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Combined Sewer Overflow Technology Fact Sheet
Inflow Reduction

DESCRIPTION

This fact sheet describes inflow reduction, a practice designed to minimize the volume of storm water runoff that enters a combined sewer system (CSS). Inflow reduction can result in a lower combined sewer overflow discharge volume and may reduce the number of combined sewer overflows.

CSSs are wastewater collection systems designed to carry both sanitary sewage and storm water runoff in a single pipe to a wastewater treatment plant. During wet weather periods, the hydraulic capacity of the CSS may become overloaded, causing overflows to receiving waters at discharge points within the CSS. These overflows are called combined sewer overflows, or CSOs. Inflow reduction refers to a set of control technologies that are used to reduce the amount of storm water entering the CSS from surface sources. Inflow reduction can be a cost-effective way to reduce the volume of flow entering the CSS and the volume and/or number of CSOs. It is particularly applicable in CSO communities where open land is available to accommodate redirected flow for infiltration or detention, or where storm water can be diverted to surface waters.

By helping to reduce the overall flow volumes into a CSS, inflow reduction technologies help to optimize the system's storage capabilities. Maximizing storage in the collection system is one of the nine minimum controls that every CSO community is expected to implement in accordance with the Environmental Protection Agency's 1994 CSO Control Policy.

Technologies used to reduce inflow include:

- Roof drain redirection.
- Basement sump pump redirection.
- Flow restriction and flow slipping.
- Storm water infiltration sumps.
- Stream diversion.

All of these technologies have relatively low costs, and most require little maintenance in comparison with other CSO controls.

APPLICABILITY

Roof Drain Redirection

Roof drains often convey rainfall directly from residential and commercial roofs into a CSS. Flow into the CSS can be reduced by redirecting roof drains onto lawns or into dry wells or drainfields where flows can infiltrate into the soil. Roof drain redirection (redirection) works best in residential areas where homes have open yards. Telephone, mail, or door-to-door surveys are necessary to determine the extent of roof drain connections to the CSS. Because the net volume reduction per household is small, implementation needs to be broad and consistent throughout the service area. The cumulative reduction effects of such a program can be substantial. Redirection can be either voluntary or mandatory. Cash or other incentives can be instrumental in achieving widespread redirection.

Roof drain redirection is a relatively simple task that can be done easily by individual homeowners. Therefore, it is essential to prepare guidance for homeowners who elect to perform the redirection themselves. This guidance material should also include a list of contractors able to provide redirection for a reasonable cost. Homeowners should be reminded to periodically check to make sure that redirected water is infiltrating and is not contributing to other surface water problems. The community should develop a schedule and check that homeowners who have agreed to disconnect have remained disconnected. Roof drain redirection should be combined with basement sump pump redirection where possible.

Basement Sump Pump Redirection

Many buildings have sump pumps to pump floodwater from basements. Often this water is discharged directly into the CSS. Redirecting this flow away from the CSS and onto lawns or dry wells or drainfields reduces the volume of storm water entering the CSS.

Unlike roof drains, which are common to most buildings, basement sump pumps usually exist only in discrete areas. Therefore, surveys (preferably on-site) are necessary to determine where sump pumps are located, whether they discharge directly to a CSS, and whether it is feasible to redirect them into a yard, a dry well, or an infiltration field. It is important to note that the feasibility of discharging downspout and basement sump discharges into a yard, a dry well, or an infiltration field depends on the soil type, the slope, and the drainage conditions around the home.

As with roof drain redirection, guidelines for basement sump pump self-redirection should be distributed, and the area should be checked regularly to ensure that redirected water is infiltrating and is not contributing to other surface water problems.

Flow Restriction and Flow Slipping

Flow restriction and flow slipping methods utilize roadways and overland flow routes to temporarily store storm water on the surface, or to convey storm water away from the CSS. Flow restriction is accomplished by installing static flow or "braking" devices in catch basins to limit the rate at which surface runoff can enter the CSS. Excess storm flow is retained on the surface and enters the system at a controlled rate, eliminating or reducing the chance that the system will be hydraulically overloaded and overflow. The volume of on-street storage is governed by the capacity of the static flow device, or orifice, used for restriction, as well as surface drainage patterns.

As opposed to flow restriction, where flow rates into the CSS are reduced but all storm flow eventually flows into the storm sewer system, flow slipping refers to the intentional blocking of storm water from entering the CSS at catch basins for the purpose of routing, or "slipping", it elsewhere. Flow slipping is accomplished by partially or completely blocking the entry of surface runoff at catch basin inlets and letting the runoff follow overland flow routes.

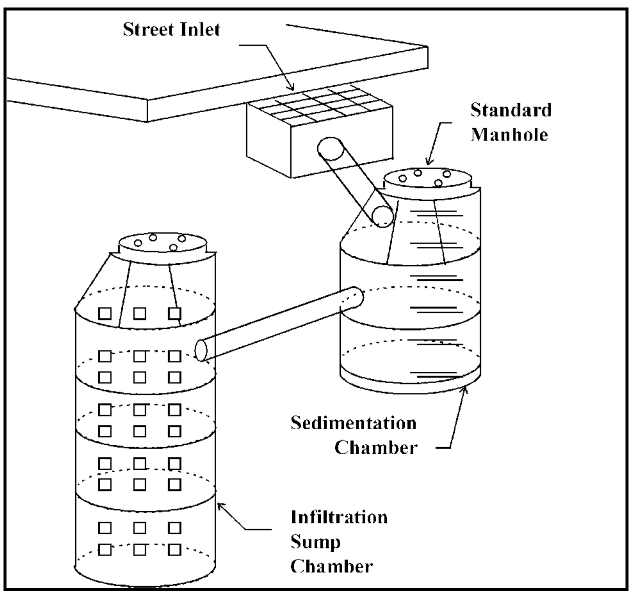
Flow restriction and flow slipping can effectively reduce inflow during peak runoff periods and can decrease CSO volume. Use of these methods must be carefully planned to ensure that sufficient surface storage or overland throughput capacity exists in the drainage area. These methods are almost always used in conjunction with other practices, such as roof drain and basement sump pump redirection.

Flow restriction works best in relatively flat areas where temporary ponding and detention of water on streets is acceptable. Extensive public education and testing are required to build support and address concerns that residents and elected officials may initially have regarding on-street storage. Flow slipping is an option where opportunities for on-street storage are not available. The "slipped" flow can be diverted along natural drainage routes to separate receiving waters, separate storm sewer systems, or even to more optimal locations within the CSS.

The use of flow restriction and flow slipping requires a detailed evaluation of the collection system and catch basins. The community must assess the potential for unsafe travel conditions, flood damage, and damage to roadways. Pilot studies and monitoring are recommended to identify impacts and confirm performance.

Storm Water Infiltration Sumps

Storm water infiltration sumps are below-ground structures used to collect storm runoff and pass it into the soil. The infiltration sumps collect runoff in standard storm water inlet structures at the ground surface, and rout it to a two-chambered system consisting of a manhole structure and an attached sump chamber. The manhole chamber serves as a sedimentation basin. As this chamber fills, flow reaches an overflow point and begins to fill the second chamber, the perforated sump. The perforations allow the water to percolate outward into the soil. The sump chambers are typically 8 to 12 meters (25 to 35 feet) deep and are surrounded with granular backfill to promote infiltration. A typical infiltration sump assembly is shown in Figure 1.



Source: Modified from city of Portland, 1997.

FIGURE 1 TYPICAL INFILTRATION SUMP ASSEMBLY

Infiltration sumps can reduce inflow in areas where the underlying soils are moderately to highly permeable, and the water table is well below the ground surface. They are generally more applicable in residential areas that are less than 50 percent impervious. It is important to get the surface runoff to streets where sumps have been installed, and implementation in conjunction with roof drain and basement sump pump redirection is recommended. Due to the potential for chemical contamination of ground water, infiltration sumps are not recommended for commercial or industrial areas.

Before starting construction of a storm water infiltration sump, the community should develop a sump management plan that addresses the policy, design, construction, maintenance, and public education aspects of the infiltration sump program, as well as addressing spill response, well monitoring, storm water runoff quality, and storm water sampling protocols. Consideration should be given to local traffic disruptions during sump installation. Sumps will need to be cleaned every two to three years to remove material that collects in the sedimentation basin.

Stream Diversion

As cities grew during the nineteenth and early twentieth centuries, many small streams were routed into pipes to facilitate development. In communities where streams have been routed into CSSs, the surface runoff once conveyed in these streams reduces capacity in the CSS and contributes to overflows. Rerouting natural streams and surface runoff away from the CSS and back to their original watercourse or to other receiving waters can have a significant impact on CSS capacity.

Urban stream diversion is one of the more expensive inflow reduction options since it typically requires design and construction of new storm drain lines. Stream diversion resembles CSO separation in that new alternative flow routes are required for surface runoff. It is typically employed in situations where less expensive and less disruptive options for inflow reduction are not feasible, or do not provide sufficient inflow reduction. The potential amount of inflow to be diverted from the CSS needs to be well documented in order to assess its cost-effectiveness.

The first step in implementing a stream diversion program is to identify and evaluate alternative routes from the stream to nearby receiving waters. It may be possible to "daylight" streams by allowing them to flow in an open channel in some semblance of their natural condition. Daylighting can provide greenspace and can serve as an amenity to the community. However, daylighting opportunities are limited in most CSS communities because the streams were originally piped in order to support property development. Diversion through separate pipe systems is also an option, and may be more practical where open space is limited and the potential for flooding is high.

ADVANTAGES AND DISADVANTAGES

Inflow reduction can be a very important part of a CSO management program. By reducing the amount of extraneous inflow to a system, CSSs may avoid CSO problems. Specific advantages and disadvantages of each of the inflow reduction methodologies discussed in this fact sheet are presented below.

Roof Drain Redirection

Roof drain redirection is a relatively simple and low cost (per unit) option for reducing storm water inflow to a CSS. However, in order for a roof drain redirection program to be successful, the public must be educated as to the benefits and methods for implementing such a program. This can be time-consuming and will most likely require some sort of rebate program or other incentive for compliance. In addition, because the effect per individual roof drain redirection is small, this program must be implemented in a wide service area to be effective.

Basement Sump Pump Redirection

Advantages and disadvantages of a basement sump pump redirection program are similar to those of roof drain redirection programs. A basement sump pump redirection program can be a relatively inexpensive and easy way to reduce flow to CSSs. However, unlike roof drains, basement sump pumps may occur less frequently and their locations may be harder to determine. And as with roof drain redirection, a basement sump pump redirection program can be time-consuming and will most likely require some sort of rebate program or other incentive for compliance. And similarly to roof drain redirection, because the effect per individual sump pump redirection is small, this program must be implemented in a wide service area to be effective.

Flow Restriction and Flow Slipping

Flow restriction and flow slipping methods can be effective ways to manage flow in specific parts of the CSS. They are relatively inexpensive and easy to implement. However, implementation will require a public awareness campaign to inform the public of the purpose of the flow diversions. In addition, these inflow reduction methods require large surface areas to temporarily store flow before it enters the CSS.

Storm Water Infiltration Sumps

While more expensive than roof drain or basement sump pump redirection, storm water infiltration sumps can be very effective in areas where there is highly permeable soil and little chance of groundwater contamination. However, infiltration sumps are not recommended for use in areas with high groundwater tables or in soils with low permeability.

Stream Diversion

Stream diversion can be an expensive method for reducing storm water inflow into the CSS. Changing a stream channel may also require numerous permits and may not meet with public approval. However, stream diversion will often cause a significant decrease in the amount of storm water flowing into a CSS.

PERFORMANCE

The performance of inflow reduction programs is usually measured by the reduction in CSS volume. As sources of inflow are identified and eliminated, the overall flow volume in the CSS decreases, and the likelihood of CSOs decreases as well. Several specific cases studies for inflow reduction are presented below.

Roof Drain Redirection

In St. Paul, Minnesota, an estimated 20 percent of CSO volume came from roof drains. As a result of a $40 rebate for voluntary redirection and other innovative outreach efforts, approximately 18,000 homes redirected their roof drains over a three year period. Presently, 99 percent of all residential properties are disconnected. In addition, the city is evaluating creative funding options to assist commercial and industrial property owners to disconnect roof drains.

Basement Sump Pump Redirection

South Portland, Maine, conducted a visual survey of the 6,000 residential buildings in the city and found 380 homes with roof drains and 300 homes with sump pumps discharging directly into the CSS. The city mailed letters offering to reimburse each property owner for redirecting their roof drains and sump pumps. After the work was completed and inspected by the city, homeowners were reimbursed $75 for each redirected roof gutter and $400 for each redirected sump pump. The program has redirected more than 379 roof drains and 304 basement sump pumps. The resulting reduction is approximately 58 million gallons of water per year. Because of the variables involved (rainfall patterns, differing drainage areas, etc.), the city has not determined a direct correlation between these programs and CSO events; however, overall flow to the city's wastewater treatment plant has been reduced by 2 percent through these efforts.

Flow Restriction and Flow Slipping

Gently graded berms can be added to roads and used in conjunction with flow restriction to maximize on-street temporary storage. In Skokie, Illinois, a fully developed suburb of Chicago served by a CSS that covers 8.6 square miles, an integrated program was developed that emphasized berms and flow restrictors to both increase on-street storage and to reduce the peak rate of flow entering the CSS. In order to accomplish this, 2,900 flow restricting devices were installed at catch basins, and 871 berms were constructed on streets. In addition, 100 percent of the roof drains previously connected to the CSS were disconnected.

South Portland, Maine, conducted a detailed evaluation of 750 catch basins within the CSS and determined that 30 catch basins could be eliminated without any adverse safety or flood damage consequences. Solid covers were placed on these catch basins to direct flow to separate storm sewers or natural drainage. Flow slipping in this manner has reduced flow in the CSS by approximately 12 million gallons per year.

In Hartford, Connecticut, a pilot flow slipping project was implemented as part of the city's CSO abatement plan. The method employed catch basins that completely crossed the streets, incorporating sumps that could be located anywhere in the roadway. This strategy allowed the city to work around the myriad of existing subsurface utility lines. To ensure safe pedestrian crossings, the catch basins were located upgradient of pedestrian crosswalks.

Storm Water Infiltration Sumps

Infiltration sumps can be retrofitted within combined sewer areas, usually beneath the street system. In Portland, Oregon, much of the combined sewer area has highly permeable soils with a high hydraulic capacity. Portland is currently wrapping up a program that installed approximately 4,000 infiltration sumps between 1994 and 1998. Combined with other CSO control programs, including a successful roof drain disconnection program, sewer separation, and stream diversion, it is predicted that the total CSO volume will be reduced by 3 billion gallons per year (approximately half of the total CSO volume). Portland is initiating another program to maximize storage capacity in the CSS to further reduce the overflow volume.

Stream Diversion

Portland, Oregon's Ramsey Lake Wetland Project involved completely separating an urban stream from the CSS, creating a wetland to treat the separated storm water flow prior to discharge into a receiving stream. The project also provides community involvement opportunities such as school field trips for the planting of wetland plants, and there are future plans to use the facility as a nature interpretive center. Portland has six additional stream diversion projects planned.

COSTS

Cost comparisons for the wide range of inflow reduction techniques are difficult to make without consideration of site specific factors. The following section discusses the range of costs representative of inflow reduction programs. Findings are summarized in Table 1:

Roof Drain Redirection

Some programs have offered rebates or incentives of from $40 to $75 to homeowners and businesses participating in voluntary redirection programs to offset typical costs for redirection.

Basement Sump Pump Redirection

Typical costs for basement sump pump regulations are $300 to $500 per home. Full rebates can be used to encourage homeowners to participate.

Flow Restriction and Flow Slipping

Flow restricting orifice devices for catch basins are priced from $500 to $1,200 each depending on the size and number ordered. In contrast, simple steel plates to cover catch basins can be fabricated and installed for approximately $100 each. Detailed engineering studies to evaluate the collection system and catch basins require substantial in-house expertise or consultant assistance.

Storm Water Infiltration Sumps

Costs are closely related to the type of soil, the density of the sumps, and the desired amount of inflow reduction. Depending upon site specific conditions, total costs are expected to range from $2 to $8 per 1,000 gallons per year.

Stream Diversion

Costs for the Ramsey Lake Wetland Project included $500,000 for purchasing the 29.75 acre wetland area; $2.6 million for wetland planning and construction costs; $10 million for sewer separation and $3 million for new storm sewer trunklines; and $1.3 million for sump disconnection. This wetland drains 640 acres.

REFERENCES

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TABLE 1 COSTS OF INFLOW REDUCTION ACTIVITIES

Technology	Cost	Comments
Roof Drain Redirection	Costs range from $45-$75 for individual homeowners to disconnect	Rebates for individual homeowners to disconnect
Basement Sump Pump Redirection	Disconnection costs approximately $300-$500 per home	Incentive programs usually used to reimburse homeowners
Flow Restriction and Flowslipping	Flow restrictors can cost between $500 and $1,200; covers for catch basins to encourage flow slipping can cost as little as $100	Indirect additional costs may be incurred because of additional water pooling on surface streets
Storm Water Infiltration Sumps	$2-$8 per 1,000 gallons inflow removed	Costs are closely related to the type of soil, the density of the sumps, and the desired amount of inflow reduction
Stream Diversion	$17.4 million for 29.75 acre stream diversion into a created wetland in Portland, OR	Costs included land acquisition, storm sewer separation and new trunk lines, and wetland design and construction.

Source: Compiled by Parsons Engineering Science, Inc., 1999.

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