runoff Program (NURP) recognized the importance of addressing pollutants from inappropriate entries to the urban storm drain system (Lalor and Pitt, 1999). A recent example from the state of Virginia further illustrates the need for such programs. In 1998, sanitary sewer lines from nine condos inside a large housing complex were found to have been inadvertently connected to a roof drain that drained to storm sewer pipes. This cross-connection into the storm drainage system went undetected by authorities (despite periodic odor complaints by local residents) for more than 27 years. While this problem has been fixed, more than 6 million gallons of raw sewage were estimated to have been discharged into the Four Mile Run stream over the course of that 27 years (NVRC, 2001).

Examples such as these demonstrate the need for illicit connection elimination programs. By preventing wastewater discharges to the storm drain system, these programs reduce pollutant loads and protect water quality and the aquatic environment from the effects of these non-storm water discharges.

Cost Considerations

The costs of illicit connection detection and elimination programs vary with the intensity of effort and the amount of staff dedicated to the program. Wayne County, Michigan, has an average annual cost of \$187,000 for their program. This budget pays for a full-time, two-person field crew and one part-time field crew and allows them to perform 325 to 350 site inspections annually.

Some programs have offset the cost of field monitoring by using volunteers to adopt outfalls and monitor stream quality. Citizen hotlines broaden the involvement of the public in illicit discharge surveillance. These measures help identify areas where inspection crews can focus their efforts.

Another way to save staff time and money is by establishing a certification program. This program could identify properties that have checked their buildings and found no illicit connections. If inspectors know what buildings have been evaluated, time could be saved when tracking down contamination.

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Illegal Dumping

Illicit Discharge Detection and Elimination

Description

Illegal dumping is disposal of waste in an unpermitted area, such as a back area of a yard, a stream bank, or some other off-road area. Illegal dumping can also be the pouring of liquid wastes or disposing of trash down storm drains. It is often called "open dumping," "fly dumping," and "midnight dumping" because materials are often dumped in open areas, from vehicles along roadsides, and late at night. Illegally dumped wastes are primarily nonhazardous materials that are dumped to avoid paying disposal fees or expending the time and effort required for proper disposal (USEPA Region 5, 1998).

Applicability

Illegally dumping wastes down storm drains and creating illegal dumps can impair water quality. Runoff from dumpsites containing chemicals can contaminate wells and surface water used as sources of drinking water. Substances disposed of directly into storm drains can also lead to water quality impairment. In systems that flow directly to water bodies, those illegally disposed-of substances are introduced untreated to the natural environment. For example, the state of Oklahoma has 2,446 illegal dumps, which will cost \$3,922,000 to clean up. As part of its pollution prevention efforts, the Oklahoma State University's Cooperative Extension Service has developed a series of posters and other displays to promote awareness of the problems that result from illegal dumping.



A "No Dumping" sign discourages illegal dumping by threatening arrest (Source: @Home WebSpace, Neuskool, 2000)

Implementation

Municipalities and organizations all over the United States have implemented programs to stop the illegal dumping of trash and used materials. The most important method of implementing such programs is public education. To ensure their effectiveness, some programs allow for citizen reporting of illegal dumpers, who can then be fined, sentenced to jail, or be required to perform community service.

Some clues can help citizens identify illegal dumpers (Fairfax County, 2000):

- Illegal dumping often occurs late at night and before dawn.
- There is often no company name on the construction vehicles or equipment.
- The construction activity occurs on a site with no company advertising sign.
- There is no construction entrance adjacent to the roadway (an area of large stone and gravel placed to keep mud off streets).

In 1993 the North Central Texas Council of Governments (NCTCOG) initiated a public outreach program called *Our Water—Take It Personally*. The campaign includes storm water stenciling that reads "Don't Dump—Protect Our Water." In 1993 NCTCOG won the Keep Texas Beautiful President's Award for its efforts to address illegal dumping. Tarrant County, Texas, has initiated an aggressive public reporting program to stop illegal dumping. Work with public and private entities to develop a manual, *Storm Water Quality Best Management Practices for Industrial Activities—North Central Texas*, has also been successful (NCTCOG, 2000a, 2000b).

The Dallas County Illegal Dumping Hotline (1-888-335-DUMP) is a 24-hour hotline for citizens to report illegal dumping in Collin, Dallas, Denton, Ellis, Erath, Hood, Hunt, Johnson, Kaufman, Navarro, Palo Pinto, Parker, Rockwell, Somervell, Tarrant, and Wise counties. Citizens are asked to leave as much information as possible—city and county of the incident, specific street location, license plate number and description of vehicle, personal description of violator, type of waste dumped, caller's name and telephone number, date of violation. As an incentive to report illegal dumping, a \$50 reward is given to reporting individuals if their information leads to an arrest (the City Web, 1998).

Earthwater Stencils, Inc., supports storm water pollution prevention by providing materials such as posters, stencils, and brochures to community-based storm drain stenciling and related programs in local watersheds. Their web site (www.earthwater-stencils.com) offers information on how and where to stencil and how to obtain stenciling materials.

Clean Ocean Action, a nonprofit organization that focuses on the New Jersey/New York coast, has designated 2 weeks of the year as "Storm Drain Stencil Week." They offer free storm drain stenciling kits to teachers and also have available a variety of lesson plans and activities about storm drains.

Effectiveness

Illegal dumping regulations must be enforced. In Chicago, Illinois, penalties for dumping without a permit can include fines up to \$2,000, 6 months in jail, and up to 200 hours of community service. Violators are liable for up to three times the cost of cleaning up a site, and city contracts can be terminated. Vehicles are subject to seizure and impoundment, with the owner of record liable for a \$500 fine in addition to towing and storage fees. Finally, owners or occupants of any unimproved parcel of real estate must remove any abandoned or derelict motor vehicle, garbage, debris, refuse, litter, or miscellaneous waste. Violations can result in fines of \$200 to \$1,000 per day. These regulations are promulgated under Ordinances 7-28-440 and 7-28-450, Municipal Code, City of Chicago (USEPA Region 5, 1998). Hawaii has instituted a similar program. In 1998 Governor Cayetano enacted a law that imposes fines and jail time on individuals or groups that operate or use illegal dumps. Open dumps throughout the state have been found to lead to groundwater and surface water pollution, as well as odor problems and fires of hazardous materials. The sites are often at least 5 acres and are not visible from public roads because they are on private property or behind closed gates (HDOH, 1998).

Local police department or other public entities can play a major role in catching illegal dumpers. The Central Oklahoma Trash Cop Program, which consists of environmental officers hired to catch and prosecute litterers and illegal dumpers in four counties, was begun with \$160,000 obtained through fundraising efforts by a local community group, Oklahoma City Beautiful. The program will be sustained by fines collected from offenders (USEPA Region 5, 1998).

Reliance on public reporting is an important factor in the effectiveness of anti-illegal dumping programs. Municipalities can develop citizen reporting hotlines or web site forms. Program administrators must ensure that these reports are followed up and that the reporter receives a notice of the results. Otherwise, the incentive for reporting could be lost. San Diego County (California) has a toll-free telephone number and a web site reporting form (www.co.san-diego.ca.us/cnty/cntydepts/landuse/env_health/stormwater/sw_report_dumping.html) for reporting illegal dumping. Citizens are encouraged to report anyone seen dumping anything onto street surfaces or into the storm drains in the county.

In some cases, citizens have been rewarded for helping clean up illegal dumpsites. PhilaPride, a nonprofit group in Philadelphia, Pennsylvania, promotes neighborhood participation in cleanup and enforcement activities. The program is funded primarily by corporations that have had dumping problems on their properties, such as the Conrail Corporation, which contributes up to \$25,000 each year (USEPA Region 5, 1998). A community group in Detroit, Michigan, uses a county grant to pay residents to bring illegally dumped tires to drop-off locations. A local waste hauler donates services to transport the tires to a tire shredder, which shreds them at no charge. A local bank donates money to cover disposal costs (USEPA Region 5, 1998).

Design Considerations

Illegal dumping programs might also include monitoring of roads that have often been used for trash disposal. Other methods are as simple as public education, such as storm drain stenciling (See [Storm Drain Stenciling](#) fact sheet). Both programs depend on citizen reporting of illegal dumpers.

Storm drain stenciling is an effective method of raising public awareness of the impacts of storm water runoff on water quality. Stenciling neighborhood storm drains reminds car owners not to dump their motor oil down the drain. It helps all neighbors realize that throwing their trash down the storm drain could have negative effects on their local river. Storm drain stenciling programs can be started by any local group, such as the Boy Scouts, a school class, or a neighborhood association. It is an activity that is quick, easy, and fun.

Limitations

Determining which storm drains to stencil is a vital step. Groups must ensure they have the proper authority's permission to paint storm drains. In terms of reporting illegal dumpers, citizens must be assured that their efforts to contact reporting agencies will result in action by authorities. The city of Jacksonville, Florida, has a citizen complaint form on its web page at www.coj.net/pub/resd/airwater/CCFORM.HTM.

Some of the categories of complaints are "discharge of pollutants to storm drains, ditches, rivers or creeks," "overflowing manholes or pump stations," "uncontrolled erosion from land clearing activities," and "pumping of muddy water into creeks, storm drains, or ditches." City staff have established a goal of contacting complaint submitters within 24 hours (City of Jacksonville, 2000).

Maintenance

Municipalities should set goals for reducing the number of illegal dumping acts. The city of Sacramento, California, has set a goal of stenciling 45,000 storm drains throughout the city.

Citizen participation and reporting are important steps in maintaining an anti-illegal dumping program. Furthermore, proper enforcement must be implemented to discourage others from performing these illegal acts.

Cost Considerations

Costs for implementing illegal dumping programs vary. Storm drain stenciling by volunteers is inexpensive because there are only small costs for the stencils and paints. Cash incentives like the \$50 reward offered in Dallas County are likely to be minimal costs, because the rewards would not be granted until after a conviction. Actual monitoring by local police or another authority can be more expensive and would require funding in the locality's budget.

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