

INFLOW AND INFILTRATION TOOL BOX



Overview

This "toolbox" or guide highlights possible programs and products as potential solutions to I/I problems that communities can use.

For communities in the Twin Cities area, the ideas outlined in this document are advisory only and are not part of the Metropolitan Land Planning Act's requirements.

Please give your feedback about this guide to Kyle Colvin at the Metropolitan Council (kyle.Colvin@metc.state.mn.us).

DISCLAIMER FOR EXTERNAL LINKS

Some of the links on this site may lead to resources outside of the Metropolitan Council that are created and maintained by other public or private organizations. Links to these sites are provided as a convenience and service to users of the Council's website and may provide additional information that may be useful or interesting. However, in using such links, users must be aware of the following:

- The external linked sites are not under the control of the Council and the Council has not reviewed or investigated in any way the information at such linked sites. The Council cannot attest to the accuracy of information provided at such linked sites and makes no representation or warranty as to the contents of any linked site or any link contained in a linked site.
- The inclusion of an external link does not imply or constitute an endorsement by the Council of the linked site, or the information, products or services contained on the site.
- When users access an external linked website they are subject to the privacy and security policies of the owners/sponsors of the external site and the Council is not responsible for the information collection practices of such sites.

Please advise us about any existing external links found on this website that you believe are inappropriate.

Introduction

The MCES Inflow and Infiltration (I/I) Task Force recommended that MCES staff provide technical assistance to communities that need to reduce the peak I/I from their collection system. Rather than be prescriptive in how to reduce I/I, MCES was asked to provide information on the techniques for I/I reduction and allow local communities choices in meeting the goal for I/I management. Toward this end, MCES has prepared this document as a “tool box” for communities as they initiate programs to reduce I/I from their system.

The I/I Tool Box consists of six sections **Page**

- Section 1: Getting an I/I Reduction Program Started..... 1**
 - Legal Authority 1
 - Scope of the Program 1
- Section 2: Investigative Techniques 5**
 - Flow Monitoring 5
 - Smoke Testing 12
 - Dye Water Flooding 14
 - Closed Circuit TV Inspection 16
 - System Modeling 18
 - Building Inspections 20
 - Foundation Drain Testing 22
- Section 3: Corrective Actions: Private Property I/I Sources 24**
 - Foundation Drain Disconnection 24
 - House Lateral Repair 26
- Section 4: Corrective Actions: Publicly Owned Sewers 29**
 - Joint Sealing 29
 - Pipe Lining 29
 - Sealers..... 29
 - Spot Repairs 29
 - Line Replacement 30
- Section 5: Sample Specifications for New Construction 31**
 - Sanitary Gravity Sewers 31
- Section 6: Sample Ordinances 34**

Each section contains pertinent information to help communities understand the steps to reduce I/I. There are also references for additional information. Because I/I is a national problem, many Web sites are referenced to augment this information.

SECTION 1:

GETTING AN I/I REDUCTION PROGRAM STARTED

Communities that are about to start an I/I reduction program will want to consider several important elements of the program before proceeding. First, there is the scope of the program which affects the schedule and resources required. Because the scope is dependent on a series of investigations, the program is usually undertaken in phases. Initial phases address finding the major sources of I/I, and subsequent phases address corrective actions. Many communities already have undertaken a program to reduce I/I and may be well along the usual sequence of I/I reduction.

Legal Authority

Most communities have enacted sewer use ordinances and plumbing codes that prohibit the discharge of uncontaminated water into the sanitary sewer system. When a community needs to investigate I/I sources on private property, the community should make sure it has the legal authority to do so.

Some programs will require new ordinances to address compliance with current requirements. One example is requiring documentation of compliance at the point of sale of property. Another is enacting a special charge (penalty) for continued noncompliance.

Scope of the Program

For most communities, the I/I reduction program starts after I/I has been determined to be excessive. In the MCES service area, flow monitoring by MCES has been evaluated to identify communities that have excessive I/I. Therefore, the community I/I reduction program is likely to start with the field tests that locate the primary sources of the I/I. The usual sequence of field tests is as follows:

1. Flow Monitoring
2. Smoke Testing
3. Dye Water Flooding
4. Closed Circuit Television Inspection
5. Building Inspections
6. Foundation Drain Testing

The first four steps address I/I sources within the publicly owned collection system. Steps five and six address I/I sources on private property. These steps are described in the Investigative Techniques section of this document.

The scope of the program might include all of the above steps, but the magnitude of the effort for each step will depend on the findings of prior investigations. The purpose of proceeding sequentially is to undertake the program in the most economical way. Flow monitoring should help narrow down the area to be smoke tested. For example, dividing the service area into five similarly sized sub-areas for

flow monitoring could eliminate 20 percent of the total area from further investigations if the I/I from one sub-area is insignificant.

Resource Requirements

The I/I reduction program will require administrative support, assignment of staff, and possibly outside services. At a minimum, the program will likely require assignment of someone in the public works department or sewer utility to oversee its implementation. An assessment needs to be made regarding use of in-house staff versus contracting with private companies that offer these services. This will affect how the program is budgeted and the schedule. Use of in-house staff saves costs, but could also lengthen the schedule for implementation.

Funding of the I/I reduction program depends on the relative magnitude of the I/I from publicly owned sewers versus I/I from sources on private property. If the I/I is primarily from sources on private property, the community's participation on the cost of the corrective action will significantly affect the budget. If the cost is to be borne 100 percent by the property owner, the community costs will be limited to the investigation and enforcement. On the other hand, many communities chose to share costs with property owners, thereby taking on significant additional cost to assure program success.

Schedule

The schedule for most communities will be driven by the deadline set by MCES to eliminate excessive I/I. A typical flow of the activities, as indicated below, starts with the field investigations and ends with implementation of corrective actions (for both public and private I/I sources). For many communities, past I/I investigations have already been addressed I/I within the publicly owned system, leaving I/I from private property as the primary I/I source to be addressed.

Figure 1.1. General Schedule of I/I Reduction Activities

ACTIVITY	YEAR 1				YEAR 2				YEAR 3			
	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
Field Investigations												
Flow Monitoring	█	█										
Smoke Testing			█	█								
Dye Water Flooding			█	█								
Closed-circuit TV					█	█	█	█				
Building Inspections						█	█	█				
Foundation Testing							█	█				
Corrective Actions: Public System												
Plans and Specifications								█	█	█		
Construction									█	█	█	
Corrective Actions: Private Property												
Prepare Program									█	█	█	
Implementation										█	█	█

Communication

An important element of the I/I reduction program is public communication. Most likely, the cost of the program will affect sewer rates and implementation will

require some corrective actions on private property. As part of the program, a communication plan should be prepared to make sure the public is aware of the need for the program and the status of activities.

Public Information Programs

Public information programs provide an effective way of gaining voluntary compliance with local ordinances and codes that prohibit clear water entry into the sanitary sewer system. They are also effective in obtaining public support for the I/I reduction programs that require additional cost and inconvenience to the residents and businesses in the community. It is almost impossible to communicate too much with the public. Public information can be delivered through all types of media. Many communities maintain a Web page that is updated with information about ongoing programs.

[Reference: [Examples of Community Communication: Maplewood, Golden Valley](#)]

Other media successfully used for I/I reduction programs include:

- [Newsletters](#)
- [Newspaper articles](#)
- [Neighborhood meetings](#)
- [Flyers and door hangers](#)
- [Cable TV programs](#)

Newsletters: Newsletters issued on a routine basis have been used to introduce programs and update the public about progress and program effectiveness. Quarterly or semi-annually, a newsletter allows for a significant amount of information to be conveyed. Shorter versions can accompany the sewer bill to maintain communication.

Newspaper articles: Press releases and feature stories can broaden public support and awareness of key issues. These are particularly helpful if there will be field-testing in parts of the community.

Neighborhood meetings: In areas where there will be significant field activity affecting private property or disruption in the street right-of-way (smoke testing, foundation drain testing, sewer construction, etc.), a neighborhood meeting can help dispel resident concerns and heighten awareness for the necessity of the activity. The number of meetings should account for the duration of the activities in a neighborhood and the turn over of residents during the activities.

Flyers and door hangers: These communications are often used to alert certain areas of something that will affect private property or cause a disruption to the neighborhood. Prior to smoke testing and foundation drain testing, door to door communication is helpful in giving advance notice of the activity and what it entails. Similarly, advance warning is helpful prior to construction along a street.

Cable TV programs: An alternative to provide educational information about the sewer system and the importance of I/I reduction.

Reference

[Example of Communication Methods, Plymouth, MN]

Program Management

Management of the program is essential in keeping work focused and on track with the schedule and budget. Project management software tools are available to aid with tracking progress.

New Construction

Efforts to prevent I/I occurring in new construction should be ongoing as the I/I reduction program addresses existing I/I sources. Use of sound engineering specifications in the design and inspection, as well as enforcement of the specifications during construction, are sound key elements of having a tight sewer system. Plumbing inspections and certifications can help prevent I/I from private property sources as well.

References:

Sewer System Infrastructure Analysis and Rehabilitation Handbook, EPA, 1991

Wastewater Collection Systems Management, Manual of Practice No. 7, Water Environment Federation, 5th Edition, 1999

Control of Infiltration and Inflow in Private Building Sewer Connections – Monograph, Water Environment Federation, 5th Edition, 1999

Existing Sewer Evaluation & Rehabilitation, WEF manual of practice FD-6, ASCE Manual and report on engineering practice No. 62, 1994

Sewerage Rehabilitation Manual, 3rd Edition, Water Resource Centre, 1994

Demonstration of Service Lateral Testing and Rehabilitation Techniques, EPA, 1985

Handbook for Sewer System Evaluation and Rehabilitation, EPA, 1975 EPA/430/0-75/021

[www.mass.gov/dep/brp/mf/files/liquidIn.pdf]

SECTION 2: INVESTIGATIVE TECHNIQUES

This section consists of descriptions of various investigative techniques often used to identify sources of I/I and the amount of I/I the sources contribute to the sewer system. The general approach outlined in Section 1 is based on following these basic investigative steps:

1. Flow Monitoring
2. Smoke Testing
3. Dye Water Flooding
4. Closed Circuit Television Inspection
5. Building Inspections
6. Foundation Drain Testing
7. System Modeling

Flow Monitoring

Purpose and Use of the Tool

Flow monitoring is a basic tool for the quantification of I/I entering a sanitary sewer system. One purpose of flow monitoring is to measure how the flows in a sewer system change during and after a rainfall. Consequently, flow monitoring is usually accompanied by rainfall monitoring. Another purpose is to measure how the flows in a sewer system change as a result of differing groundwater conditions. The characteristics of the flow changes can often be related to the pattern of precipitation and groundwater conditions to quantify inflow and infiltration rates.

Once the flow monitoring confirms a problem with I/I, the portions of the service area with the greatest amount of I/I can be determined, follow-up field tests can be conducted and beneficial results can be expected. Hence, flow monitoring should lead to more efficient follow-up field tests.

The initial indication that I/I is a problem in a service area is often based on the results of a single flow monitor serving a specific service area. Within the MCES service area, however, some communities have the flow entering their community measured as well as the flow leaving their community. The difference is attributable to the intervening flow from the community. Such information merely indicates the gross magnitude of the problem and provides a general characterization of the dominant source of clear water.

Isolation flow monitoring is used to narrow the search for I/I sources in a large service area. Flow monitors are usually placed in strategic locations to characterize the I/I generation from specific service areas. For example, field tests to locate and eliminate I/I sources in a service area of one square mile (640 acres) might be more efficiently undertaken if isolation flow monitoring was initially conducted to narrow the search. Installation of just four flow monitors, each monitoring about 160 acres of service area, could conceivably narrow the follow-up field tests on 640

acres to 160 acres, if the problem was concentrated in that 25 percent of the service area.

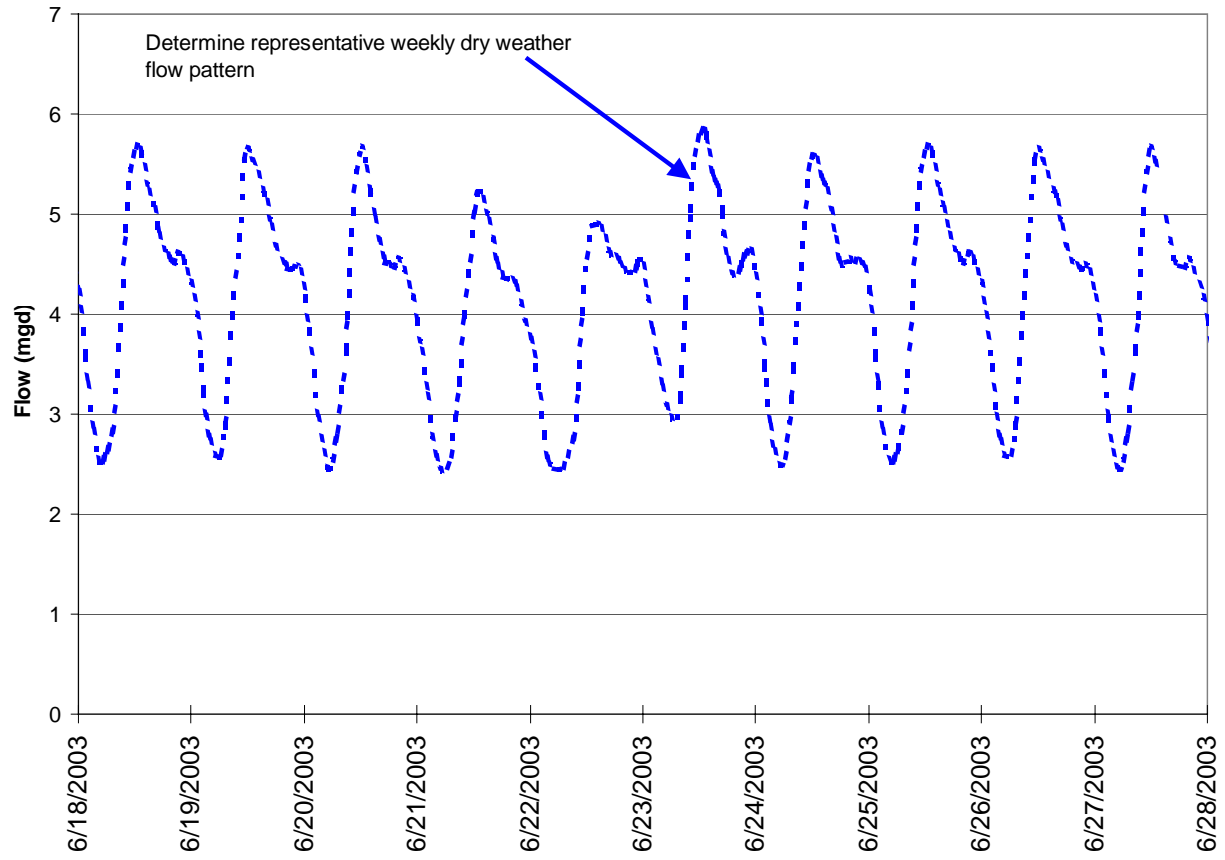
The magnitude of the flow monitoring program is dependent on several factors. The duration of the flow monitoring is dependent on the weather, the reliability and consistency of the flow data, and the number of seasons needed to gain adequate understanding of the I/I sources. With a limited number of flow monitors it is possible to evaluate a portion of the collection system for one season and then move the monitors to another portion the next season. This will prolong the investigation but allow work to continue with fewer flow monitors.

The number and location of flow monitors will depend on several factors. For most communities, a flow monitor should be located at every point of connection to an MCES interceptor. This approach is not applicable where the connections serve very small areas or single lots. Isolation monitoring upstream of a connection point can take into consideration differences within the service area that could cause some portions to have higher I/I contributions than other portions. Age of the buildings is a good example of a differential, because building codes changed in the late 1960s and early 1970s to disallow foundation drain connections to the sanitary sewer system. Soil types, depth to groundwater, and the age and type of sewers are other factors to consider. Older sewers tend to have shorter sewer sections (more joints) and the joint seals may be more of a problem. If the upstream area is very uniform with respect to these attributes, isolation flow monitoring may be effective in narrowing further field investigations.

The flow response to wet weather can provide significant information about the I/I sources in an area. The best information is derived from long periods of continuous flow monitoring at a location so that seasonal trends are discernable and groundwater influences as well as precipitation influences are observed.

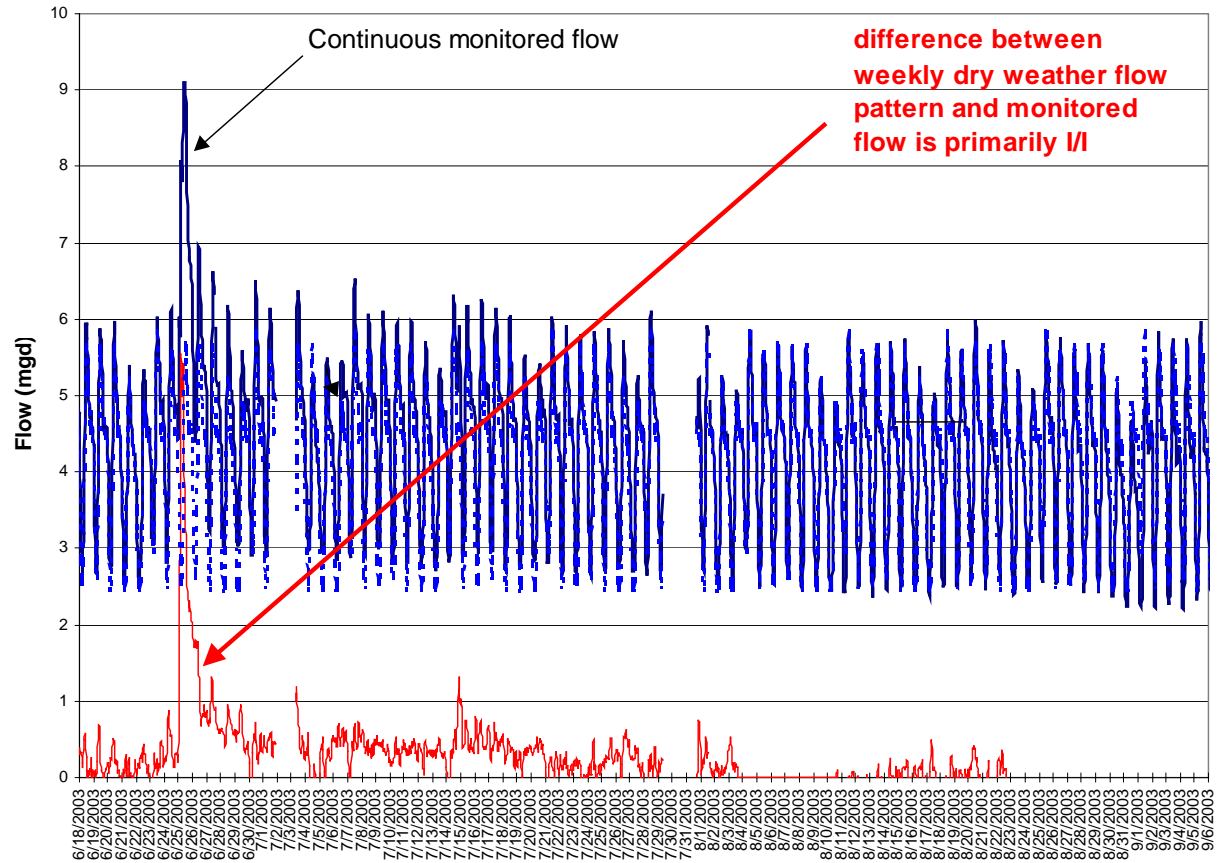
The analysis of the flow data, often condensed to hourly or 15 minute increments, is generally straightforward. A weekly dry weather flow pattern, often reflecting winter conditions, establishes a base to subtract from the long-term record. The weekly average can be compared to the average winter water consumption to assess how close the weekly average value is to the actual wastewater generation rate. A major difference may represent a significant ground water contribution even during the winter months. Refer to graph on the following page.

Figure 2.1. Characterizing Dry Weather Flow



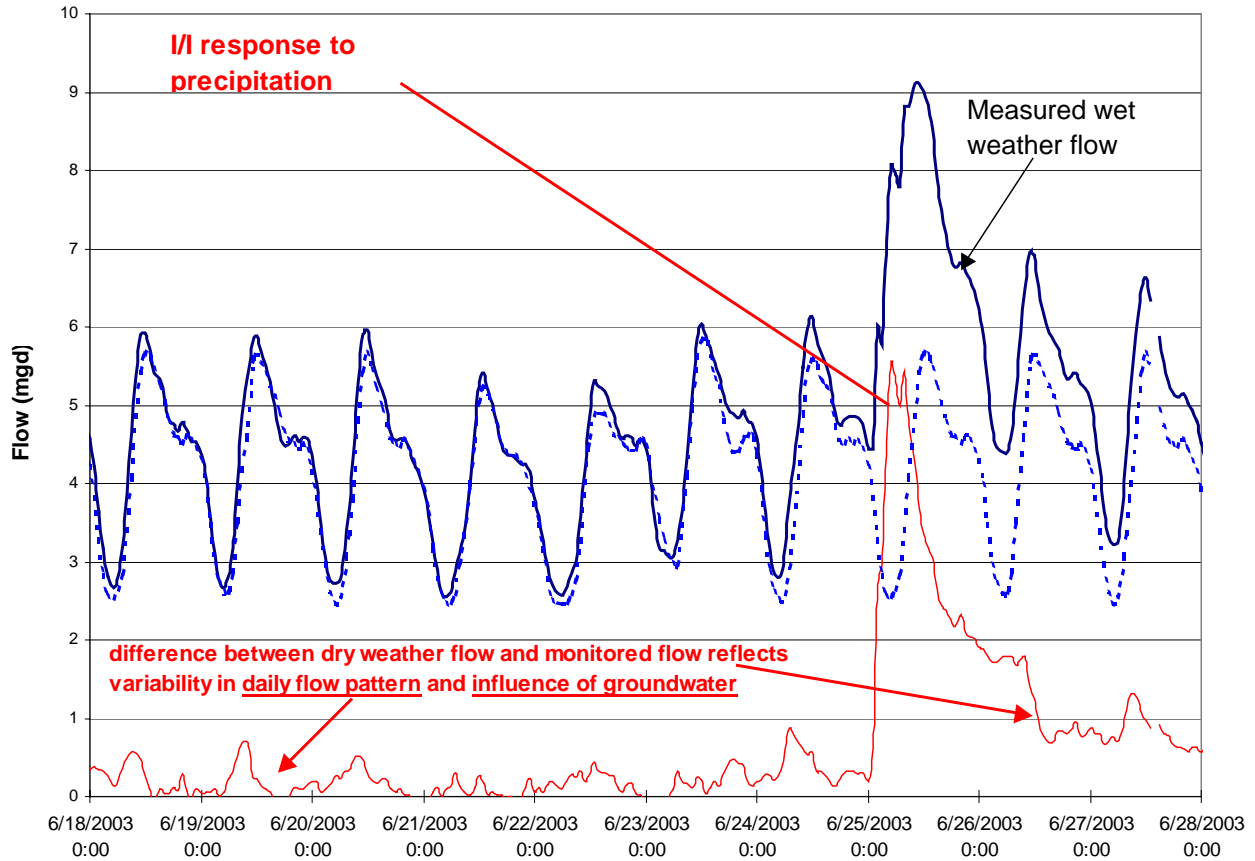
The long-term flow monitoring data can be compared with the weekly dry weather flow pattern to determine an hourly difference. This difference represents the normal variation in a diurnal flow pattern as well as the influence of precipitation and groundwater on the wastewater flow, as indicated below.

Figure 2.2. Inspect Long-term Record



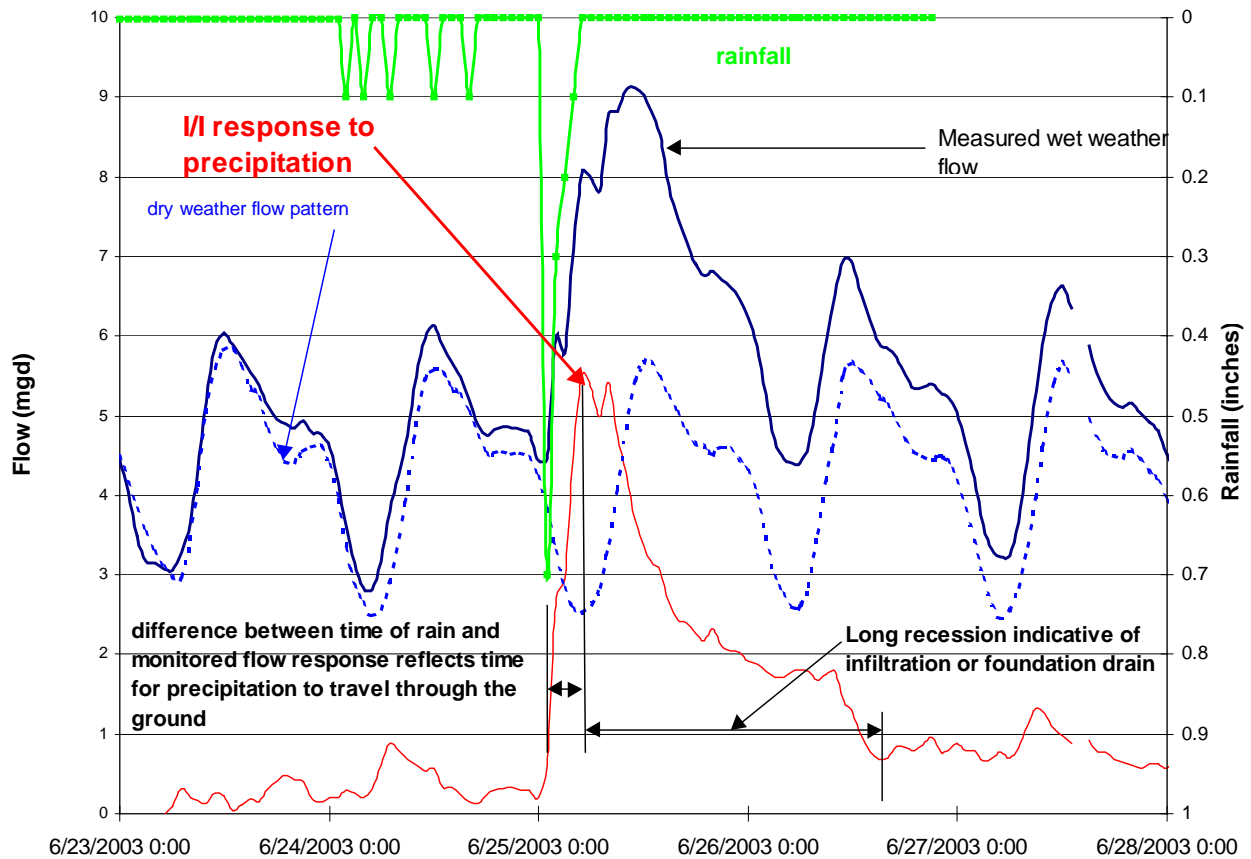
The analysis of the I/I can focus on specific rain events to quantify the peak I/I rate. For this the flow monitoring data is evaluated for a relatively short period of time, such as one week. The difference between the observed flow during and after a rain event and the dry weather flow pattern represents rain dependent flow. The magnitude the difference represents the peak I/I rate for that event.

Figure 2.3. Quantifying I/I for a Precipitation Event



For each event, one can also characterize the sources of I/I by plotting the precipitation data along with the flow data. Timing is an important indicator of the I/I sources. Inflow tends to cause a rapid (one or two hour) flow increase in a sewerage area and a quick return to the antecedent flow condition. As shown below, the time delay of the flow response and the rather long time of flow recession are indicative of the precipitation moving through the soil to get to the sewer.

Figure 2.4. Characterizing I/I for a Precipitation Event



Description

The initial step in flow monitoring is to design a program based on the specific needs of the community, recognizing the past I/I corrective actions and the historical development of the local collection system. As part of this program, the flow monitoring locations should be selected and then, on the basis of the field conditions, the type of flow monitor should be selected. If there is not a recording rain gauge in within a couple of miles of the area upstream of the flow monitor, a recording rain gauge should be installed as well. If ground water is expected to be a major influence on I/I, then a means of monitoring ground water levels in the study area is also recommended.

The location of a flow monitor needs to be field checked to make sure that the flow can be measured accurately, the measuring device can be readily cleaned, and the data can routinely downloaded for analysis.

The field inspection of the flow monitoring location (usually a manhole) should confirm that there is one sewer into and one sewer out of the location. More than one sewer into the location likely will cause inaccuracy in the flow measurement. The sewer into the manhole should be clean and straight so the flow is relatively laminar with little turbulence.

Temporary flow monitors typically consist of a steel ring with a pressure sensor and velocity probe at the base of the ring. The ring is inserted into the incoming sewer and fit by compression. The depth and velocity data are captured at a user-specified frequency and stored in a unit at the site. This type of flow meter requires frequent checking because material in the wastewater can catch on the probe, distorting the data. Recent developments by some manufacturers have led to flow measurement devices that are installed above the flow. For example, there are contractors that use Doppler radar for velocity measurement and ultrasonic pulse echo level sensing for depth measurement. This flow meter has the advantage of needing limited maintenance as there is little opportunity for material to catch on the sensors.

[Reference: [Types of Equipment](#)]

The frequency of data recording is very important as it affects the amount of data storage needed and how often the data must be downloaded. The data loggers can usually be programmed to capture data in very short time increments, average the data over five (5) minutes and store five (5) minute data. This level of accuracy is generally as high as one needs. For most evaluations, 15-minute averages should provide adequate information. The longer the time interval set for data storage, the longer one can wait before having to download the data logger. This is not an advantage where the integrity of the data should be checked frequently to make sure the monitor is working properly and the sensors are not fouled.

Rain gauge monitors should be installed in unsheltered locations. These rain gauges are usually tipping bucket type monitors with data loggers to capture the precipitation amounts in increments of one (1) to five (5) minutes.

[Reference: [Rain Gauge Monitors](#)]

Ground water monitoring provides information regarding the ground water level (piezometric surface) with respect to time. One common way to monitor ground water level is with a piezometer installed in a shallow, small diameter well. The data from the piezometer are captured and stored in a data logger and then periodically downloaded. A less sophisticated way is to manually record the height of the condensation line in a manhole each day. The condensation line would indicate the groundwater level where the temperature is generally 55 degrees Fahrenheit.

The number of ground water monitors will depend on the variability of the subsurface conditions within the study area. If the direction of groundwater flow is known, it may be possible to install one or two piezometers and have a reasonable understanding of the ground water levels in the study area.

Generally, the level changes slowly so that measurements once a day suffice. In some areas, however, the ground water level can change significantly in a short

period of time (hours) because of rainfall. In these areas, the water level data should be stored in at least one-hour increments.

How to Estimate Cost

The cost of flow monitoring is very dependent on the number of flow monitoring locations needed. Flow meters can be purchased or rented. The cost of the portable flow meters ranges from \$4,000 to \$6,000, depending on the size, manufacturer, and features.

The labor costs can be estimated at about eight to ten hours per week per flow monitor for visiting the site daily, or about six (6) days a week, and downloading the data to assure its integrity. The amount of time spent in labor will vary by the number of community monitoring sites and travel time. If the site is located where material tends to foul the sensor, additional time should be allocated to enter the manhole and clean the sensor.

Rain gauge monitors cost less than \$100.

Data analysis is a separate task and depends on the amount of information collected in the monitoring program.

How to Measure Effectiveness

The effectiveness of flow monitoring can be measured in several ways. First there is the simple evaluation of how much flow data is usable for the rain events that are monitored. Sometimes referred to as "up time," the percent of the time that the flow monitor records accurate data should exceed 98 percent. This is somewhat meaningless if the lost data happens to occur during a rain event and the peak flows are not recorded. Having data for the preceding 30 days is of little value if the flows during the critical period are not recorded. Consequently, diligence is required to check on the flow monitors just prior to predicted rain to make sure the sensors are not fouled and instrument is recording data.

Another way to measure the effectiveness of the flow monitoring is by the amount of information derived from the analysis of the data. Based on the analysis of the data, one should be able to characterize the types of I/I sources in the upstream service area and gain an appreciation of the relative importance of inflow sources versus infiltration sources. The data should help to structure the follow-up field tests, such as smoke testing and dye water flooding.

[\[References\]](#)

Smoke Testing

Purpose and Use of Tool

Smoke testing is an efficient and practical way to locate where inflow enters the sanitary sewer system. It is often preceded by flow monitoring, which identifies those service areas exhibiting inflow characteristics.

Smoke testing typically identifies connected downspouts and other inflow sources, such as area drains and cross connections with the storm sewer system. If the

ground is dry, smoke may travel through cracks or offset joints and up through the ground. Other defects found with smoke testing include manhole cones and covers.

[Reference: [Figure of Smoke Testing](#)]

Description of Tool

Smoke testing is conducted by placing a blower over a centrally located manhole and forcing a non-toxic "smoke" to disperse within an isolated section of the system. The "smoke" will move under pressure along the path of least resistance, indicating the pathway that water can enter the sewer. Photographs are taken of the locations where the "smoke" appears and the locations are recorded.

[Reference: [Set-up for Smoke Testing](#)]

The procedure for smoke testing requires advanced notice to property owners in the area to be investigated. Typically, each building will be visited a day or two before the test to explain the test. Door hangers will be left where no one answers. The instructions advise the occupant to make sure there is water in all floor traps. If smoke does enter a building, it is an indication that sewer gases could enter the building as well. The information advises the occupants of what may happen and what it means if smoke is observed.

The field test requires isolation of a sewer section and placement of a smoke "bomb" in the central manhole and is then covered with a blower. During the test, the area is observed and the locations of smoke emission are recorded and documented.

[Reference: [Blower Over Manhole](#)]

[Reference: [Smoke "Bombs" with Different Burn Times](#)]

How to Estimate Cost

The cost of smoke testing depends on whether the work is done with in-house staff or is done by a service provider. Typical production time for smoke testing 8-inch to 12-inch diameter sewers is 10,000 feet per day for a crew of two or three.

The material costs used by in-house staff consist of the following items:

- Air/smoke blower (1500 to 2000 cfm)
- Smoke "bombs" - typical burn time of 3 minutes for 800 feet of sewer inspected
- Sewer isolation tools, such as line plugs and sand bags (partly filled with 1/4 round stones with an attached rope for easy positioning) and canvas or rubber flaps for confining the smoke in specific sections of line
- Means of recording and documenting location of smoke observed during test

There are several firms that offer smoke testing services in the Twin Cities area. The cost of these services will depend on the size of the area to be investigated, but the range of costs will generally be between \$0.14 and \$0.18 (to be verified with vendors) per lineal foot of sanitary sewer tested.

How to Measure Effectiveness

Smoke testing should identify the majority of inflow sources causing peak wet weather flows in a given area. If the smoke testing does not locate enough of the sources to account for the flow increases, the source of the clear water is likely to be sump pumps with a connection that has a water trap.

References

Sewer System Infrastructure Analysis and Rehabilitation Handbook, EPA, 1991

Existing Sewer Evaluation & Rehabilitation, WEF manual of practice FD-6, ASCE Manual and report on engineering practice no. 62, 1994

Handbook for Sewer System Evaluation and Rehabilitation, EPA, 1975, EPA/430/9-75/021

[www.plumbertools.com/index.html?lmd=38380.661667]

[www.obg.com/infocenter/whitepapers/whitepaper_sewer_eval.asp]

Examples

[Atlanta : <http://www.cleanwateratlanta.org/SSES/Technology/SmokeTest.htm>]

[De Kalb Sanitary District : <http://www.dekalbsanitarydistrict.com/dsdssestests.html>]

Dye Water Flooding

Purpose and Use of the Tool

Dye water flooding is a field procedure for locating and confirming connections between the storm sewer system and the sanitary sewer system. This test is usually performed on a section of storm sewer where prior smoke testing has indicated a cross connection exists and flow measurement indicates a wet weather flow increase. Dye water flooding can also be performed in ditches as well as storm sewers.

This test is particularly helpful in identifying house laterals that are below the drainage system and that take on storm water as the overlying system fills. Storm sewers are usually above and perpendicular to the house lateral. If there is a storm sewer joint above the house lateral and it has opened up because of settlement in the house lateral trench, storm water can leak from the open joint and flow down the trench into the house lateral. With the dyed water in the storm sewer, leakage can be seen by observing the discharge from the house lateral.

Figure 2.5. Dyed Water Visible in Sanitary Sewer



Description

The section of storm sewer or ditch to be tested is isolated from the rest of the system to hold the dyed water in the test section. For storm sewers, the initial section to be tested is usually the most upstream section so that after the test, the dyed water can be released and flow to the next test section. This procedure minimizes the amount of makeup water needed. The source of water is usually from a fire hydrant.

The dye is a nontoxic red or green color, fluorescein dye mix for testing sewer and septic systems. The dye is commercially available as a powder or as a tablet. It is highly concentrated and quite visible when added to a large volume of water.

Once the dyed water is in the storm sewer or ditch, the sanitary sewer is inspected for the presence of the dye to confirm a connection and to estimate the rate the dyed water is entering the sanitary sewer. If the flow of dyed water is significant, it is best to quantify the rate of entry. Often a temporary weir is installed in the downstream manhole to obtain a

Figure 2.6. Dyed Water in Sewer



Figure 2.7. Dye Testing a Manhole



flow measurement before the dye water test and during the test. The measured flow increase can then be allocated to the sources observed by the inspection of the sanitary sewer.

Usually, inspection is done by CCTV to locate the specific points of entry to the sewer and define the characteristics. Prior to this inspection, it is best if the sewer has been cleaned to facilitate the inspection. Specific house laterals, joints and other defects are often the place the dyed water enters the sewer. Based on the observation, a remedy can often be formulated.

Dye testing can also be used to locate where I/I enters manholes.

How to Estimate Cost

The cost of dye water flooding is primarily in the labor to flood the storm section and televise the sanitary sewer. Direct expenses would include the cost of the water, the dye, and the videotape. The labor expenses will cover the time to isolate the storm sewer section, fill the section with water, and then up to 30 minutes to allow the dyed water to find its way to the sanitary sewer. The CCTV inspection can usually be completed within 60 minutes after the dye water has filled the storm

section. The time to fill a storm sewer section from a fire hydrant will depend on several factors as indicated in the table below.

Sewer Length (in feet)	400	400	400	400	400
Sewer Diameter (in inches)	12	18	24	36	42
Hydrant Rate (gallons per minute)	500	500	500	500	500
Time to Fill Sewer (in minutes)	5	11	19	42	58

Contractors specializing in this practice can do this on a time and materials basis or a unit cost basis if they have enough information to estimate the time to fill the storm sewer (ditch) and the cost of the water from the city. The cost of the dye is usually incidental relative to the labor and equipment costs.

How to Measure Effectiveness

The effectiveness of this field test can be assessed by comparing the estimated I/I flow rate attributable to the I/I sources found during the test to the total I/I estimated from an area.

One of the more significant values of conducting this test is that these I/I sources can be eliminated once they are found and the I/I reduction is quantifiable.

References

[Dye Types]

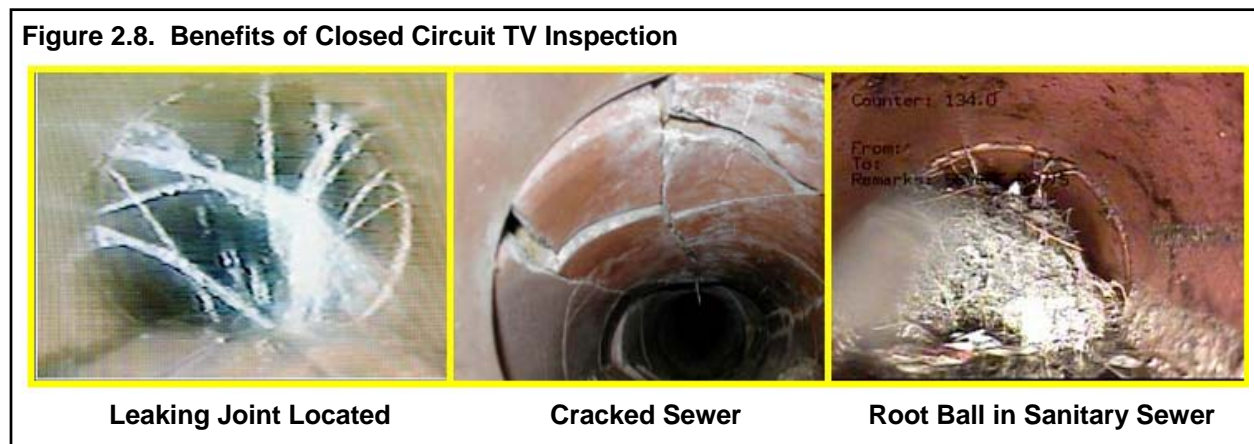
[Clean Water Atlanta]

Closed Circuit TV Inspection

Purpose and Use of the Tool

Closed circuit TV (CCTV) inspection of the sanitary sewer system is used to assess the condition of the sewers and locate I/I sources such as leaking joints and cracked pipe. When rainfall conditions are simulated or actually occurring during the CCTV inspection, additional I/I sources can be located.

CCTV provides documentation of the defect or I/I source and its specific location. While other field tests can determine that I/I enters a sewer section, the CCTV provides the specific location and nature of the problem so a remedy can be determined.



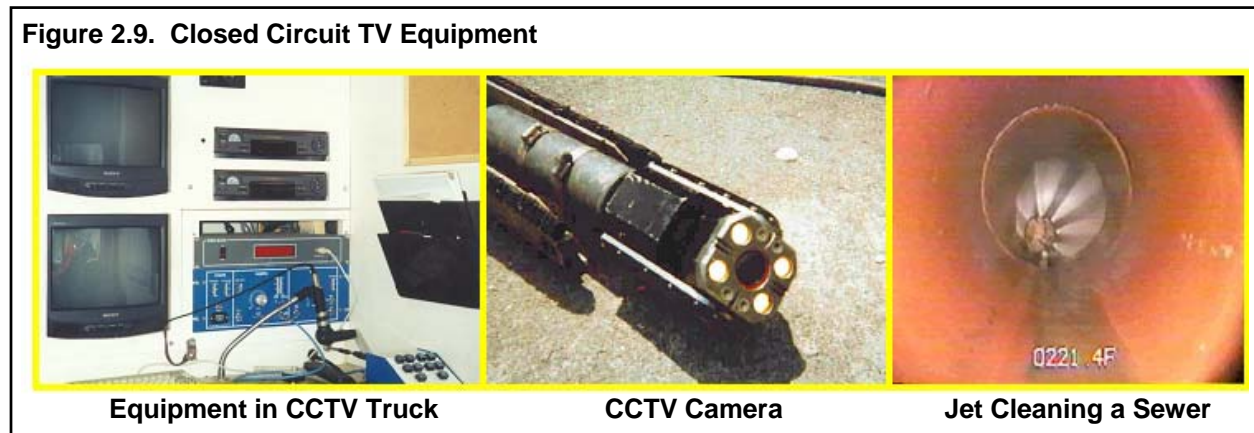
It is recommended that CCTV inspection of the sanitary sewer system be done routinely. A general rule of thumb is to inspect 10 percent of the system annually, but this varies with the age of the system and historical problems. Primarily, this is based on a condition assessment, focusing on the structural condition of the sewer rather than on I/I.

Description

CCTV inspection requires specialized equipment and a trained field crew. While many communities have the necessary equipment and trained staff, others contract this activity to specialized firms.

Prior to inspection the sewer is usually cleaned to assure the camera can be pulled through the sewer and most of the sewer is visible. The sewer is usually jet cleaned, allowing a cable to be strung through the sewer at the same time. This cable is then used to pull the camera through the sewer.

The CCTV is video taped for a permanent record and the observations are typically noted on a log that indicates the location and type of defect or observation noted.



How to Estimate Cost

The cost of CCTV inspection depends primarily upon the amount of preparatory cleaning required and the amount of time needed to set up the equipment (surface conditions). Once the equipment is setup, the camera will be pulled through the sewer at about 0.5 to 1 fps until a defect is noted. The crew will usually stop the camera at a defect to make sure it can be seen and understood.

For budgetary purposes, a sewer system requiring light cleaning (simple jetting) can usually be inspected at a rate of about 1500 to 1000 feet per day. The cost for CCTV inspection could be in the neighborhood of \$2 to \$3 per foot. Costs will increase if more time is needed to clean the sewer or if access is difficult and traffic control is needed.

How to Measure Effectiveness

The effectiveness of CCTV inspection for I/I reduction is determined by how much of the I/I can be attributed to the I/I sources identified by the CCTV. In addition, the CCTV inspection identifies structural defects and places where there is potential

for loss of ground through an opening in the sewer (joint or crack). Consequently, the CCTV is generally an effective means of condition assessment routinely done on underground infrastructure.

References

City Programs

Surrey, British Columbia, Canada

<http://www.city.surrey.bc.ca/Inside+City+Hall/City+Departments/Engineering/Operations/Sanitary+Sewer+Operations/Our+Role/Preventative+and+Predictive+Maintenance+Programs/Preventative+Maintenance+Programs/Video+Inspection/default.htm>

Equipment Vendors:

Scooter <http://www.tvinspection.com/>

Professional Equipment

<http://www.professionalequipment.com/xq/ASP/id.24/subid.149/qx/default.htm?CMP=KNC-Google>

Envirosight

http://www.envirosight.com/techdocs/techdoc_zooming.html

CSIRO Manufacturing

<http://vision.cmit.csiro.au/project/pirat/>

[Equipment Vendors]

System Modeling

Purpose and Use of the Tool

System modeling provides a way to characterize the existing conditions and simulate how changes will affect the wastewater flows. Typically, system models include a hydrologic component and a hydraulic component. The hydrologic component allows one to model time-varying flow generation into the sewer system. The hydraulic component allows one to model the routing of the time-varying flows through the collection system.

The hydrologic model generally requires a characterization of each sewer service area for which a hydrograph is to be generated and subsequently routed through the sewer system. Some models rely solely on empirical relationships to characterize the sewered area for I/I response to rainfall, and others are based on more physical models that represent movement of water overland and into the water table. The hydrologic model used by MCES to simulate the affect of I/I on the interceptor system is based on the Stanford Watershed model in which precipitation is accounted for as it runs overland and percolates into the ground.

Once the system model is calibrated and verified, the system characterization can help focus the I/I investigation. Areas characterized with direct connections (inflow) are better suited for smoke testing while areas with a significant contribution of percolated water above the piezometric surface are good candidates for private property source control.

Application of the Tool

There are several modeling packages commonly used to generate wet-weather flow hydrographs and route them through a collection system. The Stormwater Management Model (SWMM), MOUSE and Info Works are the most commonly used computer models for this application. Other models such as SewerCAT are available as well. These models can represent the gravity sewer sections as well as pump stations and force main. Input information on the collection system requires the user to specify the size and length of pipes, conduit shape, manhole inverts, ground elevation at manholes, and boundary conditions (terminal point of the system). Versions of these models allow the user to easily interface the model construction with a GIS based sewer system.

Most of the modeling packages used today are proprietary, having been developed by an engineering software company or consulting engineering firm. The SWMM-based products use the non-proprietary SWMM software (placed in the public domain by the U.S.EPA), or a customized version of that software, as the computational "engine". In contrast, the other packages are based on fully proprietary European software.

Construction of the hydraulic model involves specifying the locations where flow enters the collection system. The flow from each tributary is assigned to a specific input location (usually called a node). The input hydrograph for each area, derived from characterizing the dry weather flow and the rainfall dependent I/I (RDII), is then routed through the collection system to compare to metered flow data. Adjustments are made to the RDII characterization of each tributary area until the model is deemed calibrated. The calibrated model is then verified by simulating the system response to another rain event and confirming that the peak flow and volume simulated by the models reasonably matches the metered flow data. Properly characterizing the variability in the response due to different antecedent moisture conditions is key, as the same rainfall event occurring when the soil is wet and when the soil is dry will produce very different responses.

After system improvements are made, the RDII response to a defined rainfall/soil scenario should be different (smaller) than the response to that scenario predicted for the unimproved system by the models. The difference is a reasonable characterization of the progress that the system improvements have made. Use of the models in this way allows for a consistent evaluation of RDII reduction with rainfall/soil conditions that are markedly different than the ones used to calibrate the models.

For some hydrologic models, the RDII characterization can be adjusted to represent the new conditions by reducing the estimated area generating RDII. In other models the RDII captured fraction can be adjusted directly. These changes in the physical parameters allow for correlation with the corrective actions.

How to Estimate Cost

Modeling evaluations can be relatively expensive if one includes the flow monitoring, rainfall measurements, and construction of the hydraulic and hydrologic models. Significant cost savings result from starting with a comprehensive GIS

database for the collection system, but even this approach requires checking and fine tuning to properly characterize the collection system components. Cost correlates directly with the following factors:

1. **Level of sewer network detail.** This actually impacts cost in two ways. First, the more detail in the network, the more pipe data that must be collected, verified and input. The number of pipes increases exponentially as size decreases. Often the areas that require the most checking/correcting are the smaller pipes. Second, and perhaps more importantly, as the detail in the sewer network increases, the size of the modeled basins decreases. The smaller the basins, the more effort required to delineate the basin boundaries, define their base flow and hydrologic characteristics, and calibrate the appropriate basin parameters.
2. **Source data quality.** If the source data reside in a mature GIS, in which data quality is very good, model construction can be greatly facilitated. Without this source, research of paper records and even field surveying are required to fill data gaps and confirm suspect data.
3. **Calibration.** There are two aspects of calibration that bear heavily on project cost: spatial resolution (the number of meters) and the number of events captured/analyzed. The more events captured and analyzed, ideally representing a broad range of antecedent moisture conditions, the better the RDII parameters can be defined. And obviously the occurrence of rainfall events of sufficient magnitude to generate an RDII response is weather-dependent, and thus the required metering period is difficult to predict with certainty.

For budgetary purposes, the cost for establishing the hydraulic model from a sound GIS data base is between 4 to 8 hours per mile of sewer represented in the model. When flow monitoring and calibration costs are included, 10-40 hours per mile is required. The lower values represent economy of scale so larger systems would have a lower unit time requirement. The wide range in values represents variation in the three factors cited above, especially in the level of calibration effort.

Building Inspections

Purpose and Use of the Tool

Building inspections provide a positive way to identify buildings with a sump pump discharging to the sanitary sewer system. These buildings do not meet the current plumbing code. If the community has an enforceable ordinance regarding the connection of sump pumps to the sanitary sewer system, the building owner can be directed to have the sump pump disconnected from the sanitary sewer system.

Inspections are usually made in areas where flow monitoring indicates the likelihood of sump pump connections. Knowledge of the building practices when the homes were constructed is also helpful in deciding which areas merit building inspections. Once the inspections are made, follow-up enforcement is usually required to assure that disconnection of the sump pumps takes place.

Description

The building inspection program often consists of public information, inspector training, door to door inspections, documentation, and follow-up enforcement and advice.

It is essential to notify and inform the public about the program and why it is being undertaken. Newspaper articles, flyers, and Web sites have been used in some communities. If the inspections are going to extend over several years, the information program needs to acknowledge that some residents have moved in since the initial information was provided. It will also be helpful to work with real estate brokers as there will be questions affecting the sale of some residences.

The inspectors should be trained to deal with the public, answer the resident's questions, understand below grade plumbing systems, and document the results of the inspection. Inspectors can be city staff but usually are hired for this specific inspection program. A one or two day workshop is usually adequate to introduce the inspector to the program and provide adequate training. City staff can often provide the training.

The door to door inspections should be planned to allow for efficient use of the inspector's time. Inspectors can work alone or in teams of two, depending on the community's receptivity to the program. Official identification badges and possibly a "uniform" should be provided each inspector so the public can feel secure with letting the inspectors into their residence. Once in the residence, the inspection of the basement should be undertaken. In some programs, this inspection can also include filling out a questionnaire to supplement the findings.

The inspector should have a form to fill out with the address and resident's name. A sketch of the observed plumbing and photographs are good ways to document the findings.

The inspector should be able to answer most questions posed by a resident. Handout material can be prepared in advance for frequently asked questions. The inspector may also be able to give some ideas about how to disconnect the sump pump discharge and where it can be routed.

Building inspections are usually performed in the late spring, summer and early fall. Inspections during weekdays are not very successful in areas with two income households. Depending on the community, inspections may need to be in the early evening or on Saturdays. Often the program will include two attempts to find someone at home and if unsuccessful, the building owner is asked to set up an appointment.

How to Estimate Cost

The cost of a building inspection program is primarily for the labor of the inspectors. While the actual inspection may take less than 15 minutes, the travel time and the success rate of finding someone home tend to more than double the time. Each inspector should have a camera for documentation of the inspection.

College students provide a labor source that is generally available during the times that the inspections would be made. Based on a rate of \$12 per hour and a 40

percent overhead, the cost per building inspected should be about \$20, including all aspects of the program.

There will need to be a city staff person in charge of the inspection program. This person could spend half of their time on this program, training inspectors, scheduling the inspections, checking the quality of the inspections, compiling the documentation and coordinating with enforcement.

How to Measure Effectiveness

The effectiveness of the building inspection program can be measured by comparing the peak flow estimated from the connected sump pumps found with the peak I/I monitored from the area.

A direct measurement of the I/I removed by a subsequent disconnection program can be obtained by placing monitors on the sump pumps that have been disconnected. Such monitors can capture operating data that will document the discharge from the sump pump.

References

[City of Mounds View – Sump Pumps]

[Center Line, Michigan – Drain Disconnection Pilot Program]

[City of Cuyahoga Falls, Mississippi – Stormwater Inspection]

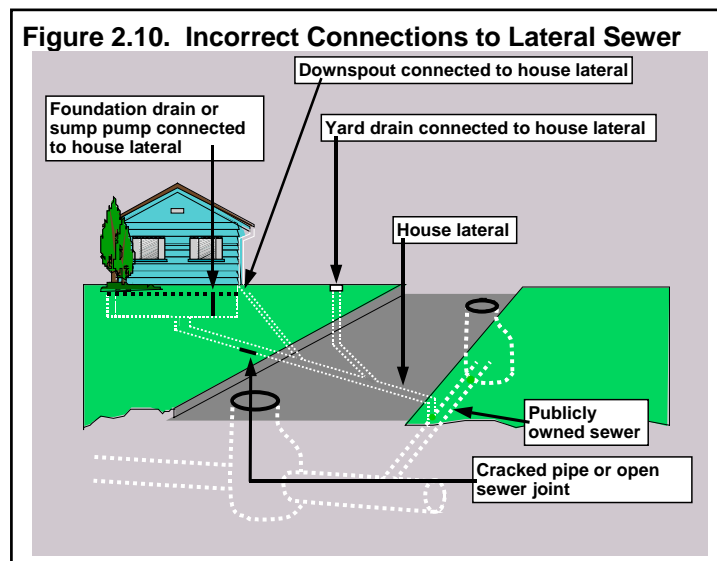
[City of Greenwich, Connecticut – Private Inflow]

Foundation Drain Testing

Purpose and Use of the Tool

The foundation drain (footing drain) around a building basement is a common plumbing feature to protect the substructure during high ground water conditions. The drain collects the surrounding ground water and keeps the basement from experiencing the buoyant force of the ground water. Prior to the early 1970's, it was common practice to connect the foundation drain to the house lateral if there was no sump pump. The plumbing code was changed in the early 1970s so that the uncontaminated ground water collected by the foundation drain could not be discharged into the sanitary sewer.

Foundation drain testing is a procedure to confirm the connection between a gravity foundation drain and the sanitary sewer system. The tests are done on buildings where connection is



suspected because of smoke testing or because the buildings in an area were constructed at a time that such connections were common.

Description

The foundation drain test is done by placing a small amount of green or red fluorescein powder along a portion of the suspected foundation. Rainfall is simulated by adding water from a city truck around the foundation. The water is added at a rate to allow the dyed water to soak into the ground and travel along side the foundation down to the drain. If the dyed water enters the house lateral from the foundation drain, it can be documented by a closed circuit TV camera in the sanitary sewer.

How to Estimate Cost

The cost of foundation drain testing is primarily labor and equipment. Each test will be approximately 15 to 30 minutes, depending on how long it takes for the water to flow down to the drain and into the house lateral. Allowing an hour to set up the CCTV and place the camera at the first house connection to be tested, one can estimate completing 10 to 12 inspections of adjacent buildings in one day with a two person crew.

How to Measure Effectiveness

The effectiveness of this tool is indicated by comparing the number of confirmed connections versus the number of suspected connections.

Each foundation drain that is disconnected will reduce peak and annual average flows.

[References]

SECTION 3: CORRECTIVE ACTION – PRIVATE PROPERTY SOURCES

Private property I/I sources constitute the greatest I/I rates and volumes for many of the communities that have already addressed I/I sources within the publicly owned sewer system. Past programs usually did not address I/I from sump pumps and foundation drains or leaking house laterals.

This section addresses programs to disconnect foundation drains and sump pumps and programs to repair leaking house laterals. At the end of this section are sample forms.

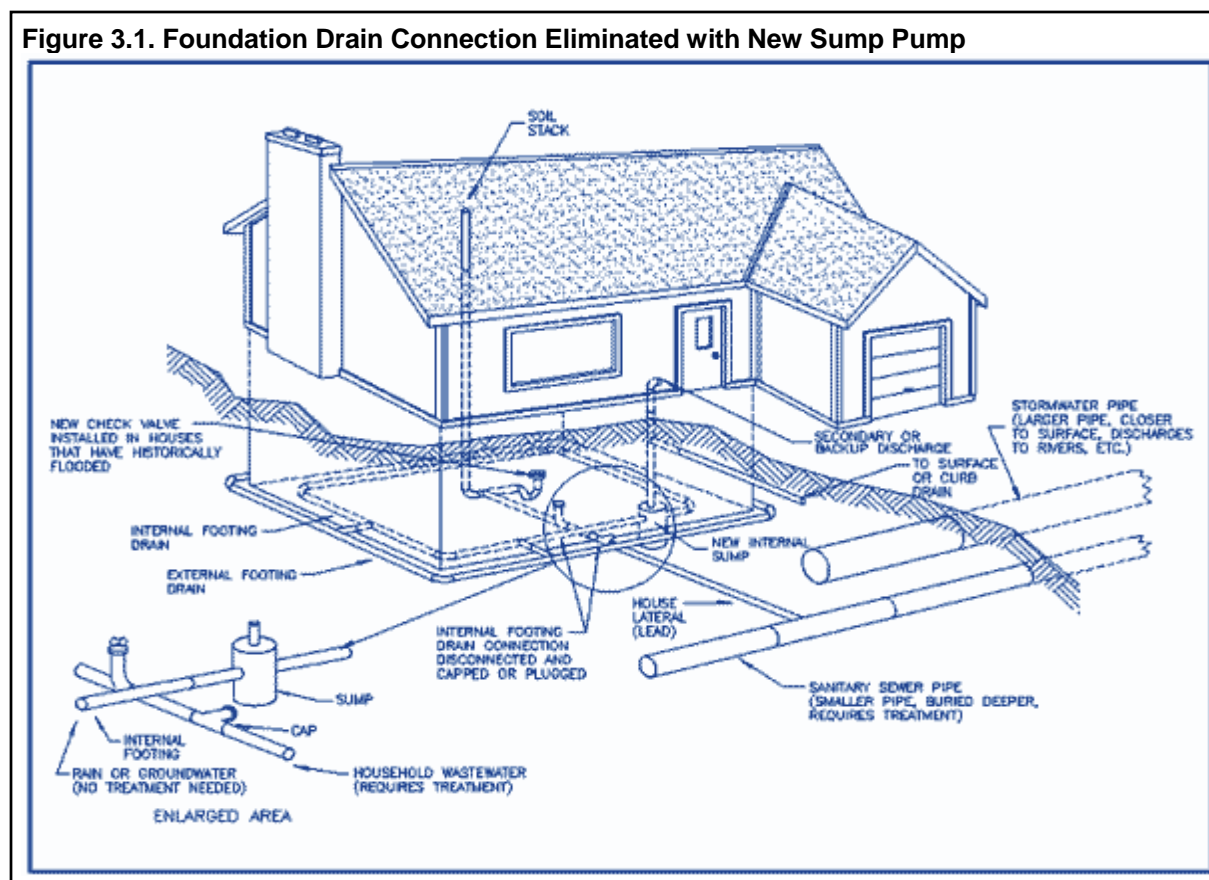
Foundation Drain Disconnection

Purpose and Use of the Tool

A community program that would have building owners disconnect the foundation drain (footing drain) from the sanitary sewer system is a way to establish a specific timeline for the elimination of this I/I source. An alternative is to have the building owner comply with a local ordinance at the time of a property sale.

Description

There are several approaches to a community program for disconnection of gravity foundation drains.



Once the properties are identified and the magnitude of the program is known, a decision can be made regarding the cost of the disconnections. Options used include providing a rebate to the property owner (fixed amount up to actual out-of-pocket costs), adding a surcharge on the sewer bill if the disconnection is not made, relying on point-of-sale compliance requirements, and providing incentives to developers to underwrite the cost of a disconnection.

In many communities the connection of the foundation drain was made when the plumbing code allowed the connection or the building inspectors did not enforce the plumbing code. Because such connections are not "illegal", there is little means of enforcement to cause the property owner to disconnect the foundation drain. The disconnection program in these cases must rely upon enacting a legal basis to proceed and providing an incentive to the property owner to comply.

The most common incentive is for a community to provide a cash rebate to the property owner after the disconnection is made. The amount of the rebate varies by community. In some communities, the rebate is a fixed dollar amount while in others it is dependent on the actual cost of the disconnection. In 2005, the city of Duluth is providing a rebate of \$1,800 to each property owner who disconnects the foundation drain from the house lateral. The city of West Lafayette, Indiana provided a 100 percent rebate of eligible items for each disconnection. The eligible items included the cost of the disconnection, new sump pump installation, and lawn restoration.

Some communities have elected to impose a strong financial disincentive to remain connected. If a property owner chooses to remain connected, an additional charge is made on the sewer bill. The additional charge can be \$100 per month or more.

In some metropolitan areas a program has been established to limit new development such that each new connection requires one or more disconnections of foundation drains. Consequently, the additional flow from a new household is offset by the reduction in flow from a connected foundation drain. The number of foundation drains to be disconnected for each new building permit depends on the severity of the I/I problem.

Once the means of implementing the disconnection program is determined, there should be a significant effort to inform the public and explain the program and funding source. Public meetings, newspaper articles, a Web page update, hotline, and other means of communication are generally important for successful implementation of the program.

Some programs offer detailed information on how to make the disconnection with guide specifications and sketches of acceptable plumbing alterations. Local plumbing contractors are provided this information and the community inspectors work closely with the local contractors to assure compliance with current codes.

In many communities, the discharge from the disconnected foundation drain will cause a nuisance unless provision is made to accept the new discharge. Several communities have implemented companion drainage improvements by installing a shallow, curbside collector sewer into which sump pumps can discharge. These collector sewers convey the sump pump discharge to the storm sewer system.

Point-of-sale enforcement is being implemented in communities so that the cost of the disconnection is associated with the sale of the house. The underlying assumption is that the value of the property will make the disconnection cost seem incidental. The Rock River Water Reclamation district, serving the Rockford, Illinois metropolitan area, requires a licensed plumber to verify conformance with the District's codes on a form for transferring or establishing a new account.

How to Estimate Cost

The cost of disconnection of a foundation drain is very site specific. For disconnection of a gravity foundation drain from the house lateral and installation of a new outside sump and sump pump, the cost could range from \$5,000 to \$10,000 depending upon the extent of restoration needed. Disconnection of a sump pump discharge and redirection of the sump to a backyard can often be done for \$500 to \$2000. Installation of a curbside collector sewer can cost \$40 to \$80 per lineal foot.

The cost of a community disconnection program should include time for administration and enforcement. Usually, the time commitment is part time but varies depending on the size of the program and the duration of the program.

How to Measure Effectiveness

Each foundation drain that is disconnected will reduce peak and annual average flows. Monitors can be placed on new sump pumps to document the amount and rate of diverted groundwater. Flow monitoring in the sanitary sewer system during and after completion of the program can provide a measure of the program effectiveness.

A foundation drain connected to the house lateral can increase the flow from the building by a factor of 25. Studies done in Ann Arbor, Michigan show sump discharges over an hour to average 3 to 5 gallons per minute (gpm) during a rain. At an average of 4 gpm per foundation drain, one city block with 20 houses could add 80 gpm to the peak flow. On a dry weather day the average flow from these 20 houses would typically be about 3 gpm. Consequently, a program to assure that all buildings meet the current plumbing code can result in a significant reduction in the peak and average flows from a community.

Implementation of a program to disconnect foundation drains (gravity and pumped) could significantly reduce peak flows and the annual average flow from a community. For example, an area with 10 percent of the foundation drains connected to the house lateral could have 20 percent of the annual volume of wastewater come from foundation drains and the peak flow could be 60 percent higher. Disconnecting the foundation drains will reduce the volume discharged to the MCES interceptor system and significantly reduce the peak flows as well.

References

[[Foundation Drain Disconnection: Ann Arbor, Welland, Garden City, Rockford](#)]

House Lateral Repair

Purpose and Use of the Tool

A community program to repair leaking house laterals may be required if this source is wide spread and a significant I/I source in the community. Leaking house laterals are identified by smoke testing under dry conditions, by dye water flooding parts of the storm drainage system that crosses over house laterals, or by televising the house lateral during wet weather.

Corrective measures for the portion of the house lateral located within the public right-of-way are usually undertaken by the public as the drainage system is often a contribution factor. A community has rarely undertaken corrective measures for the portion of the house lateral on private property. However, the city of Duluth is beginning a pilot project to repair (line) all of the house laterals along a city block using a "no dig" technique. If this proves successful in significantly reducing I/I, the city will continue to repair more house laterals.

Description

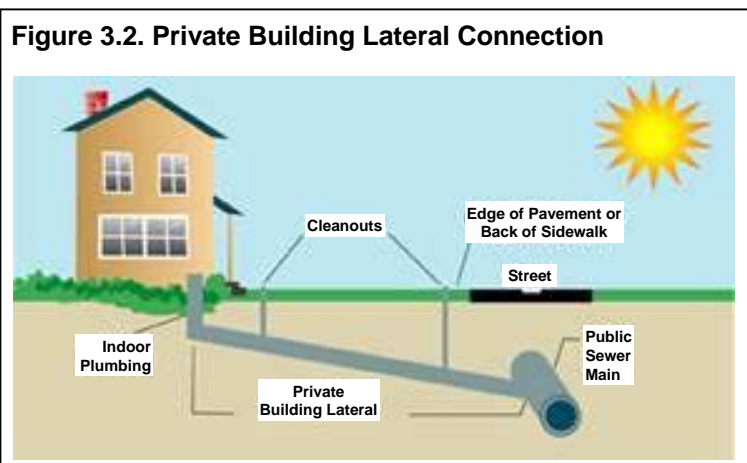
There are several approaches to a community program for the repair of leaking house laterals. Usually the problem is associated with the intersection of the house lateral trench and the storm sewer or ditch that is perpendicular to the house lateral. The storm water is able to leak into the house lateral trench and in turn into open house lateral joints.

Once the properties are identified and the magnitude of the program is known, a decision can be made regarding the cost of the repairs. There are several means of lining house laterals without excavation, but the techniques have not been widely used.

How to Estimate Cost

The cost to repair a house lateral will depend on the technique used and the degree of disruption. Budgetary numbers will require contractors to evaluate the magnitude of the project (a few houses versus neighborhoods) and consider alternative techniques. Repairs within the public right-of-way could be several thousand dollars as a spot repair, while lining the entire house lateral from the street sewer to the building connection could cost \$5,000 to \$8,000.

The cost of a community disconnection program should include time for administration and enforcement. Usually, the time commitment is part time but varies depending on the size and duration of the program.



How to Measure Effectiveness

Each house lateral that is repaired will reduce peak and annual average flows. Monitors should be placed downstream of areas where house laterals are to be repaired programmatically so the city can evaluate effectiveness after construction. The estimated flow per house lateral repaired can be based on television inspections of the flow from the house lateral during wet weather.

References

City funding program:

[\[www.fergusoncity.com/public_works/sewer_lateral_program.asp\]](http://www.fergusoncity.com/public_works/sewer_lateral_program.asp)

[\[www.fergusoncity.com/public_works/sl_program_guidlines.asp\]](http://www.fergusoncity.com/public_works/sl_program_guidlines.asp)

District program:

[\[www.cvsan.org/grants.htm\]](http://www.cvsan.org/grants.htm)

Vendor information

[\[www.performanceliner.com/renewal.htm\]](http://www.performanceliner.com/renewal.htm)

[\[www.plumber-rooter.com/pipe-relining.htm\]](http://www.plumber-rooter.com/pipe-relining.htm)

[\[www.prime-line.net/lateral2.html\]](http://www.prime-line.net/lateral2.html)

SECTION 4:

CORRECTIVE ACTION – PUBLICLY OWNED SEWERS

I/I sources within the publicly owned sewer system can be addressed by several rehabilitation or reconstruction methods.

Joint Sealing

Sewer joints can be a major source of I/I if they are leaking ground water into the collection system. In older collection systems, short sections of clay pipe were installed with tar and oakum joints. The newer systems have longer pipe sections (fewer joints) and rubber gaskets joints with compression fittings. If the joints have separated, the opening can allow groundwater to enter the sewer as I/I.

Sewer sections that have been inspected and found to have leaking joints can be rehabilitated by sealing the leaking joints with a pressure grout. Special machines can be pulled through the sewer to test a joint with air pressure and then add grout under pressure to those joints that fail the pressure test.

Failure to address leaking joints can lead to structural failure of the sewer. In extreme cases, the movement of groundwater into an open joint or cracked pipe has caused loss of ground around the sewer and development of a large void next to the sewer. The void can grow to significant size, resulting in elimination of the foundation support of a roadway, or in some cases, adjacent buildings.

The cost of joint testing and sealing depends on the diameter of the pipe.

Pipe Lining

Pipe lining is used to restore a section of sewer (manhole to manhole) by inserting a liner within the pipe. The liner typically has no joints and provides a complete seal of any leaks from open joints and cracked pipe. Usually the flow is pumped around the sewer section being lined. Once the sewer is lined, it is necessary to cut out the liner where each building lateral connects to the sewer. This can be done by a machine inside the sewer or by excavation to the connection.

Several alternatives are available for sewer liners. There are contractors that use a resin impregnated felt liner that is inverted inside the sewer by water pressure and set by hot water or steam. This type of liner has been placed 8-inch diameter pipes to 120-inch diameter pipes.

Sealers

Cone

Spot Repairs

Some short sections of sewer require replacement rather than replacement of the entire length between manholes. These sections are often sagging so that lining would not correct the problem entirely.

Spot repairs are also implemented where the storm sewer leaks over the building lateral (found by dye water testing). The excavation is usually made to the building lateral to replace a short section. Careful compaction of the trench backfill is required to make sure the storm sewer over the building lateral does not settle again and open the storm sewer joint.

Line Replacement

Pipe bursting

Directional drilling

Cut and cover - This is the most common method of line replacement but also the most disruptive as it requires a trench to be opened up to access the existing sewer, remove it and install new sewer.

References

Internet Web sites: Sewer Liners

[www.instiufom.com/howwedoit/pipebursting_animation.htm]

[www.advantica.biz/hardware_liscensing/swagelining/sewer.htm]

[www.linkpipe.com/applications.htm]

[www.jonesborsinc.com/sewer_rehabilitation.htm]

[www.rinker.com/pipelinesystems/products/Uintro.htm]

[www.visu-sewer.com/installing_u-liner.htm]

Internet Web sites: Manhole Liners

[www.globalspec.com/FeaturedProducts/Detail?ExhibitID=16500]

[www.neopoxy.com/index1.html]

[www.precast.org/publications/mc/TechArticles/00_Winter_Manholes.htm]

SECTION 5: SAMPLE SPECIFICATIONS FOR NEW CONSTRUCTION

Sanitary Gravity Sewers

Purpose and Use of the Tool

The intent of this section is to provide guidance to municipalities on ways MCES minimizes inflow and infiltration that relates to the siting, design, materials of construction, construction inspection, testing, and acceptance of its facilities.

Description of Location and Alignment

Federal Sanitary Sewer Overflow (SSO) rules and Capacity Management Operation and Maintenance (CMOM) regulations dictate that all facilities be maintainable and strictly prohibit SSOs. A primary concern in selecting an interceptor alignment is accessibility and prevention of spills.

Locate facilities located in the public right-of-way and always in areas where the ground elevation is above the 100-year flood plain. In areas where public right-of-way is not available, surface easements should allow roadway and trail improvements that provide accessibility for maintenance and repair of the system. These access features should be included in the design phase and installed as part of the construction of the facility.

Design

During the design phase of the project, the following concepts and features should be incorporated in the maintenance structure of the sanitary gravity sewer.

- Provide for off-road structure rim elevation that is a minimum of 6-inches above the surrounding grade. The ground surface should taper from the rim elevation to the surrounding ground surface.
- Avoid locating maintenance structures within roadway ditches, gutter lines, stormwater retention/detention basins, and low areas that might be subjected to periodic flooding.
- Use maintenance structure elements manufactured per ASTM C478 without lifing holes. Maintenance structure joints should be O-ring press seal, type 1 and gaskets should conform to ASTM C443.
- Use chimney seals on all maintenance structures. The chimney seal should be of robust design and capable of tolerating the freeze/thaw cycle. The seal should extend from the casting across the adjustment ring, and terminate on the first barrel section.
- A maximum of one adjustment ring may be used beneath the casting, with a full bed of mortar beneath the adjustment ring.
- Castings should have solid lids with no holes and fit tightly on the frame. The casting frame should be adequately secured to the structure barrel. There should be two rows of mastic sealing material beneath the casting.
- Maintenance structure bases should be integral with the initial barrel section.

- “Dog house” type closures at pipe penetrations should be avoided when possible.
- Concrete block construction is not allowed.
- Pipe penetrations into maintenance structures should be watertight, using an integrally cast boot or mechanically attached boot when the penetration is cored.

The trunk sewer connections to interceptors should be made at the maintenance structure sites. Individual service connections and trunk sewers should not connect directly to the interceptor pipe.

The trench design and specified pipe class/stiffness should provide for long-term pipeline serviceability and uniform pipe grade without reaches of subsidence, over-deflected pipe, cracked pipe, offset joints and separated joints.

Materials

The following materials are recommended:

1. Concrete Pipe: ASTM C-76
 - No lift holes
 - Joints: Rubber O-ring or profile gaskets. ASTM C-361
2. PVC (Polyvinyl Chloride) Pipe: ASTM D-3034, AWWA C905
 - Joints: Elastomeric gasketed joints bonded to pipe. ASTM D-3212
3. HDPE (High Density Polyethylene) Pipe: ASTM F714
 - Type Classification: ASTM D1248, PE 3408, Type III, Class C, Category 5, Grade P34.
 - Joints: Thermal buff-fusion in accordance with ASTM D2657
4. RPMP (Reinforced Plastic Mortar Pipe): ASTM D3262
 - Joints: Elastomeric sealing gaskets made of EPDM rubber ASTM D4161.
5. DIP (Ductile Iron Pipe): AWWA C115, AWWA C151, and AWWA 150
 - Joints AWWA C111
 - Fittings AWWA C110 or C153
6. Polymer Concrete Pipe
7. Maintenance Structures: ASTM C-478
 - Joints and Gaskets: O-ring, press seal, Type 1. ASTM C443, Cretex CX2
 - Integral cast gaskets into MH base. ASTM C923
 - No lift holes
 - Castings: Provide solid lids with concealed pick holes. Mating surfaces of frame and the cover should be machined.

The use of vitrified clay pipe, corrugated metal pipe, profile-wall PVC, and profile-wall HDPE pipe is NOT recommended.

Construction

The following steps should be followed during the construction phase of the project.

1. Specify a maximum of 5% allowable pipe deflection. Mandrel (Rigid Ball or 9 leg) testing of all flexible pipe should be performed 30 days after pipe installation and again after one year. Pipe that exhibits more than the specified 5% deflection should be reinstalled.
2. Infiltration and exfiltration testing should be performed after the groundwater table has returned to pre-construction levels.
 - Specified Infiltration/Exfiltration limits should not exceed 100 gallons per inch of pipe diameter per mile per day.
 - Hydrostatic testing should be conducted with a minimum of 2 feet of positive head.
 - Low pressure air (4 psig above groundwater pressure) testing may be used and shall conform to the following requirements.
 - Air leakage rates for PVC, HDPE, RPM, and ductile iron pipe should not exceed .0015 cubic feet/minute/square foot of internal surface area for plastic pipe. Testing should conform to CEAM Specification 02621.
 - Air leakage rates for reinforced concrete pipe should not exceed .003 cubic feet/minute/square foot of internal surface area for concrete pipe. Testing should conform to CEAM Specification 02621.
3. Provide for sufficient administration and inspection personnel to enforce project specifications.
 - Provide sufficient budget.
 - Provide for continuous inspection of crucial project elements: pipe delivery, pipe installation, backfill placement and compaction, compaction testing, leakage testing, deflection testing, etc.
4. Perform gradation and compaction testing at regular intervals: each backfill lift, every 50 cubic yards.

[\[References\]](#)

SECTION 6: SAMPLE ORDINANCES

One of the most important tools a City has for managing its systems are Ordinances. Ordinances are specific to each city. Following are a few examples and sites you can go to if your City wishes to adopt sanitary rules related to discharge, connections, etc.

City of Forest Lake

CITY OF FOREST LAKE ORDINANCE NO. 531

AN ORDINANCE AMENDING SECTION 18.01 SUBD. 6 OF CHAPTER 18 OF THE CITY CODE OF THE CITY OF FOREST LAKE AND PROHIBITING THE DISCHARGE OF SURFACE WATER INTO THE CITY SANITARY SEWER SYSTEM

The City Council of the City of Forest Lake hereby ordains as follows:

Section 18.01 Subd. 6 of Chapter 18 of the City Code of the City of Forest Lake is hereby amended as follows:

Subd. 6. Except as otherwise expressly authorized in this subdivision, no water from any roof surface, sump pump, footing tile, swimming pool, any other natural precipitation, cooling water or industrial process water shall be discharged into the sanitary sewer system. Dwellings and other buildings and structures which require sump pumps or footing tiles shall have a permanently installed discharge line which shall not at any time discharge water into the sanitary sewer system, except as provided herein. A permanent installation shall be one which provides for year round discharge capability to either the outside of the dwelling, building, or structure, or is connected to a city storm sewer. It shall consist of a rigid discharge line, without valving or quick connections for altering the path of discharge or a system otherwise approved by the City Administrator.

(a) Before March 15, 2004, any person, firm or corporation having a roof surface, groundwater sump pump, footing tile, swimming pool, cooling water or unpolluted industrial process water now connected and/or discharging into the sanitary sewer system shall disconnect or remove same. Any disconnects or openings in the sanitary sewer system shall be dosed or repaired in an effective, workmanlike manner.

(b) Every person owning improved real estate that discharges into the city's sanitary sewer system shall allow the city or a designated representative of the city to inspect the buildings to confirm that there is no sump pump or other prohibited discharge into the sanitary sewer system. In lieu of having the city inspect the property, any person may furnish a city inspection report from a city approved licensed plumber certifying that the property is in compliance with this section.

(c) Any property with a sump pump found not in compliance with this subdivision but subsequently verified as compliant shall be subject to an annual reinspection to confirm continued compliance. Any property found not to be in compliance upon reinspection, or any persons refusing to allow their property to be reinspected, within 30 days after receipt of mailed written notice from the city of the reinspection, shall be subject to the nonrefundable charge set forth in subsection 6(e) below.

(d) All new dwellings with sumps for which a building permit is issued after January 1, 2004 shall have a pump and shall be piped to the outside of the dwelling before a certificate of occupancy is issued.

(e) A nonrefundable fee of \$100.00 per month is hereby imposed on every sewer bill mailed on and after April 1, 2004 to property owners who are not in compliance with this section or who have refused to allow their property to be inspected to determine if there is compliance. All properties found during any reinspection to have violated this subdivision will be subject to a \$100.00 per month nonrefundable charge for all months between the two most recent inspections in addition to all other regular charges for sanitary sewer service.

(f) The city administrator is authorized to issue a permit to allow a property owner to discharge water into the sanitary sewer system. Prior to issuance of the permit, the city administrator may consult with the city engineer or public works director to verify one of the criteria to issue the permit has been satisfied. The permit shall authorize such discharge only from November 15 to March 15, shall require the owner to permit an inspection of the property on March 16 or as soon thereafter as possible to determine that discharge into the sanitary sewer has been discontinued and shall subject the owner to the \$100.00 monthly nonrefundable charge in the event the owner refuses an inspection or has failed to discontinue the discharge into the sanitary sewer. The nonrefundable charge will commence with the April water billing and continue until the property owner establishes compliance with this section. A property owner is required to meet at least one of the following criteria in order to obtain the permit:

1. The freezing of the surface water discharge from the sump pump or footing drain is causing a dangerous condition, such as ice buildup or flooding, on either public or private property.
2. The property owner has demonstrated that there is a danger that the sump pump or footing drain pipes will freeze up and result in either failure or damage to the sump pump unit or the footing drain and cause basement flooding.
3. The water being discharged from the sump pump or footing drain cannot be readily discharged into a storm drain or other acceptable drainage system.

Following ten day's written notice and an opportunity to be heard, the city administrator may require the owners of property to discharge their sump pump into the sanitary sewer from November 15 to March 15 if surface water discharge is causing an icy condition on streets.

(g) Except as hereinafter provided, no person shall discharge or cause to be discharged any of the following described waters or wastes to any public sewer:

1. Any liquid or vapor having a temperature higher than 150 degrees Fahrenheit.
2. Any water or waste which may contain more than 100 parts per million by weight, of fact, oil, or grease.
3. Any gasoline, benzene, naphtha, fuel oil, or other flammable or explosive liquid, solid or gas.

Passed and adopted by the City Council of the City of Forest Lake, Minnesota this 9th day of February, 2004.

City of Bloomington

E. Sanitary sewer system regulations, ordinances and management practices

The City has adopted a number of practices that are aimed at protecting the quality of water resources within Bloomington and the integrity of the sanitary sewer system. These practices are crucial to the future performance and investment required by the utility system because they represent the manner in which this and previous sanitary sewer plans are implemented.

- The **sanitary sewer ordinance** requires that properties where domestic or industrial wastewater is produced be connected to the public sanitary sewer system within two years of service availability. Further, the ordinance prescribes the design and manner in which individual connections and use of public sewers are to be made. To limit the amount of inflow into the sanitary sewer system, the ordinance prohibits the flows of storm water, ground water, roof runoff, surface water, unpolluted drainage, unpolluted industrial cooling water, or unpolluted industrial process water into any public sanitary sewer.

City of St. Anthony

REUSE OF EXISTING CONNECTION FOR NEW BUILDING

Where a building having a connection to the public sewer has been torn down and a new building is being constructed in its place, the abandoned house drain connection that served the previous building may be used, **PROVIDING IT MEETS ALL THE CURRENT REQUIREMENTS OF A NEW CONNECTION**, with the exception that the pipe depth must be at least six (6) feet measured to the top of pipe at the property line. If the owner elects to use the old connection, a regular permit must be taken out for such connection of the new building. The line must be flushed and televised (and reviewed by the Sewer Utility), prior to use, at the contractor's cost. Services over fifty years old cannot be reused except at the discretion of the Sewer Utility. If approved, the house Sewer Contractor must inform the property owner that they have ownership and are responsible for the re-used pipe.

When reusing an abandoned sand rock drift, the new drill hole is to be constructed in front of the old drill hole, a bulkhead must be of similar construction as used for abandoning sand rock drifts.

Agreement with the CITY OF ST. ANTHONY To Initiate I/I Program and meet its I/I Goals established by the Metropolitan Council

Paragraph3, A. Point of Sale Removal – As existing homes within the City are sold, the City will administer an ongoing program requiring an inspection of the plumbing system. If either sump pumps or passive drain tile are found that discharge clear water to the sanitary sewer system, their discharge will be routed away from the sanitary sewer.

Web site References of City Ordinances

Andover

<http://www.sterlingcodifiers.com/MN/Andover/index.htm>

[Apple Valley](#)

http://www.amlegal.com/nxt/gateway.dll?f=templates&fn=default.htm&vid=alp:applevalley_mn

[Arden Hills](#)

http://www.ci.arden-hills.mn.us/Documents/City_Code/Chapter_10-Utilities.pdf

[Blaine](#)

<http://www.municode.com/services/ordinances.asp> (must order and pay for)

[Bloomington](#)

<http://www.ci.bloomington.mn.us/cityhall/dept/pubworks/utilitie/wastewtr/policy.htm#regs>

[Brooklyn Center](#)

<http://www.ci.brooklyn-center.mn.us/vertical/Sites/{AC68FDDE-6B3F-416C-85EB-0D846EA8D6A1}/uploads/{8B7EF8B6-A34F-44CF-BFA7-1D69D4ED1008}.PDF>

[Burnsville](#)

<http://66.113.195.234/MN/Burnsville/index.htm>

[Centerville](#)

http://www.centervillemn.com/index.asp?Type=B_BASIC&SEC={EA126CC7-5AE7-4ADB-A93A-1F4C27B302EA}

[Chaska](#)

http://www.chaskamn.com/new_resident/ordinance.jsp

[Cottage Grove](#)

http://www.cottage-grove.org/docs/public_works_stormwater_swppp.pdf

[Columbia Heights](#)

Inspection program: <http://www.ci.columbia-heights.mn.us/>

[Crystal](#)

<http://www.ci.crystal.mn.us/index.asp?Type=SEC&SEC={170591C6-FE14-4988-8E03-977FEFE7C024}&DE={B8C678FC-0082-4704-A280-B50A7F394C7F}>

[Deephaven](#)

<http://www.cityofdeephaven.org/Ordinance/Ordinance%20Chapter%2010.pdf>

[Eagan](#)

<http://www.municode.com/services/mcsgateway.asp?sid=23&pid=13070> (must purchase)

[Empire](#)

No web link

[Edina](#)

http://www.ci.edina.mn.us/Pages/L4-07_CityCodeSelect.htm

[Excelsior](#)

http://www.ci.excelsior.mn.us/index.asp?Type=B_BASIC&SEC={DA39DCA5-EC74-4595-B9F4-B81EAED15743}

[Hopkins](#)

<http://www.hopkinsmn.com/cityhall/ordpol/07/705.html>

[Independence](#)

http://independence.govoffice.com/index.asp?Type=B_BASIC&SEC={189557C9-F9C1-4C21-88AE-7C6D4280B93D}&DE={D1DC7BFA-0A9C-4524-B2D0-B7F20D42BE3E}

[Inver Grove Heights](#)

<http://www.ci.inver-grove-heights.mn.us/cityhall/code.html>

[Lakeville](#)

<http://66.113.195.234/MN/Lakeville/index.htm>

[Lauderdale](#)

<http://www.ci.lauderdale.mn.us/vertical/Sites/{5F73237E-9F78-407B-A785-DA0D9F5C945F}/uploads/{587F55CD-E0A7-4353-9AD2-56FAEA540EAC}.PDF>

[Little Canada](#)

http://www.ci.little-canada.mn.us/index.asp?Type=B_BASIC&SEC={B1007D9B-ED41-447C-B9FA-99834F90C442}&DE={73B1098D-DC47-48AB-B927-4086B037FD80}

[Long Lake](#)

<http://www.municode.com/services/mcsgateway.asp?sid=23&pid=13357> (must purchase)

[Maplewood](#)

http://www.ci.maplewood.mn.us/index.asp?Type=B_BASIC&SEC={61F465FC-911C-4D0D-AA2F-C9F10EA3D912}&DE={1FDB9614-E604-4831-A0D1-CD9A4E5EB936}

<http://www.ci.maplewood.mn.us/vertical/Sites/{EBA07AA7-C8D5-43B1-A708-6F4C7A8CC374}/uploads/{793B5AFA-0B28-4F69-9DA4-EFC4AB60FDC6}.PDF>

[Maple Plain](#)

http://www.mapleplain.com/index.asp?Type=B_BASIC&SEC={84471C7F-4F20-4471-AC2D-29DEA2A4D156}

[Medina](#)

<http://www.ci.medina.mn.us/>

[Mendota Heights](#)

<http://66.113.195.234/MN/Mendota%20Heights/index.htm>

[Minneapolis](#)

http://library12.municode.com/gateway.dll/MN/minnesota/262?f=templates&fn=default.htm&npusername=11490&nppassword=MCC&npac_credentialspresent=true&vid=default

[Minnetrista](#)

<http://www.ci.minnetrista.mn.us/vertical/Sites/{4D81CC6D-EB97-4B3E-BCE8-0C281A21CCCC}/uploads/{BF9BF0D7-2271-43F6-8AF7-E7326BEABA3B}.PDF>

[Minnetonka](#)

http://www.amlegal.com/nxt/gateway.dll?f=templates&fn=default.htm&vid=alp:minnetonka_mn

Mound

<http://www.cityofmound.com/> (under City Code)

Moundsview

<http://www.ci.mounds-view.mn.us/ords/740.pdf>

New Brighton

<http://www.ci.new-brighton.mn.us/vertical/Sites/{2CF34F28-6DFB-45DA-AF59-36896254F224}/uploads/{0FC75746-D4D2-4C43-9230-96B8C0440190}.pdf>

New Hope

<http://www.municode.com/services/mcsgateway.asp?sid=23&pid=13677> (must pay for)
<http://www.ci.new-hope.mn.us/whatsnew/In%20The%20Pipeline/ITP-0505.pdf>

Newport

http://www.newport.govoffice.com/index.asp?Type=B_BASIC&SEC={B28CD173-CF19-4ABC-900C-53200A58CCDD}&DE={DD56D21A-8B21-467F-BD5C-069F03CB483D}

North St. Paul

http://www.amlegal.com/nxt/gateway.dll?f=templates&fn=default.htm&vid=alp:nstpaul_mn

Oakdale

<http://www.ci.oakdale.mn.us/Code%20Chapter%2023.htm>

Prior Lake

http://www.cityofpriorlake.com/document_center.html (may not be available)

Richfield

http://www.ci.richfield.mn.us/residents/codes/CityCodesPDF_Files/ch07.pdf

Robbinsdale

<http://www.ci.robbinsdale.mn.us/Download/City%20Code/Chapter%207.pdf>

St. Anthony

http://stanthony.govoffice2.com/index.asp?Type=B_BASIC&SEC={1447FCAC-BD50-498F-89C8-D1AE475280D1}&DE={5DD14236-47D4-4B1A-A67A-1BC0DA68BD4A}

<http://stanthony.govoffice2.com/vertical/Sites/{5ED4AFB9-D450-4F68-BA29-2600D3C2A620}/uploads/{4273B5BC-BB88-4C63-A6A8-C536E133E428}.PDF>

St. Bonifacius

<http://www.ci.st-bonifacius.mn.us/news.htm> (Sump Pump)

St. Paul

<http://www.ci.stpaul.mn.us/code/>

Tonka Bay

http://www.cityoftonkabay.net/index.asp?Type=B_BASIC&SEC={86FB0877-DA2E-419B-A018-E784A6B662FA}&DE={F4C2CE37-2EE4-4C64-A2A7-F4E5C552B8EF}

Woodbury

<http://www.ci.woodbury.mn.us/planning/cmpln/sanitary-11.pdf>

Victoria

<http://www.municode.com/services/mcsgateway.asp?sid=23&pid=19963>

Waconia

http://www.waconia.org/index.asp?Type=B_BASIC&SEC={0D38BD80-A3AA-4284-9DDE-406478433256}