SEPARATE SANITARY SEWER COLLECTION SYSTEM

OPERATION AND MAINTENANCE MANUAL

FOR LOCAL AGENCIES TRIBUTARY TO

THE METROPOLITAN SANITARY DISTRICT

OF GREATER CHICAGO

Prepared by Metcalf and Eddy, Inc.

for

**THE METROPOLITAN SANITARY DISTRICT
OF GREATER CHICAGO**

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PREFACE

This manual was prepared for the Metropolitan Sanitary District of Greater Chicago (MSDGC) by Metcalf & Eddy, Inc. as part of the ICAP Basin Analysis, Project 86-855-2S. The purpose of the manual is to provide guidelines necessary for developing a long-term operation and maintenance program for the local sewer systems tributary to MSDGC interceptors and treatment facilities.

The primary sources of information used to produce this manual were operation and maintenance manuals used by various agencies throughout the United States including the Metropolitan Sanitary District of Greater Chicago, the Milwaukee Metropolitan Sewerage District, the Washington Suburban Sanitary Commission, the Metropolitan St. Louis Sewer District, City of Madison, Wisconsin and the City of Memphis, Tennessee.

Portions of this manual were reprinted from OPERATION AND MAINTENANCE OF WASTEWATER COLLECTION SYSTEMS, Volumes I and II, copyright 1987 by Hornet Foundation, Inc., California State University, Sacramento, by permission. The entire manual may be obtained by contacting Ken Kerri, Office of Water Programs, California State University, Sacramento, 6000 J Street, Sacramento, CA, 95819.

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The user should not assume that all safety measures are indicated in this manual or that other measures may not be required. The safety guidelines presented in this manual are minimum standards only. Before commencing actual work, the latest safety standards and laws should be checked and followed. It is the responsibility of each agency to follow current and comprehensive safety standards and laws at all times.

CHAPTER 1

INTRODUCTION

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PURPOSE AND SCOPE

The purpose of this manual is to introduce sewage collection system personnel to various aspects of a preventive maintenance program. To be effective, a preventive maintenance program should include an adequate mapping system, flow monitoring, inspection, sewer cleaning, new construction monitoring, and other rehabilitation and maintenance procedures. The implementation of an effective safety program is also very important. These points, as well as personnel and equipment requirements and budgeting, will be discussed in detail throughout this manual.

Preventive maintenance is the most effective and efficient type of maintenance program. This type of program should not be designed merely to make it possible to live with problem areas. It should try to prevent stoppages, failures, and complaints, and anticipate what is going to go wrong and prevent it from happening.

Preventive maintenance should be a total concept. A good preventive maintenance program requires a supervisor that knows what is likely to happen and where. The supervisor needs accurate functional maps, good records, and an understanding of how to apply and use them. Intelligent use and assignment of available staff and equipment is important, as well as properly planned and meaningful maintenance scheduling. All these factors, properly applied, will provide a true preventive maintenance program. The program will be effective, efficient, economical, and safe.

A preventive maintenance program may be set up in several different ways, ranging from a wall chart on which preventive maintenance tasks are assigned and checked off as they are completed, to a sophisticated computer system. A chart or card system is functional and is widely used. The computerized system, however, has many advantages over the card system. For example, information can be retrieved much quicker and can be used simultaneously by more than one person, schedule revision is much easier, and the computer can be programmed to alert the users to emergency situations. Chapter 11 of this manual presents some useful recordkeeping forms and suggested schedules that may be helpful when initially setting up a long-term preventive maintenance program.

Whatever form the preventive maintenance program takes, its success depends on the care and thought with which it was developed, implemented, and maintained.

A preventive maintenance program should be simple and functional. All groups that will have a part in the program should contribute to its development and implementation, including those who will provide information and perform maintenance tasks. After the first six months, the program should be reviewed to determine its efficiency. If after review, the existing preventive maintenance program is found to require modifications, the program should be changed as appropriate.

Many preventive maintenance programs fail before they are even started due to the inadequacy of the plan to fit the need of the particular facility, failure to properly record the information necessary to keep the program workable, or design of a program that is either too simple or too sophisticated.

The development of a preventive maintenance system should consist of the following three phases:

1. An initial survey of the size of the preventive maintenance system required and the selection of the hardware to be used (computer or cards).

2. Assembly of specific information on all pieces of equipment, pipelines, manholes, lift stations, and other appurtenances of the collection system, and a listing of specific maintenance tasks required for each.

3. Fine tuning of the system consisting of a periodic review to assess the effectiveness and efficiency of the system.

Proper scheduling is an important part of the program. For basic daily or weekly inspections and maintenance, personnel should be assigned to work in a variety of areas and perform a variety of tasks. Rotating personnel on weekly or daily activities is a good practice because it promotes a wider range of capabilities for each employee. For every twelve weeks of work, it is helpful to leave one week free to allow adjustments to the schedule and updates to the program as needed.

Every program must include a feedback system to allow staff to report problems and make suggestions to improve the efficiency of the program. This can be accomplished in part through the use of detailed record keeping of all maintenance activities. Also, all maintenance personnel should take part in preventive maintenance program evaluation meetings.

This manual generally covers separate sanitary sewer collection systems. It is impossible to discuss all of the problems which may arise or all the maintenance procedures required. However, with the information contained in this manual, it will be possible to handle routine operation and maintenance, and to recognize those problems which will require outside help from suppliers, manufacturers, contractors, or engineers. For example, this manual will help in making the decision as to which rehabilitation or cleaning method is suitable for a specific problem. The discussion of the actual operation of the required equipment, however, is left to manufacturer's guidebooks.

CIRCULATION AND USE OF MANUAL

This manual was developed for the Metropolitan Sanitary District (MSD) of Greater Chicago and is meant to be used by the District's member communities to set up a long-term operation and maintenance program. The MSD Sewer Permit Ordinance requires all communities tributary to the MSD collection and treatment system to develop a long-term operation and maintenance program aimed at preventing entry of excessive infiltration and inflow into the sanitary sewer system. The amount of excessive infiltration and inflow allowed to enter the sanitary sewer systems depends on the compliance option each community has selected. Appendix E details the wet weather flow requirements for the 150 gpcpd option and ICAP (Infiltration/Inflow Corrective Action Program) option agencies.

Copies of the Metropolitan Sanitary District of Greater Chicago's Sewer Permit Ordinance and Manual of Procedures for the Administration of the Sewer Permit Ordinance have been included as Appendix B and Appendix C respectively to this manual.

This manual should be read, studied, and referred to by all sewage collection system personnel. This includes field workers, foremen, supervisors, directors of public works and other management personnel. Although certain chapters may be more beneficial to one group of people, the entire manual should be read by everyone. This will provide an adequate orientation of all workers to what is required to implement an efficient preventive maintenance program.

As stated above, this manual is not designed to solve all of the problems that can occur in a collection system. Instead, it is meant as an easy reference to the options available to the agency. It provides examples of procedures, equipment, records, and forms that will help to upgrade the existing maintenance program or to implement a new one.

The importance of a preventive maintenance program cannot be emphasized enough. Sewer overloading caused by improperly maintained systems may cause health hazards, financial loss and inconvenience to area residents. This occurs as a consequence of sewage flows exceeding the sewer system and treatment facility capacities with resultant sewage overflows into streams, buildings, yards, and onto streets. Excessive clearwater flows also result in additional sewage treatment costs which are passed along to the public. Implementation of an effective long-term sewer management program by owners of separate sanitary sewers tributary to MSD sewage treatment facilities will reduce sewage overflows and create a better environment in which to live.

A list of references is provided in Appendix A that should be investigated if more detailed information regarding selected topics is desired.

CHAPTER 2

SEWER MAPPING

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INTRODUCTION

An accurate record of the location, size, depth and type of sanitary sewers and their appurtenances is essential for effective sewer operations and maintenance. The best way to maintain these records is with detailed sewer maps. If not already available, sewer system maps should be developed, and kept updated, before any organized maintenance activities can be planned.

MAP TYPES

There are several types of mapping systems that have been used effectively by many communities. An area map is a map of the entire system. It is scaled in such a way that is shows how the entire area is served by the system and what the general patterns of the system are. Only the major items of concern are outlined on area maps, such as separate sewer areas, combined sewer areas, major trunk line connection points to other systems, pumping stations, diversion structures, overflows, treatment plants, and major roads.

At a much larger scale than area maps are section maps. These are drawn at a scale which allows for even more detail of the sewers, manholes, appurtenances, and their surroundings, such as property lines, buildings, and even trees and bushes. The size of section maps should be practical for use in the field. The number of section maps required to represent a sewer system depends on the size of the area. Ample space should be left on the maps to allow for pipe identification numbers, footages, pipe material, and pipe sizes. Section maps are necessary for planning specific maintenance tasks and for the field crews performing maintenance on the system. A set of properly prepared section maps will summarize data in one location from volumes of sewer system records normally kept by sewer system operation and maintenance personnel. Once developed, a comprehensive set of sewer system section maps will save time organizing and implementing a long-term operation and maintenance program because pertinent sewer system data will be centrally located and readily available.

Assessor's maps are also suitable for field use. These maps are usually drawn on individual pages and bound into books. They are very detailed and contain street names, street widths, property identification numbers and property sizes. Assessor's maps are usually obtainable from real estate or assessor departments.

Finally, grid coordinate maps can be used. These are developed by surveying crews and are based on a coordinate system developed by the state. This type of mapping system is very effective because the coordinate system will never change. It should be possible to locate the sewers at any time. All utility agencies can identify the location of all the important points of their underground facilities on the same grid system. This would make many jobs such as excavation much easier for sewer collection system personnel.

MAPPING DATA

When organizing a long-term operation and maintenance program it is essential to develop an accurate area map and set of section maps. Generally, the more data that is included on each type of map, the easier it will be to set up and implement a sewer maintenance program. Mapping data can be stored in a computer system's database so that computerized maps can be generated or revised quickly.

Area Maps

As a minimum, area maps should include the following sewer system data:

1. Background information including the community/agency boundary, major roadways, waterways, the boundaries of the 100-year floodplain, and any other pertinent landmarks.

2. The entire sanitary sewer collection system with the exception of the individual service connections.

   This includes:

   a. All sewer mains and local interceptors.

   b. Wastewater lift stations.

   c. Diversion structures.

d. Inverted Siphons

e. Overflows or bypasses.

f. Other major appurtenances.

3. Differentiate between areas in the community/agency which are served by separate sewers from those areas served by combined sewers.

4. In communities/agencies served by more than one MSDGC treatment plant, indicate the boundaries of the sewer areas served by each MSDGC facility and label each area appropriately.

5. Mark and label all locations where the separate sanitary sewers of the community/agency are connected to the MSDGC interceptor sewer system, local combined sewer systems, or sewer systems of other communities/agencies.

6. An area on the map should be reserved for tabulating the population equivalent served by each connection point to the receiving sewer system.

7. The scale at which the map is drawn.

8. A north arrow.

9. Date of latest map revision.

A basic example of an area map with typical useful data is included as Figure 2-1.

<u>Section Maps</u>

The data included on section maps needs to be in much greater detail than the general sewer system data included on a typical area map. Useful section maps should include the following data:

1. Location of sewers, manholes, and other appurtenances relative to the centerline of streets, property lines and benchmarks.

2. Building sewer connections located by their distance from the nearest manhole.

3. Sewer line data such as:

   a. Sewer pipe diameter.

   b. Sewer pipe material.

   c. Sewer age.

   d. Invert elevations shown at each manhole.

   e. Wastewater flow direction designated by an arrow.

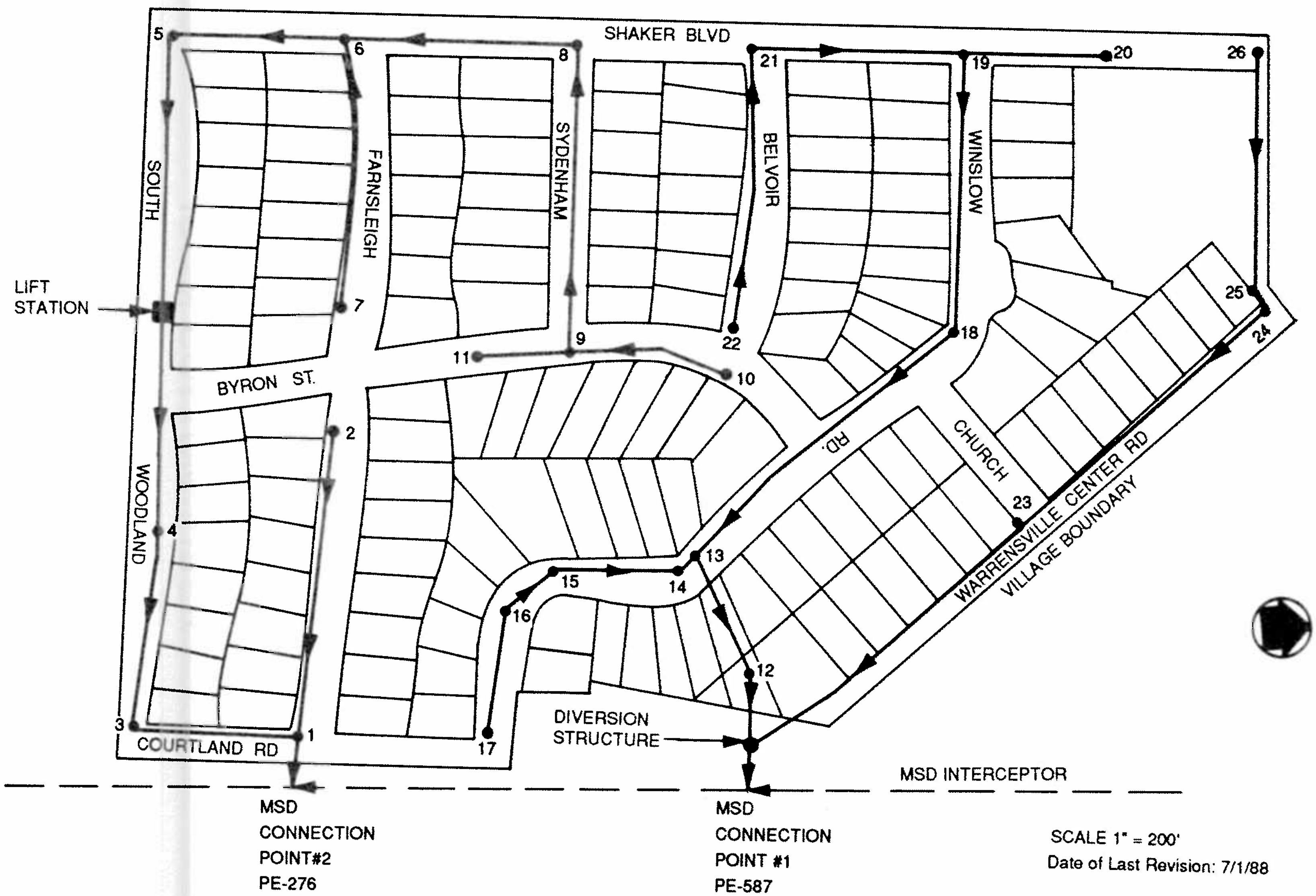

FIGURE 2-1. EXAMPLE AREA MAP

f. Differentiation between gravity mains and force mains.

g. Sewer lengths between manholes.

h. Location of flushing branches.

4. Manhole data such as:

   a. Rim elevations.

   b. Type of manhole construction.

   c. Manhole diameter.

5. Lift stations.

6. System overflows.

7. System bypasses.

8. Other utilities including:

   a. Storm sewers.

   b. Combined sewers.

   c. MSDGC interceptors and connection points.

   d. Water mains.

   e. Gas mains.

   f. Buried electrical cables.

   g. Buried telephone lines, etc.

9. Location of building service lateral cleanouts.

10. Invert elevations of building service laterals at the property line.

11. Miscellaneous data including:

    a. Width of streets.

    b. Right-of-way locations.

    c. Easement locations.

    d. Lot boundaries.

    e. Community/agency boundaries.

12. The scale at which the map is drawn.

13. A north arrow.

14. Legend defining all symbols and abbreviations used.

15. Date of latest map revision.

A basic example of a section map showing typical data is included as Figure 2-2.

Labeling Map Components

Each component of the sanitary sewer collection system shown on any sewer map must have a unique identification number. The number a sewer system component has been assigned must never be changed. Manholes that may be added later must be given new identification numbers. A length of sewer can be identified by indicating the numbers of the two manholes or other terminating structures which it connects. The service laterals can be identified by the street address or lot number which it serves. Connection points to the MSDGC system or other receiving systems must be identified and labeled.

MAP DEVELOPMENT

For communities/agencies that do not have a set of usable sewer maps, it is essential for proper operation and maintenance that useful sewer maps be developed. The development of sewer maps requires combining a variety of sewer system records. If a computerized mapping system is chosen for generating the sewer maps, the sewer system records can be used to create a database consisting of the critical information needed on the sewer system maps. Frequently the records are used to develop a base map along with a series of overlays. Base maps commonly include background information such as roads, waterways, buildings, property lines, basements, and other relatively permanent landmarks. Each overlay commonly represents a specific set of data traced onto a blank reproducible sheet which overlays the base map. Typical overlays for properly maintaining and operating the sanitary sewer system would include:

1. An overlay consisting of the sanitary sewer collection system.

2. An overlay including all utilities other than the sanitary sewer system.

3. An overlay with groundwater contours on it.

4. An overlay with ground surface contours on it.

Obtaining Map Data

Obtaining data to incorporate on sewer maps can be achieved by reviewing available records and/or by conducting field inspections. The following list indicates the common types of records that can be reviewed and field inspections that can be done to obtain the most important sewer map data:

1. Review as-built construction drawings and contract specifications. As-built drawings and specifications can provide information regarding the age of the system, pipe materials used, type of manholes installed, rim elevations of manholes, location and size of lift stations and other system appurtenance.

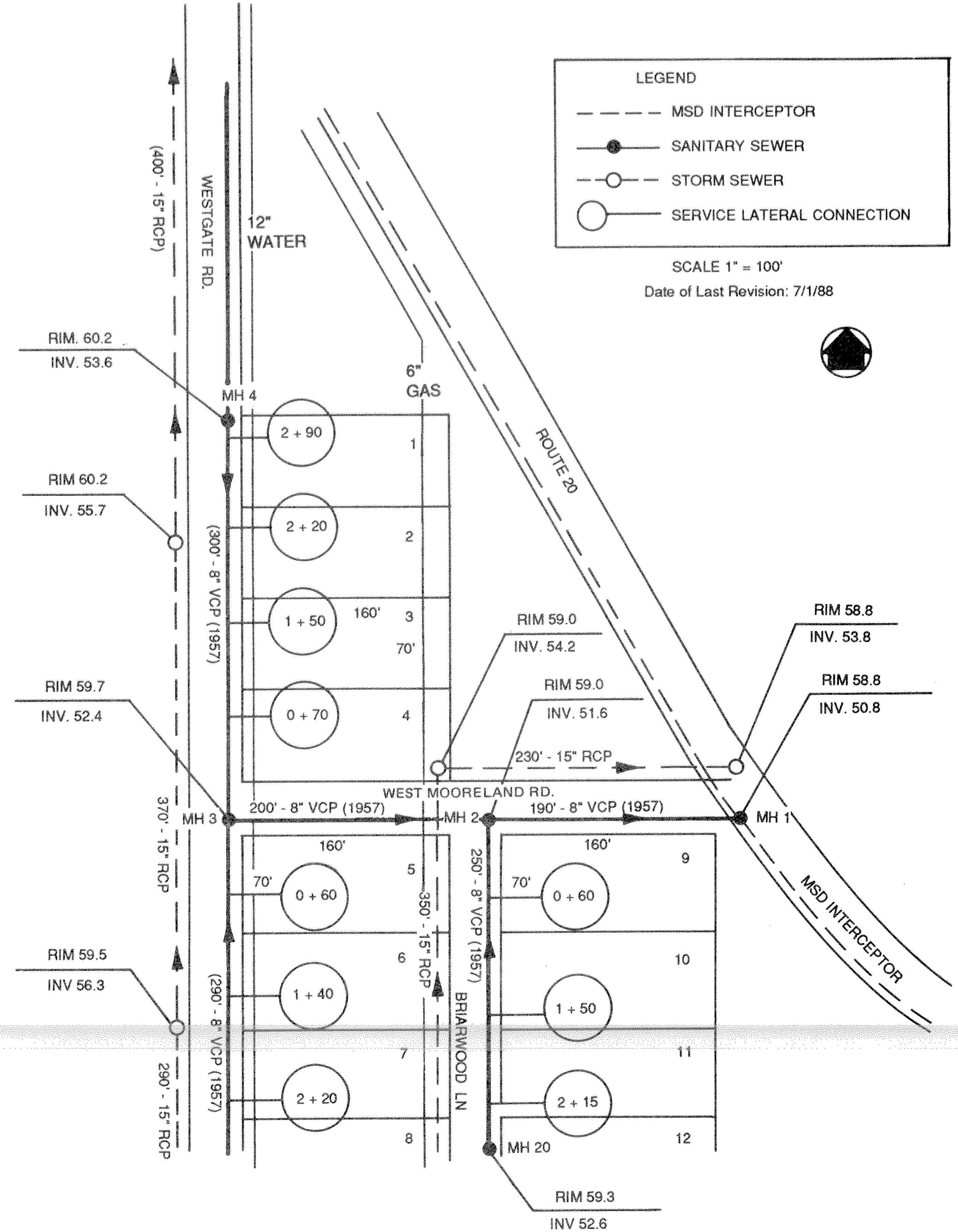

FIGURE 2-2. EXAMPLE SECTION MAP

2. Review Sewerage System Permits to verify the locations of connection points to the MSDGC interceptor system.

3. Review surveys of private property for identifying property lines and permanent easements.

4. Review maps provided by utility companies for accurately determining the location of all utilities in the sewer area.

5. If information regarding the direction of flow in the sanitary sewer system is not available, flow tests can be completed in the field. The tests are done by putting either a uniquely visible floating object into the sanitary sewer system or introducing a dye solution into the sewer system. The floating object or dye bracer is then followed through the sewer system as they are observed passing through downstream manholes.

6. Smoke testing can be done quickly and relatively inexpensively to determine the location of the sanitary sewer system. Smoke is blown through the system at a specific manhole. The smoke will surface at other system manholes located near the manhole in which the smoke was introduced.

7. Additional data for developing a sewer system map may be obtained by interviewing people familiar with the system. These people may include the director of public works, sewer maintenance personnel, the community/agency engineer, or contractors that constructed the system or have maintained it.

Map Scale and Size

The scale of each type of map should be clearly identified on each map sheet. The scale on an area map is dependent on the community/agency size. The area map scale should be determined so that the data presented on the map is clearly shown and at the same time presented on a sheet size which is easy to handle.

Section maps are typically developed at a scale between 1 inch = 100 feet and 1 inch = 200 feet. Again the actual scale chosen must be adequate for clearly representing the data typically included on section maps.

The size of the maps depends on who will be handling them. Office copies and originals of the section maps may be on standard 24" x 36" sheets. Reduced size sets for easier handling in the field should be considered for map use at the operational and maintenance level.

MAP UPDATING

Sewer system maps are only as useful as they are accurate. Any errors found in the maps or changes made to the system should be corrected or recorded as soon as they occur. This can be done with bracing overlays, or by attaching changes to the maps. The mapping personnel must be adequately trained and possess good drafting skills. It is the responsibility of the management, however, to make sure that all changes to the maps are recorded as soon as possible. Field workers can also assist in the maintenance of accurate maps by reporting any discrepancies they encounter between maps and the actual system and by participating in a regularly scheduled field checking program. It is important for the updated maps to be reprinted periodically. This updating is critical for proper maintenance of the system even though it is tedious, time consuming, and cumbersome.

One person should be assigned the responsibility of updating the sewer maps. All map update data should be given to this person so that it can be incorporated onto the reproducible map sheets. Typical items that would require periodic updating include:

1. New sewer extensions and the appropriate new appurtenances. New map components must be given new identification numbers.

2. Sewer line changes resulting from the rehabilitation of existing sewers including pipe diameter, pipe material, sewer elevations, and sewer location.

3. Buried manholes not shown on the mapping system that are located in the field.

4. Change in manhole rim elevations due to sewer system rehabilitation or other construction projects in the area of the manholes.

5. Corrections to sewer map errors noted by field maintenance crews.

6. Addition of new utilities as they are constructed.

COMPUTERIZED MAPPING

Although still a new area of mapping technology, many communities are beginning to use a computerized system to maintain their maps. A database is generated, including locations, sizes, lengths, types of material, and ages of system elements.

The advantages of a computerized mapping system are numerous. It allows for a visual checklist of land parcels connected to the system and simplifies the billing process. The sections of pipe that require replacement can be easily identified when a parameter such as age of pipe is one replacement criteria. Inflow/infiltration studies can also be simplified, as well as map updating. This previously slow and error-inducing process can be made quick and accurate through the use of computers. Although the initial cost of implementing such a system may be high, it can minimize costs in the future by reducing the time required to locate system elements, to make decisions, and to update the maps. Also, information required for the system can be input to the computer by the collection system staff.

Because the computer system's database is very extensive, combining information from perhaps hundreds of other maps and records, most communities that have implemented computerized mapping programs have contracted the job to consultants experienced in this area. The consultant is able to tailor the system to the needs of the collection system facility.

The computer system can be expanded, once the database is compiled, to include programs for generating reports, calculating costs of alternative rehabilitation procedures, or drawing maps.

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INTRODUCTION

A periodic flow monitoring program should be implemented as part of the preventive maintenance program to provide early indication of excessive or extraneous flows entering the system such as inflow or infiltration. If the inflow or infiltration is shown to be excessive, measures must be taken to correct the problems. These corrective measures are discussed in Chapter 4 and Chapter 6 of this manual.

Other specific reasons for measuring wastewater flows are to:

1. Provide operating data on sewer system operations. Information such as average, maximum, and minimum flows per day are necessary to assess sewer system capacity.

2. Permit computation of transportation costs where such costs are based upon volume of sewage treated.

3. Obtain basic data from which long-term plans can be made for sewer line capacity.

4. Provide information on the volume of sewage discharged from a subdivision or an industrial plant into the community/agency's sewers. This is particularly important if charges are made to the subdivision or industry.

To determine the extent of infiltration/inflow, the following flows need to be determined:

1. Total wastewater flows, including residential, commercial, and industrial contributions.

2. Bypass flows.

3. Overflow rates.

4. Emergency pumping rates.

Simultaneously with flow measurements, groundwater level and/or rainfall measurements may also have to be taken in some cases.

REQUIREMENTS OF THE METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO

A preventive maintenance program should include the implementation of a periodic flow monitoring program to provide early indication of excessive or extraneous flows occurring in the separate sanitary sewer system. The extraneous flows could indicate the occurrence of inflow or infiltration of clearwater in the separate sanitary sewer system. If the inflow or infiltration is shown to be excessive, measures must be taken to correct the system defects causing the extraneous flows. The amount of excessive infiltration and inflow allowed to enter the sanitary sewer systems depends on which compliance option each agency has selected. Appendix E summarizes the MSDGC wet weather flow requirements for the 150 gpcpd option and ICAP (Infiltration/Inflow Corrective Action Program) option agencies.

Corrective measures for the reduction of infiltration and inflow are discussed in Chapter 6 of this manual.

Chapter 11 and Appendix D should be referred to for suggested scheduling of periodic flow metering.

WASTEWATER FLOW COMPONENTS

It is essential to know how to interpret the flow data to determine if an infiltration and/or inflow problem exists. If the flow data does indicate that excessive volumes of infiltration and inflow enter the sanitary sewer system, knowing how to separate the various components of flow will enable a community to determine which areas will require detailed system investigations and the types of investigations which should be conducted in order to find the clearwater sources.

The wastewater flowrate measured at any one time may include one or more of the possible components of wastewater flow. The components of wastewater flow can be divided into base sewage flow, infiltration, rainfall induced infiltration, and inflow.

Base Sewage Flow

The base sewage flow component in a wastewater stream consists of contributions from the residential, commercial, and industrial water users connected to the sanitary sewer system. The base sewage flow in a system is directly proportional to the sum of the water meter readings of all the customers in a community. If water meter readings are used to estimate base sewage flow, a sewage return factor must be applied to the water meter readings to account for water used for landscape irrigation, street washing, car washing, and extinguishing fires; product water used by commercial and manufacturing establishments; and water used by consumers whose facilities are not connected to sewers. For a community that does not have any industry or industrial water consumers, the base sewage flows can be roughly approximated by using winter water meter readings.

Base sewage flows tend to fluctuate on a daily, weekly, and seasonal basis. The daily flow pattern in a residential area tends to be a minimum during the early morning hours when water use is lowest. The peak base sewage flow normally occurs in the late morning. A second peak smaller than the morning peak normally occurs in the early evening hours.

Weekly flow variations may exist in a residential area if a majority of water users do laundry on specific days of the week. Communities with large commercial or industrial bases may also see variations in base flow depending on the day of the week due to cyclical production practices.

Seasonal variations tend to occur in communities with resort areas, in communities with college campuses, and in communities with commercial and industrial customers which operate differently at different times of the year.

Infiltration

The infiltration component in a wastewater stream consists of water entering the sewer system from the ground through defective service lines and connections, defective pipes, defective joints, defective pipe connections at manholes and other appurtenances, and defective manhole walls.

Most sanitary sewer systems experience some degree of infiltration. The infiltration component of flow will vary seasonally depending on the level of the groundwater. In the Cook County area of Illinois groundwater peaks normally occur in the spring and fall of the year.

Infiltration can be estimated by analyzing flow data during dry weather periods in the early morning hours when base sewage flows are at a minimum. During these conditions, infiltration will make up the majority of flow being measured. Caution must be practiced in communities with large industrial customers who may perform cleanup operations during the early morning hours increasing the base sewage flow component of the total flow measured.

It should be noted that when estimating the infiltration component of a wastewater flow, it may include inflow sources such as cooling-water discharges, and drainage from springs or swampy areas which continually enter the sanitary sewer system independent of rainfall.

Rainfall Induced Infiltration

Rainfall induced infiltration enters the sanitary sewer system through the same types of defects as infiltration. However, rainfall induced infiltration is dependent on rainfall which percolates through the ground. On a graph where sewer flows are plotted against time, rainfall induced infiltration will appear as a steady but gradual increase in flow above the base sewage and infiltration components occurring shortly after a significant rainfall event begins. However, rainfall induced infiltration cannot be determined until after a rainstorm has ended because the increase in flow may also include stormwater inflow. After a rainstorm ends, the inflow component becomes negligible within a couple of hours depending on the size of the wastewater collection system. Once the inflow component becomes negligible, rainfall induced infiltration can be estimated by subtracting off the base sewage and infiltration components. Rainfall induced infiltration may continue to enter the sanitary sewer system for several days after a rainstorm event has ended.

It should be noted that if foundation drainage is discharged directly to the sanitary sewer system it is considered an inflow component. However, since foundation drains will capture rainwater as it percolates through the soil in the same manner as rainfall induced infiltration enters through sewer system defects, it is impossible to separate inflow contributed by foundation drains from rainfall induced infiltration while reviewing sewer system flow data.

Inflow

Inflow sources can be placed into two categories. The first category would include inflow which enters the sanitary sewer system from foundation drains, cooling-water discharges, and drains from springs or swampy areas. These sources of inflow contribute a relatively steady amount of clearwater to the sanitary sewer system and usually cannot be identified separately from infiltration and rainfall induced infiltration. The second category consists of inflow entering the sanitary sewer system as a result of stormwater runoff which causes an almost immediate increase in the sanitary sewer flows. Types of defects which contribute to inflow causing immediate increases in sanitary sewer flows include downspouts, yard drains, area drains, cross connections from storm sewers and catchbasins, manhole covers, and poorly sealed manhole frames.

The inflow component of wet weather wastewater flows can be estimated by subtracting base sewage flow, infiltration, and rainfall induced infiltration from the total wastewater flow.

Figure 3-1 shows an example of a typical sewer system hydrograph for a system which is subject to all four types of wastewater flow components. The determination of infiltration/inflow components is provided in detail in the following reference handbook:

> Handbook for Sewer System Evaluation and Rehabilitation, U.S. Environmental Protection Agency, EPA 430/9-75-021, Washington, D.C., December 1975.

FLOW MEASUREMENT PLANNING

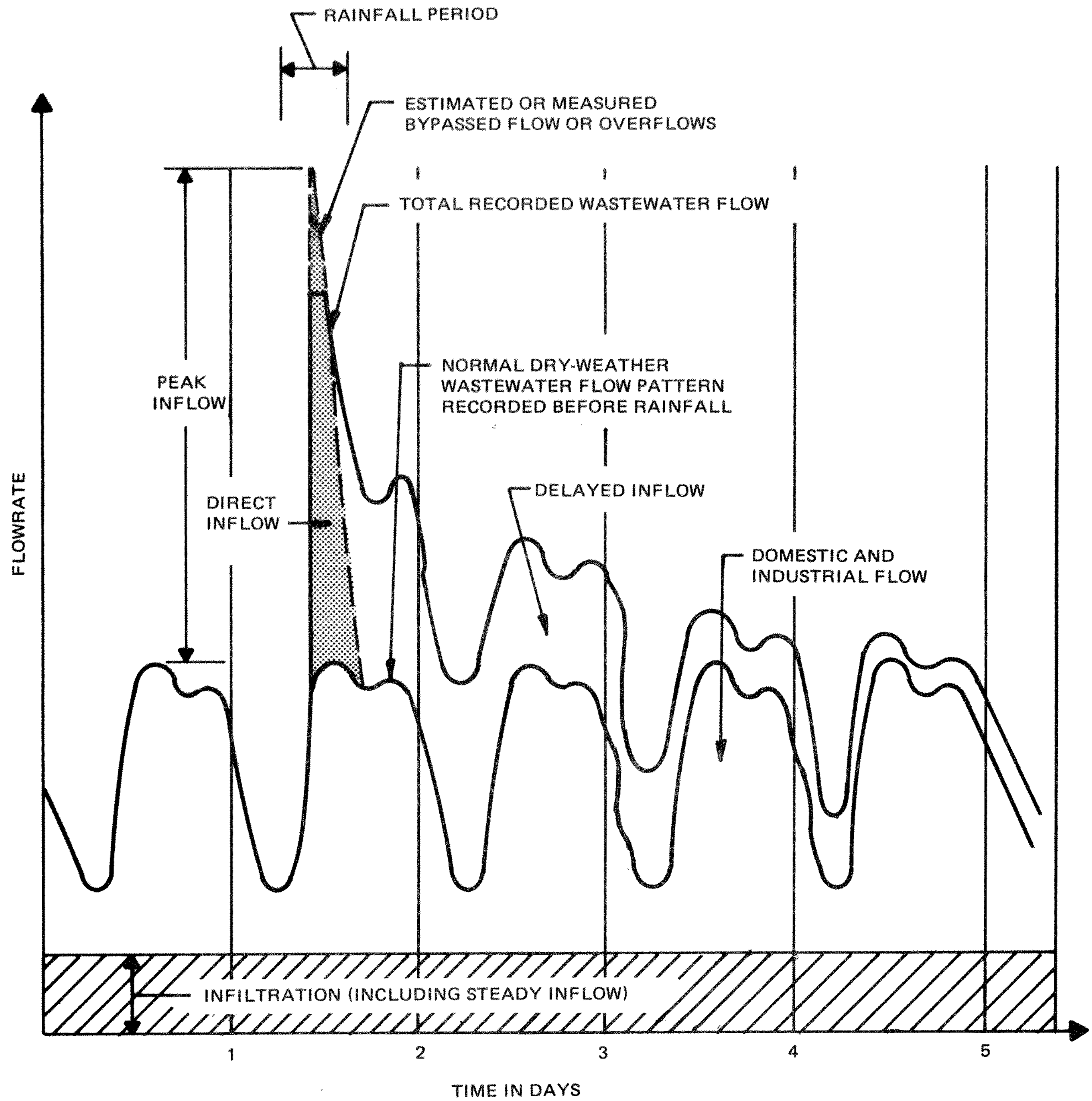
Proper planning is essential to efficiently obtain sufficient flow data for an infiltration/inflow analysis. It is essential to have up-to-date sewer maps of the study area before starting any flow monitoring program. Some valuable information may also be obtained from the United States Geological Survey topographic maps; state agencies such as a department of natural resources, geologic survey, and health department; regional planning organizations; county governments, and utility companies. A review of these data before or very early in the study will be a valuable orientation to the area and may indicate potential trouble spots.

By spending some time setting up a logical flow monitoring program, time and money can be saved when conducting the actual flow monitoring program. The following sections identify some of the more important aspects that should be considered when planning a flow metering program.

Review of Existing Records

The review of existing records can help isolate areas in the system subject to deterioration, structural failure, and excessive infiltration/inflow. Some basic information that the existing records should be reviewed for include:

1. Sewer sizes.
2. Type of pipe material.
3. Depth of sewer mains.
4. Age of sewers.
5. Type of construction of pipe joints and manholes.
6. Location of lift stations.
7. Location of utilities, particularly storm sewers and water mains.



REFERENCE: FROM METCALF & EDDY, INC., WASTEWATER ENGINEERING: COLLECTION AND PUMPING OF WASTEWATER, McGRAW-HILL, 1981.

FIGURE 3-1. GRAPHIC IDENTIFICATION OF INFILTRATION/INFLOW

8. Identification of soil types by area including:

    a. Soil classification; clay, sand, peat, silt, etc.

    b. Structural support characteristics.

    c. Soil corrosivity.

9. Past system flow studies.

10. Bypass and overflow data including locations and frequency of discharge.

11. Areas of known problems; i.e. overflows, frequency of discharge, customer complaints, root problem areas, areas frequently repaired in the past, etc.

12. Areas with past record of illegal private sector connections.

13. Water usage data for residential, commercial, and industrial customers.

14. Population equivalent trends since the last flow monitoring program.

<u>Selection of Suitable Flow Monitoring Period</u>

The flow monitoring period selected depends on the type of flow analysis being conducted. The various components of a wastewater flow stream can be isolated by conducting metering at different times of the year.

<u>Infiltration Analysis</u>. The flow monitoring period suitable for determining infiltration will depend on whether a peak infiltration rate or the average annual infiltration rate is required. For the determination of peak infiltration, flows should be measured during the highest groundwater period of the year. In the Cook County area of Illinois, groundwater levels are normally elevated during the spring and fall months of the year. In general terms, dates between April 15 and June 30 and September 1 and November 15 could be used to determine peak infiltration rates. However, actual groundwater conditions should be verified during the metering program since annual variations in the quantity and monthly distribution of precipitation can be highly variable.

For the determination of average annual infiltration, flows need to be measured during periods typical of other groundwater conditions so that a range of infiltration rates can be averaged. Measurements during minimum groundwater level conditions may also be used to verify the base sewage flow component of the wastewater stream.

The following should be considered when planning and performing an infiltration analysis:

1. Continuous flow measurements throughout a high groundwater period are desirable. However, instantaneous measurements may be sufficient since the groundwater level is normally stable over a period of several days.

2. The measurements should be taken during non-rainfall days preferably 24 hours after a rainfall in order to minimize the direct influence of rainfall.

3. To minimize the interferences caused by domestic, commercial, and industrial flows, measurements should be made between midnight and six a.m. It

should be noted that the industrial component of base sewage flow may still be partially present during these hours.

4. Repeated flow measurements should be taken on at least three consecutive nonrainfall days for each typical groundwater condition.

5. To avoid surge flows, all pumps in the sewer system should be temporarily shut down during instantaneous flow measurements.

Inflow Analysis. For direct stormwater runoff related inflow measurement, system flows should be monitored continuously throughout each rainfall event. To increase the probability of capturing a significant rainfall event, flow monitoring for isolating inflow should be conducted during heavy rainfall seasons. In the Chicagoland area, the heaviest rainfall seasons normally are spring and fall.

Since the quantity of inflow is dependent on a number of variables, it is desirable to capture several significant rainstorms during the flow monitoring period. A significant rainfall event would be one approximately equal to or greater than 1 inch of rain in a 24 hour period. The variables which can affect the quantity of inflow measured include but are not limited to:

1. Soil moisture conditions. The soil moisture conditions at the time of a rainstorm will affect the quantity of stormwater runoff and inflow. Saturated soil conditions will allow a greater percentage of the rainfall to runoff and possibly become inflow into the sanitary sewer system.

2. Rainfall intensity. Greater intensity rainstorms generally produce more runoff and therefore increase the inflow potential when compared to less intense rainstorms. Rainfall intensity is particularly important when calculating peak sewer flows. Peak sewer flows are affected most by relatively short intense storms.

3. Rainfall volume. Rainfall volume is the product of rainfall intensity and rainfall duration. Average daily inflow amounts are generally proportional to rainfall volume. However, it should be noted that peak inflow rates can vary significantly for a given rainfall volume. For example, a 1 inch storm occurring in a 30 minute period would cause a higher peak inflow rate than a 1 inch storm occurring in a 24 hour period. Even though the peak inflows are significantly different, the 24 hour average inflow for both storms could be approximately the same.

Because inflow rates are a function of highly variable soil conditions and rainfall characteristics it is important to note for each inflow measurement taken what the specific soil conditions and rainfall characteristics were to cause the inflow measured.

When planning a flow monitoring program for the purpose of isolating inflow, it is essential to install a continuously recording rain gage within the boundaries of the study area so that the measured flows can be compared to the beginning and end of each rainfall event.

Subsystem Identification

In many communities/agencies it is possible to measure the majority of the sewer system flow at one location. An analysis of the sewer flows at one location will indicate whether or not the community/agency has an excessive infiltration/inflow problem. However, if an infiltration/inflow problem is observed, flow data from a single location measuring flows for the majority of the sewer system will not indicate in which areas investigations should be concentrated to find the sources of excessive infiltration/inflow. Therefore it is common to divide a sewer system into a number of subsystems that can be monitored for flow separately.

The number of subsystems identified for separate flow monitoring will vary depending on the size, configuration, and physical characteristics of each sewer system. A sewer system can be divided into subsystems using any one or more of the following guidelines:

1. Drainage areas. A sewer system can be separated into subsections based on the system configuration. The system configuration may result in sewer flows converging at a point downstream of one drainage area before mixing with flows from another drainage area. Each sewer system may consist of several drainage areas. The sewers within each drainage area would be considered a subsystem and could be monitored separately for flow.

   For a community/agency with several connection points to a MSDGC interceptor, the group of sewers upstream of each connection point could be considered a separate subsystem. Large areas upstream of one particular MSDGC connection point could be further divided into subsystems by drainage area.

2. Sewer age and construction type. Many sewer systems have increased in size over time to keep up with a community/agency's growth. As a result, different areas in the sewer system may have been constructed at different times with different types of pipe material, joint construction, and manhole construction. Since infiltration/inflow problems may vary with age and construction type, a sewer system can be divided into subsystems based on age or construction type. It should also be noted that a new subsection constructed poorly may contribute more infiltration/inflow than an older subsection. For this reason, newly constructed subsystems should not be omitted from a flow monitoring program.

3. Groundwater and soil types. In some of the larger communities/agencies, groundwater levels and soil types may vary in different areas of the system. Groundwater levels in some areas may normally be above the sewer mains either because of naturally high groundwater levels or because the sewer system is quite deep in an area of the system. Groundwater levels would be naturally high in the vicinity of any natural surface water. Since different groundwater conditions can affect the amount of infiltration entering a sewer system, the system can be divided into subsystems using groundwater conditions as the criteria.

   Different soil conditions in a study area may warrant dividing the system into subsystems by soil type. Different soil types can cause varying degrees of infiltration and rainfall induced infiltration. Soil parameters that may be considered for determining subsystems are soil class, soil permeability, corrosiveness, and soil strength.

4. Problem areas. Another criteria that could be used for dividing a sewer system into subsystems would be by isolating problem areas. If certain areas have a history of private sector illegal connections to the sanitary sewer

system these areas can be grouped into subsystems and monitored for flow to determine if illegal connections have been reconnected to the sewer system. Areas reporting basement flooding and system overflows during rainfall events also may be grouped together and monitored separately from the rest of the system.

Selection of Key Manholes

Before a flow monitoring program can be started, the locations for installing the flow metering equipment must be identified. Initially, key manholes can be selected by reviewing the sewer system configuration on the sewer maps. Key manholes are initially selected based on the criteria previously used to divide the sewer system into subsystems. The manholes selected for measuring flow should be along straight sections of pipe with constant slopes both upstream and downstream and should be far enough away from lift stations so that the flow measurements will not be affected by the lift station operation.

After key manholes have been selected on the sewer maps and before initiating the flow monitoring program, the manholes should be inspected in the field for flow metering suitability. The field inspections should include or identify the following items:

1. Verify that the key manhole selected on the sewer map can be located in the field.

2. Take necessary safety precautions before entering the manhole.

WARNING: MANHOLES ARE CONFINED SPACES AND MAY HAVE DANGEROUS ATMOSPHERES. FOLLOW PROPER SAFETY PRECAUTIONS OUTLINED IN CHAPTER 9 WHEN WORKING NEAR AND BEFORE EVER ENTERING A MANHOLE.

3. Make sure the manhole is not subject to frequent surcharging.

4. The manhole should be relatively dry.

5. The size of the manhole opening and inside diameter must be large enough for safe entry and workability inside the manhole.

6. The manhole depth.

7. The stability of the manhole structure.

8. The condition of the manhole steps, or note if the manhole does not have steps.

9. Verify that the flow conditions in the manhole are suited to the type of flow metering equipment being used.

10. The amount of debris that has accumulated in the manhole.

11. Verify that the number of pipe connections in the manhole is consistent with what is shown on the sewer map.

12. Verify that the manhole is suitable for installing the flow monitoring equipment.

13. Study the traffic conditions around the manhole to determine if the monitoring program will affect traffic or if the traffic will pose a serious threat to the personnel conducting the monitoring program.

14. Make an assessment of the possibility of vandalism at the key manholes selected.

If the field inspection indicates that a manhole selected during a sewer map analysis is not suitable for flow monitoring purposes, another more suitable manhole should be selected.

<u>Selection of Flow Monitoring Equipment</u>

When planning a flow monitoring program, the type of flow monitoring equipment used must be determined. There are many types of flow monitoring devices on the market. When selecting flow monitoring equipment it is important to select equipment that will meet the goals of the monitoring program. The following items should be considered when selecting the type of equipment:

1. Ease of installation.
2. Maintenance requirements.
3. Calibration requirements.
4. Accuracy
5. Reliability
6. Expected flow range.
7. Potential for measuring flow during surcharged conditions.
8. Type of monitoring program.
    a. Quick flow measurement checks (instantaneous).
    b. Continuous flow monitoring program.
9. Ease of calculating flow from the data presented.
10. Total manpower requirements for:
    a. Maintaining equipment.
    b. Calibrating equipment.
    c. Analyzing data.
11. Cost.

Agencies electing to monitor flow in a percentage of their sewer system each year on a rotating basis may benefit the most by purchasing and operating their own equipment. Other agencies may find that it is more economical to either rent flow metering equipment or contract out the flow metering work. Agencies that would benefit most by renting equipment or contracting out the flow metering work are smaller agencies that could economically monitor their entire sewer system at the same time.

The different types of metering equipment currently available for measuring sewer system flows are presented in another section of this chapter.

Rain Gages

When planning a flow monitoring program, it is important to make sure the necessary steps have been taken for obtaining accurate rainfall data. Since rainfall amounts and intensities can vary from community to community, it is desirable to collect rainfall data within the area being monitored for flow. Therefore before a flow monitoring program begins, a rain gage needs to be obtained and a location selected for installation.

The type of rain gage selected needs to be one that continuously measures and records rainfall amounts at intervals no longer than once per hour. For the most accurate sanitary sewer flow analysis, rainfall amounts should be recorded every 15 minutes or less. If infiltration/inflow is present in a sanitary sewer system, the immediate sewer flow response to a rainfall event is important to know when estimating the various components of flow.

The basic types of rain gages available include:

1. Tipping bucket.
2. Weigh and record.
3. Calibrated tubes.

Since the tipping bucket and the weigh and record type rain gages are suited for continuous recordings, these types are the most useful in a flow monitoring program. There are a variety of calibrated tube-type rain gages which are designed for manual reading. These types of gages can be used before a monitoring program begins to roughly estimate soil moisture conditions and groundwater levels.

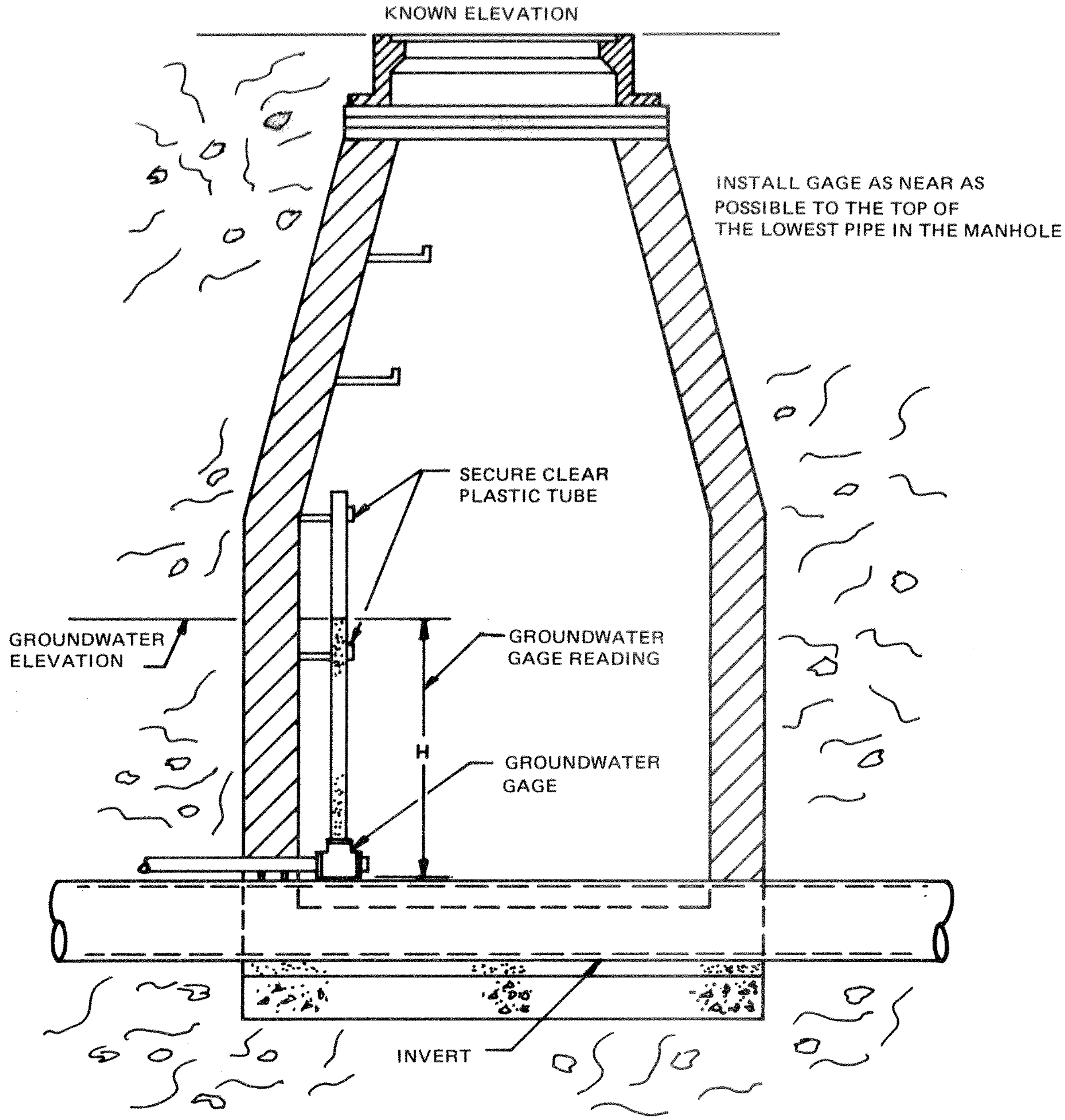
Groundwater Monitoring

A knowledge of the groundwater elevation during a flow monitoring program is important since infiltration is directly related to groundwater levels relative to the sewer system depth.

Groundwater monitors can be installed on a permanent basis so that the data provided by them can be used to plan isolation flow gauging and internal TV inspections. Both isolation flow gauging and internal TV inspections should be conducted when the groundwater levels are higher than normal.

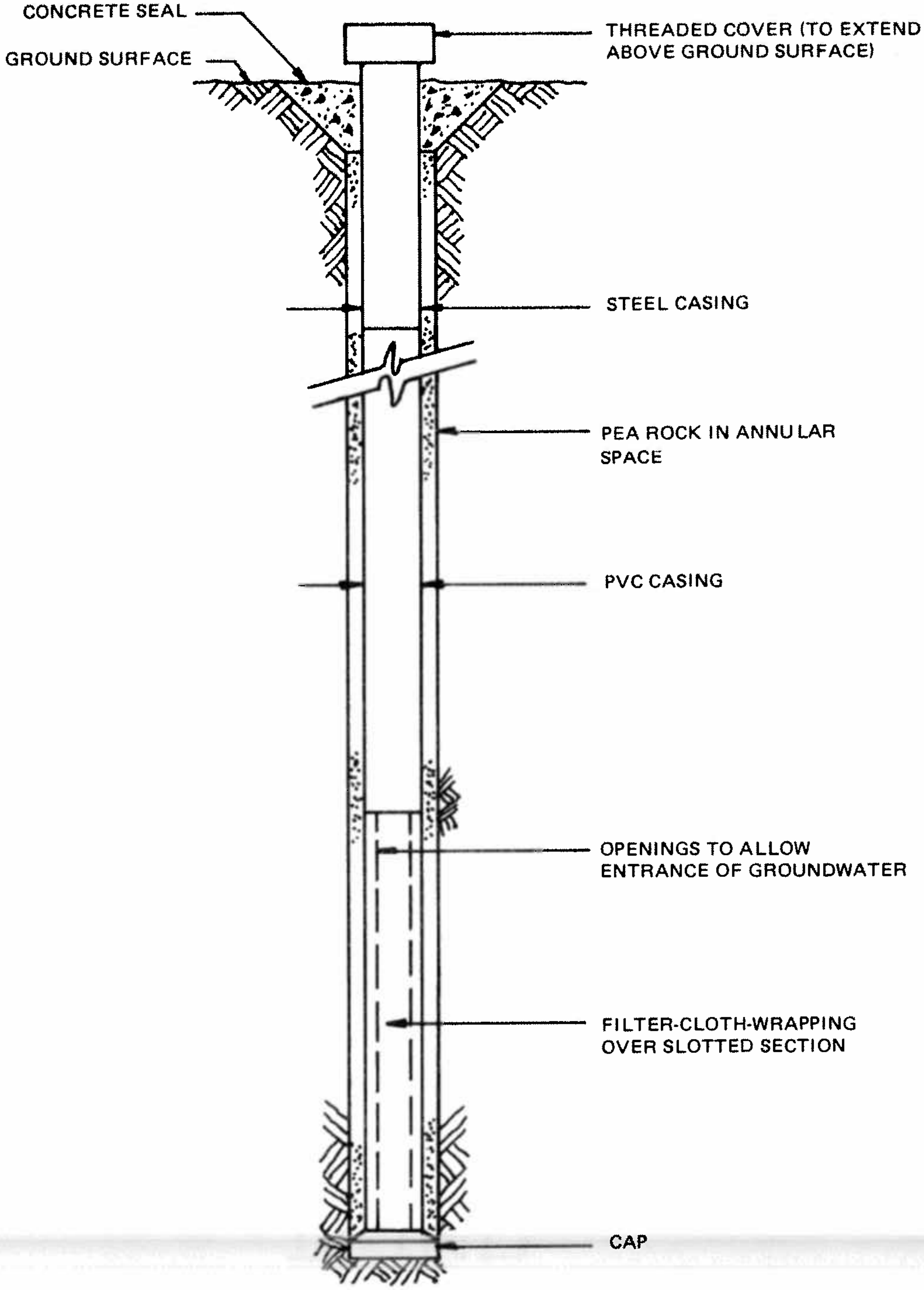
There are two common types of groundwater monitors for measuring groundwater levels. Figure 3-2 shows a groundwater monitor installed inside a manhole. This type of monitor measures the groundwater level next to the manhole. The manhole gage is inexpensive and easy to install but they do commonly clog. Therefore, they need to be cleaned or replaced periodically.

The second type of groundwater monitor commonly used is a piezometer type shown in Figure 3-3. These monitors are more permanent than the manhole gages and are installed using an auger. They are also more expensive than the manhole gages but less likely to



REFERENCE: FROM EXISTING SEWER EVALUATION AND REHABILITATION, ASCE-MANUALS AND REPORTS ON ENGINEERING PRACTICE NO. 62 AND WPCF MANUAL OF PRACTICE NO. FD-6, 1983

FIGURE 3-2. STATIC GROUNDWATER GAGE INSTALLATION ELEVATION



REFERENCE: FROM EXISTING SEWER EVALUATION AND REHABILITATION, ASCE-MANUALS AND REPORTS ON ENGINEERING PRACTICE NO. 62 AND WPCF MANUAL OF PRACTICE NO. FD-6. 1983

FIGURE 3-3. GROUNDWATER GAGE INSTALLATION DETAIL

clog. They should be installed in areas where they will not be damaged by roadwork, landscaping operations, or vandalism and where their installation will not damage other buried utilities.

FLOW MEASUREMENT TECHNIQUES

Monitoring flows within a wastewater collection system is important. The resulting data form the basis for determining user costs, volume of rainwater or groundwater entering the system, existing line capacity, treatment plant operations, effectiveness of a rehabilitation program, and future design needs. It is therefore necessary to use a sound approach and good measurement techniques to ensure reasonable flow monitoring results. Flow measurements may be taken at several locations, one of which is at a key manhole, as previously described. Flow measurements may also be obtained at treatment plants, pumping stations, known infiltration or inflow sources, industrial waste sources, and overflows and bypasses.

There are a variety of methods and equipment available for measuring flow in sewers. The selection of the proper method or equipment depends on the cost, source to be measured, accessibility, available manpower, degree of precision, and type of data required. Several of the most common techniques are presented below with their advantages, limitations, and equipment requirements.

Manual Flow Measurements

Manual flow metering equipment is only useful for obtaining instantaneous flow measurements. Their usefulness in a flow monitoring program is therefore limited to spot checks. Spot checks are a quick and easy way to determine if a subbasin is contributing excessive inflow or infiltration to the system.

Weirs. Weir measurements are made by observing the water level above the crest of the weir and converting this measurement to a flow with the use of calculations, nomographs, or tables.

Types of Weirs:

1. Triangular or V-notch.
   a. Designed to measure small flows (0-3 cfs).
   b. Ideal for small diameter sewer pipe flow measurement.
2. Rectangular - Suppressed.
   a. Crest is same width as channel.
   b. Not designed for pipe flow measurement.
   c. Designed for rectangular channel measurement.
   d. Designed to measure large flows.

e. Complex discharge equation.

3. Rectangular - Contracted.

   a. Weir crest is fitted with end contractions.

   b. Designed for rectangular channel or pipe flow measurement.

   c. Designed to measure large flows.

   d. Complex discharge equation.

4. Trapezoidal or Cipolletti.

   a. Similar to contracted rectangular weir.

   b. Trapezoidal shape simplifies discharge equation.

5. Compound weir.

   a. Two weirs, usually a V-notch and a rectangular are used in conjunction.

   b. Designed for pipe flows which are normally low, but occasionally increase substantially.

   c. Measurements made at the transition zone between the two weir types may not be accurate.

Maintenance:

1. Minimal amount of maintenance required.

2. Sewer should be clean prior to weir installation.

3. A check for debris buildup at the base of the weir and on the weir crest should be made prior to each weir reading.

Advantages:

1. Inexpensive.

2. Easy installation.

3. Quick, accurate results.

4. Knowledge of the sewers physical parameters not required.

Disadvantages:

1. Accuracy affected by approach velocity.

2. Accuracy affected by debris accumulation upstream of the weir.

3. Accuracy affected by turbulent flow.

4. Fairly high head loss, which could cause sewers to surcharge.

5. Results not accurate during surcharged conditions.

6. Must enter manhole to take readings and to install.

Flumes. A flume is a device which acts as a restriction in a pipe or channel. The flume creates critical flow in its throat. The depth of flow above the flume throat can be converted into a flow by the use of calculations, nomographs, or tables.

Types of Flumes:

1. Parshall.

   a. Designed for permanent installation in rectangular channels.

   b. Requires a minimum head-loss of three inches which could cause sewers to surcharge.

   c. Not practical for sewer pipe flow measurements.

2. Palmer-Bowlus.

   a. Designed for installation in round bottom channels or pipes.

   b. Easy to install.

   c. Portable.

   d. Small head-loss requirements.

3. H-Flume.

   a. Designed to measure a large range of flows.

   b. Best suited for stormwater or combined sewer flow measurements.

   c. Large head-loss is required to measure flow.

4. Trapezoidal.

   a. Designed for a rectangular channel.

   b. Measures small flows only.

   c. Small head-loss is required to measure flow.

Maintenance:

1. Before taking depth readings, the flume should be checked for silt deposits and cleaned if necessary.

Advantages of Flumes Suited for Sewer Pipe Flow Measurements:

1. Self-cleaning.
2. Easy to install.
3. Portable.
4. Small head-loss required to measure flow.
5. Quick, accurate results.
6. Knowledge of the sewer's physical parameters not required.

Disadvantages of Flumes Suited for Sewer Pipe Flow Measurements:

1. Results not valid during surcharging.
2. Flow must be laminar at the entrance to the flume. Therefore manholes with converging flows or bends are not suitable for flume readings.
3. Must enter the manhole to take readings and to install.

Dye-dilution. This manual metering technique consists of feeding fluorescent dye at a constant rate to an upstream manhole. Samples are collected at a downstream manhole and analyzed for dye concentration. Flow can then be calculated by knowing the concentration of the dye in the sample.

Equipment:

1. Solution feeder.
2. Glass containers for samples.
3. Sampler.
4. Dye/tracer analyzer (fluorometer).
5. Some commonly used fluorescent dyes: Rhodamine WT, Fluorescein, and Uranine.

Maintenance:

1. Solution feeder battery will need to be changed every other week.
2. Fluorometer battery will need to be changed every 2 days.

Advantages:

1. Manhole entry not required.
2. Accurate for surcharged sewers.
3. Simple.

4. Quick.

5. Knowledge of the sewer's physical parameters is not required.

Disadvantages:

1. Expensive equipment costs.

2. Temperature and sunlight can affect results of sample analysis.

3. Labor intensive.

Dip Stick. Flow depth measurements are taken with a dip stick, yard stick, or similar measuring device and flows are then calculated using the Manning equation.

Equipment:

1. Measuring stick.

Maintenance:

1. None.

Advantages:

1. Manhole entry not required.

2. Easy.

3. Inexpensive.

Disadvantages:

1. Not accurate for most sewers. The following conditions must exist in order to accurately apply the Manning equation:

    a. The pipe upstream of the flow measuring point should be straight for a minimum of 200 feet.

    b. The channel in the manhole must approximate the shape of a round pipe.

    c. The inverts of the influent and effluent pipes of a manhole must be the same.

    d. Flow through a manhole must be a single stream and travel straight through.

    e. There must not be any downstream blockages.

2. The Manning roughness coefficient should be determined in the field for best results.

Manual Pressure Meter. The Manual Pressure Meter measures the head on a V-notch weir by sensing the pressure differential between the liquid and the atmosphere. Pressure is read from a manometer and converted directly to a flow using calibrated metering sticks.

Installation:

The metering insert is placed in the pipe from outside of the manhole with the use of up to sixteen feet of interlocking aluminum pole. The metering insert is stabilized in the pipe with an inflatable rubber collar.

Maintenance:

1. Metering inserts need to be cleaned after use.
2. Manometer must be filled and emptied with water before and after use, respectively.

Advantages:

1. Manhole entry not required.
2. Since manhole entry is not required, one person can make the measurements.

Disadvantages:

1. Can only be used in 6, 8, 10 and 12 inch diameter pipes.
2. Cannot be used in manholes which are deeper than 16 feet.

Continuous Flow Measurements

There are two types of continuous flow meters; depth recorders and depth/velocity meters. Depth recorders are automatic metering devices which continuously record the depth of flow in a pipe, the head over a weir, or the depth in the throat of a flume. Depth measurements are recorded on circular charts, strip charts, or electronic memory. It is strongly recommended that a primary device (weir or flume) be used in conjunction with a depth recorder. The primary device simplifies calculations and increases accuracy.

Depth/velocity meters do not require a primary device. Flow information is stored on electronic memory or can be sent to a central computer through telephone lines. These meters are the most accurate because flow is calculated directly from the velocity and depth measurements.

Depth Recording Meter - Probe. This meter continuously records water level in a pipe, the head over a weir, or depth in the throat of a flume. Depth measurements are recorded when a battery operated electrical probe makes contact with the water surface. This contact completes an electrical circuit which causes the chart pen arm to record the reading. The probe then retracts slightly from the water surface and will repeatedly seek the water surface every few seconds.

Installation/Calibration:

For best results, installation should include a stilling well and primary measuring device. The meter can be mounted in the manhole with a bracket. The probe hangs down to the stilling well water surface. Calibration is accomplished by manually reading the head on the weir and adjusting the pen arm to correspond to the manually observed flow height. Depth recordings can be easily converted to flows using published flow charts for the primary device used.

An alternate installation, which is not recommended, consists of mounting the probe in the manhole with no primary device. Depth of flow in the pipe is then measured directly. The Manning equation is then used to convert depth measurements to flow. Accuracy of this method is dependent on the parameters used in the Manning equation. For most sewer systems the Manning equation does not yield accurate results unless detailed field investigations are done prior to flow metering to accurately determine the parameters. Calibration is accomplished by measuring depth in the pipe with a dip-stick and adjusting the pen arm to correspond to the observed flow height.

Maintenance:

1. Battery must be re-charged weekly.
2. Spring clock must be wound weekly.
3. Recording pen should be changed every 50 charts or as needed.
4. Recording charts should be changed daily or weekly.
5. Meter should be checked after a significant rain event.
6. Probe should be checked weekly for proper operation and debris.
7. Recorder calibration should be checked weekly.
8. The primary measuring device should be checked weekly for debris.

Advantages:

1. Easy to install, manhole entry not required.
2. Debris is not likely to attach itself to the probe due to the dipping action.
3. Versatile installation.
4. Easy to understand and troubleshoot.

Disadvantages:

1. Turbulence affects accuracy.
2. Foaming affects accuracy.
3. Cannot be used to measure flow during surcharged conditions.

Depth Recording Meter - Float. This meter records water level with a float which continuously rides on the water surface. A mechanical pen arm is connected to the float and records water depth.

Installation/Calibration:

For best results installation should include a stilling well and a weir as the primary measuring device. The recorder can be mounted in the manhole with a bracket. The float sits in the stilling well and measures the water surface. Calibration is by measuring the head on the weir and adjusting the pen arm on the recorder accordingly.

Installation can also be with a scow float. A scow float is anchored to the side of the manhole to keep the float from drifting. Depth of flow in the pipe is measured directly since no primary device is used. The Manning equation is then used to convert depth measurements to flows. Accuracy of this method is dependent on the parameters used in the Manning equation. For most sewer systems, the Manning equation does not yield accurate results unless detailed field investigations are done prior to flow metering to accurately determine the parameters. Dip-stick readings are used for calibration.

Maintenance:

1. Battery must be re-charged weekly.
2. Spring clock must be wound weekly.
3. Recording pen should be changed every 50 charts or as needed.
4. Recording charts should be changed daily or weekly.
5. Meter should be checked after a significant rain event.
6. At a minimum, the float should be checked weekly for debris.
7. Recorder calibration should be checked weekly.
8. The primary measuring device should be checked weekly for debris.

Advantages:

1. Easy to install.
2. Versatile installation.
3. Easy to understand and troubleshoot.

Disadvantages:

1. Stilling-well installation requires manhole entry.
2. Floating debris affects accuracy.

3. Turbulence affects accuracy.

4. Debris is likely to attach to the float.

5. Cannot be used to measure flow during surcharged conditions.

Depth Recording Meter - Bubbler. This meter measures actual water depth by sensing the pressure differential between the bottom of the pipe and atmospheric pressure. This pressure differential is converted to a depth reading. A bubbler tube is placed on the bottom of the pipe and a constant bubble rate is supplied by air tanks or air compressors. The pressure required to maintain the bubble rate is measured, and this is proportional to the depth of flow which is recorded on a strip chart.

Installation/Calibration:

The meter is installed with a primary device. The bubbler is mounted on the bottom of the pipe with the use of a collar. The meter is hung from the manhole steps with a harness. Calibration is accomplished by manually reading the primary device and adjusting the pen arm to record the observed height.

Maintenance:

1. Battery must be re-charged weekly.
2. Spring clock must be wound weekly.
3. Recording pen should be changed every 50 charts or as needed.
4. Recording charts should be changed weekly or after a significant rain event.
5. Meter should be checked after a significant rain event.
6. Bubbler should be checked weekly for clogging or debris.
7. Recorder calibration should be checked weekly.
8. The primary measuring device should be checked weekly for debris.
9. Air tanks should be replaced when empty.
10. Air compressors should be maintained in accordance with the manufacturer's recommendations.

Advantages:

1. Accuracy is not affected by floating debris, foam, turbulence, temperature or velocity.

Disadvantages:

1. Manhole entry required for installation.

2. Bubbler may become clogged if flow contains large amounts of suspended solids or grease.

3. Cannot be used to measure flow during surcharged conditions.

Depth Recording Meter - Pressure Sensor. This meter measures the pressure of the liquid directly and converts this pressure reading to a flow depth. Readings are recorded on a strip chart or on electronic memory. Data stored on memory can be retrieved with a lap top computer, magnetic tape, or telephone modem.

Installation/Calibration:

The sensor can be mounted on the bottom of the pipe with a collar or can be snapped onto specially designed flumes. Strip chart and electronic memory calibration are completed at the manufacturer's factory. Calibration checks can be made in the field by measuring the depth of flow in the primary device and comparing that reading to the strip chart position or the flow rate on the liquid crystal display if storage is on electronic memory.

Maintenance:

1. Battery needs to be charged every 6 months.
2. Strip charts must be changed every 20 days or more frequently if desired.
3. Data stored on electronic memory should be retrieved every 6 weeks, or more frequently if desired.
4. Meter should be checked after a significant rain event.
5. Sensor should be checked weekly for debris.
6. Calibration should be checked weekly.
7. The primary device should be checked weekly for debris.

Advantages:

1. No moving parts.
2. Floating debris does not affect accuracy.

Disadvantages:

1. Manhole entry required for installation.
2. More difficult to evaluate operational problems due to the electronic components.
3. Temperature affects accuracy.
4. Turbulence affects accuracy.
5. Cannot be used to measure flow during surcharged conditions.

Depth Recording Meter - Ultrasonic. This meter records the amount of time it takes for an echo to reflect off the water surface and return to the sensor. This time increment is then converted to a flow depth and recorded on electronic memory or on a strip chart. Data stored on memory can be retrieved using a lap top computer, magnetic tape, or telephone modem.

Installation/Calibration:

The sensor is installed in the crown of the pipe with the use of a collar. A primary device should be used and a stilling well is recommended because turbulence will affect the readings. The computer chip which converts the time interval to a flow depth is calibrated at the manufacturer's factory. Chips are programmed for a primary device or can be programmed for a pipe diameter. If a chip is programmed for a pipe diameter, a new chip will need to be purchased if the meter is to be installed into a different diameter pipe.

Maintenance:

1. Battery needs to be changed every 6 months.
2. Strip charts must be changed monthly, or more frequently if desired.
3. Data stored on electronic memory should be retrieved every 6 weeks, or more frequently if desired.
4. Meter should be checked after a significant rain event.
5. Calibration should be checked weekly.
6. The primary measuring device should be checked weekly for debris.

Advantages:

1. Very low maintenance.
2. Automatically compensates for temperature (temperature affects the speed at which sound moves through air).

Disadvantages:

1. Manhole entry required for installation.
2. Accuracy is affected by foam.
3. Accuracy is affected by turbulence
4. Not suited for winter use. Calibration must be re-set if sensor freezes.
5. Echo can be interfered with by machinery which creates cyclic vibrations.
6. Cannot be used to determine flow during surcharged conditions.

Depth/Velocity Meter - Pressure Sensor/Doppler. This meter measures depth of flow with a pressure sensor and velocity using the Doppler method. It is not used with a primary device. Flow readings are stored on electronic memory and can be retrieved with a lap top computer, magnetic tape, or telephone modem.

Installation/Calibration:

The depth/velocity probe is mounted to the invert of the pipe. Calibration of the probe is completed at the manufacturer's factory. Calibration checks for depth can be made by placing the probe in a bucket with a known depth of liquid and comparing the sensors depth reading with the known depth. Velocity can be checked in the field with a portable velocity meter.

Maintenance:

1. Battery must be changed every 6 months.
2. Flow data should be retrieved from the memory using a lap top computer, magnetic tape, or telephone modem every 6 weeks, or more often if desired.
3. Meter should be checked after a significant rain event.
4. Calibration should be checked weekly.
5. Probe should be checked weekly for debris.
6. Pipe must be kept clean of sediment.

Advantages:

1. Very accurate.
2. Low maintenance.
3. Data can be transmitted via telephone lines to a central computer.
4. Accurate even during surcharge conditions.
5. No primary device necessary.
6. An optional rain gage can be connected to the unit.
7. Portable.

Disadvantages:

1. Manhole entry required for installation.
2. Debris on the probe will affect the velocity readings.
3. Turbulence will cause erratic velocity readings.
4. Sediment on the pipe bottom affects accuracy. The probe is calibrated for a circular cross-section.
5. Expensive repair cost if repairs are necessary.

6. Must have a minimum depth of flow of 2 to 2.5 inches in order to get an accurate velocity reading.

Depth/Meter - Pressure Sensor/Faraday. This meter measures depth of flow with a pressure sensor and velocity using the Faraday principal. It is not used with a primary device. Flow readings are stored on electronic memory and can be retrieved with a lap top computer or magnetic tape.

Installation/Calibration:

The depth/velocity probe is mounted to the invert of the pipe. Calibration of the probe is completed at the manufacturer s factory. Calibration checks for depth can be made by placing the probe in a bucket with a known depth of liquid and comparing the sensors depth reading with the known depth. Velocity can be checked in the field with a portable velocity meter.

Maintenance:

1. Primary battery must be changed every 35 days.
2. Flow data should be retrieved from the memory using a lap top computer or magnetic tape every 4 to 5 weeks, or more often if desired.
3. Meter should be checked after a significant rain event.
4. Calibration should be checked weekly.
5. Probe should be checked weekly for debris.
6. Pipe must be kept clean of sediment.

Advantages:

1. Very accurate.
2. Low maintenance.
3. Accurate even during surcharge conditions.
4. No primary device necessary.
5. Portable.

Disadvantages:

1. Manhole entry required for installation.
2. Debris on the probe will affect the velocity readings.
3. Turbulence will cause erratic velocity readings.
4. Sediment on the pipe bottom affects accuracy. The probe is calibrated for a circular cross-section.

5. Expensive repair cost if repairs are necessary.

6. Must have a minimum depth of flow of 2 to 2.5 inches in order to get an accurate velocity reading.

Lift Station Monitoring

Wet Well Depth Measurement. An average daily flow from a pump station can be calculated by continuously recording the water level in the pump station wet well and knowing the wet well dimensions. Water level drawdown and return is measured by a continuously recording depth recorder. The volume of flow pumped per day can then be calculated from the number of water level drawdown/return cycles per day.

Velocity Measurement. An alternate lift station monitoring technique consists of recording the amount of time that each pump runs during the day and multiplying this by the average velocity in the discharge pipe. Duration of pump operation is recorded by a continuous event recorder and average velocity is measured with a portable velocity meter. Flow is then calculated by multiplying the average velocity by the cross-sectional area of the discharge pipe.

Advantages.

1. Easy installation of metering equipment.

2. No primary measuring device is required.

3. All types of depth recorders are suitable for wet well installation.

Disadvantages.

1. Velocity method can only be used if the discharge pipe is a long straight section, since turbulence will affect the velocity readings.

2. Turbulence in the wet well will affect depth readings.

3. Flow results are difficult to correlate to a specific storm event.

4. Inflow and rain induced infiltration components of flow are difficult to distinguish.

FLOW MONITORING DURATION

The type of flow data required governs the duration of a flow monitoring program. Monitoring programs can be classified as instantaneous, short-term continuous, or long-term continuous.

Instantaneous Monitoring

Instantaneous monitoring is useful for making quick depth and velocity measurements in the sewer system at a specific point in time. Dry weather flow patterns can be roughly estimated by measuring flows at different times of the day. Periodic instantaneous measurements can identify problems in the sewer system as soon as they occur. Instantaneous flow measurements should also be taken before a continuous flow monitoring program begins so that the equipment selected for the continuous flow monitoring program is compatible with the range of flows in the sewer system.

Since instantaneous flow measurements provide flow data at a specific point in time, they are not useful for accurately estimating wastewater flow components. More specifically, instantaneous flow measurements are not useful for measuring rainfall induced peak flowrates.

Short-Term Continuous Monitoring

Is is necessary to periodically monitor flow continuously at key manholes for a short period of time to gather specific data. If the data required in needed to assess dry weather flow patterns, it may only be necessary to monitor flow for a couple of weeks. If the data required is needed to determine sewer flows resulting from significant rainfall events, a monitoring period of several weeks may be necessary to capture the desired number of rainstorms.

Short-term continuous flow monitoring reports need to be prepared and submitted to the Metropolitan Sanitary District of Greater Chicago once every 5 years as documentation that long-term maintenance programs have been successfully implemented for each agency.

Long-Term Continuous or Permanent Monitoring

There are occasions when it may be useful to establish semi-permanent or permanent monitoring within a community. For instance, it may be beneficial to monitor the effectiveness of a large scale rehabilitation program aimed at reducing infiltration/inflow. Long-term flow monitoring can also provide data necessary to:

1. Plan for sewer system expansion projects necessary to meet the demands of a growing community.

2. Schedule maintenance programs in areas of rapid deterioration indicated by increases in infiltration/inflow.

3. More accurately predict the sewer system response to rainfall as the number of rainstorms occurring during flow monitoring increases.

FLOW MONITORING REPORTS

After a flow monitoring program is completed, it is suggested that a report be prepared which describes the results and findings. The report for a short-term continuous monitoring program should include basic information such as:

1. Raw flow data.

2. Rainfall data.

3. Groundwater conditions.

4. Description of soil moisture conditions during the monitoring period.

5. Type of flow monitoring equipment used and maintenance performed on it.

6. Type of rain gage used.

7. Certification that flow meters were installed and operated properly.

8. Summary of flows measured in each subsystem including:

   a. Average daily dry weather flow.

   b. Average daily wet weather flow.

   c. Average daily infiltration.

   d. Average daily inflow.

   e. Peak 4 hour flow.

   f. Projected peak 4 hour flow for a 3 year recurrence storm with a duration of 2 hours or less (ICAP option communities only).

   g. Projected peak 24 hour flow for a 3 year recurrence storm with a duration of 24 hours or less (150 gpcpd option communities only).

NOTE: Flows should be presented in both units of million gallons per day, MGD, and gallon per capita per day, gpcpd.

9. Percentage of the community's population equivalent monitored.

10. Estimated flows for the entire community if less than 100 percent was monitored.

11. If flows are excessive, a summary of the steps to be taken to reduce infiltration and inflow.

For a community that sets up a permanent flow monitoring program an annual report summarizing the data collected during each year should be prepared and filed for future reference. The information included in the annual report would typically be similar to the information required in a short-term continuous flow monitoring report.

CHAPTER 4

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INTRODUCTION

A continuous sewer system inspection program is an important part of any preventive maintenance program. Inspections are required regardless of flow monitoring results. In addition to locating sources and quantities of infiltration/inflow, inspections are necessary to reveal blockages in the sewer system, to identify structural defects in the system, to identify potential safety hazards, and to observe the condition of control mechanisms.

Sewer system defects due to poor structural condition or poor construction practices can cause surcharging, overflowing manholes, sewer backups in buildings, exfiltration of wastewater into the ground, infiltration of groundwater, collapse of roadways, sewer sag, and increased sand and gravel deposits in lift station wet wells. A continuous inspection program serves to identify the system defects which contribute to sewer system failures before a failure occurs. The defects identified during a continuous inspection program can be scheduled for routine repair before it becomes necessary to make an expensive emergency repair.

A continuous inspection program must be developed, to include manholes, sewer lines, lift stations, and other appurtenances such as junction chambers and siphons. The program should also include the inspection of private buildings for illegal connections to the sanitary sewer system and the inspection of new construction. In some cases smoke testing and dye testing may be required in problem areas to identify sections of the sewer system that warrant detailed inspections.

Figure 4-1 shows some of the defects and private building connections that typically allow infiltration and inflow to enter the sanitary sewer system. These sources of I/I can be identified and scheduled for repair only if a continuous inspection program is implemented.

MANHOLE INSPECTION

General

Manholes are subject to a variety of forces which cause them to structurally deteriorate over time allowing for infiltration and inflow to enter the sanitary sewer system through the defects. The most common forces which cause manholes to deteriorate include vibration and pounding from traffic passing over them, freeze-thaw cycles, settlement which usually occurs at a different rate for manholes than for the sewers to which they are connected, and chemical attack due to the nature of the wastewater being conveyed through the system.

Manhole inspections should be done immediately on newly constructed manholes before they are accepted for use. Existing manholes should be routinely inspected at the suggested cycle of once every five years. Areas subject to heavy traffic and areas where many defects have been found in past inspections should be inspected more frequently.

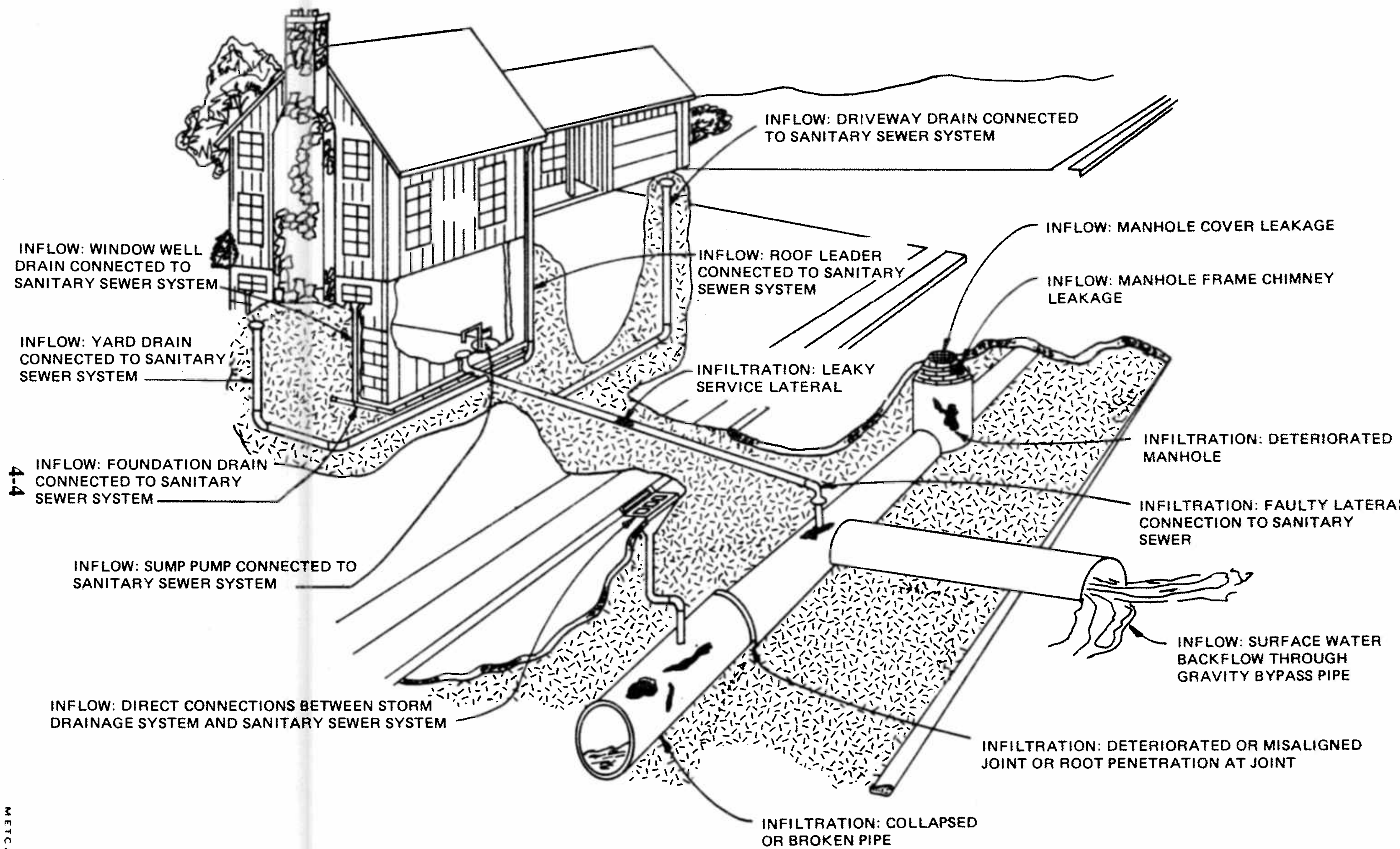

FIGURE 4-1. TYPICAL SOURCES OF INFILTRATION AND INFLOW

Inspection Procedure

WARNING: MANHOLES ARE CONFINED SPACES AND MAY HAVE DANGEROUS ATMOSPHERES. FOLLOW PROPER SAFETY PRECAUTIONS WHEN WORKING NEAR AND BEFORE EVER ENTERING A MANHOLE.

Proper procedures must be followed when inspecting manholes and recording data. Manhole inspections require entering manhole structures. Manhole inspection crews must be instructed or reminded of the safety requirements that must be followed when inspecting manholes. Details regarding safety procedures are included in Chapter 9 of this manual.

An inspection procedure that can be used to help identify manhole defects is as follows:

1. Check the area around the lid for proper drainage away from the lid. Use a straight edge to see if the manhole is at proper elevation and grade with the surrounding ground.

2. Check for combustible gases inside the manhole before removing the manhole cover.

3. Prior to entering a manhole verify that the atmosphere within is safe. Manholes can be flushed prior to entry. Flushing will remove gases, slime and debris from the walls, and clean ladder rungs for better inspection and footing. If a power jetter is available, chlorine can be added to the water supply.

4. With a flashlight or other adequate portable lighting, inspect all surfaces and joints inside the manhole for:

    a. Cracks or breaks in manhole walls and bottom.

    b. Sources of infiltration.

    c. Joint security.

    d. Offsets and misalignments.

    e. Root intrusion.

    f. Grease accumulation around the arch or inside of sewers.

    g. Gravel or debris in invert.

    h. Grout bed of frame and condition of frame seal.

    i. Condition of steps.

    j. Debris on shelf or steps.

    k. Sluggish flow or backed up wastewater.

    l. Separation of grade rings.

m. Corrosion.

n. Manhole section lifting holes that have not been plugged.

o. Surcharge line.

p. Wetness or condensation on walls that indicates the groundwater level.

5. Clean the ledge of the manhole ring and inspect for cracks in the metal parts.

6. Replace the lid and check for warped or misfit lid and rattling or rocking of lid.

While inspecting manholes, wastewater flow characteristics through the manhole should be observed. Grease and scum present in the sewer can usually be detected by these observations. Excessive or sluggish flows can also be detected through manhole observations. Comparisons should be made between the amount of flow passing through adjacent manholes. If low flow is found in a manhole downstream of one which has larger flows, it is likely that an obstruction of some sort exists in the sewer line between the two manholes which is causing wastewater to either backup into private sewers and possibly into buildings or exfiltrate into the ground. Further inspections are required when a sewer obstruction is suspected.

Recording Inspection Data

An important part of every manhole inspection is the recording of all observations on an inspection record. The following information should be recorded:

1. The manhole identification number and location.

2. The materials and condition of the manhole including construction type, cover, ring, frame seal, cone, chimney, walls, steps, lift holes, benches, and channels.

3. The manhole depth and opening size.

4. The number and size of holes in the manhole cover.

5. The frame grade and alignment.

6. Visible infiltration sources and estimated flow rates.

7. Evidence and location of leaks.

8. The level of the high water mark.

9. The type and depth of debris found in the manhole.

10. The groundwater level at manhole (indicated by wet marks on the wall).

11. Specific problems and conditions such as inflow sources, overflows, bypasses, and manholes in natural ponding areas.

12. Date of inspection.

13. Names of the inspectors.

14. Weather conditions.

An example data sheet for manhole inspection is shown in Figure 4-2.

SEWER INSPECTION

General

As a sewer system ages the sewer pipes are subject to deterioration or damage due to a variety of reasons. Some of the more common causes of sewer deterioration and damage include:

1. Poor construction practices such as improper placement of pipe bedding and backfill, improper installation of the pipe material, not installing the sewer to the specified grade, and improper connection of private service laterals to the public system.
2. A poor structural base beneath the sewer allowing settlement to occur.
3. Corrosion both externally and internally.
4. Poor system maintenance allowing small problems to become big problems.
5. Carelessness on the part of contractors installing or maintaining other utilities and constructing new buildings and roadways.
6. Live loads which exceed the pipe strength.
7. Earth movement from freeze-thaw cycles.

To ensure that the sewer system will not deteriorate to the point of requiring emergency repairs and to identify any damage done to the sewers, periodic sewer inspections should be made. It is suggested that all sewers be inspected on a cycle of once every five years. More frequent sewer inspections may be necessary where sewers pass beneath waterways, roads, railroads, low lying areas subject to ponding of rainwater, large trees (especially Willow trees), and in areas with a history of sewer defects.

Sewer inspections can be done by looking into a sewer segment from inside a manhole, by walking through the sewer line if it is large enough, or by pulling a closed circuit television camera through the sewer. Visual inspections may be adequate for short-term inspections or to indicate if infiltration or blockages exist, but the limitations of visually inspecting sewers from adjacent manholes warrants periodic televising of the entire system.

MANHOLE INSPECTION FORM

MH # ________________ LOCATION ________________

INSPECTOR ________________ DATE ________________

RAIN: NONE _____ LIGHT _____ HEAVY _____ / SNOW: NONE _____ FROZEN _____ MELTING _____

1. Surface at Manhole: Gravel Turf Concrete Blacktop Other
2. Subject to Ponding/Flooding: YES NO
3. Cover: Standard ________ Watertight ________
   Pickhole Size ________ Number of Holes ________
4. Atmospheric Conditions in Manhole prior to Ventilation: ________________
   ____
5. Manhole Diameter ________ inches
6. Frame alignment and Seal: Good Fair Poor
7. Construction Type: Brick Block Precast Other
8. Structural condition: Good Fair Poor
9. Rim/Invert Elevations: ________________
10. Evidence of Infiltration: Leaks Stains None
11. Frame Grade: Above Below Flush
12. Manhole Steps: None Corroded Loose Other Safe ________ Unsafe ________
13. Bench: Flat Steep None Condition ________________
14. Invert: Shaped Properly ________ Shaped Improperly ________
15. Number and Sizes of Sewers Entering Manhole Number ________ Sizes ________
16. Direct Service Connections Entering Manhole Number ________ Direction: N S E W
17. Equipped with Groundwater Gauge: YES NO
18. Groundwater Level Above Sewer Invert ________ inches
19. Surcharge Evidence: Waterline Height ________
20. Debris: None Minor Needs Cleaning
21. Describe Debris: ________________
22. Manhole Type: Standard Drop
23. a) Seal at Manhole Frame: GOOD NEEDS REPAIR
    b) Seal at Riser Joints: GOOD NEEDS REPAIR
    c) Seal at Bench: GOOD NEEDS REPAIR
24. Remarks ________________
    ____

FIGURE 4-2. EXAMPLE DATA SHEET FOR MANHOLE INSPECTIONS

Inspection Procedures

WARNING: SEWER LINE INSPECTIONS REQUIRE ENTERING CONFINED SPACES WHICH MAY HAVE DANGEROUS ATMOSPHERES. FOLLOW PROPER SAFETY PRECAUTIONS WHEN WORKING NEAR AND BEFORE EVER ENTERING A MANHOLE OR SEWER LINE.

Walk-through. Sewers that are large enough to accommodate workers should be inspected by walking through the sewer. The structural integrity of the sewer should be assessed. This includes checking for loose bricks, deteriorated concrete or cement, cave-ins, cracks, crushed pipe, misalignments, sags, open joints, and protruding taps. Any visible inflow and infiltration sources should be noted with an estimate of the flow rate observed.

The sewer pipes should also be inspected for root intrusion so that if found, proper corrective measures can be taken to eliminate them before they seriously damage the sewer system. Other problems with the sewer pipes should be noted during the walk-through such as illegal house connections.

Lamping. Small sewers can be inspected for obstructions and infiltration using a mirror and/or light beam. Reflected sunlight or a powerful beam of light is directed down the pipe from one manhole. If the light can be seen from the next manhole, it indicates that the line is open and straight. The number of sewer segments in a system that can be successfully inspected visually using the lamping technique is normally limited by the distance between manholes, slight bends in the sewer between manholes, sagging sewers, root blockages, collapsed pipe, and other types of blockages. Just because light cannot be seen at the next manhole does not mean that a sewer blockage exists. If a section of pipe cannot be successfully lamped, past sewer records should be reviewed to determine if there is a reason other than blockage explaining why the light beam did not pass through the sewer. If the review of records points toward a blockage it may be necessary to televise the pipe segment in order to pinpoint the problem.

Even when sewer lamping indicates that a sewer segment is open and straight, it does not provide any information about the structural condition of the sewer except for maybe a few feet adjacent to each manhole.

Sewer lamping is normally done in conjunction with manhole inspections since manhole entry is required for both types of inspections and the additional work necessary to do both inspections simultaneously is only slightly more than doing either one individually.

Closed Circuit Television. Closed circuit television (CCTV) inspection is a very effective and useful technique for observing the condition of the sewer. In this method, a TV camera is pulled through the sewer while the picture is shown on a monitor and observed by a worker outside the manhole. CCTV inspection is applicable to sewers four to forty-eight inches in diameter. CCTV inspection can help to generate inspection reports and provides a permanent visual record of all sewer conditions. The use of a color camera system gives added depth perception although black-and-white systems are usually adequate. Light sewer cleaning is usually required prior to inspection with a closed circuit television to allow the camera to pass through each line giving an unobstructed view of the pipe interior to assess its condition.

Televised pictures can be recorded on video tapes which can later be played back for further inspections. An audio portion of each tape can be provided by a technician commenting on the pipe conditions seen on the television monitor. The following can be accomplished through CCTV inspection:

1. Inspect the structural condition of the sewer and to determine the location of problem areas such as pipe or joint separations, drops, ruptures, leaks, service connections, obstructions, corrosion, misalignments, and root intrusion.

2. Identify damage done by excavation and construction on utilities, roads, and buildings.

3. Locate unrecorded connections and illegal taps.

4. Determine inflow and infiltration amounts.

5. Examine newly installed and/or repaired taps or pipes.

6. Help evaluate the effectiveness of corrective methods.

7. Assist in rehabilitation techniques such as grouting, sliplining, and inversion lining.

The equipment requirements for closed circuit television inspection are extensive and costly. It is possible to hire a company which specializes in CCTV inspection. Larger communities may wish to purchase equipment, while smaller ones may decide to rent because of the cost. The decision to rent or to buy equipment, or to contract with a specialty company, depends on many factors. These include the amount of pipe to be televised, how long it will take, how much money is available, and whether or not qualified maintenance personnel are available to do the job.

Recording Inspection Data

Like manhole inspections, every sewer inspection requires a detailed inspection record on which the following typical information should be recorded:

1. The length, size, type, and depth of the pipe, along with an estimate of the amount of work required or preventive maintenance needed.

2. The depth of flow for assessment of pipe capacity and detection of extraneous inflow of water.

3. Extent of root intrusion and suggested control techniques.

4. Type and depth of deposits and recommended cleaning methods.

5. The location of visible infiltration and inflow sources such as open joints, misaligned joints, cracked pipe, and mineral deposits. If infiltration or inflow is observed, an estimate of the flow rate should be recorded.

6. The structural condition of the pipe.

7. The presence of special problems and conditions such as collapsed pipe, sagging sewers, and corrosion.

8. The location, type, and condition of all service lateral connections and other tap-ins that are observed.

9. The date of inspection.

10. The names of the inspectors.

11. The weather conditions during the inspections.

12. The type of surface over the sewer being inspected.

13. The groundwater level if available.

Figure 4-3 shows an example sewer inspection data sheet designed for closed circuit TV inspections. The data sheet could be modified slightly for use during a walk-through inspection in large sewers.

Figure 4-4 shows an example data sheet for sewer lamping inspections. Although sewer lamping does not provide a large amount of data about sewer conditions, it is still important to keep a record of where it was done and what observations were made.

LIFT STATION INSPECTION

General

Inspection of lift stations, like sewers and manholes, should be performed routinely as part of an effective preventive maintenance program. The typical problems encountered in lift stations include power failures such as electrical circuit failures and burned out motors; control system failure; pumping failures; mechanical failures such as breakdown of a bearing, vibrations, poor shaft alignment, etc.; and solids depositions such as grit, grease or floating debris in the wet well, or force mains becoming restricted or plugged. Through a carefully followed inspection program many of these failures can be prevented or corrected before further, more serious problems occur.

Inspection Procedures

Before entering any lift station facility, inspection and maintenance personnel must be fully aware of the safety procedures that need to be followed. Safety procedures are presented in Chapter 9 of this manual.

Lift stations are normally designed to operate with limited operator attention, but their operation depends on the condition of the equipment. Regardless of the level of work required to operate and inspect a lift station, a minimum of two operators should make the round of inspections for safety reasons. Inspections must be made frequently to ensure smooth operation.

VIDEO TAPE NO. ____________

COMMUNITY ______________________________________ ______________

DATE:

PIPE LOCATION ____

SURFACE OVER SEWER: ASPHALT CONCRETE GRASS OTHER ______________

PIPE SIZE / DEPTH / MAT'L ________ / ________ / ________

WEATHER: SUNNY RAIN SNOW TEMP: ____________

CLEANING: NONE JET ROOT CUTTING OTHER ______________________

IN CONJUNCTION WITH DYE-FLOODING: YES NO

CREW CHIEF: ______________________________

MH# MH#

0 · · · · · · · 0

DIRECTION OF FLOW ____________

DIRECTION OF CAMERA ____________

N

FOOTAGE	SERVICE CONNECTIONS	REMARKS	I/I (gpm)

EXAMPLE REMARKS:

- Brick demortared, but still intact
- Brick missing, backfill showing
- Camera blocked; unable to proceed
- Camera submerged
- Crack in pipe - lateral
- Crack in pipe - transverse
- Corrosion (indicate severity)
- Collapsed pipe
- Damage (specify type)
- Debris accumulated in invert
- Distorted shape
- Flow depth
- Infiltration flow rate
- Inflow rate
- Grease accumulation
- Invert damage (specify)
- Offset joint
- Separated joint
- Leakage observed
- Mineral deposits
- Root intrusion
- Sagged line
- Abandoned tap
- Protruding tap
- Tap with roots
- Structural damage (spalled concrete, loose bricks)

FIGURE 4-3. EXAMPLE SEWER INSPECTION DATA SHEET

COMMUNITY: ____________________

INSPECTION CREW: ____________________

WEATHER: TEMP: ____________________ SUNNY RAIN SNOW

DATE	SECTIONS LAMPED (MH TO MH, LIN. FT.)	OBSERVATIONS

FIGURE 4-4. EXAMPLE SEWER LAMPING DATA SHEET

Suggested inspection and maintenance tasks that should be performed on a daily basis include:

NOTE: Follow manufacturers inspections for operation and maintenance of all equipment. Requirements vary from manufacturer to manufacturer.

1. Check to make certain the electric power is on.
2. Make sure no circuit breakers have been tripped.
3. Read and record values on counters and timers.
4. Inspect, clean, and lubricate motors and rings.
5. Inspect and clean wet well level sensor electrodes and bubbler tubes.
6. Inspect and clean motor starters and relays.
7. Check the operation of the gland water pump motors and electric valves.
8. Inspect and clean all automatic gate controls.
9. Check kilowatt meters and charts and record data.
10. Check the motor, heating elements and belts on auxiliary equipment such as heaters, fans, and dehumidifiers. Replace any broken or badly worn parts when they are detected.
11. Check the float switches and motors on lift station sump pumps.
12. Inspect and clean bar screen or communitor and controls.
13. Inspect indicating lights on all equipment and telemetry equipment controls if applicable.
14. Inspect pumps and bearings. If needed lubricate and repack bearings following manufacturer instructions.
15. Inspect and lubricate line shaft bearings.
16. Inspect and lubricate gland water pumps and bearings.

NOTE: Never substitute a cheap or economy lubricant for the type recommended by the pump or equipment supplier.

17. Make sure the pump packing is not leaking too much water and is not too tight.
18. Inspect check valves and verify that they are not stuck either open or particularly closed.
19. Inspect sump pump floats and all discharge piping and valves.
20. Check the position and operation of all flow control gates.

21. Check the drives and screens on all mechanically cleaned bar screens.
22. Inspect comminutors for proper operations.
23. Inspect, clean, and lubricate all air compressors.
24. Manually clean bar screens.
25. Make sure all vent fans and lights are operating properly.
26. Enter any observed problems in to the lift station log books.
27. Pick up all debris in side and outside of the facility.
28. Before leaving the facility make sure it is secure.
29. Plow snow if necessary.

Suggested inspection and maintenance tasks that should be performed once a week include:

1. Check all equipment, piping and valves for leakage.
2. Operate each wastewater pump in the "manual" or "hand" position and inspect the pump and motor for excessive noise or vibration.
3. Check all motors for excessive temperature increases.
4. Check all pressure and vacuum gauges.
5. Inspect and clean sump pump wells if necessary.
6. Clean and reposition floats and level sensor electrodes in the wet well.
7. Inspect wet well piping and ladders.
8. Mow the lift station yard if necessary.
9. Wipe down all equipment.
10. Replace recording charts as required.
11. Exercise standby equipment to dry out water, redistribute lubricant and ensure operational readiness.
12. Check operation of all lift station alarm systems.

Suggested inspection and maintenance tasks that should be performed once a month include:

1. Operate all flow control gates and valves to prevent them from seizing.
2. Remove the pump casing inspection plates and remove any debris that has accumulated.

3. Check calibration and recalibrate flow meters if necessary in accordance with the manufacturer's instructions.

4. Clean all ventilation openings.

5. Check first aid supplies.

6. Take inventory of spare parts. Verify that depleted parts have been ordered.

7. Check the condition of paint both inside and outside the lift station.

Suggested inspection and maintenance tasks that should be performed once a year include:

1. Dismantle the wastewater pumps to inspect the impellers, shafts, and shaft sleeves.

2. Inspect and clean all components of the ventilating fans, heaters, sump pumps, and dehumidifiers.

3. Inspect the condition of all electrical equipment.

4. Paint areas both inside and outside of the lift station as needed.

5. Inspect the inlet and outlet piping at the lift station. Clean the piping if needed.

6. Clean the wet well of accumulated grease, floating debris, and grit. Grease and floating debris can be removed with a vacuum unit mounted on a truck or trailer. Grit can be removed by pumping down the wet well level and vacuuming out the grit. Grit can also be removed by using a clam shell or bucket machine if there is available access. Commonly grit is removed by resuspending it using a high pressure water stream and allowing it to be pumped through the collection system. This method of cleaning grit from wet wells has the disadvantage of causing additional wear on the pumps.

7. Check flowmeter calibration and recalibrate if necessary.
(NOTE: Calibration requirements vary from supplier to supplier. Manufacturer calibration requirements must be followed.)

Daily visits to pump stations may seem excessive for some communities, or may not be feasible due to employee and/or time constraints.

Equipment lubrication reservoirs must be large enough to supply lubricants between station visits. A telemetry system can also be installed to increase the amount of time between station inspections. At the minimum, a high water alarm should be installed. Other recommended alarms include those for the water level in the sump pump pit of the dry well, power failure, air compressor failure and intrusion. Auxiliary alarms can be used to indicate water supply pressure, chlorine leaks, and high temperature of motors and engines.

Every lift station must have a well-organized operation and maintenance manual that can be used during routine inspections and maintenance. The operation and maintenance manual for the lift station should include:

1. A functional description of the lift station.
2. The lift station location, which can be indicated on an area map.
3. Equipment data sheets for all mechanical and electrical equipment including:
    a. Manufacturer's name.
    b. Model number.
    c. Type.
    d. Size/capacity parameters. (gpm, hp, rpm, kv, etc.)
    e. Spare parts.
    f. Any other pertinent data.
4. Valve and piping data.
5. A schematic drawing or flow diagram showing all important equipment.
6. Schematic wiring diagrams for all electrical equipment.
7. A description of lift station startup procedures and normal mode of operation.
8. Description of alternate operating modes.
9. A description of potential emergency situations and emergency modes of operation.
10. Safety instructions associated with operating and maintaining the lift station.
11. A summary of the preventive maintenance schedule using the equipment manufacturer's literature to develop the schedule.
12. Operation and maintenance manuals supplied by the equipment manufacturers.
13. Emergency phone numbers and key contact personnel.

Recording Inspection Data

All inspections and routine maintenance tasks, along with problems encountered and repairs should be recorded on data sheets. The data sheets should be designed to include all specific inspections and maintenance tasks at each lift station.

Most lift stations will be unique with respect to the pump station type (wet well/dry well or wet well), type and number of equipment units, and equipment manufacturers. Therefore inspection and maintenance requirements will vary at each lift station making it difficult to use a standard data sheet for recording data at all lift stations. Inspection and maintenance tasks at each lift station should be recorded on data sheets designed in accordance with the preventive maintenance program dictated by the design, equipment, and operation of each station.

Data should be entered on data sheets developed separately for daily, weekly, monthly, and annual maintenance and inspection tasks. The data sheets should be stored in a log book at the lift station with at least one duplicate copy stored in the community's central office area. The data sheets generally should include the following basic information:

1. The date.
2. The inspectors names.
3. Time inspectors arrived/time inspectors left (important for budgeting and manpower projections).
4. The pump running time for each pump.
5. Readings indicated on all station meters and gauges including utility company meters.
6. Check off all equipment inspected and note any unusual observations.
7. Check off the routine maintenance tasks that were completed on specific equipment and controls i.e. cleaning and lubricating.
8. Indicate if wet wells were cleaned.
9. Indicate if sump pump wells were cleaned.
10. Note any emergency conditions encountered.
11. Record station equipment failures.
12. Indicate if cleaning of debris was done inside and outside of the lift station.
13. Indicate if yard mowing was done.
14. Check off if painted areas were inspected and indicate if painting work was completed or if it is required.

Equipment failures and emergency conditions encountered should be recorded on a separate data sheet and stored in the lift station log in an area designated for emergency conditions and equipment failures.

INVERTED SIPHON INSPECTION

General

An inverted siphon can be defined as any sag or depression purposely designed into a sewer to allow for it to pass under manmade or natural obstructions such as other utilities, rivers, streams, subways, and valleys. Inverted siphons normally remain full of wastewater even during low flow conditions. Most inverted siphons contain at least two parallel pipe barrels, each a different diameter. The smaller pipe barrel conveys wastewater during low flows at a velocity high enough to scour solids from the invert of the siphon.

During higher flows the larger siphon barrel would convey the larger flows. For maintenance and inspection purposes an inlet and outlet structure are designed as part of the inverted siphon.

Because solids tend to settle out in inverted siphons, the siphons must be inspected and flushed regularly. Inverted siphons also allow for odors to be released if provisions have not been made to allow sewer gases to be transferred from the upstream end of the siphon to the downstream end.

Inspection Procedures

WARNING: INVERTED SIPHONS AND THEIR INLET AND OUTLET STRUCTURES ARE CONFINED SPACES AND MAY HAVE DANGEROUS ATMOSPHERES. FOLLOW PROPER SAFETY PRECAUTIONS WHEN WORKING NEAR AND BEFORE EVER ENTERING AN INVERTED SIPHON OR RELATED STRUCTURES.

Inverted siphons must be inspected routinely to verify that they are operating properly. Since the routine inspections require entry of siphon inlet and outlet structures where dangerous atmospheres can exist, proper safety precautions must be followed.

Frequent inspections are necessary to make sure obstructions are not affecting the operation of the inverted siphon. These inspections should include:

1. Observing flows upstream and downstream of the siphon. Sluggish upstream flows with lower than usual flows observed downstream would indicate a blockage.

2. All mechanical parts should be inspected for accumulated debris and cleaned if necessary.

3. The entrance hatches for the inlet and the outlet structures should be checked for security.

4. If the siphon is equipped with air vent piping between the inlet and outlet structures, it should be checked for proper operation.

5. Slide gates should be exercised to prevent seizing.

To assist during the inspection procedure, an operation and maintenance manual should be available for each inverted siphon in the system. The design and operation may be different at each siphon location. The operation and maintenance manual should include as a minimum the following information:

1. A location map.

2. A functional description of the inverted siphon and appurtenances.

3. Description of startup and normal operation.

4. Description of alternate operating modes.

5. Description of emergency operation.

6. A schematic including all piping, valves, gates, and weirs.
7. Mechanical and electrical components if any.
8. A listing of tasks and procedures that need to be followed during routine visits.
9. A listing of emergency phone numbers and key contact personnel.
10. Safety associated with the various tasks required.

Recording Inspection Data

During each routine inspection at an inverted siphon a data sheet should be completed which summarizes the inspections and any routine maintenance that was completed. The data sheets should be stored in a log book for the inverted siphon and associated appurtenances. The data sheet typically should include:

1. The date of inspection.
2. The inspector's names.
3. General weather conditions.
4. The arrival and departure time of the inspection crew.
5. Observations regarding accumulated debris in the inlet and outlet structure.
6. Flow observations.
7. Note any cleaning or rodding which was required.
8. Note if odors were detected.
9. The condition and operation of air vent piping.
10. Record any unusual observations.

JUNCTION CHAMBER INSPECTION

General

Junction chambers are required when one or more branch sewers join with or enter a main sewer resulting in changes in sewer diameter, direction of flow, and sewer slope.

For small diameter sewers, the junction can be made at a standard size manhole. When sewers are too large to join at a standard sized manhole structure, a junction chamber must be provided in conjunction with manhole riser sections.

Junction chambers are normally designed to minimize turbulence at the structure in order to minimize the release of odors. Design features also are aimed at minimizing the accumulation of grit, rags, and other typical wastewater debris in the junction chamber.

Inspection Procedures

WARNING: JUNCTION MANHOLES AND CHAMBERS ARE CONFINED SPACES AND MAY HAVE DANGEROUS ATMOSPHERES. FOLLOW PROPER SAFETY PRECAUTIONS WHEN WORKING NEAR AND BEFORE EVER ENTERING A SEWER JUNCTION CHAMBER.

Junction chambers must be routinely inspected to ensure that the junction outlet does not become obstructed. The structure itself needs to be periodically inspected following the procedures for a typical manhole. A junction chamber will require more frequent cleaning than a standard manhole.

Recording Inspection Data

During each routine junction chamber inspection, observations should be recorded. Frequent inspections require only a small amount of data to be recorded such as:

1. Date of inspection.
2. Inspector's names.
3. Observed flow conditions.
4. Amount and type of debris accumulated.
5. Unusual conditions observed at the junction chamber site.
6. Indication of odors.

Data from less frequent inspections of the junction chamber structure can be summarized on a modified manhole inspection form.

PRIVATE PROPERTY INSPECTIONS

General

Each local agency must periodically inspect all buildings with potential illegal connections to the sanitary sewer system. When illegal connections are found, they must be removed regardless of the actual system flows. Some agencies may initiate a program where all buildings are inspected for compliance with local plumbing ordinances each time a building is put up for sale. In areas where excessive wet weather flows have been measured and private property illegal connections have been a problem in the past, inspections should be done more frequently to ensure that reconnections have not been made.

Building to Building Inspection Procedures

Building inspections are conducted to identify private sector sources of infiltration and inflow. These sources typically include sump pumps, downspouts, foundation drains, area drains, and defective service laterals.

All personnel assigned to inspecting buildings for illegal connections must be trained to know what to look for and how to communicate with the public. The training should also cover collecting and recording data.

Before starting the field inspections, all property owners should be notified by letter or flier delivered to each building in the scheduled inspection program.

At each building (residential, commercial, or industrial) the inspector must request permission to inspect the basement or crawl space and the outside of the building. Basements are inspected for sump pumps that discharge stormwater or groundwater to the sanitary sewer system. Commonly a basement will have one sump pump well which collects groundwater from foundation drains around the building and also wastewater from floor drains and laundry tubs located in the basement. When this type of plumbing exists it needs to be modified so that the floor drain and laundry tub discharge to the sanitary sewer system and the foundation drainage is discharged to the ground surface around the building or to a storm sewer. Outside of the building, the inspectors should look for exterior sump pumps, downspouts that discharge below grade, and area drains such as patio, window well, and driveway drains.

If permission to enter a building is denied, it should be noted and legal options pursued to gain the necessary access.

<u>Recording Inspection Data</u>

Each time a building inspection is conducted, observations made should be recorded on a data sheet. Typical information that should be recorded on the building inspection data sheet includes:

1. The date of inspection.
2. The inspector's names.
3. The address and building owner's name.
4. The building type; residential, industrial, commercial, or other.
5. Status of entry, allowed or refused.
6. Whether a basement exists or not.
7. The number, type, and discharge points for sump pumps identified.
8. Number, type and discharge points for floor drains, foundation drains, window well drains, stairwell drains, downspouts, driveway drains, and types of yard drains identified.
9. Answers to interview questions regarding:
   a. Number of years owner has owned property.
   b. Number of basement flooding occurrences.
   c. Factors that may have caused basement flooding, if any.

10. Status of building, in violation or in compliance.

An example data sheet for building inspection is shown in Figure 4-5.

NEW CONSTRUCTION INSPECTION

General

New construction of sewer system components in the public and private sector must be thoroughly inspected before they can be accepted and put into service as part of the sewage collection system. As well as assuring compliance with plans, specifications, local plumbing ordinances, and safety regulations, early inspection will alert personnel to any unexpected modifications that have been made to the plans. Inspection of new construction will also decrease the need for future maintenance, and when documented will also provide a record of construction progress useful for future maintenance which may be required. It is important to remember to record any new data generated due to construction on the existing sewer maps. This should be done as quickly as possible. Remember to give new sewers and new manholes their own unique identification numbers.

Inspection of New Sewers

Inspections during the construction of new sewers begins when the new sewer pipe is delivered to the construction site. The quality of the pipe delivered must be as specified. Pipe not meeting the specified quality requirements must be rejected. Inspections must continue during the pipe installation to ensure that the trenching operations, pipe laying procedures, and trench backfilling are all done in accordance with the specified requirements.

When the sewer pipe first arrives at the construction site it should be inspected for:

1. Proper unloading procedures. High impacts and point loadings on the pipe during unloading should be avoided.

2. Cracks or other defects that are visible.

3. Compliance with the specifications with respect to diameter, length, and thickness.

4. The specified pipe class.

5. Proper certification from the pipe supplier which states that the pipe supplied is in compliance with the pipe specifications.

As the sewer trench is being excavated for the open cut installation method inspect for:

1. Correct trench width at the bottom and top of the trench as specified for the type of pipe being installed.

2. A solid base at the bottom of the trench to place the pipe bedding on. Overexcavation may be required if the trench bottom is not suitable for supporting the sewer pipe. Stable material must be used to replace the unsuitable material removed.

DATE: ______________________ VIOLATION: YES NO ENTRY REFUSED

COMMUNITY: ______________________ INSPECTOR: ______________________

BUILDING TYPE: RESIDENTIAL COMMERCIAL INDUSTRIAL

ADDRESS: ______________________ OWNER: ______________________

BASEMENT: YES NO CRAWL SPACE:

SUMP PUMPS:

TYPE	DISCHARGE TO	SUMP BOTTOM SEALED?	TYPE	DISCHARGE TO
			A. SANITARY	SANITARY SEWER
			B. STORM	STORM SEWER
			C. COMBINED	OUTSIDE SURFACE
			D. NONE	UNKNOWN

IF TWO OR MORE SUMPS EXIST, ARE THEY PIPED TOGETHER?

INFLOW SOURCE	NUMBER	DISCHARGE TO:
Foundation Drains		
Window Wells		
Stairwell Drain		
Floor Drain		
Downspout		Underground
Downspout		Surface
Yard Drains		
Driveway Drains		
Other (Specify)		

How long has owner lived there?

Have they experienced any sewer backups?

REMARKS:

FIGURE 4-5. EXAMPLE BUILDING INSPECTION DATA SHEET

During the pipe laying procedures inspect for:

1. Proper placement and compaction of pipe bedding. The bedding should be placed at the specified thickness, it should be firm, and placed uniformly at the proper grade to provide support under the entire length of the pipe barrel. Make sure the specified bedding material is being used.

2. Proper handling of pipe. Handling should not introduce high impacts or point loadings on the pipe.

3. Debris on the bell and spigot end of the two pipe sections being connected. The pipe ends should be cleaned before making each joint.

4. Proper seating of the joint gasket.

5. Debris left inside of the pipe. Before each pipe section is installed make sure rags, boards, buckets, tools, and other debris have been removed from the last section of pipe installed.

During the backfilling operations inspect for:

1. Proper placement and compaction of select granular backfill around the pipe. Be sure that backfill placement does not cause lateral or horizontal displacement of the pipe.

2. Large hard objects such as rock, in the backfill material that could induce damaging point loads on the installed pipe.

3. Proper compaction techniques. Compaction limits vary depending on the location of the sewer main. Backfill compaction can be tested with soil density meters.

4. Proper restoration of the ground surface to preconstruction conditions or other conditions as specified.

Sewer Acceptance Tests. Before accepting a newly constructed sewer main the sewer main should be tested for potential infiltration of groundwater, exfiltration of wastewater and intrusion of tree roots, using one or several common leakage tests. The sewers should also be checked for any obstructions that may exist.

One test for locating obstructions is done by pulling a cylindrical plug with a diameter equal to 95 percent of the pipes inside diameter through the pipe. The plug locates obstructions such as deflections, offsets, and protrusion of building sewer connections. This test is particularly helpful in the inspection of new construction of plastic sewer pipes which have a tendency to be more flexible and to become misaligned or deflected. Any obstructions identified should be repaired before accepting a sewer main for use.

Air testing can be used to locate potential leaks in pipes. An air compressor is used to pump air into a section of sewer pipe, raising the pressure inside the pipe to a value greater than the pressure on the outside of the pipe. If a leak is present, the air pressure inside the pipe will decrease. More specific procedures for air testing sewer lines are available from the American Society for Testing and Materials (ASTM). A drawback of air testing is that air can leak through smaller cracks than wastewater can, and the results of such a test can yield results indicating a more serious problem than actually exists. The results of air tests can also be influenced by high groundwater conditions if the actual static groundwater level is not compensated for during the test.

Air testing sewers can be dangerous to personnel if proper safety precautions are not followed. If the sewer plugs are not installed properly or if the sewer line is accidentally covered the plugs can blow out and possibly cause severe injury. Therefore the following safety precautions should be observed:

1. The sewer plugs should be installed properly and be securely braced.

2. No one should be allowed in the trench or manhole while the air test is being performed.

3. Plugs should not be removed until the pressure has been reduced to equal the outside air pressure.

4. Do not overpressurize the sewer.

5. Install a pressure relief valve on the testing equipment to prevent the possibility of overpressurizing the sewer.

An infiltration test can be conducted on a new sewer if the groundwater elevation is known to be at least 4 feet above the top of the sewer pipe. A flow measuring device, typically a v-notch weir, is installed downstream of the new construction and flows are measured. If no leakage is measured the pipe passes the infiltration test. Based on the types of pipe material, and pipe joint design available today, infiltration rates can be limited to 50-200 gpd/inch-diameter-mile of sewer pipe or less.

If the groundwater level is less than 4 feet above the top of the pipe an exfiltration test can be performed by plugging the pipe at the manhole downstream of the test section and filling the test section with water. At the manhole upstream of the test section, the upstream sewer should also be plugged so that the manhole can be filled with enough water to exceed the groundwater level surrounding the test section. After a specified amount of time has passed, the water level in the manhole at the upstream end of the test section is measured and a leakage rate is determined. If the leakage rate is greater than the specified limit, the leaks must be located and repaired. This test is limited to sewers where no building services have been connected and where full lengths between manholes can be tested at one time.

Inspection of New Manholes

New manholes must also be inspected for any defects or potential problem areas. When a manhole is being constructed the following items should be inspected:

1. The manhole foundation. The manhole base whether cast-in-place or precast should be installed on a firm foundation.

2. The manhole barrel. Typically the manhole barrel is delivered to a construction site in the form of precast sections. Normally the sections are available in a range of lengths and diameters with manhole steps included. The barrel sections should be inspected for structural damage and the steps should be checked to make sure they are not loose.

3. The barrel joints. When the manhole barrel is assembled, the barrel joints should be made watertight by using elastomeric gaskets or a joint filler.

4. The manhole frame and cover. Make sure the manhole cover provided is the specified size. Make sure the frame and cover supplied meet the specifications for loading, especially if they will be subject to traffic loads. Make sure the frame and cover fit without rattling. Make sure the cover is as specified with respect to the number and type of pick holes.

5. The grading around the manhole cover. When the construction of a manhole is complete the grade around the manhole cover should not allow for water to pond over the manhole cover.

6. The connection between the manhole and sewer. Flexible gaskets and couplings are available for making connections to manholes which allow for some differential settlement which normally would break a pipe. Proper methods for connecting different material pipes to manholes must be observed.

7. The manhole steps. After a manhole has been constructed, the steps should be inspected to verify that they are secure and spaced properly.

8. The manhole channel and bench. The channel and bench should be inspected to make sure they were installed according to specifications.

<u>Manhole Acceptance Tests</u>. Before accepting a newly constructed manhole, it should be tested for infiltration. The manhole can either be visually inspected for infiltration if the groundwater level is known to be much higher than the bottom of the manhole or the manhole can be air tested. When a manhole does not pass an infiltration test, it should be repaired before accepting it. Manholes typically can be constructed so that infiltration rates should not exceed 0.1 gal. per hour/ft. diam./ft. static head.

<u>Inspection of New Lift Stations</u>

During the design of a new lift station, it is important to verify that considerations for maintenance and safety have been incorporated into the design. Some common safety and maintenance design features include:

1. Make sure access has been provided so equipment can be removed from the lift station.

2. Make certain that emergency lighting is available.

3. Make certain that adequate head room and floor space has been provided for performing routine maintenance.

4. Make sure hose stations have been provided for cleaning wet wells, sump pump wells, floors, etc.

5. Make sure proper ventilation has been provided.

6. Make sure the design has provided for safe access into wet wells and dry wells.

If a new lift station is being built, the following items should be inspected before accepting the station for use:

1. Inspect the electrical equipment and major circuits.
2. Verify the location of all electrical lines.
3. Inspect the pumps for correct direction of rotation, for proper alignment of drive and pump, and for clear suction and discharge lines.
4. Check that the engine has sufficient oil, water, and fuel.
5. Make certain that all controls are easily operated.
6. Pressure test suction and discharge piping for leaks.
7. Check to make sure the wet well is clean of debris.
8. Perform leakage tests on sluice gates and slide gates.
9. Load test standby generators.
10. Balance the ventilation system and check for proper operation.
11. Verify pump performance curves.
12. Inspect fences for security.
13. Make sure all paved surfaces adequately drain to the stormwater collection system.

Inspection of New Private Building Construction

When new buildings are constructed within an agencies service area the inside plumbing and service connection should be inspected. The inside plumbing should be inspected for compliance with local plumbing ordinances. Foundation drainage collected in basement or crawl space sumps should be discharged to the ground outside of the building or to a storm sewer. Downspouts, window well drains, driveway drains, stairwell drains, and other types of yard or area drains must be inspected to verify that they are not connected to the sanitary sewer system. Service laterals should be tested for infiltration and inspected for proper connection to the sewer main. The builder should be required to submit certification that all local plumbing codes have been complied with and that no illegal connections to the sanitary sewer system exist.

DYED WATER TESTING

General

In areas where problems exist with complaints and sewerage backups, dyed water tests may be required to identify sources of inflow that are difficult to locate with other inspection techniques. If problems do exist dyed water tests should be considered in areas where:

1. The storm sewers run parallel to or cross the sanitary sewers and service laterals and are located above the sanitary sewer system.

2. Stream sections, stormwater drainage ditches, and areas subject to ponding are located above the sanitary sewer system.

3. Flows from private property drains, sump pumps, and downspouts are suspected to be connected to the sanitary sewer system.

Testing Procedures

To conduct a dyed water test the following materials are needed:

1. Water Supply.

   a. Fire hydrant.
   b. Tanker truck.

2. Sandbags or sewer pipe plugs.

3. Fluorescent dyes selected on the basis of:

   a. Safety in handling.
   b. Easy to see at low concentrations.
   c. Non-reactive with soils and debris in the sewers.
   d. Biodegradability.

4. Portable flow metering equipment.

Before starting a dyed water testing program the testing crew must be trained or reminded of safety requirements for entering manholes. The testing personnel should also be advised of safety requirements necessary for using pipe plugs and fire hydrant hoses. Also the testing crew should be warned of potential overflows if certain sewer segments are plugged off. If applicable, traffic control and safety must also be considered.

To conduct dyed water tests on stormwater drainage systems the following procedures should be followed:

1. Block off the section of storm drain that is suspected to contribute inflow to the sanitary sewer system. For stormwater drainage ditches use sand bags and for storm sewers use sewer plugs.

2. Fill the storm sewer or stormwater drainage ditch with dyed water.

3. Observe the flow in the downstream sanitary sewer manholes for the presence of dye.

4. Measure flows in the downstream manhole before and during the dyed water tests.

5. If dye is detected in the sanitary sewer and the flowrate measured during the dyed water test increases significantly, the dyed water test should be repeated while a closed circuit TV camera is pulled through the sanitary sewer to identify the location of the sewer defect.

To conduct dyed water tests on private property drains the following procedure should be used:

1. Notify the building owner of the impending dyed water tests.

2. Pour dyed water down the suspect drain, downspout, or into the sump pump well.

3. Check the sewer flow for the presence of dye at the first downstream manhole in the sanitary sewer system.

Recording Testing Results

Dyed water testing results should be recorded on a data sheet for each test set up. The data sheet should include information such as:

1. The date.

2. The names of the personnel conducting the test.

3. The location of the setup. A sketch should be included on the data sheet which clearly indicates what was flooded with dyed water and the relationship to the sanitary sewer system. The sketch should include the manhole numbers where dye was checked for.

4. The type of setup,

   - Storm sewer.
   - Stormwater drainage ditch.
   - Catch basin.
   - Private property drain or discharge (specify type).

5. The time that flooding began and ended.

6. The time that dye was observed and the concentration of the dye.

7. The time that the checking for dye ended if none was observed.

8. Flow measurements (or depth of flow) before testing began and during the time dye was observed in the sanitary sewer.

9. The length of storm sewer or ditch that was flooded.

10. The diameter of the storm sewer flooded or general ditch dimensions.

11. The amount of water that was used for the set up.

12. Remarks related to the set up such as:

    a. Soil conditions.

    b. Previous weather conditions and weather conditions during the set up.

    c. Unusual observations made during the test.

    d. Problems encountered during the test.

    e. Type and description of private property fixture that were tested.

An example data sheet for dyed water testing is shown in Figure 4-6.

SMOKE TESTING

General

In areas where complaints pertaining to the sanitary sewer system are common and in areas where sewers backup, smoke testing may be required to identify sources of inflow that are difficult to locate with other inspection techniques. Smoke testing is an inexpensive and simple preventive maintenance and troubleshooting tool. Sewer lines don't have to be cleaned prior to testing, and a smoke testing crew of 3 can test up to 10,000 feet of sewer per day. Smoke testing is also useful for tracing and verifying sewer map data. Like dyed water testing, smoke testing can locate cross connections between the storm and sanitary sewers, private property drains connected to the sanitary sewer, defective service connections, and defects in the public sewer mains.

Unlike dyed water testing, smoke testing has several limitations that may lead to false conclusions when smoke testing results are negative. When smoke testing produces negative results, it should not be assumed that the section of sanitary sewer tested is free of inflow sources. The following conditions will produce negative but inconclusive smoke testing results:

1. Sewer lines with sags or dips filled with water or sewer lines equipped with water traps.

2. High groundwater conditions where the groundwater level is above the sewer line.

3. Sewers that are flowing full.

4. If the soil above the sewer line is saturated, frozen, or covered with snow.

5. If it is very windy smoke rising from the ground may be dispersed by the wind before it can be detected.

6. If private sector drains have been installed with water traps.

DATE: ____________

COMMUNITY: ______________________________ JOB NO. ____________

SET-UP LOCATION: ______________________________

START/END TIME: _____/_____ CREW: ____________

TYPE OF SET UP: STORM SEWER DIA. ____________ CATCH BASIN ________

DITCH ______________________________

PRIVATE SECTOR TEST: DOWNSPOUT ____________ DRIVEWAY DRAIN _____

WINDOW WELLS ____________ OTHER ____________

TEST(MH/MH): _____/______________________

FLOW DEPTH BEFORE FLOOD (MH/TIME/DEPTH): _____/_____/_____ INCH

FLOW DEPTH FOLLOWING DYE OBSERVATIONS (MH/TIME/DEPTH): _____/_____/_____ INCH

CONCENTRATION OF DYE OBSERVATION: TRACE MEDIUM HEAVY

NO DYE OBSERVED (MH/TIME): _____/_____

SKETCH	SKETCH OF SET UP
LEGEND SANITARY SEWER STORM SEWER CATCH BASIN FIRE HYDRANT FL FILLING LOCATION X PLUG	

REMARKS: ______________________________

FIGURE 4-6. EXAMPLE DYED WATER TESTING DATA SHEET

Testing Procedures

The smoke testing technique involves blowing a large volume of smoke filled air through a manhole into the sanitary sewer collection system. The smoke follows the sewer main and other passageways leading to the ground surface, disclosing points of infiltration and inflow, stoppages, and breaks. The equipment required includes:

1. Portable air blower (normally gasoline powered) with a minimum capacity of 1,500 cubic feet per minute.

2. Camera and film.

3. Sewer line plugs and sand bags.

4. Sewer maps and/or plans.

5. Smoke bombs with 3-5 minute capacity.

Before a smoke testing program actually begins the following preliminary steps should be taken:

1 Personnel should be trained or reminded of manhole entry safety precautions (see Chapter 9).

2. Personnel should be trained in proper traffic control and safety methods.

3. Personnel should be trained how to use the smoke testing equipment including the safety aspects of using sewer plugs. Potential sewer backups when using plugs must also be addressed.

4. Alert the fire and police departments of the smoke testing schedule. Update them from time to time on the progress and if the schedule has changed.

5. Notify the property owners in the areas scheduled for smoke testing so that they will not be alarmed when smoke enters their building or rises from their yards.

The following procedures should be followed when conducting a smoke test:

1. Isolate the section of sewer to be testing by plugging adjacent sewer lines and sand bagging over manhole openings. Typically 1000 feet of sanitary sewer can be tested at a time.

2. Locate a manhole near the center of the test section for introducing smoke with the blower.

3. Begin blowing smoke through the system. The number of smoke bombs used depends on the size and length of the sewer section being tested.

4. The smoke should be generated constantly while visual inspections are made above the sewer line, and around private property. Special attention should

be given to storm sewer inlets, downspouts, driveway drains, and building foundations. Most buildings have vent stacks which should always smoke. If they do not there is probably a water trap in the service lateral. Suspect drains on these properties should then be tested with dyed water.

5. Take photographs of all locations where smoke was observed. Photographs should be taken while the smoke is rising. Each photo should be numbered for future reference.

6. When the smoke testing is complete, remove the sewer plugs following the necessary safety precautions.

Recording Testing Results

Smoke testing results should be recorded on a data sheet for each section of sanitary sewer tested. The data sheet should include information such as:

1. The date.

2. The names of the personnel conducting the test.

3. The two manholes between which the smoke test was done.

4. The length and diameter of the sewer section tested.

5. The manhole identification number for the manhole where the smoke was introduced to the sewer system.

6. The type of smoke bomb used.

7. Identification and description of smoke sources.

8. The photograph number for each smoke source.

9. An estimate of the area drained by each smoke source. Also include the type of surface area drained.

10. The address of buildings where no smoke was observed emerging from the vent pipes.

11. A sketch of the setup including:

    a. The manhole identification numbers in the test section and the manhole where smoke was blown in.

    b. The north arrow.

    c. Locations of all smoke sources. The smoke sources should be tied to landmarks so they can be easily found again at a later date.

    d. At each source of smoke the corresponding photograph number should be recorded.

An example data sheet for smoke testing is shown in Figure 4-7.

COMMUNITY: ______________________________ DATE: ____________

CREW NAMES: ____

Set-Up Information: Pipe Size Smoked: ____________

Length of Pipe/MH to MH: ______ ft./ MH No. ________ to MH No. ________

Type of Smoke Bomb Used: ______ 3 min. ______ 5 min. ______ other ____________

LEGEND		SKETCH OF SET-UP
●	Sanitary MH	
○	Storm MH	
———	Sanitary Sewer	
··········	Storm Sewer	

Source of Smoke	Description of Source of Smoke (address/other)	Surface Type/Area Drained by Source of Smoke	Address Where Vent Pipes Showed No Smoke	Photo No.

POTENTIAL SOURCES OF SMOKE

01 Downspout
02 Roof Drain
03 Yard Drain
04 Catch Basin
05 Storm Sewer Manhole
06 Manhole Frame
07 Cracked Pavement
08 Lateral
09 Surface Over Sewer
10 Sump Pump
11 Foundation Wall
12 Driveway Drain
13 Other - Describe

Additional Observations: ____

____

FIGURE 4-7. EXAMPLE SMOKE TESTING DATA SHEET

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INTRODUCTION

One of the most productive parts of a preventive maintenance program is the systematic cleaning of sewers. Another important part, inspection, was discussed in Chapter 4, while the topics of repair and rehabilitation will be discussed in Chapter 6. A cleaning program is necessary to ensure proper functioning of the collection system operation, and to minimize the chances for the development of more serious problems, such as sewer backups and overflows.

The frequency of sewer cleaning depends on many factors. A complete inspection of the system will help with making a decision as to how often any particular section of sewer line should be cleaned. Generally, smaller pipes should be cleaned more often than larger pipes. Also to be cleaned more often are pipes that have shown to be subject to root penetration or grease accumulation. The amount and type of suitable equipment, the availability of trained workers, and the amount of sewer to be cleaned are also factors to consider when developing a sewer cleaning program.

Typically, most communities try to schedule sewer cleaning of their entire sewer system every 1-5 years. An effective cleaning frequency must be determined by each agency for their specific system. Problem sections of pipe will need to be cleaned more often and sections scheduled for certain types of rehabilitation and inspection work will require cleaning prior to the start of work. It should be noted that following an extensive rehabilitation program to remove infiltration and inflow the collection system may require cleaning more frequently. Cleaning action may occur naturally in a sewer system prior to a rehabilitation program if wet weather flows provide sufficient velocities to flush accumulated debris from the sewer system. If the rehabilitation program is successful and wet weather flows are reduced, the cleaning effects previously provided by the wet weather flows may be decreased causing debris to accumulate in areas that were not considered problem areas prior to the rehabilitation program. Problem areas that did exist prior to rehabilitation should be inspected frequently and cleaned when necessary.

LOCATING AND IDENTIFYING STOPPAGES

Investigations

Stoppages or obstructions to wastewater flow can be located by the inspection processes described in Chapter 4. These include manhole inspections, sewer lamping and television inspection. Identification of dry manholes through surface inspections may indicate a blockage. This inspection technique, however, will not identify partial blockages nor will it identify the cause of the blockage.

Sewer lamping, which consists of shining light beams or reflecting sunlight through a sewer, can identify partial and total sewer stoppages under the right conditions. However, this technique may not be able to identify the cause of the stoppage.

Television inspection of the sewer line can identify a full or partial blockage and also the cause of the blockage. Television inspection is more costly than the other two investigative techniques and is therefore commonly used in conjunction with one of the other two techniques. Problem areas can be located by manhole inspections or sewer lamping and then specific sewer lines can be televised to confirm a blockage and identify what type of cleaning or repair method will be required.

Causes of Stoppages

Once a stoppage is located, it is important to identify the cause or type of problem to simplify follow-up maintenance work. Stoppages are caused by obstructions such as roots, grease, debris, structural or joint failures. These obstructions require removal, repair, or replacement immediately to correct the problem.

Many stoppages are caused by vandals who place debris into lines and structure openings which were designed to vent the collection system. Vandals will sometimes remove manhole covers in isolated sewer easements, and these manhole openings may receive large amounts or surface debris which can cause a serious backup of wastewater.

Some stoppages in sewer easement areas also may be caused unintentionally. This is especially true when a large piece of construction equipment begins rough grading work and knocks off the top of a manhole, spilling dirt, rocks, and other material into the opening. In most cases, the equipment operator is not aware of the location of the manholes because they are buried or covered with overgrowth.

Other causes of physical stoppages are obstructions found in the barrel of the sewer. These obstructions are sometimes found to be created by plumbers, equipment, or by some force of nature. An obstruction made by a plumber can be caused by the placement of a building sewer tap connection that protrudes into the main sewer, a poorly repaired pipe section, backfill damage to pipe during backfilling and misuse of trench compacting equipment. Improper use of sewer cleaning equipment also contributes to physical stoppages.

Obstructions caused by natural forces include the penetration of roots into pipe joints, cracks or openings which cause pipes to break and/or restrict wastewater flow. Ground movement which shifts the pipe, freeze thaw conditions, soil conditions surrounding the pipe, and the deterioration of other utility pipes are other natural forces that could cause obstructions in the sewer system.

Stoppages

Some of the most common types of debris found when removing a stoppage are a build-up of solidified grease, detergents, sticks, rags, plastic bags, broken pipe, brick, rocks, sand, eggshells and silt, to name a few. Larger items removed from lines and manhole openings, which have caused major problems in removal, include broken manhole and flushing inlet castings, concrete and asphalt rubble, steel rebars, large metal and plastic buckets, broken and lost plumber rods, snakes and plugs, wooden posts and timber material, barbed wire, tree limbs, stumps, and many other items.

In some cases, where the invert of a small diameter sewer is connected to the invert of a large diameter sewer, which is flowing at maximum flows, hydraulic conditions can cause serious stoppages to develop. This is caused by a sudden decrease in velocity of the flow when it enters the larger pipe. The velocity decrease may cause solids to settle and cause a blockage. Not only do stoppages develop in the sewer, but solids can build up in a manhole and produce harmful and malodorous gases. Most instances of hydraulically-caused stoppage conditions are found in sewers that have been extended to new developments from existing mains which were not designed for the future potential growth of the community.

Preventing Stoppages

Stoppages can be minimized by routine maintenance and proper design. An annual visual inspection of all manholes for debris and structural defects, such as missing or broken manhole covers, can help to prevent physical stoppages. Areas of the system which are susceptible to vandalism should be checked more frequently. Proper design of the sewer system, can help to prevent hydraulic stoppages. A frequent cleaning schedule is the best possible solution to all stoppages.

Once the cause of the problem has been identified, the methods for solving it can be analyzed.

METHODS FOR CLEANING SEWERS

General

Sewer cleaning methods depend on the characteristics of the wastewater being conveyed, fluctuations in wastewater flows, alignment or grade of the sewer, pipe material, size, and structural condition of the sewer. Stoppages can be cleared or prevented, and sewers cleaned by either hydraulic or mechanical methods. Traps should be placed in manholes downstream from the sewer cleaning operation to catch debris loosened during cleaning. Debris removed from the sewer should be observed for content. The type of debris removed will give a good indication of what types of defects may exist in the sewer and the severity of these defects. The debris removed should be disposed of in an approved location.

Hydraulic Cleaning Methods

Hydraulic cleaning methods such as jet cleaners, jet rodders, and high velocity cleaners consist of cleaning a sewer with a high pressure water jet. This jet produces water velocities which are usually high enough to wash most grit, grease, and debris down the sewer and leave the pipe clean.

Balls, kites, bags, pigs, tires and scooters are all examples of hydraulic cleaning equipment. These devices fit into a sewer and partially block the flow. Water builds up behind the device and creates pressure. This pressure forces water at a high velocity around the outside edge of the cleaning device. This high water velocity cleans the walls of the sewer and pushes the material and debris downstream where it can be removed at a manhole.

Sewers can also be cleaned or kept clean by flushing. Flushing is most effective with a sudden rush of deep water down the sewer. It is important that dept and velocity are used together because the use of either depth or velocity alone will be ineffective. Devices are available that provide automatic and frequent flushing. Otherwise, hand flushing may be done at specified intervals. The devices commonly used in flushing operations include automatic flush tanks, flushing manholes, a fire hose, a connection to a water main with an air gap device, a temporary fixed dam, and a moving dam.

Mechanical Cleaning Methods

Mechanical cleaning methods consist of using equipment that scrapes, cuts, pulls, or pushes debris out of the pipe. Mechanical cleaning equipment consists of bucket machines, power rodders, and hand rods. A bucket machine operation includes a special bucket-type device that is pulled through a sewer. This device removes debris as it is pulled through the pipe. Rodding can be done by power or hand. It entails pushing or pulling a steel rod or snake through a sewer with special tools attached to the end. These tools are used to cut roots or to chop up large chunks of debris. Mechanical devices are more effective in clearing blockages than in cleaning, and the sewers sometimes have to be flushed following a mechanical cleaning operation.

Chemical Cleaning Methods

Chemicals can also be very helpful aids in sewer cleaning. The proper application of chemicals can be used to control roots, grease, odors, concrete corrosion, rodents, and insects. The use of chemicals is strictly to keep these problems under control they are not the solution to these problems. Be very cautious when using chemicals.

CONTROL OF ROOTS

General

Intrusion of roots into sewers is a problem that requires more discussion. Roots in the soil seek warmth and moisture, which are the conditions found in a sanitary sewer. Roots can penetrate sewer pipe through small hairline cracks, open joints or other structural defects. Once inside, the roots grow and expand in the warm, moist pipe. Root problems are more common in service connections because they are shallower and usually not as well constructed as sewer mains. The presence of roots in sewers causes increased structural damage and infiltration by expanding openings, increasing blockages, decreasing upstream velocities, and increasing solids deposition.

The ideal control method against root intrusion would be to have watertight sewers free from imperfections that will not crack, break, or deteriorate. This calls for thorough inspection of new sewer construction. However, when roots succeed in entering pipes there are techniques available to control or correct the problem.

Mechanical

Cutting roots with a sewer rod and an auger tool solves the immediate blockage problem. Some types of mechanical equipment used for root cutting are rodding machines, bucket machines, winches equipped with root cutters, root saws, porcupines, and hydraulic jet machines equipped with hydraulically driven cutters. However, roots grow back thicker after they have been cut, so simply cutting roots can cause an increase in root regrowth. For this reason cutting of roots should be followed by chemical treatment or by flooding with scalding water to retard root regrowth.

Chemical Removal

Chemical treatment of roots involves applying a herbicide, commonly dichlobenil, sodium methyldithiocarbonmate, or 2,6, dichlorobenzonitrile by soaking, spraying, or foaming.

Soaking is accomplished by plugging the sewer at the downstream manhole. The pipe is then filled with a one percent solution of herbicide solution and is allowed to sit for an hour or more. This method requires that sewer service be interrupted. Spraying is not highly effective due to short contact time and is therefore not recommended. Foaming does not require isolating the sewer section, therefore interruption of sewer service is not required. Foam is applied with a hose which is pulled through the sewer to an upstream manhole. The foam generator is then started and the hose is retracted to the downstream manhole at a rate specified by the equipment manufacturer. The foam tends to cling to the the top section of the pipe and is not easily washed away. If used properly, foam will not kill trees, grass, or endanger residents or pets.

Another root control method consists of mechanically removing roots followed by grouting joints with a grout mixture which contains a herbicide. The grout mixture discourages root regrowth.

It is important to carefully evaluate the sewer system and all costs involved before making the decision to use herbicides as a root control technique. The decision to use herbicides should be based on the severity of the local root intrusion problem.

EQUIPMENT USED FOR SEWER CLEANING

Deciding which type of equipment is best suited for removing stoppages and cleaning sewers can be done only after analyzing the cause of the problem. The following two sections describe the basic types of hydraulic and mechanical cleaning equipment used and advantages and limitations of each.

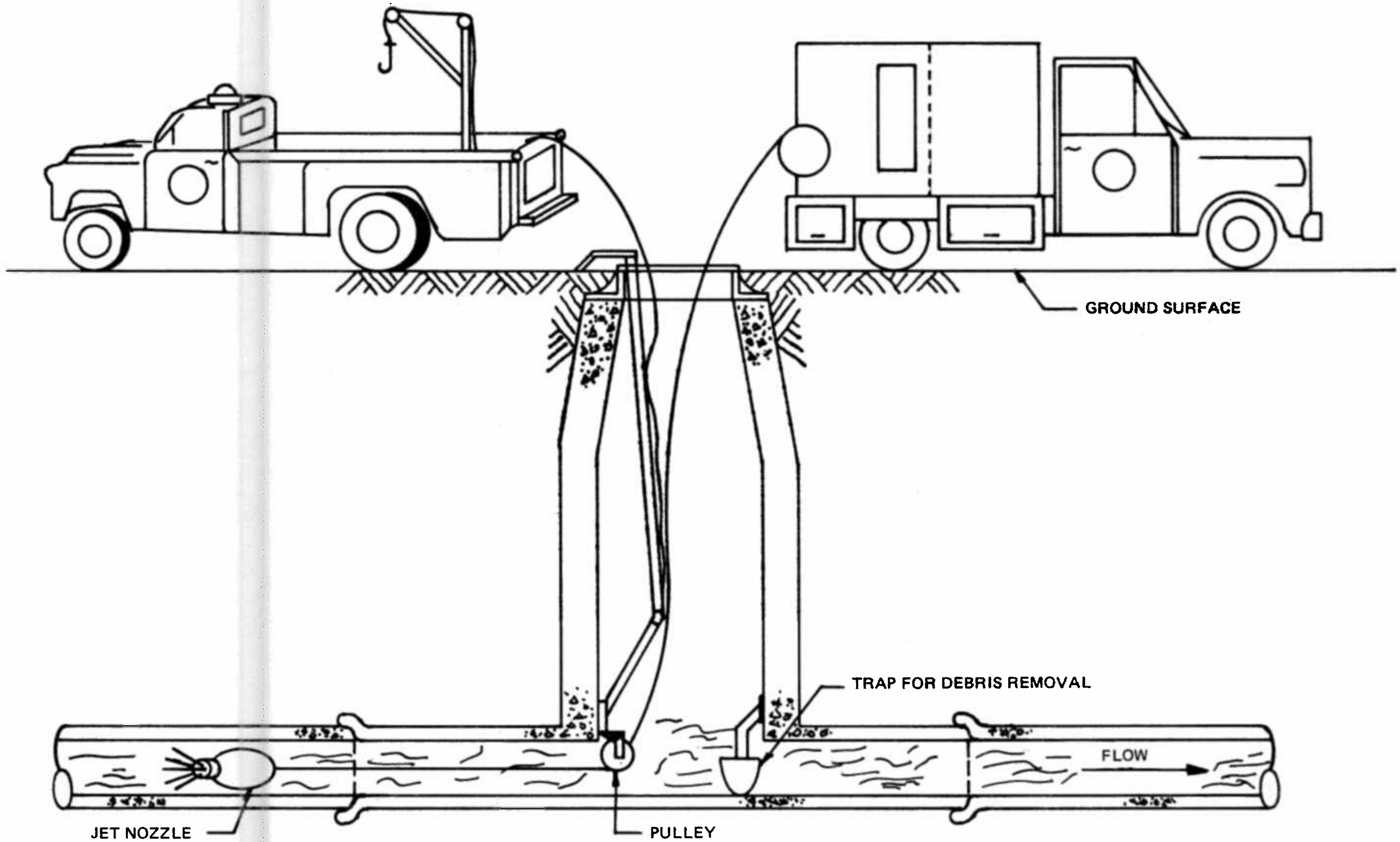
Note: Regardless of type of equipment used, it is highly desirable to have an eductor truck positioned at the downstream manhole to remove and collect the material rather than to successively chase it downstream.

HYDRAULIC CLEANING EQUIPMENT

Sewer cleaning methods described as hydraulic rely on the cleansing action caused by high velocities of water in the line. High water velocities can effectively remove grease, sand, and other debris. Cleansing velocities can be obtained by allowing water pressure, or head, to build up in the line, or by using a pump to produce the water pressure. Hydraulic cleaning methods include high velocity cleaners, balling, flushing, sewer scooters, kites, tires, and poly pigs.

High Velocity Cleaning Machines

The use of water pressure to clean sewers dates back to the early 1900's, however this method has been improved upon by the present day high velocity cleaning machines (Figure 5-1). The fundamental idea of using a self-propelling nozzle on the end of a hose is still used. Instead of using a fire hose hooked to a hydrant, a self-contained portable machine with hoses and nozzles is used, which not only does a better job, but is faster and cheaper. Although the design of the velocity cleaning machine will vary with different manufacturers, they are essentially all the same. Examples of high velocity cleaning equipment are balls, kites, bags, tires, pigs, and scooters.



REFERENCE: FROM OPERATION AND MAINTENANCE OF WASTEWATER COLLECTION SYSTEMS: A FIELD STUDY TRAINING PROGRAM. UNITED STATES ENVIRONMENTAL PROTECTION AGENCY AND OFFICE OF WATER PROGRAM OPERATIONS. CALIFORNIA STATE UNIVERSITY, SACRAMENTO.

FIGURE 5-1. HIGH VELOCITY CLEANING OPERATION

Manpower and Equipment. The high velocity cleaning machines consist of a water supply tank, usually with a capacity of 1,000 gallons or more; a high pressure water pump and an auxiliary engine for the operation of the pump. The units have a powered drum reel capable of holding at least 500 feet of hose, usually one inch in diameter. To the end of this hose, a nozzle is attached which will create water velocities to do the cleaning. Accessories are varied, and new tools continue to be developed, as well as techniques for their use.

Among the accessories for this cleaning method are a nozzle with rear jets only, a nozzle with rear jets and one forward jet, a dual nozzle, a hose roller or hose guide, and a wash-down gun or nozzle. In addition, sand or debris traps, manhole shovel, debris bucket and hand line, and a manhole cover hook are essential tools.

The machine is operated by one worker. This worker needs help in order to be notified when the cleaning nozzle has reached the upstream manhole, and when the grit and debris are removed from the working manhole. Safety regulations usually require two workers topside when a worker is in a manhole. Refer to Chapter 9 for safety precautions before entering a manhole.

Precautions and Safety. Although some of the precautions of operation have already been given, there are others which soon become obvious. One of these is cleaning from manhole to cleanout. Most often the cleaning nozzle will stop at the bottom of the cleanout. On short runs, however, it is possible to have enough speed and thrust that the nozzle will go up to the street surface, and even knock small cleanout covers out of place. When cleaning up to a cleanout, there is also the chance of getting the nozzle stuck. If this should occur, shut the machine off, pull the cleanout cover, and dislodge the nozzle with a long rod or pole.

While cleaning, so much material can build up below the nozzle that the nozzle cannot be pulled through under pressure. When this happens, stop the pressure and pull the nozzle back through the stoppage without water flowing out of the nozzle. If this fails, try to get the nozzle to the upstream manhole and take it off, thus allowing only the hose to be pulled back through the stoppage to the downstream manhole. Replace the nozzle and go back up the line after the stoppage.

Often a bend in the line will prevent pulling the nozzle back under full pressure. The more pressure at the nozzle, the stiffer the hose becomes. Reduce the pressure, or even turn it off, for a short time until past the bend.

In cold weather, particular precaution has to be taken to prevent the equipment from freezing. Special attention should be given to the high-pressure pump to make sure that it is properly drained. If the machine is equipped with a canopy over the engine and pump area, the areas can be separated by a curtain, and a small electric heater can be left inside the pump area overnight, or when not in use during freezing weather. Another approach to prevent freezing during cold weather is to install a piping system which allows water to circulate through the pump and hose. Be sure to include the hose because some water always remains in the hose, no matter how much time and care are taken to drain it.

An inexperienced worker should not operate the machine alone. Personal safety is not the biggest problem because of the design of the machine; however, costly problems can develop if care is not given to existing conditions in the collection system and those that the cleaning operation can create. Caution and experience are required to prevent "blowing toilets" with a high velocity cleaner.

Also, do not sacrifice clean lines for footage. This equipment is capable of doing a thorough cleaning job. When running low on water, there is the tendency to consider the line to be clean. Take the time to get more water, and make sure the line is properly cleaned before terminating the operation.

Advantages: Very effective in cleaning flat, slow flowing sewers. Efficient in removing grease, sand, gravel and debris in smaller diameter sewers. Effective in breaking up solids in manholes and washing structures. May be used to remove emergency stoppages.

Limitations: The efficiency is decreased as the size of the pipe increases. May cause backups into residences if not done properly.

Balling

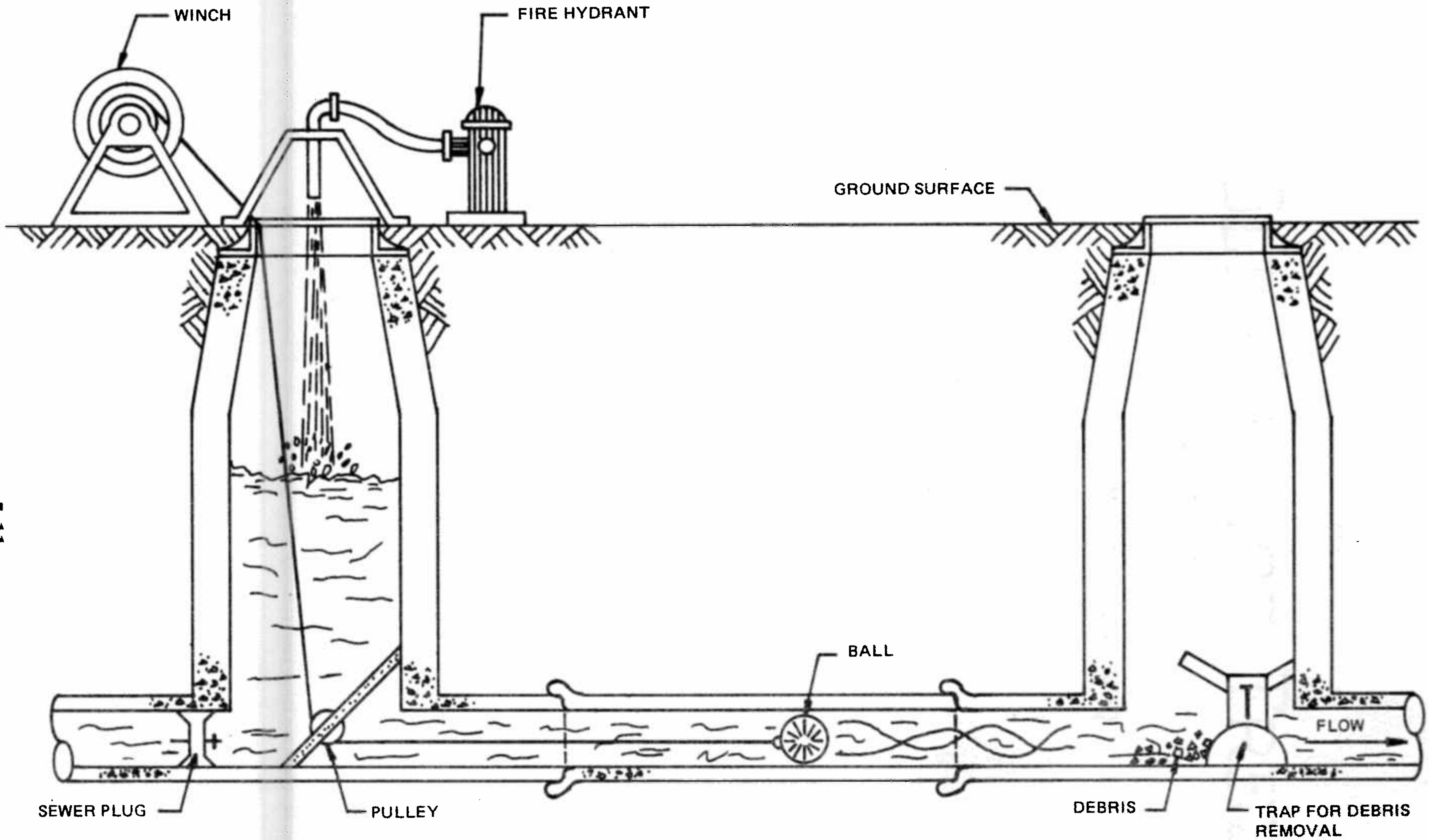
This cleaning procedure is one of the least expensive methods and is quite popular in some cities (Figure 5-2). Usually, balling is not the only cleaning method used by a sanitation agency, since the ball primarily removes deposits of inorganic (grit) material lying on the bottom of the line, and grease buildup inside the line. Balling can be used only in areas where the necessary water pressure behind and around the ball can be obtained without flooding basements or homes at low elevations. Flooding can occur when the elevation of the head of water on the upstream side of the ball is higher than a plumbing fixture in a home or basement. If many roots are in the line, a power rodding machine will probably be needed. Power rodding and other cleaning methods and procedures will be discussed fully in other sections.

Balling is most commonly used in preventive maintenance programs. Under these conditions, balling is very effective in reducing the possibility of stoppages developing. The main purposes of balling are to keep the sewer clear of debris, and to maintain flow velocities of two feet per second or more in the sewer. An effective balling program can also reduce the production of hydrogen sulfide in collection system, thus reducing corrosion and the release of rotten egg odors.

Some sewers require cleaning by balling more frequently than others. Required frequency may vary from six months in some sluggish lines, to three to five years in other lines. These are only typical frequencies. Some sewers may require monthly cleaning, while others may never need cleaning. Many communities try to ball their entire collection system every year. The frequency of cleaning the various sections of a collection system are based on the following:

1. The desire to reduce the number and types of stoppages and complaints by analyzing records and inspecting manholes for the presence and amount of debris.
2. The size of the area served by the collection system.
3. Types of waste carried by the collection system, such as residential, commercial, or industrial.

Manpower and Equipment. At least three workers are needed for cleaning lines up to ten to twelve inches. When cleaning lines located in easements or off the street, additional help may be required, depending on the difficulty of the job.



REFERENCE: FROM OPERATION AND MAINTENANCE OF WASTEWATER COLLECTION SYSTEMS: A FIELD STUDY TRAINING PROGRAM. UNITED STATES ENVIRONMENTAL PROTECTION AGENCY AND OFFICE OF WATER PROGRAM OPERATIONS. CALIFORNIA STATE UNIVERSITY, SACRAMENTO.

FIGURE 5-2. BALLING OPERATION

Basic equipment requirements include:

1. Water truck holding 1,000 or 2,000 gallons.
2. Tag line and a suitable reel to store it on.
3. Manhole jack or roller.
4. Plugs.
5. Balls. These are available in sizes up to 48 inches for trunk lines.
6. Equipment truck.
7. Debris and grit trailer.
8. Ladder.
9. Manhole bars or hooks.
10. Buckets, rope, and manhole shovel.
11. Hip boots and gloves.
12. Waterless hand cleaner and hand towels.
13. Safety equipment.

In some instances, water will be obtained from a fire hydrant to provide the necessary head for a balling operation. In all cases, before using a fire hydrant, check the hydrant usage map and contact the agency water department. If fire hydrants are used, the following additional equipment will be needed:

1. Five to eight fifty foot lengths of 2.5 inch fire hose.
2. Hydrant wrench.
3. Water meter.
4. Control valve for regulating flow at manhole.
5. Traffic ramp to protect hose.
6. Air gap device.

Air gap devices are required to prevent any backflow of wastewater from a manhole into a drinking water supply. The purpose of an air gap device is to provide adequate space above the top of a manhole and the end of the hose from the fire hydrant so no wastewater will flow out of the manhole, reach the end of the hose, and be sucked back up the hose to the water supply from the fire hydrant. Suction conditions could develop if the water supply pipe near the fire hydrant should rupture and cause a washout, or any other rare condition develop that could cause a backflow through the hose.

The tag line material may vary from plain manilla rope to synthetic rope or steel cable required for the larger balls. Some synthetic ropes may be adversely affected by constituents in wastewater, and break in many locations with no previous evidence of deterioration. Cables are considered more reliable.

The reel on which the tag line is stored should hold at least 1,000 feet. The reel should be portable, and the rope easily uncoiled and recoiled. The reel, although used primarily to hold the rope, is also used to apply a brake, or drag, to control the travel of the ball down the sewer.

When cleaning large lines, 14 to 48 inches, a power driven reel is needed, and steel cable is used for the tag line. Usually the cable is one-quarter inch in diameter, and is available with standard balling machines. Power bucket machines can easily serve this dual purpose.

Power driven reels are either truck mounted or trailer mounted, with stabilizer legs to hold the machines firmly in place over the manhole while in operation. Because of the tremendous strain and pressure generated as water builds up behind the ball, a strong steel cable is needed. Truck mounted winches are preferred by some agencies because this method allows the truck to tow other trailer mounted equipment, such as exhaust blowers.

The smaller balls are designed with diagonal ridges and grooves on the outer surface. As water builds up in the sewer in back of the ball, water will flow through these grooves, and the ball will rotate. The outside design of the large balls differs slightly, usually having a heavy tread surface to encourage a scouring action to the interior of the sewer.

Sewer balls are resistant to punctures, and are inflatable by means of a valve core. A strong metal eye lug is molded into each side of the ball to which a clevis and swivel can be attached. The tag line is then attached to control the ball and to allow it to spin. The clevis and ball bearing swivel are very essential items, since they keep the line from twisting. The clevis is quickly and easily fastened to the tag line and ball.

The manhole guide jack or roller is essential to guide the tag line into the sewer without causing unnecessary wear, and to give proper rolling action as the tag line is pulled back and forth or the ball is restrained.

Plugs, either mechanical or inflatable, are needed to control water coming into the working manhole from upstream. If there is insufficient flow in a sewer for balling, this method of "plugging off" the upstream water provides a method of getting an adequate supply of water to begin the balling procedure. A two foot head of water on the ball usually provides sufficient water velocity around the ball to clean the sewer. Plugs are not needed if the flow in the sewer is sufficient to develop the necessary head behind the ball.

If the material removed from the line is to be hauled away by the balling crew, a truck is needed. This truck can be the same vehicle used to carry the balling equipment to and from the job site.

<u>Precautions and Safety.</u> Certain precautions have to be taken, or at least considered, before and during all cleaning operations.

1. Using water pressure in the cleaning of gravity flow sewers always requires care and judgement with respect to basement fixtures and low elevation homes. If there is any possibility of the water level behind the ball becoming higher than basement fixtures, inspect these residences or businesses for potential problems, or use another method of cleaning such as a high velocity cleaner.

2. If a stoppage occurs below the ball, it must be cleared as soon as possible to avoid flooding homes or streets. First try to break the stoppage by using the ball. If that doesn't work, use a hand rod, power rodder, or high velocity cleaner at the downstream manhole to clear the stoppage.

3. All street work requires safety measures sufficient for the particular conditions involved. It is important to place barricades or other warning measures a good distance from the working areas. Flagmen should be used where extensive traffic control is required.

4. If a sewer ball becomes stuck, try to work it loose without breaking the cable. A high velocity cleaner, inserted in the downstream manhole, may be able to knock the ball loose. Another approach is to use a power rodder and try to puncture the ball. When a ball becomes stuck, be sure upstream homes do not flood while working the ball loose.

Kites, bags, tires, and poly pigs describe equipment used to clean larger diameter sewers (Figure 5-3). For example, instead of using a sewer ball to clean a large diameter sewer, use a tire slightly smaller in diameter (two inches smaller) than the sewer. With a small head (two feet) on the sewer, the velocity of water flowing around the outside of the tire will create a cleansing velocity like the velocity around a sewer ball. Kites are sometimes called parachutes. Poly pigs are frequently used in force mains similar to balling, but a cable is not usually attached to the poly pig.

Advantages: The hydraulic action of spinning balls and high velocity water flowing around the ball dislodges debris from pipe walls and moves debris downstream. Very effective in removing large concentrations of sand, grit, rock, and grease from sewers.

Limitations: Dangerous to use in locations with basement fixtures. Possibility of flooding dwellings. Cannot be used effectively when sewers have badly offset joints or protruding service connections because the ball can become distorted.

Flushing

Flushing is another method of hydraulic cleaning (Figure 5-4). It is occasionally used at the beginning of the collection system where low or sluggish flows permit the deposition of solids. This procedure may be effective in removing floatable debris, but not grit and other heavy solids. Flushing is also used with mechanical cleaning operations such as power rodders and bucket machines. High velocity cleaners and balling do a much better job of cleaning sewers than flushing.

During the flushing operation, observe the flow characteristics in the sewer - is the flow through the manhole slow or sluggish. A partial stoppage may restrict the flow of the flushing water being discharged into the sewer. Observations of lower than expected flows at a downstream manhole indicate that the upstream segment of the line requires additional cleaning. As the water flows, a physical and visual check can be made of the material in the line such as sand, grease, and debris. This observation may also dictate that more extensive cleaning is needed.

Stoppages are often located during the flushing operation. Material often will have just built up to the point of causing a stoppage such that a sudden charge of water will be able to

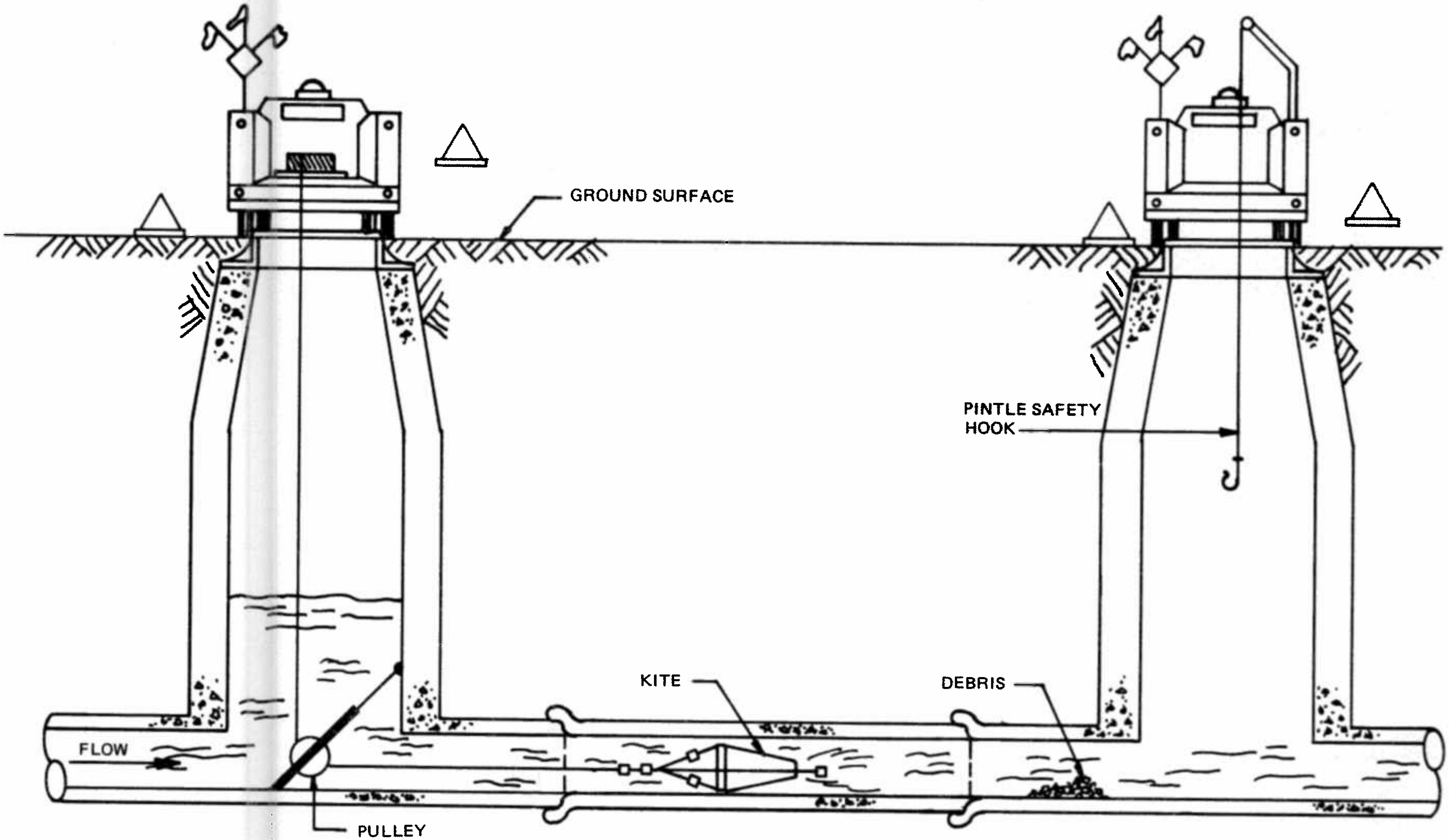


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FIGURE 5-3. KITE CLEANING OPERATION

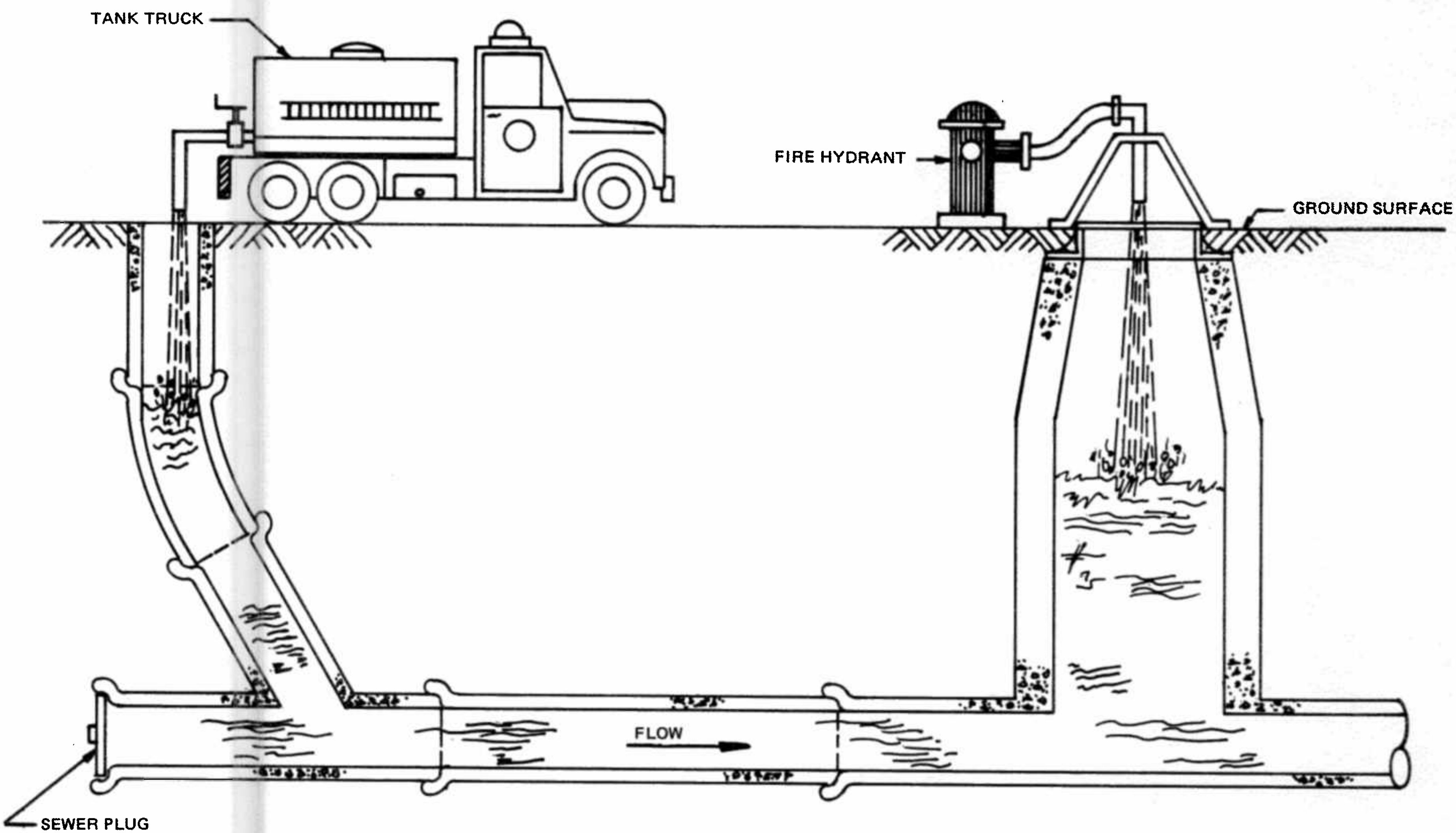

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FIGURE 5-4. FLUSHING OPERATION

break it loose, thus clearing the line. Having this large amount of water passing through all at once also provides control of rodents and insects.

Also, cleaning the manholes with water pressure eliminates manhole shelf build-up of street dirt and debris. Cleaning the manhole with water pressure, combined with the flushing action within the sewer, will minimize the build-up of hydrogen sulfide and slime in the line. This is one of the primary problems of line decay and replacement.

This method of cleaning in smaller collection systems usually must be repeated frequently to prevent the occurrence of many routine problems, but requires large volumes of water. The opening and closing of hydrants must be done with great care, because improper procedures could create water quality problems in the water distribution system.

Manpower and Equipment. Because of the small amount of equipment and small number of workers required for flushing, the cost appears attractive. However, the procedure may not be cost effective because of the limited cleansing action provided by flushing.

A tank truck with a capacity of 1,500 to 2,000 gallons is needed. The truck should be equipped with a reel for holding approximately 100 feet of one inch inner diameter hose and a pump to give sufficient pressure to do an effective job of manhole cleaning. The nozzle type may vary from an adjustable model to a plain piece of pipe reduced to give a good cutting action. A one-quarter inch pipe nipple, brazed onto a one inch female hose fitting, provides a good stream (if the pump provides 25 to 30 psi in the line) for hosing down the manhole barrels and shelf prior to flushing the line.

A two-and-one-half inch or larger gravity discharge from the bottom of the tank on the truck should be provided to permit a large flow of water. Location of the line must be convenient for the truck driver to position it over the manhole. If possible, the ideal location is just ahead of the left front wheel. This line should be equipped with a quick opening, full flowing valve. A short piece of old inner tube, fastened just above street level, will help direct the flow of water into the manhole if positioning is difficult.

The tank truck equipment should include a good filler hose, usually a short length of fire hose to reach from a fire hydrant to the top of the tank's filling hatch, hydrant wrench, water meter, air gap device and manhole cover lifter. Some communities require a two-and-one half inch water meter so they can pay for the water used in flushing operations.

A debris bucket, rope, and manhole shovel are other pieces of essential equipment, plus the usual safety equipment (see Ch. 9). The equipment and tools for this operation should be arranged on the tank truck in such a manner as to be handy and within the limits of space available.

If the flushing crew consists of only two workers, neither one should ever be allowed to enter a manhole. Flushing crews usually have to enter every third or fourth manhole to remove debris. Whenever a worker enters a manhole for any reason, two workers must be topside at all times. A third worker should be readily available when needed. Refer to Chapter 9 for safety procedures associated with entering a manhole.

Precautions and Safety. Safety measures need to be followed carefully at all times, from properly protecting the equipment and working area with safety cones, to checking manholes for hazardous atmospheres. When flushing, the turbulence may force accumulated gases, from dislodged debris or slime, downstream. Flushing presents problems very similar to those of balling. Care has to be taken not to put more water into the collection system than it can handle. Caution must be taken against creating a stoppage which, in turn, may flood a residence or business. The amount of material and debris being flushed through should not be allowed to accumulate.

Advantages:	Supplies a surge of water to move light, decaying organic matter in slow flowing sewers downstream.
Limitations:	Causes a temporary movement of debris from one point to another in the collection system. Flushing does not remedy the cause of the problem, and does not move heavy debris and grit. Must use caution in locations with basement fixtures.

MECHANICAL CLEANING EQUIPMENT

Wastewater collection line cleaning techniques described in this section rely on a mechanical action to clear the sewer. This cleaning action results from the material in the sewer being removed by the scraping, cutting, pulling, or pushing action caused by a mechanical device or machine. Cleaning techniques outlined here include bucket machines, power rodders, and hand rods.

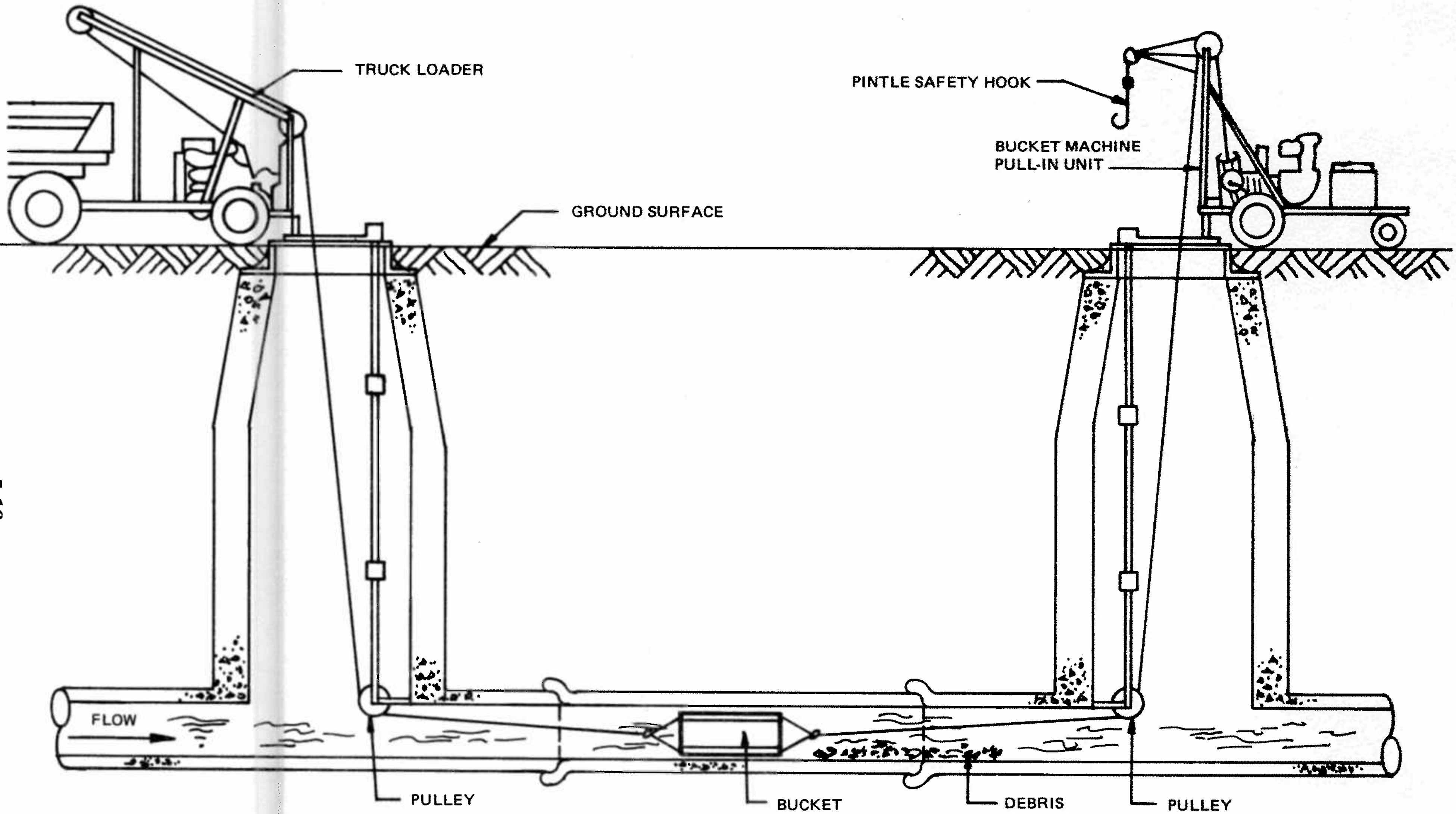
Power Bucket Machines

Sewers are purposely designed to develop sufficient velocity to provide a self-cleaning action, and to convey solids through the system to the wastewater treatment plant. When deposition of solids occurs in a sewer, first consideration should be given to hydraulic cleaning methods to remove the solids from the sewer. Hydraulic cleaning techniques are used due to their simplicity, effectiveness and the costs of removing the deposited solids in comparison to other sewer cleaning techniques.

There are instances, however, when the hydraulic techniques are not the best method of removing deposited solids or roots because of the volume, size, weight, or type of the material found in the sewer. This material may be concentrated in one area or spread evenly along the line. Types of deposits include silts, sand, gravel, or some type of industrial solid waste. The entry of silt, sand and gravel, and rocks into the collection system is often traced to some damage done either to the sewer line or manholes, or a section where repairs were made to the system. Pipes or manholes may be broken by various construction projects, grade changes of streets, earthquakes, or excessive loads from vehicles and heavy equipment. When a pipe breaks, large quantities of debris can enter the collection system.

When there is an indication that a sewer is failing, and that sand or mud is entering the sewer, a high velocity cleaner should not be used. Nozzle action develops a negative pressure that can hasten the collapse of a failing section of pipe. A bucket machine (Figure 5-5) can be used to remove the sand or mud when proper care is exercised. If possible, a television inspection of the pipe should be performed as quickly as possible to determine the cause of the problem and the condition of the pipe before a cleaning method is chosen.

To clean a line after a pipe breaks, the power bucket machine can be used effectively, both before and after repair, to remove the heavy deposited material. Next, the sewer should be cleaned hydraulically to restore it to full capacity. A damaged line must be repaired to prevent the entry of more material.



NOTE: WORKING MACHINE IS AT THE UPSTREAM MANHOLE

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FIGURE 5-5. POWER BUCKET OPERATION

The power bucket machine is one of the essential maintenance tools, but it should be used only when absolutely necessary. They are heavy, and the cleaning operation is a slow process. Power bucket machines are used mainly to remove debris caused by pipe failures, or other debris that cannot be removed by hydraulic cleaning techniques. They can also be used as scrapers with a root cutter or porcupine. They should not be used as a routine cleaning tool on a regular basis. Broken lines must be repaired and kept tight so the bucket machine will not have to remove debris from the same broken pipe location in the future.

Manpower and Equipment. Buckets range in size from six to thirty-six inches in diameter. Volumetric capacity of the buckets range from 0.13 cubic feet to 8.5 cubic feet. An 18 inch diameter bucket will pass through a standard 24 inch diameter manhole opening, and has a volume of approximately 1.6 cubic feet.

The bucket machine is usually trailer-mounted, but can be trucktrailer-mounted bucket machine units must have a pintle safety hook attached to the truck that tows the trailer to the job site. Also, a wire cable and shackle should be placed around the truck frame and to the frame on the bucket machine for added safety, in case the pintle hook fails.

The bucket machine units have a steel framework on which is mounted a gas engine and a drum winch. The drum is coupled to the engine through a controllable drive train, usually a chain and belt drive combination. The drum is capable of holding 1,000 feet of one-half inch steel cable, and is mounted on the framework in such a position that it can be centered over a manhole. The framework includes a vertical "A" frame of sufficient height to allow the cleaning bucket to be lifted above ground level.

Two machines are needed for this operation, and both are basically the same in design. At least one machine will also be equipped with an additional smaller drum capable of holding 1,000 feet of one-quarter inch cable. This drum can be operated separately from the one-half inch drum. The purpose is to thread the sewer-line from manhole to manhole, and the other is to have a suitable cable which can be left in the line overnight. The drum, therefore, is often referred to as an overnight drum.

An optional addition to one machine may be a chute with rollers and a shaker bar which allow the material removed to be deposited directly into a dump truck. Machines without this attachment have the "A" frame as previously mentioned. The machine which pulls the bucket out of the manhole will be referred to as the working machine. It will have a small swinging boom or arm attached to the "A" frame which is used for dumping the full buckets. Operation of this machine will be described later.

With each bucket machine, equipment will be needed in the manhole to guide the cable into the sewer line without rubbing or cutting into the pipe. At the working machine, use a v-shaped roller of sufficient size to accommodate the size bucket being used. This roller will be held in place by means of a steel pad which, in turn, is firmly secured flush with the street surface by two adjustable stabilizer legs on the machine. The companion machine may use the same method, or alternately, a slant jack can be used in the bottom of the manhole for the cable to travel over. This would dispense with the use of the pad and roller.

A variety of tools are available for use with these machines, and more are being developed, making the power bucket machines usable for purposes other than bucketing of debris. Root cutters and insertion pullers can be used with bucket machine power winches.

Clamshell buckets and porcupine tools are available in sizes from six to 36 inches in diameter, but sizes under twelve inches are rarely used. The bucket is of such design that when being pulled into the sewer line, the jaws are in an open position. The jaws dig into the deposits of material. When the working machine pulls the bucket out, the jaws are forced closed by means of a slide action. Any material in or in front of the bucket is scooped up.

The porcupine tool is a steel cylinder having solid ends, with eyes cast in them to which a cable can be attached. Many short pieces of cable protrude from this cylinder like a round brush. This tool is quite effective for final cleanup, since the bristles produce a scrubbing action.

Equipment needed other than that furnished with the bucket machines includes: sandtraps, manhole shovel, debris bucket and hand line, manhole cover lifter, pipe wrenches and hand tools such as crescent wrenches and pliers.

Safety equipment includes flags, cones, barricades, traffic signs, sewer gas detection equipment, safety harness, rope, and other safety devices as the job setup may require.

Experience has shown that many unexpected repairs occur during the clearing operation. Extra cable swivels, clevises, cable clamps, and other essential accessories should be readily available to make such repairs.

The number of workers needed to effectively conduct the clearing operation will vary, but at least three are required, and four workers are recommended. If traffic control dictates, flagmen will also be needed.

Precautions and Safety. Because a rather large tool is being used in the sewer, any problems encountered which would keep the bucket, porcupines, or other such clearing devices from moving can cause water to build up behind it. Prevention of stoppage during clearings should be foremost in the mind of the operator. If there is any questions of the clearing tool getting through, try a smaller size, and determine if a larger tool would pass through the sewer. As mentioned previously, it is important to know the location of the clearing tool at all times. Footage counters are recommended, but if they are not available, keep track of the wrap of cable. In the event the clearing tool has to be dug up, it helps to know where it is stuck.

Regularly inspect cable clamps, clevis and swivels, bucket condition, cable condition, and condition of accessories. If a cable should come loose from the bucket on the wrong end for any reason, you may not be able to pull the bucket through the debris to the manhole at the other end.

If a bucket becomes lodged, do not try to force it through. If pulling the bucket upstream, have the downstream machine pull it back a few feet and try again. Pulling it back will open the jaws, and will likely let the bucket come into the problem area at a different angle. If repeated attempts fail, have the bucket pulled back a few feet, enough to open the jaws, and then hold the brake tightly on the upstream machine while working the machine pulls. This tends to hold the jaws open, and also gives a lifting effect to the bucket.

Be careful when lowering the bucket into the working manhole. Do not allow the cable to tangle or come off the lower roller, by keeping the slack out of the cable. Prevent the bucket bowl from folding back on the bucket when it is pulled into the sewer, because there is no way of flipping back over when the bucket is being pulled.

Personal safety must be stressed when using cable operated equipment. Be especially careful when guiding cable onto the drums. Hands should be kept clear of the drum. Use a manhole hook to guide the cable. In an instant, hands and fingers can become entangled, and the operator cannot stop the machine fast enough to avoid injury.

New or inexperienced workers should not operate this equipment without proper training and supervision. Some of the safe practices used are techniques acquired through repeated operations and observations of problems encountered during rewinding.

Advantages: Removes large amounts of sand and debris from larger diameter sewers.

Limitations: May leave as much debris as it removes. Should be followed by other methods. Can damage sewers. Equipment setup it time consuming.

Power Rodding

Power rodding machines use a steel rod to push or pull various clearing tools through sewers. These machines, illustrated in Figures 5-6, 5-7 and 5-8, vary in design; but are equipped to store either continuous or sectional rods in a reel type cage in lengths up to approximately 1,000 feet. This reel can be rotated to give turning action at the same time the rod is pushed out or in.

Power rodders can be used for the following purposes:

1. Routine preventive maintenance.

2. Scheduled clearing of roots, grease deposits, and debris accumulations.

3. Threading cable for balling equipment, TV inspections, and bucket machines.

4. Emergency use for clearing stoppages.

Power rodders are one of the most widely used methods for clearing a wastewater collection system. Since the machine were introduced for commercial use in the early 1950's, many improvements have been made in design, operation, and clearing tools.

Although other clearing methods play an important role in maintaining the collection system, the power rodder can handle stubborn stoppages of roots, grease, and debris. The power rodder is called for when emergency crews cannot clear a stoppage with hand rods. This could be due to the type or size of stoppages, or if the stoppage is at a distance too great for hand rods to be effective. The power rodder is a handy tool as support equipment to thread cables in lines for other cleaning and maintenance methods. After a sewer has been cleared with a power rodder, it should be cleaned hydraulically to restore the line to full capacity.

Classification: The power rodder can be classified according to several different characteristics. Basically, consideration is given for either sectional or continuous type machines. There are, however, machines which employ coiled rod, and are called coil rodders. The electric unit is usually equipped with one oiled rod, and is capable of clearing pipe sized to eight inches in diameter and to distances of as much a s 250 feet. The gas powered coil rodder is capable of clearing line sizes of ten inches and distances of as much as 500 feet. A one inch coiled rod is used on gas powered units. The coil rod for both gas and electric powered units is available in 25 and 50 foot sections with a thread and nut coupling.

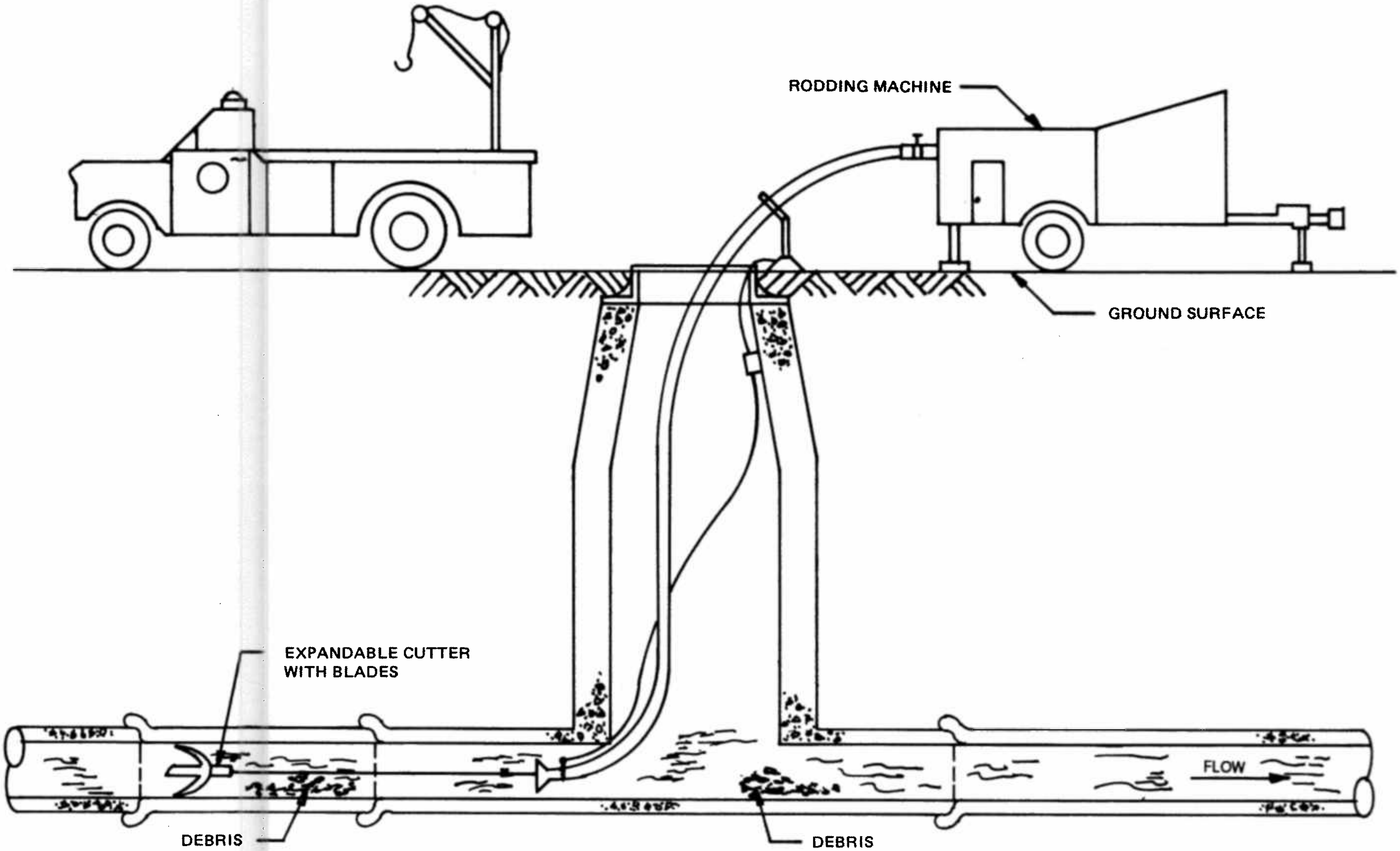

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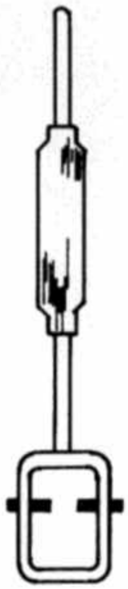
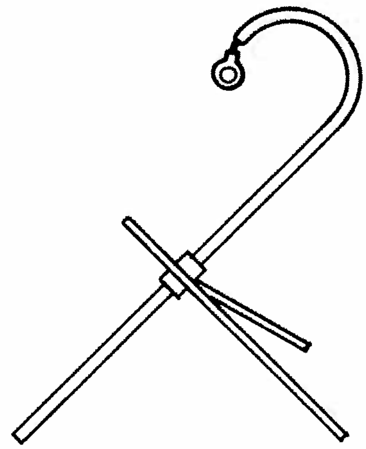
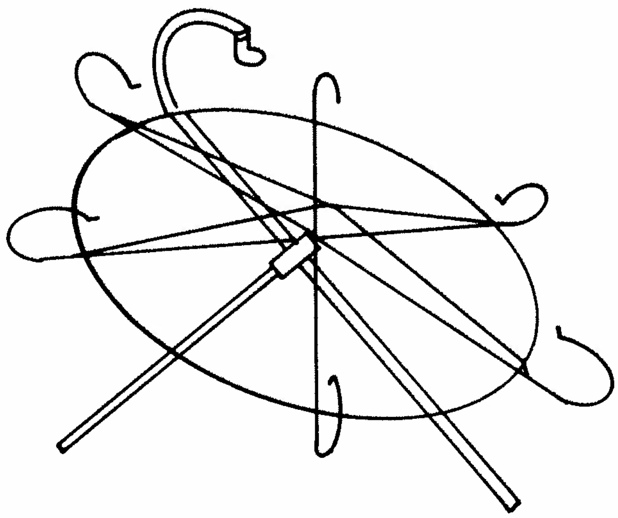
FIGURE 5-6. POWER RODDER OPERATION



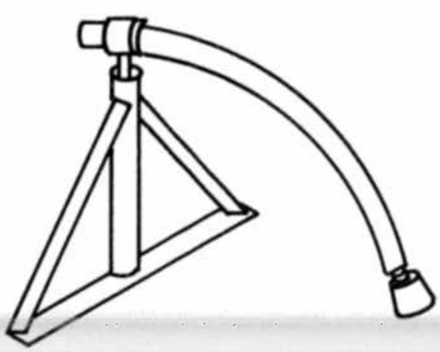
ROD GUIDE HOLDER



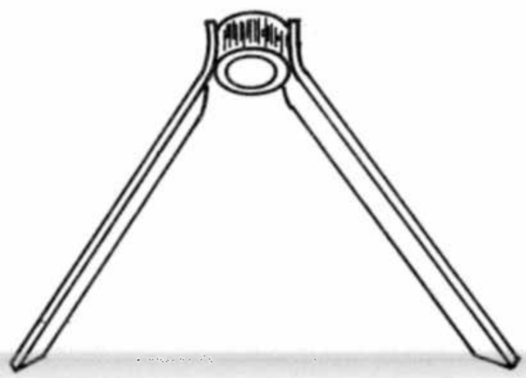
ROD SAFETY STAND



ROD REEL SAFETY STAND



ROD LINE PULLER
GUIDE PIPE STAND



ROD GUIDE FOOT BRACE

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FIGURE 5-7. POWER DRIVE AND HAND RODDING ACCESSORIES

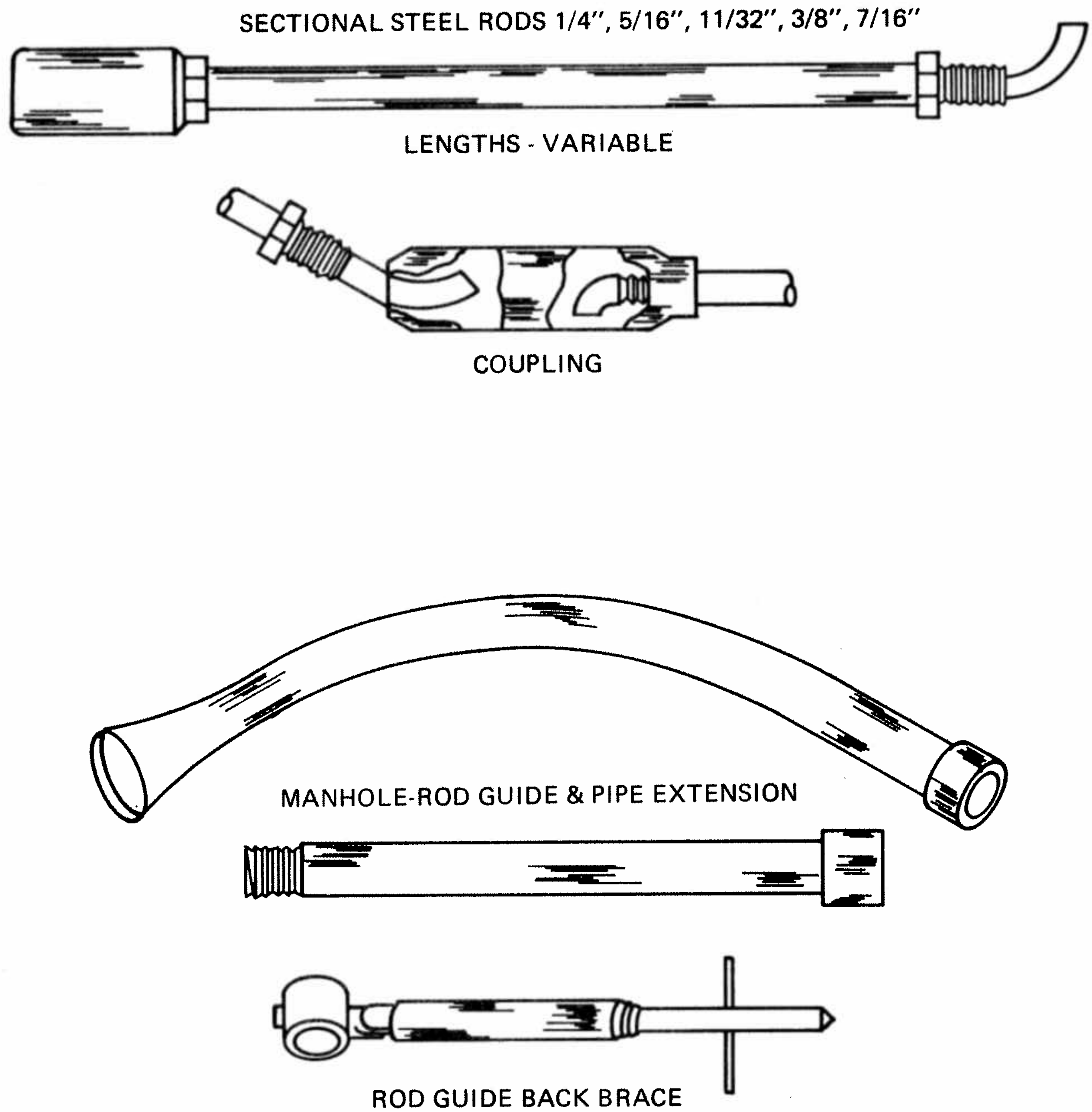

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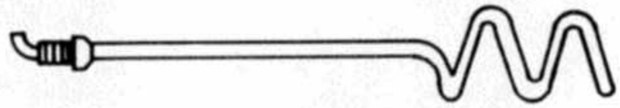
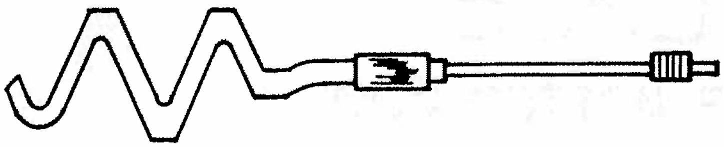
FIGURE 5-7. (Cont.). POWER DRIVE AND HAND RODDING ACCESSORIES



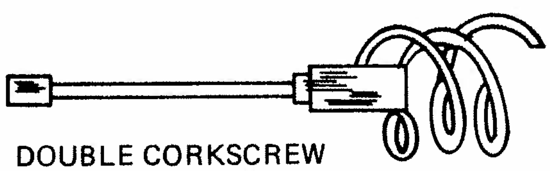
ROUND STOCK CORKSCREW

FOR RODDING THROUGH SEWERS WHERE CONDITIONS ARE UNKNOWN.



SQUARE STOCK CORKSCREW

FOR REMOVING HEAVY ROOT GROWTH, SHARPENED CUTTING EDGE WILL TEAR LOOSE ROOTS AND REMOVE OTHER RIGID OBSTRUCTIONS WHEN PULLED BACKWARDS.

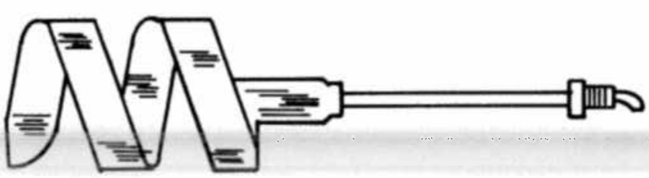


DOUBLE CORKSCREW

A DOUBLE-PRONGED TOOL TO REMOVE MISCELLANEOUS OBSTRUCTIONS.

DOUBLE SAND CORKSCREW

THE BORING ACTION OF THE CORKSCREW HELPS TO PULL ROD THROUGH LINES IMPACTED WITH SAND, GRAVEL AND SIMILAR BUILD-UPS. THIS TOOL MUST BE KEPT MOVING SINCE IT MAY SETTLE INTO BUILD-UP MATERIAL AND BECOME STUCK.

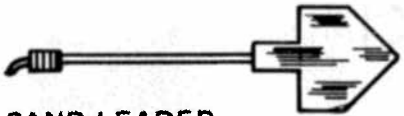


AUGER

THIS TOOL IS USEFUL IN THE CUTTING OF LONG STRINGY ROOTS AND THE LOOSENING OF SEDIMENTARY DEPOSITS IN SEWER PIPE.

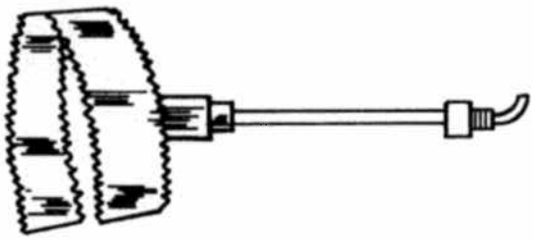
REFERENCE: FROM OPERATION AND MAINTENANCE OF WASTEWATER COLLECTION SYSTEMS: A FIELD STUDY TRAINING PROGRAM. UNITED STATES ENVIRONMENTAL PROTECTION AGENCY AND OFFICE OF WATER PROGRAM OPERATIONS. CALIFORNIA STATE UNIVERSITY, SACRAMENTO.

FIGURE 5-8. SEWER RODDING TOOLS AND USES



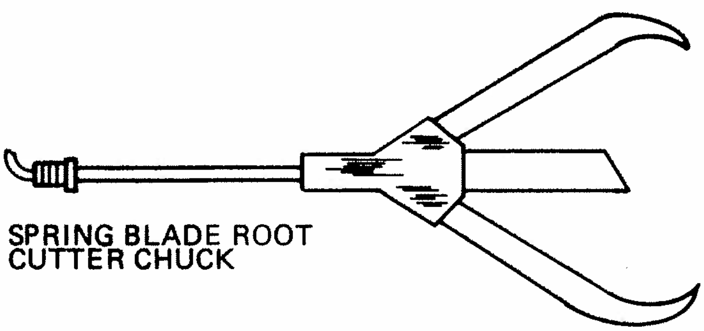
SANDLEADER

USED TO GUIDE RODS ACROSS THE TOP OF BUILT-UP MATERIALS IN THE LINE BY THE FLIPPING ACTION OF BLADES



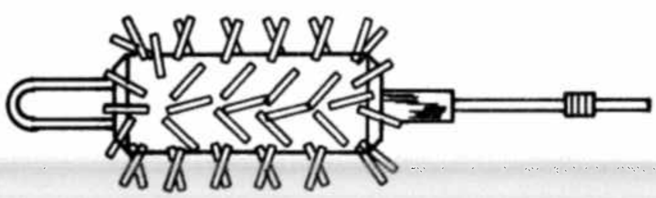
ROOT SAW

USED FOR POWER SAWING OF STUBBORN ROOT MASSES IN THE SEWER PIPE



SPRING BLADE ROOT CUTTER CHUCK

THIS CUTTER WITH THE PROPER SIZE BLADES IS USED IN PREVENTIVE MAINTENANCE SEWER WORK. SHOULD BE ROTATED AT HIGH SPEED (POWER RODDER MACHINE) AND PULLED SLOWLY THROUGH THE LINE WHILE ROTATING TO EFFECT A THOROUGH SCOURING OF THE PIPE. NOTE: THIS TOOL IS NOT DESIGNED TO BE PUSHED INTO A SEWER LINE.

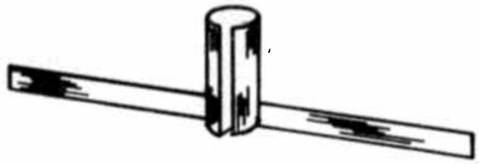


PORCUPINES

THE USE OF TURN-TYPE PORCUPINES IS USED IN LINES UP TO 21 INCHES IN DIAMETER AND ITS FUNCTION IS TO SCOUR LINES OF LIGHT BUILD-UPS IN CONJUNCTION WITH WATER FLUSHING OF SEWER LINES.

REFERENCE: FROM OPERATION AND MAINTENANCE OF WASTEWATER COLLECTION SYSTEMS: A FIELD STUDY TRAINING PROGRAM. UNITED STATES ENVIRONMENTAL PROTECTION AGENCY AND OFFICE OF WATER PROGRAM OPERATIONS. CALIFORNIA STATE UNIVERSITY, SACRAMENTO.

FIGURE 5-8 (Cont.). SEWER RODDING TOOLS AND USES



PULLOUT TOOL

USED TO ENCIRCLE ROD COUPLER TO PUSH RODS INTO OR PULL RODS OUT OF LINE.

ASSEMBLY TURNING HANDLE

USED FOR ASSEMBLING NUTS AND COUPLERS FOR TURNING RODS, SPRING LOADER PIN ENGAGES HOLE IN COUPLER.

BAR TURNING HANDLE

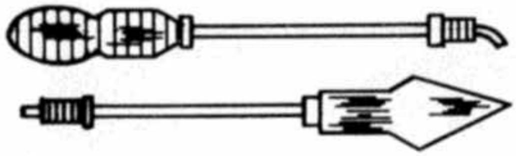
USED TO SECURE INTO HOLE IN COUPLER FOR TURNING, PUSHING AND PULLING RODS.

ROD END SWIVEL

USED FOR PULLING CABLES AND WIRES THROUGH A PIPE AND IS DESIGNED TO BE FREE TURNING UNDER LOAD AT THE ROD END COUPLING.

REFERENCE: FROM OPERATION AND MAINTENANCE OF WASTEWATER COLLECTION SYSTEMS: A FIELD STUDY TRAINING PROGRAM. UNITED STATES ENVIRONMENTAL PROTECTION AGENCY AND OFFICE OF WATER PROGRAM OPERATIONS. CALIFORNIA STATE UNIVERSITY, SACRAMENTO.

FIGURE 5-8 (Cont.). SEWER RODDING TOOLS AND USES

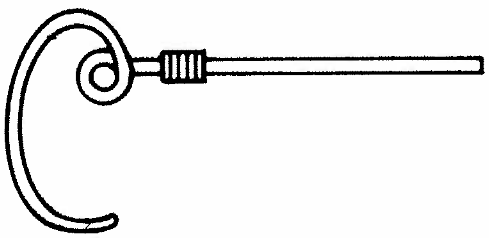


SPEARHEAD BLADES

USED IN SMALL PIPES TO REMOVE HARD DEPOSITS AND BREAK UP HARD OBSTRUCTIONS SUCH AS GLASS, BOTTLES, CANS AND PLASTER.

BULLET NOSE

DESIGNED TO BE SCREWED INTO END OF COUPLER FOR LEAST RESISTANCE WHEN RODDING THROUGH HEAVY ROOTS, ETC.

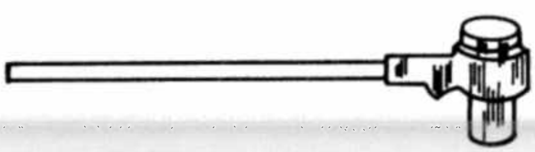


PICK-UP TOOL

USED TO SNARE BROKEN SECTIONAL SEWER RODS.

ASSEMBLY WRENCH

USED FOR HOLDING AND TURNING NUTS AND COUPLERS IN ASSEMBLY RODS AND TOOLS.



RATCHET TURNING HANDLE

USED WITH LOCKING PIN THROUGH PULLOUT TOOL AND COUPLER TO TURN RODS.

REFERENCE: FROM OPERATION AND MAINTENANCE OF WASTEWATER COLLECTION SYSTEMS: A FIELD STUDY TRAINING PROGRAM. UNITED STATES ENVIRONMENTAL PROTECTION AGENCY AND OFFICE OF WATER PROGRAM OPERATIONS. CALIFORNIA STATE UNIVERSITY, SACRAMENTO.

FIGURE 5-8 (Cont.). SEWER RODDING TOOLS AND USES

Both machines are usually trailer mounted with the trailer equipped with storage boxes for tools and other equipment. The clearing tools used on the coil rodders, though basically designed the same as those used on the large rod machines, have a different type of connection for attaching to the coil rod.

The sectional power rodder is designed to use rods put together in sections. Rod size is 5/16 inch diameter, and is available in lengths of 36, 39, and 48 inches. They are connected with a double nut coupling. The sectional machines will be equipped with a chain drive "head" for one of these lengths, and only that length rod can be used.

The sectional machine, usually 9 to 12 horsepower, is capable of clearing lines effectively of diameters to 12 inches and distances up to approximately 750 feet. In smaller diameter lines it may be possible to extend this to 1,000 feet if the machine's rated capacity will allow. These distances are too long for effective clearing if the sewer contains sand or grit.

The continuous rodder is capable of holding approximately 1,000 feet of one piece continuous rod. Effectiveness decreases with the large line sizes, and consideration must be given to the capabilities of the rodding machine and equipment. Most machines are powered by a 20 horsepower engine, and use a rod with a diameter of 3/8 inch. Other models are available which can use rod diameters up to one-half inch, and lengths of 2,000 feet.

These larger machines are not commonly used for clearing sewers, except for special applications. Generally, a .375 inch diameter rod is used.

Power rodding machines can be operated by a mechanical or hydraulic drive mechanism, or a combination of both. Both styles, sectional or continuous, are basic in their design, and are available either as truck or trailer mounted. There are some small differences in styles, but most of these differences are relative to the individual machine's operation. The following is a comparison between sectional and continuous rods:

1. Continuous rodding machines are quickly and easily loaded, while a sectional rodding machine requires several hours to couple the sections together and tighten them.

2. Sectional rods are pushed through the drive head by a positive drive, not by rollers which can slip and cause wear; however, the "drive dogs" push against the individual coupling, and cause wear to the "drive dogs" and coupling. Couplings on sectional rods cause more wear on the guide liner than continuous rods do.

3. Continuous rodders can rod greater distances than sectional rodders can, and are less apt to break at great distances.

4. Couplings and nuts on sectional rods tend to work loose, and require constant inspection.

5. Continuous rodders are easier to clean than are sectional rodders. Constant care must be given to cleaning both types of rods when they are being retrieved to prevent grit from going up the roller system.

6. When a sectional rod is broken, repair can be quickly done in the field by replacing the broken section or recoupling the rod and adding a new rod when more footage is needed. When a continuous rod breaks, repair is difficult. One

style of rod requires flat spots to be ground on the rod tip for seating set screws. Filing is not recommended because of the hardness of the rod. Another style requires a short, sharp bend at the tip to fit the coupling. Often the rod will break off before a usable bend is attained.

7. A broken continuous rod in a sewer is more difficult to retrieve, since the pick-up tool does not have couplings to grab. The broken end of the continuous rod cannot be reused, and possibly the remaining portion of the rod on the machine is also unusable if remaining footage is too short.

Manpower and Equipment. Two workers are needed to properly operate the power rodder, but three are recommended. One worker performs the actual operation, and an assistant is needed for close observation of the action of the rod and guide hose at the working manhole. The third worker is needed to notify the operator when the cleaning tool has reached its destination, when it is to be removed, or when it is changed to a different tool. If a two-worker crew has to enter a manhole, a foreman or someone else must be called to the job site so two workers will be topside when the third worker enters the manhole.

The operator should be well trained in the use and operation of the power rodder, and will be responsible as well for supervision of the proper setup, safety measures, and selection of clearing tools to be used. The effective use of the selected tool will depend, to a great extent, upon the operator - how well the operator analyzes the problem at hand, and how conscientious the operator may be in getting the sewer as clear as possible.

Tools and accessories are varied, but basic in design. Many have been developed on the basis of field reports, and the industry continues to produce more effective new tools and techniques. The same basic tools are used for either the continuous or sectional power rodder. These tools include root saws, square bar augers, spring blade cutters, round or square bar corkscrews, pick-up tools, and assembly wrenches.

Precautions and Safety. An emphasis must be placed on the speed of rod travel and rotation. These two items combined tend to break or twist most rods. Most machines will be capable of holding close to 1,000 feet of rod. With the weight of the rod on a spinning reel, considerable twisting power is developed, but it also takes a few moments to get it stopped. An operator can get through some difficult stoppages or root problems with skill and patience.

It is not advisable to rod distances greater than from one manhole to the next unless absolutely necessary. Trying to avoid extra set up time in this manner can only compound the hazards associated with power rodding.

With constant use, rods do suffer from fatigue; and when a rod breaks, it is likely to be in the sewer. Avoid turning the rod without rod travel in the sewer. Heat builds up very quickly at any bend when the rod is turning. Therefore, it is important to keep it moving at all times, if possible.

Porcupine cleaning tools are available for attachment to the power rodder. Their use presents several safety hazards. If a porcupine must be used, a winch and tag line must be used to guard against these hazards. Other tools can do a similar job in a safer manner and should be used when possible or practical.

Maintenance of Rods and Equipment: Sectional rods should have the rod couplings kept tight at all times. These will work loose during a rodding operation, and a visual inspection by the operator, even while working the machine, can detect a coupling that is loose.

A practice should be made of running the rod out on top of the ground on occasion, to inspect the rod for bent pieces and loose couplings. When they are allowed to stay loose, the rod will wear and become weak at that point. Couplings can be reused, so they should not be thrown away.

Continuous rods are driven by rollers pressing on the rod. A clearing tool in the form of a clamp is furnished with the machine and has a very important function. A coarse piece of cloth or similar material is kept in the clamp tool; and when the rod is ready to be pulled back into the machine, the tool is clamped around the rod at the head of the machine and wipes the rod clean as it is returned to the reel. If grease and grit are allowed to continue passing on into the pressure rollers, they will build up and cause wear on the rod.

Even with a clean rod, the pressure of its being rolled back and forth results in some wear. Therefore, the torque on the drive rollers has to be periodically checked and reset. Specifications for the particular machine are furnished by the manufacturer.

Always avoid sharp bends in the guide hose, regardless of the type of machine. The metal liner can become bent and distorted. Inspect the guide hose frequently and carefully for wear, mounting, and mechanical damage such as crimping. Inadequate maintenance before rodding a sewer can result in considerable lost time while attempting to recover a broken rod. The following necessary maintenance items can easily be done on the job:

For sectional rodder:

1. Inspect for loose rod couplings.
2. Keep drive head chain tight.
3. Inspect for worn drive dogs and improperly adjusted belts.
4. Look for "stacking" of the rod on the reel when bringing the rod back into the reel cage.

For continuous rodder:

1. Maintain proper torque on the drive rollers.
2. Examine for wear on the rod guide bushings.
3. Inspect for sharp teeth on drive gears. This indicates wear or needed adjustment.
4. Look for leaky hoses and fittings on hydraulic units. Maintain proper oil level in the hydraulic oil tank. Keep the hydraulic oil filter clean.
5. Fluctuating oil pressure may be due to hot hydraulic oil. This may or may not be from continuous use. Be sure to check for other problems.

Always keep the rodder, tool, and accessories as clean as possible. The engine should receive the maintenance and care as recommended by the shop foreman or the manufacturer's instructions. With proper maintenance and care, the rodding machine will do a good job of clearing a sewer. Like any other machine, it has its limitations, and as experience is gained in its operation, so will knowledge of what it can and cannot do.

Advantages:	May be used to clear stubborn blockages of roots, grease and debris. A wide variety of tools can be attached to the rods.
Limitations:	Rods can break off inside the sewer line. Excavation may be required to remove the broken rods. Hydraulic cleaning is generally required following power rodding. Some of the power rodding tools can damage the sewer pipes.

<u>Hand Rodding</u>

Despite all of the modern equipment available, it is still necessary to have hand rods available. (Figure 5-9). One of the main reasons is that hand rods can be used when and where the modern methods cannot be used effectively. Hand rods are a quick and simple solution for many stoppage problems. Hand rods are often used on "service request" trucks and for "off-hours" stoppage calls. They are used extensively for emergencies at night or during weekends. After the stoppage is cleared, thorough cleaning can be done at a later date.

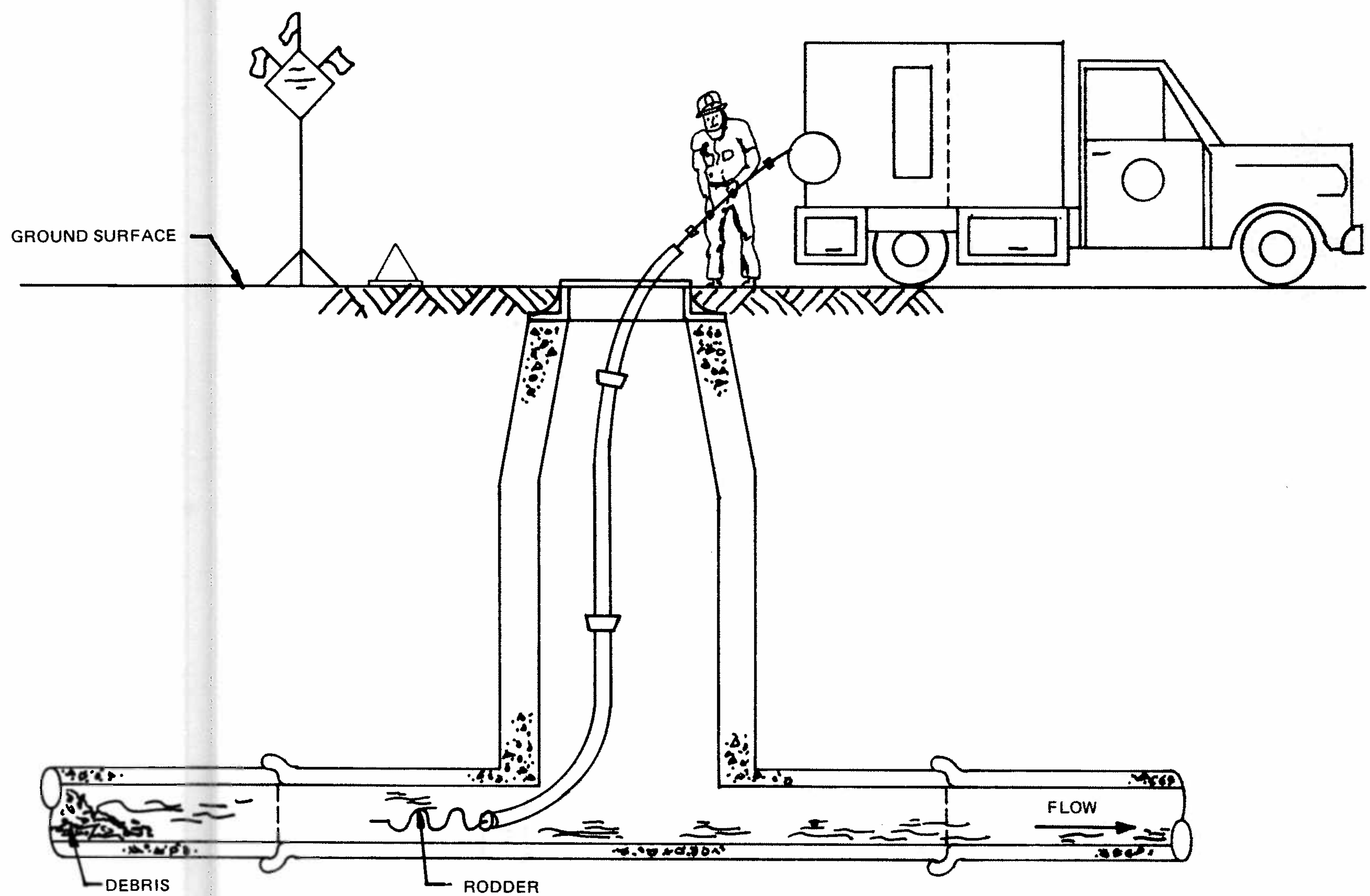
Often, maintenance crews will carry a reel of hand rod on the work truck, to be used in conjunction with the power rodder. If, when clearing a particular area, the power rodder cannot be put to use (such as in an easement), the hand rod can be used. This will ensure that the section will be cleared and not forgotten. Also, a hand rod can be used from the opposite manhole to free a stuck or broken power rod.

Other maintenance crews may do only hand rodding. This is not uncommon in sanitary districts with hilly areas, also in very small districts where the total length of sewer in the system does not warrant machine clearing with other types of equipment. Other factors may be involved, but the main point is that the hand rod is still a very useable cleaning method and will remain to be so, at least for the foreseeable future.

<u>Manpower and Equipment.</u> The particular job will often dictate how many workers will be needed. However, if a crew is essentially doing only hand rodding, at least two workers are recommended. A three-worker crew is required if one worker has to enter a manhole. Usually rod crews or "service request" crews consist of two workers, and they never enter a manhole. See Chapter 9 for safety precautions before entering a manhole.

The hand rods are regular sectional rods as used on power rodders. Usually the rod length is 36 inches. The length is easy to control and makes it simple to keep track of footage or number of sections used. The rod is stored in a shallow reel, approximately four feet in diameter, and so constructed as to keep the rod contained on the reel. It is equipped with a removable tripod which allows the reel to be set up quickly near the work site, at an angle convenient for operation. When the reel is properly set up on the tripod, the rod can be pulled off or onto the reel, allowing the reel to turn freely. Many work trucks are equipped with this reel fastened to the truck. When rodding is needed when the truck cannot be taken, such as at an easement, sections of the rod are simply removed from the reel and pulled to the working area by hand.

Hand rod trailers are available, as well, that are compact, and have the reel mounted at an angle convenient for use. These trailers also have a box for tools, and a rack for a three-wheel, gas powered unit to turn the rod. This power drive is essential, especially when other rodding equipment is not available or useable. The power drive has a lightweight



REFERENCE: FROM OPERATION AND MAINTENANCE OF WASTEWATER COLLECTION SYSTEMS: A FIELD STUDY TRAINING PROGRAM. UNITED STATES ENVIRONMENTAL PROTECTION AGENCY AND OFFICE OF WATER PROGRAM OPERATIONS. CALIFORNIA STATE UNIVERSITY, SACRAMENTO.

FIGURE 5-9. HAND RODDING OPERATION

engine with a gear reduction control which allows the end of the rod to be attached for turning. With a hand control, rotation of the rod can be accomplished to cut roots or to make penetrations into stoppages very similar to the operation of large power rodders. However, the distance of penetration is not as great.

Other than these basic items - reel, rod, power drive, and perhaps a trailer unit - tools would include root saws, augers, cutter blades, pick-up tool, assembly wrench, turning handle, rod guide tube and extension pipe, guide tube jack, sand traps, manhole shovel, debris bucket and hand line, and a manhole pick or hook.

<u>Precautions and Safety.</u> One particular problem occurs all too often when hand rodding. That is, having too much loose rod unattended or used in an unsafe manner. Because it is time consuming to be continually fastening short sections of rod together, the tendency is to use a long section. If proper care and attention are given to this loose rod, a certain amount of looseness is acceptable. However, someone can be seriously injured, and considerable property damage done, should a car run over and catch hold of a loose piece of rod.

Another problem arises when using the power drive unit. If too much distance is allowed between the power drive and the manhole rod guide tube, a loop can easily and suddenly be thrown in the rod, and someone may be injured.

Never use rubber gloves while handling or guiding a rod that is turning. Even if the rod is wet, it will seize the palm of the rubber glove, and if not stopped in time, either twist the glove from the worker's hand or cause injury. Use a manhole hook or other devices to guide a turning rod.

On steep grades where a root mass has been broken loose, it is not uncommon for the water pressure to literally force the rod back out of the guide tube so powerfully that it cannot be held. In that instance, all that can be done is to control the loose rod as much as possible.

Advantages:	May be used to cut roots, scrape, dislodge and remove certain types of materials found in sewers. This equipment is very effective in removing emergency stoppages.
Limitations:	Ineffective for removing sand and grit accumulations, but may loosen material so it can be flushed out of the sewer. Rods have a tendency to coil and bend when used in large diameter sewers.

SEWER CLEANING RECORDS

A record of all cleaning operations should be made and filed for future reference. These records should include the date, street name or number, line size, distance, and manhole identification numbers. It is also important to note the type and amount of material removed. For example, if pieces of broken sewer are removed, this may indicate a TV inspection is needed and a repair made on the broken sections of pipe. The amount of auxiliary water used should also be recorded. If particular problems were encountered, these should also be noted.

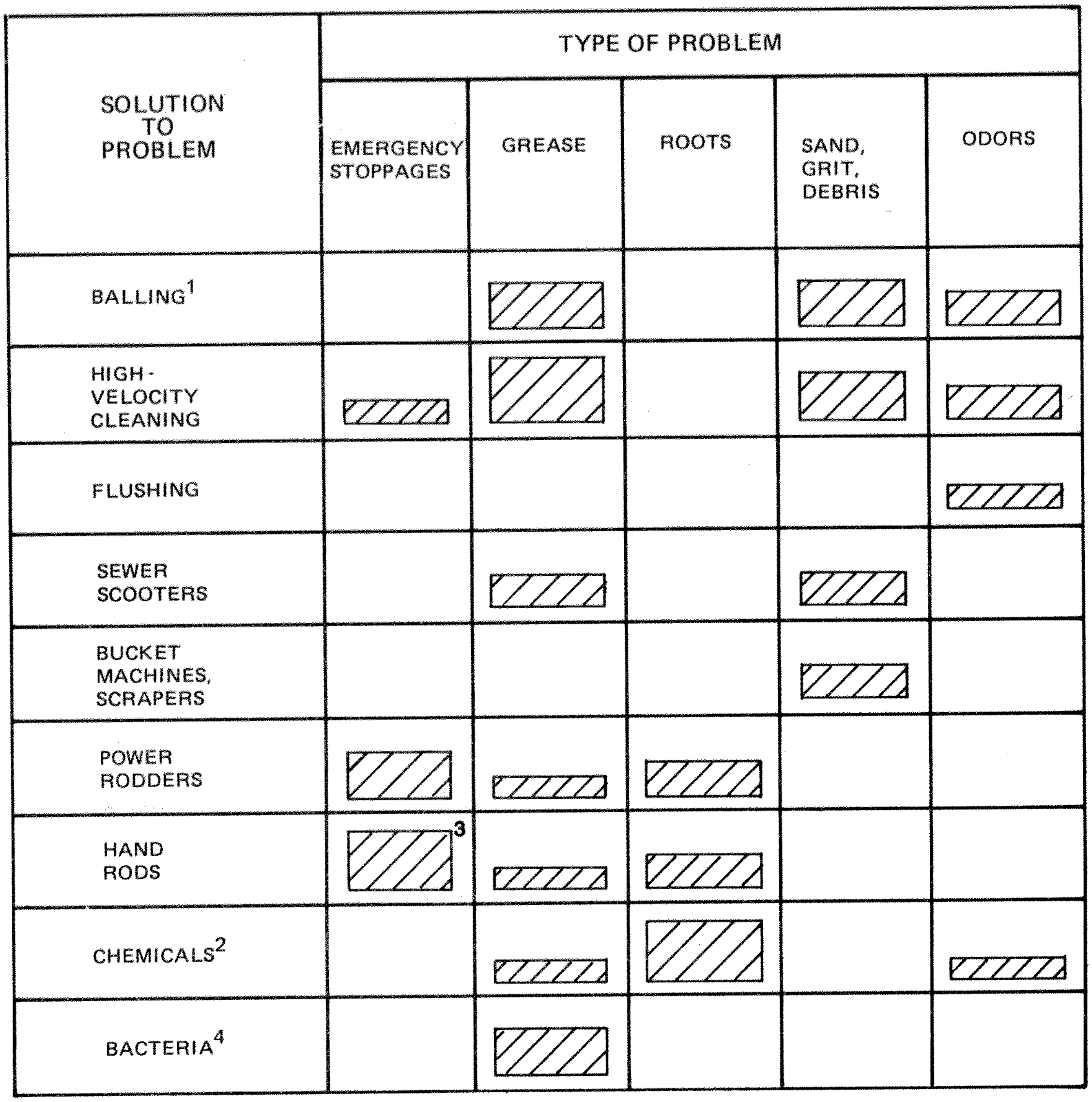
CLEANING VEHICLES

High velocity water jets, rodders, and bucket machines can be purchased mounted on trailers or trucks. The water jet equipment can be used alone or with hydraulic cleaning equipment such as balls, kites, bags, and pigs. Miniature, portable water jets can be purchased which are either gasoline or electrically powered. These portable water jets cannot produce as much water pressure as trailer or truck mounted water jets and are therefore united to small diameters pipe cleaning. Common uses for these machines include cleaning of materials, floor drains, sink drains, window wells, etc. Some water jet trucks are also equipped with vacuum loaders which are capable of cleaning debris out of sewer manholes, catchbasins, lift station wet wells, etc.

SUMMARY OF CLEANING METHODS AND SOLUTIONS

Table 5-1 shows the relative effectiveness of the possible cleaning methods when applied to different problems. The larger the size of the box in the square, the more effective the solution is for a particular problem. One problem may have several effective solutions, while another problem may have only one possible solution. Table 5-2 is a summary to provide an indication of the general effectiveness of solutions. Evaluate every problem and select the best solution using available equipment.

TABLE 5-1. EFFECTIVENESS OF SOLUTIONS



NOTES:

1. KITES, TIRES, BAGS, PARACHUTES, AND CONES ARE COMMONLY USED INSTEAD OF BALLS IN LARGER SEWERS (GREATER THAN 24 INCHES IN DIAMETER) WITH SIMILAR RESULTS.
2. EFFECTIVENESS DEPENDS ON TYPE OF CHEMICAL AND ITS INTENDED USE.
3. POWER RODDERS AND HIGH-VELOCITY CLEANERS MAY BE FASTER (IF AVAILABLE) UNDER CERTAIN CONDITIONS.
4. EFFECTIVENESS DEPENDS ON FORMULATION OF CULTURES.
5. THE LARGER THE SIZE OF THE BOX IN THE SQUARE, THE MORE EFFECTIVE THE SOLUTION IS FOR A PARTICULAR PROBLEM.

REFERENCE: FROM OPERATION AND MAINTENANCE OF WASTEWATER COLLECTION SYSTEMS: A FIELD STUDY TRAINING PROGRAM. UNITED STATES ENVIRONMENTAL PROTECTION AGENCY AND OFFICE OF WATER PROGRAM OPERATIONS. CALIFORNIA STATE UNIVERSITY, SACRAMENTO.

TABLE 5-2. CLEANING AND MAINTENANCE PROBLEMS AND SOLUTIONS

Identification of Problem	Source or Cause	Solution Method	Comments
1. Stoppages - emergency condition such as overflowing manholes and/or flooding of residences or businesses.	a. Grease	Hand rods and high velocity cleaner	Hand rods will usually unplug most grease stoppages. Rod from downstream manhole with 4" auger into stoppage. When clear, run 6" auger through restricted area. Write work request to high velocity clean line as soon as possible. If cannot open with hand rods, try high velocity cleaner. A high velocity cleaner will open most grease stoppages.
	b. Roots	Hand rods	Rod from downstream manhole with 4" auger or saw. Be cautious in opening stoppage if there is a high head on the upstream manhole. Remove as much of the root mass as possible. Request TV inspection for root concentration; schedule power rodding to open line and chemical treatment to control future root growth. Hand rods are effective 90% of the time. If cannot clear roots with hand rods, try high velocity cleaner.
		High velocity cleaner	High velocity cleaner will usually open stoppage and restore service. Schedule TV check and treatment. If unable to clear roots with high velocity cleaner, try power rodder.
		Power rodder	Power rod line to clear stoppage. Schedule TV check, cleaning, and chemical treatment.
	c. Debris stoppage such as rocks, lumber		Caused by broken lines, open manholes, vandalism.
		High velocity cleaner	Clean line with high velocity cleaner.
		Power rodder	Use caution. May jam tool in line requiring a dig-up to clear line and remove broken rod and tool.

TABLE 5-2 (Cont.). CLEANING AND MAINTENANCE PROBLEMS AND SOLUTIONS

Identification of Problem	Source or Cause	Solution Method	Comments
2. Grease Stoppage causes grease build up	a. Restaurant on blocked segment of sewer	High velocity cleaner	High velocity cleaner is an effective tool in removing grease build-ups in line sizes up to 15 inches. High velocity cleaner becomes ineffective in larger diameter pipes.
TV report on routine inspection	b. Low velocity allowing grease build-up from home disposal unit. Problems often develop where high velocities are suddenly slowed down.	Balling	Balling will remove grease deposits from pipe walls, but will not clean walls as effectively as high velocity cleaner.
Observe build-up on side walls of sewer		Kite	More effective in greater than 18-inch diameter lines than high velocity cleaner.
Past records		Power rodder	Extensively used, but not as effective in grease removal as high velocity cleaner and balling - usually ineffective in lines above 10 inches.
		Chemicals	Be sure to insist on a performance contract. Do not pay until the chemical or material performs as claimed.
Grease trap		Clean trap regularly	A regular maintenance program must be established and continued.
3. Roots TV report	a. Trees and shrubs	Chemicals	For long-term control, chemical treatment provides the best solution with up to three years between applications.
Poor joints or damaged pipe allow root entry Past records		Power rodder	May be used to clear an opening so that flow may pass. Cutting roots stimulates root growth. Therefore, if power rodding is only control used, it must be repeated frequently.
		Repairs	If TV report shows only one section of broken line or a few bad joints, dig up and repair. If a great number of defects are observed, consider pressure sealing or relining the pipe.

TABLE 5-2 (Cont.). CLEANING AND MAINTENANCE PROBLEMS AND SOLUTIONS

Identification of Problem	Source or Cause	Solution Method	Comments
4. Sand, grit, debris TV report	a. Eggshells, coffee grounds, bones from residential disposal units	High velocity cleaner	For light concentration of grit in small lines, not effective in lines above 15 inches.
Grit settles during low flows		Balling	The work horse for cleaning. Large volumes can be removed at a reasonable cost. Requires careful control in shallow lines. Not manageable in sewers larger than 24 inches.
Grit sticks to grease or slime	b. Broken china, bones, and glass from restaurant disposal units	Kites	More effective in larger lines. Removes some dangers of flooding in shallow lines that balling may create if not properly controlled.
Routine inspection	c. Sand, silt from poor joints and broken lines	Bucket machines	Used where extreme concentrations of grit and sand have loaded the line to extent that the above methods are ineffective due to cost and handling of materials to be removed.
Past records	d. Lines with low flows or velocities permitting deposition of solids		
5. H_2S and odor control	a. Force mains	High velocity cleaner	Fast cleaning of slimes in lines up to 15 inches.
Odor complaints	b. Low flows and velocity	Balling	Best for sewers with bellies and offset joints in lines up to 24 inches, but expensive operation for odor control only.
Manhole inspection reveals line deterioration	c. Bellies in line	Flushing	Small lines. Usually not effective for more than one week.
	d. Drop manholes	Plug lifting and vent holes in manhole cover	Roofing cement makes a satisfactory hole sealer.
	e. Manhole where trucks dump septic tank contents	Control program	Develop program using combination of solutions.

CHAPTER 6

REHABILITATION

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INTRODUCTION

Sewer system rehabilitation is a necessary part of any wastewater collection system operation and maintenance program. When sewer system defects have been identified during routine inspections, they need to be repaired before an emergency situation occurs.

Sewer systems deteriorate over time as a result of chemical attack, ground movement, excessive load transfers, root intrusion, and poor construction of the original system. When selecting a rehabilitation technique the following factors should be considered:

1. The cause of the deterioration.
2. Cost.
3. Potential infiltration and inflow reduction.
4. Traffic disruption and effect on other public utilities.
5. Maintaining sewage flows.
6. Safety.
7. Structural characteristics of the sewer system.
8. Compatibility with other planned public works projects.
9. Long-term effectiveness of the technique used.

If an emergency situation does occur and the repair work must be done by an outside contractor, measures should be taken to retain a contractor who will agree to mobilize and make the necessary repair immediately. The names, addresses, and phone numbers of contractors agreeing to provide emergency repairs should be recorded in convenient locations.

Before any type of rehabilitation program begins, it is important to notify the public utility companies with lines near the proposed rehabilitation of the type of work which will be completed and the work schedule. Utility lines should be clearly marked before any digging begins.

The personnel actually assigned to do the rehabilitation work must be trained properly regarding safety requirements before starting the rehabilitation work. The training program should include direction on safely entering confined spaces such as manholes and sewers and the safety requirements for using and handling rehabilitation equipment and materials. If necessary, traffic control measures must also be planned before starting the rehabilitation work. Details on safety are included in Chapter 9.

MANHOLE REHABILITATION

General

Manholes are usually rehabilitated to correct structural deficiencies or to eliminate the entrance of surface water or groundwater. Manhole rehabilitation may be required to minimize or prevent corrosion of the internal surface caused by sulfuric acid which can form when hydrogen sulfide is released from the wastewater. Rehabilitation procedures are often applied to manhole covers and frames to prevent the entry of surface waters. This extraneous flow enters through holes in the cover, through spaces between the frame and cover, and under the frame if it is poorly sealed. A program should be developed to insure that manhole rim elevations are properly adjusted following paving work.

Most rehabilitation work involving manhole sidewalls and bases is intended to reduce infiltration of water into the collection system. If a manhole is severely deteriorated, it is often less costly to replace the manhole. However, when a manhole is structurally sound, repair methods are normally effective for correcting the problem. The cause of deterioration must be determined and a comparison of costs of replacement versus rehabilitation must be done before a decision as to which corrective measure to use can be made.

Manhole Cover Rehabilitation

Manhole covers with open pick holes can contribute significantly to an inflow problem especially if the manhole is located in a low lying area subject to frequent ponding of stormwater. Several solutions are available for reducing inflow into the sewer system from manhole covers including the following:

1. Install bolts through the holes. Use stainless steel bolts sealed with caulking compound or neoprene washers installed on the bottom of the cover.

2. Use commercially available inserts installed under the cover which prevent water, sand, and grit from entering the manhole while gas is allowed to escape through vents.

3. Replace cover. A cover with concealed pick holes and a well-machined cover and frame joint is often the best solution. Sometimes it may be better to replace both the frame and cover at the same time to insure that the new cover fits the frame properly.

4. Self-sealing manhole covers with flexible gaskets bearing on the frames are available. The disadvantage of using these self-sealing covers is the difficulty of inserting the gasket into the groove. Also, the gaskets normally do not last very long. In areas where manhole covers are subject to removal by vandals, commercially available bolt down covers can be used.

Manhole Frame Rehabilitation

Deteriorated manhole frame and grade adjustment rings can be a significant source of inflow of surface waters. Manhole frame seals are often damaged by construction work, heavy traffic loads, freeze-thaw cycles, exposure to damaging chemicals and snow plowing. The method of repair depends on whether or not the frame must be raised or lowered.

Frame Seal. If a manhole frame does not need to be replaced and is properly graded, but is poorly sealed to the manhole, one of the following in-place rehabilitation techniques can be used:

1. Frames may be sealed in place by chiseling cracks and openings at the interface between the manhole frame and cone (or grading rings) and applying hydraulic cement coated with a waterproofing epoxy. Oakum rope is sometimes used to fill large openings before applying the hydraulic cement. This type of seal normally cannot withstand freeze-thaw forces.

2. Flexible rubber sleeves can be compressed against the side of the frame and adjusting rings with stainless steel expansion rings are available. These are referred to as manhole chimney seals and they can be placed internally, externally, or both internally and externally.

3. Elastomeric sealants are effective in sealing manhole parts subject to movement from freeze-thaw forces. The sealant is placed at potential lines of movement both inside and outside of the manhole.

Frame Adjustments. If a manhole frame must be adjusted several materials are available to provide the necessary adjustment and a watertight seal. These include:

1. Frame extension rings. These are commonly used during road resurfacing projects to raise the manhole rim elevation. They are designed to eliminate excavation of the existing frame and the need to install concrete grading rings. Frame extension rings are available to increase the rim elevation of a manhole by several inches. They also are designed to fit in the existing frame and to allow the existing manhole cover to be used. The extension rings are secured to the existing frame using set screws, epoxy compounds, or expansion bolts and are used with watertight caulks or sealing gaskets between the existing frame and the extension ring.

   Frame extension rings can also be purchased that allow for adjustments in grade, and slope of the manhole cover after installation.

2. Precast concrete adjusting rings with flexible rubber-like gasket material. The gasket material is placed in between all the joints, and the weight of the ring compresses the gasket to seal the joint. The adjusting rings can also be made with brick or concrete blocks. Installing adjusting rings requires some excavation and restoration around the top of the manhole.

   Precast concrete adjusting rings are available with flat tops or inclined tops. The type of adjusting ring selected should match the surrounding grade at the top of the manhole.

Structural Rehabilitation

Structural rehabilitation of manhole walls is required when they have deteriorated to the point of being unsafe to enter or work inside.

Severe structural deterioration is generally due to corrosion by sulfuric acid produced in the sewer system, poor original construction, ground movement, age, or overloading normally in areas of heavy traffic. Correction of severe deterioration problems is usually done by replacing the manhole or by performing extensive repair work. Whatever corrective measure is decided upon, it should perform the following functions:

1. Remove the causes of deterioration or include means to resist it. This might entail the application of high strength compounds such as hydraulic cement mixed with additives (plaster additives, bonding agents, etc.) to the manhole walls.

2. Ensure manhole safety. If a manhole is severely deteriorated, then the manhole ladder rungs are also suspect. Weak or corroded rungs should be removed and not replaced, or replaced with corrosion resistant rungs.

3. Ensure efficient use of pipe capacity. If the flow is restricted or totally obstructed, corrective measures should be taken to improve the wastewater flow characteristics.

Manhole Repair. Structural repair of manholes involves several steps. The removal of all deteriorated materials from the interior surface is of primary importance. This can be done by waterjetting, sandblasting, applying acid solutions or by using mechanical tools. If a coating is to be applied to the manhole to restore structural integrity, the entire surface should be thoroughly cleaned first. Also, any surface irregularities such as missing bricks or spalled concrete should be patched. Finally, the lining or coating system is applied. Coatings are commonly applied to manhole walls using spray guns, gunite guns, rollers, brushes or hand trowels. If corrosion is a problem, plastic or epoxy coatings are often applied to provide an effective barrier between the concrete and the corrosive atmosphere. Also available are precut polyethylene or fiberglass sheets that can be used to line manhole walls.

Manhole Replacement. When structural deteriorations are too severe or too costly to be corrected by repair methods, the manhole can be partially or completely replaced. When determining if a manhole is more costly to repair than to replace the following replacement factors must be weighed against repair costs:

1. Excavation.

2. Pavement removal and replacement.

3. Traffic disruption.

4. Excavation dewatering requirements.

5. Conflicts with other utilities and structures.

6. Shoring requirements.

7. Maintaining sewage flows.

8. Landscaping or other restorations.

9. Labor, material, and equipment requirements.

Manhole sections are typically replaced with precast concrete sections with tongue and groove joints sealed with a flexible rubber-like gasket material. The manhole sections are easily moved using standard construction equipment with lifting rings precast into each section.

Existing manholes can also be replaced using prefabricated fiberglass plastic manholes. These are corrosion resistant and effective for sealing out groundwater. To prevent uplifting of these lightweight structures concrete bases are normally used. The manhole bench and channel would also need to be replace to match the existing sewer inlet and outlet piping.

Sealing Manhole Walls. When infiltration through structurally sound manholes is a problem, a variety of repair techniques are available for sealing the manhole walls. The most common techniques include:

1. Pressure injecting chemical grouts. This method requires drilling holes through the manhole walls at each point where infiltration is entering the manhole. For best results, chemical grouting should be done during high groundwater conditions so the maximum number of leaks will be visible. Chemical grout is pumped through the previously drilled holes through an injection packer until sufficient grout has been pumped to fill in voids on the outside of the manhole. While pumping the grout, the pressure being exerted against the outside of the manhole walls must be monitored to insure that it does not increase to a point where it can cause damage to the manhole structure. After the pumping stops, the injection hole is filled with hydraulic cement.

2. Install rubber joint seals at leaking precast manhole section joints. These types of joint seals are similar to manhole chimney seals. They are compressed against a leaking joint with stainless steel expansion bands.

Channel and Bench Rehabilitation

Channels and benches at the bottom of manholes often need to be repaired or replaced if they have deteriorated to the point of allowing significant amounts of infiltration to enter the sanitary sewer system through the bottom of the manhole or if the channel needs to be modified to improve the hydraulics through the manhole. Sometimes when the bottom of a manhole deteriorates the structural damage is not visible. Evidence of deterioration may be observed in the form of clear water bubbling up from the bottom of the manhole channel if the defect is severe enough and groundwater levels are high enough.

Manhole channels and benches can be partially or totally removed and then reconstructed. When channel and bench work is being done sewage flows need to be temporarily rerouted. When a channel is reconstructed it is important to allow enough space in the new channel to properly operate sewer maintenance equipment in the future such as sewer cleaning equipment, closed circuit TV cameras, and sewer line grout injection packers. Corrosion resistant materials can be used when reconstructing manhole channels and benches in manholes where corrosion is a problem.

Manhole Pipe Connections

A common source of infiltration at manholes is at the manhole pipe connection. These connections become defective as a result of differential settling between the manhole structure and sewer pipe. To effectively seal out the infiltration, the area around the manhole base needs to be excavated. Flexible couplings are manufactured to provide a watertight seal between the manhole and pipe. New manhole sections can be purchased with the flexible pipe couplings precast into the manhole barrel. The sewer pipe is inserted into the coupling and secured with stainless steel clamps. Typically, a limited length of new sewer pipe is installed next to the manhole to complete the repair. It is important to compact the bedding material under the pipe and around the manhole base before backfilling to minimize further differential settling.

SEWER PIPE REHABILITATION

General

Damage done to sewer pipes can occur from natural causes or from industrial wastes, overloading, poor design and workmanship. The most common pipe failures are either structural or corrosive in nature, and occur most often in gravity flow pipes. Corrosion failures are usually found in the crown or invert of sewer pipes, in joints where cement mortar was used, and in other areas where various types of acidic corrosion cause impending failure of the materials used in sewer construction. Corrosion of inverts is often caused by the disposal of corrosive or erosive industrial wastes, while external corrosion is evident in pipes buried in soils with an extremely high level of acidity and with a groundwater level that rises above and falls below the pipeline frequently.

Structural sewer pipe failures are generally due to the following causes:

1. Improper pipe bedding. Failure occurs when a pipe is laid in a trench that has a rock bottom, or when it is laid in a trench where rock protrudes. A pipe failure can also occur if the bedding is not placed uniformly in the pipe trench during construction of the sewer line. Also, if improper bedding material is used on steep slopes, fines can be washed downhill through the bedding eventually, causing failure due to non-uniform support beneath the pipe. Pipe sections failing in this manner require replacement and should be bedded properly and backfilled carefully.

2. Failure due to live loads. Pipe laid with insufficient cover may be broken by a surface load imposed on it by traffic or by heavy construction equipment. If adequate cover cannot be placed over the pipe to protect it from traffic loads, the damaged pipe can be replaced with stronger pipe. Also a loading slab or concrete arch can be installed over the pipe to protect it from live loads.

3. Failure due to earth movement. This type of damage is caused by frost-heaving or shifting soil. Pipes damaged in this manner must be rebuilt, preferably below the frost line.

4. Root-growth damage. Where a root has become so large that it has displaced or crushed a pipe, it is usually necessary to dig up the pipe, cut the root, and replace the damaged pipe.

5. Failure due to openings into the sewer. Any opening into a pipe, whether from an open joint or break, will eventually cause a cave-in or collapsed pipe as the surrounding soil supporting the pipe is washed into the sewer with infiltration.

Sewer pipe rehabilitation is required when the sewer line repeatedly shows partial or complete stoppage of flow due to broken or collapsed pipes and offset joints. These failures can cause excessive infiltration to enter into the system as well as further, more serious structural failures of the pipe. Generally, sewers can be repaired from inside the pipe without any or only limited excavation, or by excavating the damaged pipe and replacing it with new pipe.

When selecting a sewer pipe rehabilitation method the following factors should be considered:

1. The physical condition of the existing sewer. Knowledge of the existing sewer condition is needed to determine the best rehabilitation method and the most cost effective solution.

2. Cost. Generally repairing pipes from the inside without excavation is cheaper than the excavation and replacement method.

3. Hydraulic capacity. When selecting a rehabilitation method, the effect on the hydraulic capacity of the sewer must be considered. This is particularly important for sewer lining methods.

4. Types of materials used. When selecting rehabilitation materials, factors such as durability, chemical and abrasion resistance, and strength must be considered.

5. Installation factors such as:

   a. Maintaining sewage flows.
   b. Safety.
   c. Traffic disruption.

6. Effectiveness of each potential rehabilitation choice.

The most common methods used to rehabilitate sewer pipes include:

1. Injecting chemical or cement based grouts through pipes at ground level to stabilize soil and fill voids around the sewer pipe.

2. Chemical joint sealing from inside the pipe.

3. Sewer lining with a variety of materials.

4. Coating the interior surface of the pipe with a mixture of cement and additives.

5. Excavate and replace sewers in spot locations or completely between two manholes.

<u>External Grout Injection</u>

Chemical and cement grouting is done to stabilize soils, fill underground voids or washouts, and to reduce groundwater movement. This is done by pressure injecting grout through a pipe from ground level into underground soils surrounding a sewer pipe. Chemical grouts usually consist of two or more chemicals that react with each other to form a gel or a solid product which creates a plug to fill voids in the soil where the grout has been injected. A chemical mixture often used for external rehabilitation techniques is acrylamide gel.

While chemical grouts are best used on fine soils, cement grouts are more effective in medium sand and coarser soils because of the larger size of the cement particles. Instead of producing a gel as chemical grouts do, cement grouts create suspensions of solid materials in a fluid. These solid particles fill the voids in the surrounding soils. Cement grouts are generally less expensive than chemical grouts.

The external grouting method is better for stabilizing soils around sewer pipes than for sealing out infiltration. The grout must be injected in areas where known leaks exist. By injecting the grout from above ground, the chance of filling the void around the known leak is not real good. There is also a chance that the injected grout could enter the sewer pipe through the leaks.

Internal Joint Sealing

Internal chemical grouting is the most commonly used method for sealing leaking joints in structurally sound sewer pipes. Although smaller pipes receive more treatment by this method than larger pipes, with special equipment chemical grouting techniques can be applied to large diameter pipes. To seal a leaking joint or radial crack in the sewer system the chemical grout gels are forced out of the pipe through the leaks where they displace groundwater, mix with the soil, and begin to solidify. When the grouts finish solidifying, they form a flexible barrier around the pipe against incoming groundwater or exfiltrating wastewater. Chemical grouts which are used for sealing joints include urethane base gels and foams, acrylate base gels, and acrylamide base gels. Chemical grouts can also be applied to manhole walls, wet wells in pumping stations, and small holes.

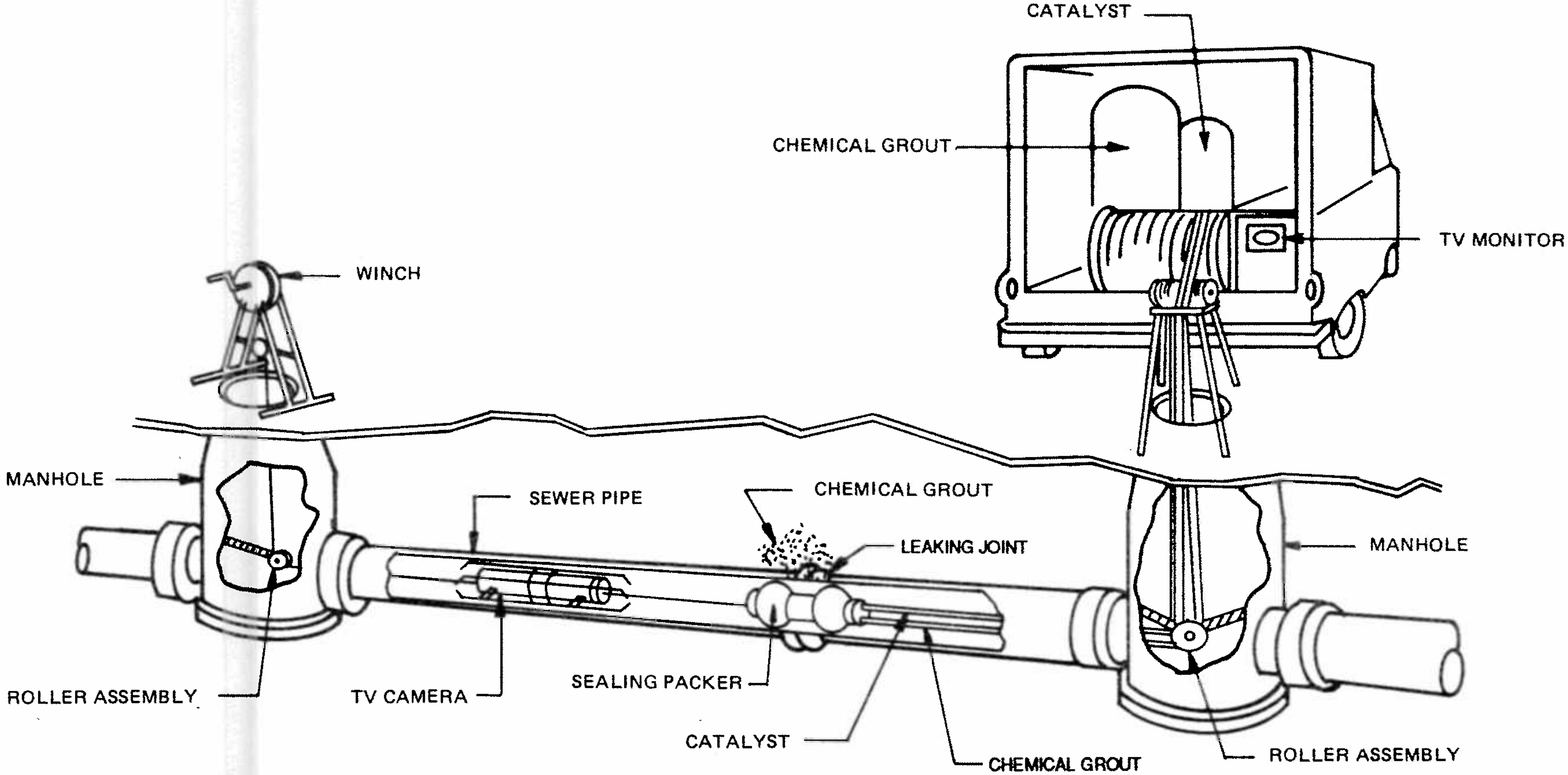
Before a sewer pipe can be chemically grouted, the sewer must be cleaned and roots removed. The structural integrity of the pipe must also be analyzed. The inside pipe walls must be smooth enough to allow proper operation of the chemical grouting equipment. To determine the estimate of chemical grouting cost, the pipe size and percentage of joints requiring sealing must be taken into account.

In small and medium sized pipes up to about 48 inches in diameter, it is common to air test all joints within a sewer reach. All joints failing the air test are grouted. This method minimizes the potential for groundwater to migrate and leak into other unsealed joints.

When using the air test and grout method to seal the interior of a pipe, the primary equipment necessary is a closed circuit TV camera and monitor, and a joint sealing packer. The TV camera equipment is used to locate the pipe joints and to monitor the grouting process. The packer is used to apply grout under pressure at the location of sewer leaks. After a sewer joint has been identified by the TV camera, the packer is positioned over the joint and tested for airtightness. If the joint fails the air test, chemical grout is pumped through the packer into the leak until either a specified maximum volume of grout has been pumped or until a specified pressure is measured. Figure 6-1 shows a typical chemical grouting set up using a joint sealing packer and closed circuit TV camera equipment.

Chemical grouting can be done when sewers are flowing partially full. Maximum flow depths for effective chemical grouting have been recommended by the National Association of Sewer Service Companies (NASSCO) and they are:

1. For 6-12 inch pipes the flow depth should not exceed 25 percent of the pipe diameter.



REFERENCE: FROM HANDBOOK FOR SEWER SYSTEM EVALUATION
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, DEC. 1975.

FIGURE 6-1. TYPICAL ARRANGEMENT FOR CHEMICAL GROUTING

2. For 15-24 inch pipes the flow depth should not exceed 30 percent of the pipe diameter.

3. For 27 inch pipes and larger the flow depth should not exceed 35 percent of the pipe diameter.

When flow depths exceed the recommended maximum depth of flow values the sewer flow must be restricted or bypassed around the section during grouted. When restricting sewer flows care must be taken so that wastewater does not backup and overflow onto private property.

The advantages of using chemical grouts to seal leaking joints include:

1. They are less costly than other internal rehabilitation methods.

2. The application time is only a few hours.

3. The operation causes little traffic disruption.

4. Because of its internal application procedure, there is no interference with other underground utilities.

5. No excavation is required.

6. No surface restoration is required.

7. In sewers where depths of flow are small, sewer flows do not need to be rerouted.

The disadvantages and limitations of chemical grout joint sealing are listed below:

1. The process requires temporary rerouting of sewer system flows when the depth of flow is greater than the recommended maximum values.

2. Toxicity problems sometimes occur.

3. Chemical grouting does not improve structural strength.

4. Is not applicable when the pipe is cracked longitudinally, crushed, or broken.

5. Joints are not sealable if they are badly offset or misaligned.

For grouting large diameter pipes, pressure grouting or manual placement of oakum soaked with grout may be used. Grouting sealing rings or predrilled injection holes can be used to pressure grout. Sealing rings are placed over the defective joint and inflated to isolate the joint. Sealing grout is then pumped into the small void between the pipe wall and the face of the ring.

With the chemical grouts available today, sewer joint grouting when done properly can provide a very effective seal against infiltration of groundwater and exfiltration of wastewater at the joint that is grouted. Unless grouting is done over a large area of the sewer system, the overall effectiveness of infiltration reduction may be limited. When random joints are grouted between manholes or when random sections of the sewer system are air tested and grouted there is a possibility that groundwater will migrate to unrehabilitated areas of the sewer system and enter through other defects.

Cement Mortar Lining

The application of coatings to the inside surface of a sewer pipe is used to rehabilitate cracked or damaged sewers and also to protect pipelines from internal corrosion. One such coating is a 1:2 portland cement mortar coating applied at thicknesses greater than one-quarter inch. For sewer pipes less than 24 inches in diameter, no reinforcing is required. For sewer pipes greater than 24 inches, reinforcement is installed using spirally-wound reinforcing rod. All diameters, however, require cleaning, temporary rerouting of sewer flows and dewatering of the line before the cement mortar can be applied.

Three processes are commonly used in the application of cement mortar:

1. The centrifugal process utilizes a variable speed winch which pulls a revolving mortar dispenser through the pipe. Its use is most economical on pipes greater than 24 inches in diameter, but can be used on 8 to 144 inch pipe. The process is slower than others, but the coated line can be opened for use within 24 hours after application.

2. The reinforced centrifugal lining process uses less steel than other processes and conforms to the inside contour of the pipeline. The applications are the same as for the centrifugal process.

3. The manual process is used on smaller pipes, from 4 to 16 inches in diameter, that have few service connections. This process requires frequent excavations, has high cost and cannot be done quickly.

Gunite Lining

Another coating material often used is reinforced shotcrete, or gunite. Gunite is a mixture of fine aggregate, cement, and water applied by air pressure using a cement ejector. Compared to cement mortar, gunite is denser and stronger. Like cement, gunite improves a pipeline's structural integrity. In fact, the greater the structural deterioration, the more effective the gunite process is compared to cement mortar linings. Gunite adheres well to other concrete and brick sewers and is more corrosion resistant than normal concrete. Its finish, when troweled, is similar in smoothness to cement mortar linings, and can improve a pipeline's flow characteristics.

Gunite is ideal for extremely deteriorated large sewers where persons and equipment can work without restriction. Long lengths of sewers may be effectively renewed with little excavation and minimal traffic disruption. Safety precautions must be observed whenever personnel enter the sewer system.

Installing gunite takes more time than installing a cement mortar lining. It can be applied under low wastewater flows. However, installing gunite is more effective when sewer flows are temporarily rerouted and the pipeline is dewatered totally. For pipelines carrying corrosive or aggressive wastewater, special aggregates and high alumina cements may be used. Welded wire mat or small diameter rod reinforcing is used for structural gunite applications.

Sliplining

Sliplining of pipelines is another versatile rehabilitation procedure. The sliplining procedure involves inserting a flexible liner pipe of slightly smaller diameter into an existing circular pipeline and then reconnecting the service connections to the new line. Sliplining an existing pipeline segment, where applicable, can usually be done in less time and at a considerably lower cost than conventional excavation and sewer replacement.

Sliplining is used to rehabilitate extensively cracked sewer pipe, especially ones in unstable soils. It is also used to rehabilitate deteriorating pipe installed in a corrosive environment, pipes with massive and destructive root intrusion problems, and pipelines with relatively flat grades.

One of the advantages of relining over replacement is that it requires minimal excavation and.limits traffic disruption. Sliplining also avoids the extensive dewatering that may be required for open trench construction. With sliplining, dewatering is limited to the insertion pit and excavation of the service connections. Sliplining can be installed in pipelines having moderate horizontal or vertical deflection caused by shifting soils. The flexibility of the sliplining allows for a normal amount of future settlement or deflection.

Before an existing sewer line can be lined with flexible pipe, it must be cleaned and inspected internally. The internal inspections are required to identify the location of all service connections, severely misaligned joints, collapsed pipe, and any other obstruction that will not allow the liner to be installed. If an obstruction is identified that will not allow the liner to be installed, it must be repaired by excavating prior to lining the pipe.

A pit must be excavated at the end where the liner pipe will be inserted into the existing pipe. The dimensions of the pit excavation are based on the diameter and material properties of the liner pipe. Each size and type of liner will have a maximum bending radius that must be considered when digging the liner insertion pit. Shoring and bracing may be necessary depending on the depth and soil conditions.

The liner is commonly pulled through the existing sewer pipe using a winch assembly set up at an existing manhole.

During the lining process, sewage flows can be allowed to pass through the annular space between the existing pipe and the liner. If the hydraulic capacity of the annular space is not adequate to handle the sewer flows temporary bypassing of sewer flows around the section being lined is necessary.

After the liner has been installed, the service connections must be connected to the liner. This is normally done by excavating the service connection at the .sewer main and using a heat fusion saddle or a strap-on saddle to make the connection.

After the service connections have been reconnected, the annular space between the new liner and existing pipe can be sealed off partially or completely. If there is a chance that the old pipe will collapse and possibly damage or collapse the liner, the annular space should be filled completely with either sand or grout. If it is not necessary to fill the entire annular space between the liner and old pipe the annular space at the two ends should be sealed off.

Figure 6-2 shows a typical sliplining set up.

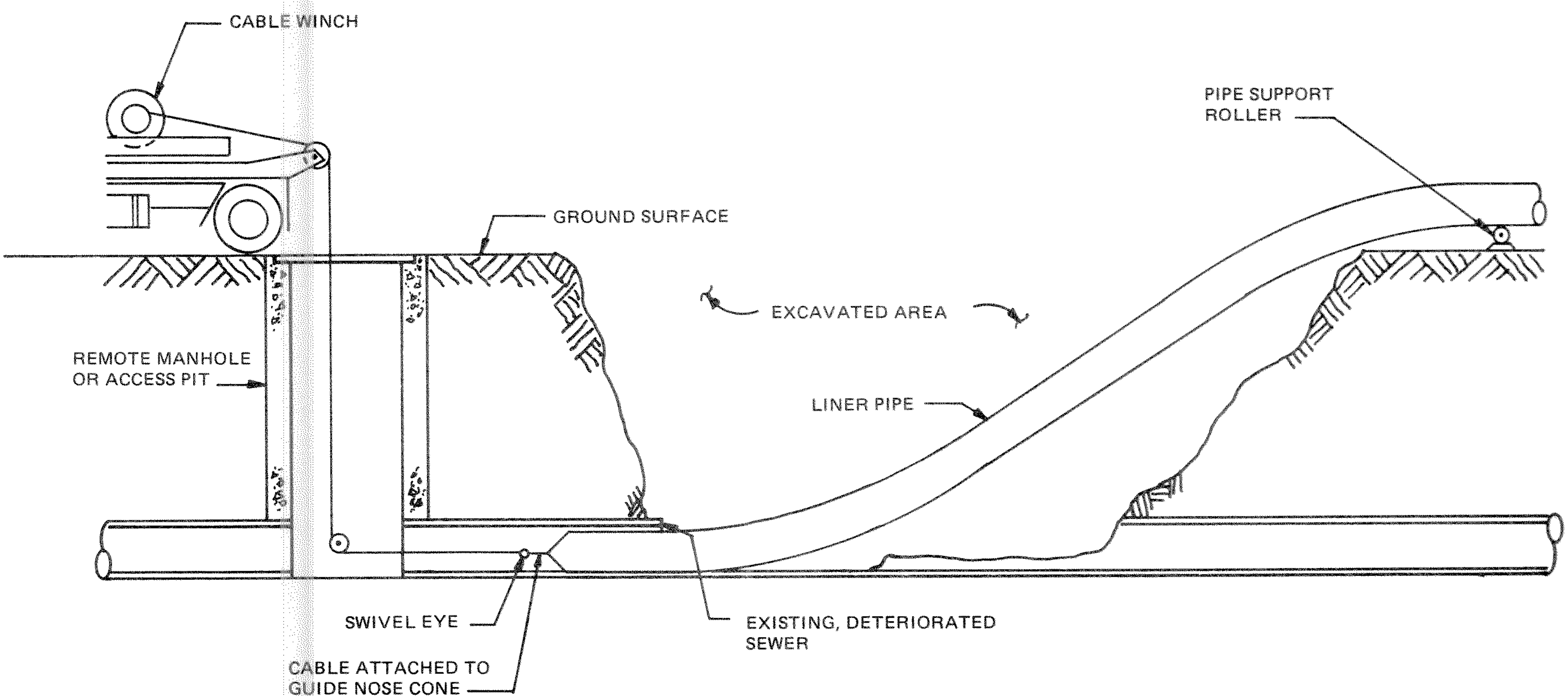


FIGURE 6-2. TYPICAL ARRANGEMENT FOR SLIPLINING

There are several different types of liner materials, polyethylene being the most common material used. Many of the common materials are listed here:

1. Polyethylene pipe (extruded). This material is available in low, medium, and high density and provides excellent corrosion and abrasion resistance. It's application is suitable for pipes 8 to 48 inches in diameter.

2. Polyethylene pipe (spiral-welded). Similar to extruded polyethylene pipe, this material differs essentially in that it can be inserted in pipes 12 to 144 inches in diameter.

3. Polybutene pipe is a good choice for pipes where extra protection is required against excessive temperatures and aggressive industrial wastes. It can be applied in pipes up to 24 inches in diameter.

4. Reinforced plastic mortar pipe is used to reline extensively cracked, corroded, and severely deteriorated sewers 18 to 108 inches in diameter. It can generally be inserted while sewage is flowing.

5. Reinforced thermosetting resin pipe is lightweight and high in strength, but has high cost and limited flexibility. It provides a smooth interior which improves flow characteristics. Pipes 8 to 144 inches in diameter are suitable for this relining material.

6. Polyester resin lining is inserted from an existing manhole without the need for special excavations. Installation is quick and labor requirements are low.

7. Fiberglass reinforced cement liners provide good resistance to abrasion and have high strength, although the installation procedure requires many workers and is slow. It is applicable to pipes greater than 42 inches in circular, oval, rectangular, elliptical, ovoid, and v-shaped sewers.

Inversion Lining

Inversion lining of sewers is another method that can be used to rehabilitate an existing sewer with little if any excavation. The inversion lining procedure involves the installation of a resin impregnated flexible felt tube which is inverted into the existing sewer utilizing hydrostatic pressure. After the lining is in place, the resin is cured to form a hard watertight lining. Inversion lining is a patented process and is only available through licensed contractors.

The inversion lining process is commonly done to sewer sections between manholes but has been done to longer sections including several manholes. Before beginning the inversion lining process, the sewer line must be cleaned and inspected. Any obstructions located must be removed. Sewer flows must be plugged or rerouted during the inversion lining process. The water service to each building that discharges to the sewer section being lined should be shut off during the lining process since the liner will temporarily plug all service connections.

After the liner has been allowed to cure, the service connections are opened using, a remotely controlled cutter in conjunction with a closed circuit TV camera.

The ends of the inversion liner must also be cut and trimmed at the manholes after curing is complete. The flow channel in the manholes may require minor adjustment to provide a smooth flow transition from the channel to the lined sewer.

Figure 6-3 shows the inversion lining process.

Pipe Replacement

The option to excavate and replace damaged pipe cannot be ignored. This option may produce the most effective rehabilitation results despite its high cost. If pipe size enlargement, change in grade, or realignment is needed, in addition to pipe defect corrections, replacement is a good choice. Many times pipe replacement can be used if the cause of deterioration in the existing sewer is known. By knowing the cause of deterioration in the existing sewer, the replacement sewer can be installed with properties such as corrosion resistance and strength that will reduce the chances of the same type of failure from occurring in the replacement sewer.

The possible benefits of pipe replacement include:

1. Increased hydraulic capacity.
2. Correct misalignment of grade or.line.
3. Concurrent repair of service connections.
4. Elimination of direct sources of stormwater entry.
5. Removal of incidental infiltration and inflow sources.
6. Increased pipeline service life.

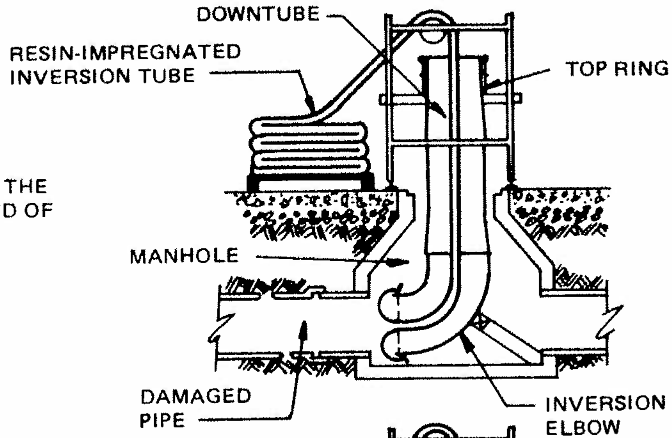
Before selecting the option of sewer replacement, the disadvantages must be considered. The major disadvantages include:

1. High cost relative to other rehabilitation techniques.
2. Need for pavement removal and replacement.
3. Traffic disruption for extended periods of time.
4. Potential damage to existing buildings, utilities, and large trees.
5. Excavation requirements such as dewatering and shoring.
6. Rerouting sewer flows.

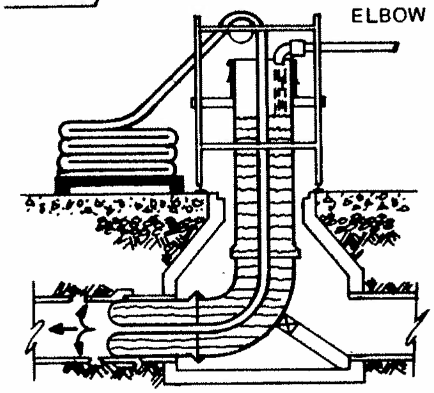
Service Connection Repairs

Service connections, the pipes which branch off the sewer main and connect building sewers to the public sewer main, can be a significant source of inflow and infiltration, if they possess excessive defects. These can include cracked, broken, or open jointed pipes. Several patented methods exist for rehabilitating service laterals including variations of the standard chemical grouting method using specialized TV cameras and grout packer and

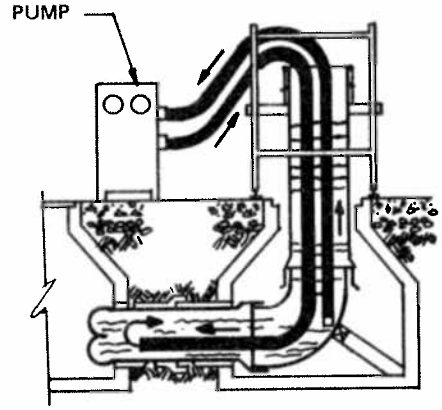
THE INVERSION TUBE IS LOWERED THROUGH THE DOWNTUBE AND BANDED TO THE BOTTOM END OF THE INVERSION ELBOW.



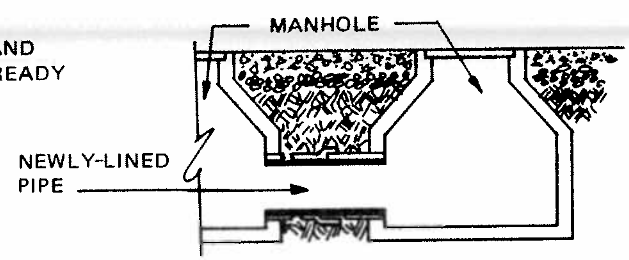
WHEN WATER IS ADDED TO THE DOWNTUBE ITS WEIGHT PUSHES THE INVERSION TUBE THROUGH, AND TIGHT AGAINST, THE OLD PIPE.



WHEN THE INVERSION TUBE IS FULLY EXTENDED THE WATER IS SLOWLY HEATED, CURING IT TO A ROCKHARD, PERMANENT, PIPE-WITHIN-A-PIPE.



AFTER THE NEW INVERSION TUBE HAS CURED AND ITS ENDS CUT FLUSH WITH THE OLD PIPE, IT IS READY FOR IMMEDIATE USE.



REFERENCE: "ENGINEERING DESIGN GUIDE," INSITUFORM OF NORTH AMERICA, INC., 1985.

FIGURE 6-3. THE INVERSION LINING PROCESS

inversion lining. The option to replace service lateral piping is also available for consideration. The costs of these methods vary depending on difficulties encountered.

<u>Summary of Sewer Rehabilitation Methods</u>

A summary of the various sewer rehabilitation methods and their applications is given in Table 6-1. Table 6-2 indicates typical service lives for common sewer system repairs in Northeastern Illinois.

TABLE 6-1. SUMMARY OF MOST COMMON SEWER REHABILITATION METHODS

Method	Application	Advantages	Disadvantages
Chemical Grouting	* Leaking, structurally sound sewer pipes. * Can be used to seal open joints and some cracks. * Used to control infiltration and inflow.	* Cheaper than replacement * Minimal traffic disruption. * No excavation required. * Grouting can be done during low sewer flows. * Existing utilities and buildings not affected.	* Grout packers difficult to seal where surface is not smooth. * Does not improve structural integrity. * Grouts can shrink if they dehydrate. * Infiltration reduction may not reach predicted values due to migration of groundwater. * Questionable service life. * Not effective for sealing widely separated or badly misaligned joints.
Cement Mortar Linings	* Used to line interior of cracked or damaged sewers. * Can be applied to sewers subject to internal corrosion.	* Improves structural conditions of the sewer. * Minimal traffic disruption. * Minimal excavation required. * Existing utilities and buildings not affected. * Provides some protection against corrosion.	* Sewer flows must be temporarily rerouted. * Application surface must be relatively dry. * Quality control is difficult. * Dewatering may be required to control infiltration while lining.
Gunite Lining	* Used to structurally repair large diameter sewers.	* Can improve pipeline flow characteristics. * Improves structural condition of the sewer. * Higher strength than cement mortar linings. * Requires little if any excavation. * Can be applied to various shaped pipes. * Minimal traffic disruption. * Existing utilities and buildings not affected. * Provided some protection against corrosion.	* Temporary rerouting of sewer flow and pipeline dewatering is required for best results. * Control of infiltration during gunite lining is required. * Not applicable to small diameter pipes. * Quality control is difficult.
Sliplining	* Used to repair cracked or deteriorated sewer pipes.	* Cheaper than excavation and replacement. * Minimal excavation. * Minimal traffic disruption. * Can use corrosion resistant liner pipe. * Existing utilities and buildings not affected in general. * May increase hydraulic capacity. * Low flows tolerated during lining process.	* May decrease hydraulic capacity. * Not applicable for pipelines with short radius bends, badly misaligned joints or sewer sags. * Only good for circular pipes. * Expensive for deep sewers. * Grouting of annular space may be required. * Excavation of service connections commonly required.

TABLE 6-1 (cont.). SUMMARY OF MOST COMMON SEWER REHABILITATION METHODS

Method	Application	Advantages	Disadvantages
Inversion Lining	* Can be applied to any type and shape pipe. * For pipelines with minor structural defects.	* Ideal for sewer repairs under busy streets, buildings or large trees. * Minimal if any excavation required. * Quick. * Service connections can be reopened without excavation. * Bends and minor pipe alignments are not a problem. * Pipe capacity not affected significantly. * Minimal traffic disruption.	* Can only be done through a few licensed contractors. * Very expensive for small jobs. * Temporary rerouting of sewer flows required.
Pipe Replacement	* For pipelines with major structural defects. * For increasing capacity. * For installing new pipelines with properties to reduce the chance of future deterioration.	* Can increase pipeline capacity. * Substitute modern pipe material for outdated material. * Increases service life. * May be best method for reducing infiltration and inflow.	* Most expensive type of repair. * Disrupts traffic for long periods of time. * May affect buildings and other utilities. * Dewatering and shoring requirements are likely. * Rerouting sewer flows is required.

TABLE 6-2. TYPICAL SERVICE LIVES FOR SEWER SYSTEM REPAIRS

DEFECT	REPAIR METHOD	SERVICE LIFE[1] (YEARS)
MANHOLE DEFECTS		
Leaking cover - flowing water	gasket cover/insert dish	10-20
Leaking cover - ponded water	bolted waterproof cover and frame	20
Leaking frame to	butyl rubber rope gasket	5-10
manhole joint and	bolt on rubber boot	10-20
leaking adjustment	bonded rubber seal	5-15
Manhole wall leaks		
brick and block	external grout	5-10
	internal grout	3- 5
precast	tuck point	3- 5
Manhole pipe connections	tuck point	3- 5
Structurally defective manhole	replace	20
SEWER LINE DEFECTS		
Random leaking joints	air test and grout	3- 5
Cracked pipes	lining	20
	spot replacement	20
	manhole to manhole replacement	50
Defective service connections	spot replacement	20
ILLEGAL CONNECTIONS		
Storm inlet/Catch basin	disconnect	20
Storm sewer cross connection	disconnect	20
Defective service line	replace	20
Abandoned service line	plug	20

[1]Service lives are typical for Northeastern Illinois.

Source: Attachment G to a December 5, 1986 memorandum distributed by the Metropolitan Sanitary District of Greater Chicago.

CHAPTER 7

PERSONNEL

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INTRODUCTION

Each agency is responsible for developing a plan which will provide for sufficient staffing or subcontracting necessary to carry out the long term operation and maintenance programs. The most important factor influencing the amount of staffing required for a sewage collection system agency is the size of the collection system to be operated and maintained. Another key factor which affects the staffing requirements is the type and availability of sewer maintenance equipment. Other important factors include age of the system, condition of the system, types of waste being transported, and population growth rates. The first concern of any collection system agency should be to have adequate staffing to meet the portion of the work load that is constant.

The personnel required to maintain and operate the sanitary sewer collection system should be included on an organizational chart showing their title. Each position on the organizational chart should have a job description on file with the agency along with the minimum qualifications necessary to fill each position.

CREW REQUIREMENTS

The number of people assigned to a crew and the skills required of them are determined by the agency supervisors based on the type of work to be done (inspection, repair, cleaning), number of people available, total number of crews required for each agency system, work backlog, performance standards or criteria, and projected or anticipated emergencies. The crews must be able to handle normal workloads and most emergencies. Scheduling is accomplished by setting priorities and transferring personnel between crews as necessary. Periodic analysis of system maintenance requirements will indicate if expansion or reduction of the work force is necessary, or if crew reassignments, overtime, and changes in schedules and procedures are needed.

Most crews will consist of two to four people. At least three people must be present during any underground work or inspection. At least two people must be present during pump station maintenance. All crews should be equipped with first aid kits, portable gas detectors, and traffic safety control devices such as barricades and signs.

Good planning and scheduling of routine maintenance and inspections can reduce the number of unscheduled repairs and emergency situations. Assignment of responsibilities according to the functions common to each work crew is recommended to help attain efficiency. For example, if closed circuit television is frequently used to inspect sewers, it may be worthwhile to organize a specially trained crew for that type of work. For some types of work it will be more cost-effective to contract out the work. Work involving the use of modern power cleaning equipment, or expensive excavating machinery are examples of work tasks that may be done more efficiently with an outside contractor.

A summary is given below of typical crew sizes for several sewer system operation and maintenance tasks. Actual crew sizes will depend on the safety requirements for specific tasks, the depth and diameter of the sewers being maintained, and the location of the maintenance task. It is important to remember that when certain crews are not busy, they can be used to help other crews with larger operations or to participate in system inspection or other tasks. In smaller collection systems, one group of people may be responsible for doing all of the operation and maintenance tasks.

CREW TYPE	NUMBER OF WORKERS REQUIRED	NOTES
Emergency service request crew	2	When not clearing emergency stoppages, crew can be used for inspection, repair, map checking, etc.
Balling crew	3	More workers required if work takes place in heavy traffic or in large sewers.
Bucket machine crew	3	
High velocity cleaning crew	2	
Power rodding crew	2	
Closed circuit television crew	3	If television inspections will be done frequently, one crew should be specially trained in this operation.

CREW TYPE	NUMBER OF WORKERS REQUIRED	NOTES
Smoke testing crew	3-5	This crew is rarely required on a full-time basis.
Chemical application crew	2-3	This crew is rarely required on a full-time basis. This crew requires specialized training.
Repair crew	3-6	This crew is responsible for routine repairs. If not on a full-time basis, available existing crews can perform these duties.
Construction crew	3-6	This crew performs new construction or extensive replacement. Often several crews are combined to complete the work more quickly.
Inspection crew	2-3	Use available existing crews for part-time inspection programs.
Flushing crew	2	

It is extremely important to remember that at least three workers are required whenever it is necessary to enter a manhole. This allows for two workers to be topside at the manhole tending the safety line while one is in the manhole. The two workers topside must have sufficient strength to pull the third worker out of the manhole in an emergency.

OTHER STAFFING REQUIREMENTS

Other staffing requirements for a collection system agency include the following:

1. A superintendent or chief engineer who is in charge of dispatching and organizing emergency crews, as well as the overall system operation including development of annual budgets.

2. A general foreman who is responsible for the rest of the crews, such as cleaning, repairs, inspection, etc. The general foreman should also be designated as the safety officer.

3. An office manager and secretary who are responsible for general bookkeeping, permits, record keeping, general information, payroll, billings, and trouble calls.

This is only an example of a typical agency's staff. Staffing requirements may vary according to system size and other previously discussed factors. Typical staff requirements for wastewater collection system serving agencies with populations between 5,000 and 150,000 are shown in Table 7-1.

PERSONNEL TRAINING

General

A prime responsibility of every supervisor is to see that all workers are properly technically trained to do the work and to recognize all hazards involved. Supervisors must motivate workers to use safe procedures and must also provide the leadership and discipline needed to make a good work force.

The personnel should be trained in all areas of sewer system operation and maintenance applicable to performing the job requirements outlined in their job description. The various training programs may include:

1. General safety.
2. Methods used to inspect the sewer system.
3. Proper equipment use and maintenance.
4. Sewer system repair and maintenance methods.
5. Public relations.

Personnel training can be achieved "on-the-job", by studying available references, by attending formal training sessions, or by attending seminars or workshops.

On The Job

Because, to date, there has been little offered in the field of formal courses for training collection system workers, much of the training given has been "on-the-job" training. There is no doubt that this type of training is effective to a degree. However, it is limited in that the training given is restricted to local conditions and the experience of the staff providing the training. The instructor should make a special effort to broaden the scope of any on-the-job training sessions.

Reference Material

Another valuable source of training is available through articles or national trade magazines, reference books, and manuals. They can provide detailed information on operations and maintenance procedures, suggestions for more efficient operations, or results from specific emergency response programs in other communities. A partial listing of references in the area of collection system operation and maintenance is included as Appendix A to this manual.

TABLE 7-1. TYPICAL STAFF REQUIREMENTS FOR WASTEWATER COLLECTION SYSTEMS.

Occupational Title	Population Size											
	5,000		10,000		25,000		50,000		100,000		150,000	
	a	b	a	b	a	b	a	b	a	b	a	b
Superintendent	1	5	1	10	1	20	1	40	1	40	1	40
Asst. Superintendent											1	40
Maintenance Supervisor							1	40	2	80	2	80
Foreman	1	15	1	20	1	20	1	40	1	40	2	80
Maintenance Man II	1	15	1	20	1	20	1	40	1	40	2	80
Maintenance Man I			1	20	2	60	3	120	5	200	8	320
Mason II							1	40	1	40	2	80
Mason I	1	15							1	40	1	40
Maintenance equipment operator					1	40	2	80	3	120	5	200
Construction equipment operator	1	15	1	20	1	20	1	40	1	40	2	80
Auto equipment operator									1	40	1	40
Photo inspection technician									1	40	1	40
Laborer	1	15	1	20	2	40	2	80	5	200	6	240
Dispatcher							1	40	2	80	2	80
Clerk typist							1	20	1	20	2	80
Stock clerk							1	40	1	40	1	40
Sewer maintenance staff	6	80	6	110	9	220	16	620	27	1060	39	1560
Maintenance mechanic II[c]												
Maintenance mechanic I[d]												
Maintenance mechanic helper[d]												
Construction inspector[e]												
Construction inspector supervisor[f]												
Total staff												

[a] Estimated number of personnel.
[b] Estimated total man-hours per week.
[c] Multiply the number of pumping stations maintained by 2.67 to approximate number of personnel needed.
[d] Multiply number of pumping station visits per week by 2.67 to approximate number of personnel needed.
[e] Multiply estimated construction site visits per week by 2.67 to approximate number of personnel needed.
[f] Determined by the number of construction inspections employed and developed on a judgmental basis.

Reference: Namour, Clie, "Manpower Requirements for Wastewater Collection Systems in Cities and Towns up to 150,000 in Population." U.S. EPA, Office of Water Populations, Washington, D.C. (1973).

Formal Training

Recently, through the efforts of local and state water pollution control associations, the Water Pollution Control Federation, and the United States Environmental Protection Agency, attempts are being made to make formal training available to all collection system workers, and to those who would like to prepare for jobs within the field.

Formal training can also be given in the form of seminars and workshops sponsored by professional organizations and schools. Typically, experienced collection system workers are asked to make presentations at seminars so their knowledge can be shared with others. These seminars and workshops can make employees more competent in their jobs and can add interest to the work. Discussions with other collection system personnel at these programs often will provide a different perspective and insight into solving common operational problems.

Informal Training

A supervisor should participate in whatever training is currently available. This includes meeting with work crews to learn about any problems that exist with materials and equipment being used. Meetings with equipment and material vendors can provide information on new material and equipment available. Informal staff meetings can also be held so all workers can share their knowledge with the other workers.

CHAPTER 8

MATERIALS AND EQUIPMENT

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INTRODUCTION

The tools, equipment, and materials required to effectively operate a preventive maintenance program depend on the size, age, and condition of the collection system as well as the work load and objectives of the program. To determine what equipment is needed, an analysis of the system needs to be done to determine what problems occur in the system and what equipment is required to correct the problems. The following lists of equipment required for several operations should serve as guidelines. It is the responsibility of all collection system workers to determine if this equipment is adequate for the proper operation and maintenance of the system.

YARDS AND SHOPS

The yards and the shops of the collection system agency should be adequately equipped with the following:

1. Storage for all materials which cannot be stored on the maintenance vehicles including pumps, compressors, and other large equipment.

2. Office storage for maps, records, etc.

3. Personnel facilities including a locker room with showers, laundry facilities, and a lunch room.

4. A fuel storage area.

5. A machine shop.

6. A storage room for all safety and personal protection gear.

7. Adequate yard lighting and fenced enclosure.

8. Adequate parking for service vehicles and employee owned vehicles.

The trucks used by the foreman and the various crews should be:

1. Capable of carrying a crew of 3-6 people, tools and equipment.

2. Capable of transporting an air compressor.

3. Equipped with outlets and piping around the truck body.

4. Equipped with many locked storage compartments for equipment storage.

5. Equipped with a water tank for cleaning operations.

6. Painted bright, eye-catching colors for high visibility.

7. Supplied with blinking lights and roadway flares to serve as warnings.

8. Supplied with a two-way radio.

Each truck should be equipped with the following tools and equipment depending on the intended operations:

1. Pumps.

2. Rods.

3. Root cutters.

4. Generators.

5. Blowers.

6. Ducts.

7. Fire hose and flushing nozzles.

8. Hydrant wrench.

9. Air gap device.

10. Shovels

11. Picks.

12. Hammers.

13. Non-sparking tools.

14. Traffic cones.

15. Barricades.

16. Axes.

17. Buckets.

18. Rubber boots.

19. A minimum of 25 feet of rope.

20. Explosion-proof flashlights.

21. First-aid kits.

22. Wire brushes.

23. Maps.

24. Atmospheric testing equipment.

25. Gas calibration cartridges.

26. Fire extinguishers.

27. Self-contained breathing apparatus (SCBA).

28. Broom.

29. Cement working tools.

MAINTENANCE EQUIPMENT

Specific equipment usually required for maintenance includes:

1. Testing and sealing equipment used with closed circuit television.

2. Sewer balls, available 6 to 48 inches in diameter. Those greater than 12 inches become expensive. Buy the common sizes and rent the uncommon sizes as needed.

3. Pump with a 1-1/2 to 4 inch discharge.

4. Portable generators. Gas powered generators supply 110 volt power to the field for lights and tools. Truck mounted generators operate from the truck's electrical system and also supply 110 volts.

5. Electronic locaters such as valve or lid locaters and pipe locaters.

6. Inflatable sewer plugs.

7. High velocity cleaners, either truck mounted or trailer units.

8. Closed circuit television equipment.

9. Rodding machines. Although both truck and trailer mounted units are available, if rodding is to be performed full-time, truck mounted is preferable.

10. Bucket machines. These are trailer mounted and used in pairs.

11. Flushing equipment.

12. Maintenance records and forms.

13. Safety equipment such as:

    a. Atmospheric testing equipment.

    b. Harness and rope.

    c. Blower.

    d. Self-contained breathing apparatus.

INSPECTION EQUIPMENT

In inspecting sewer lines and manholes, the following equipment is usually necessary in the field, and is therefore normally stored on the maintenance vehicle:

1. Powerful explosion-proof flashlight or mirrors.

2. Maps of system.

3. Manhole lid lifter or other type of lid remover.

4. Scrapers and wire brushes for cleaning the manhole ring.

5. A five or six foot straight edge.

6. Leather gloves.

7. Traffic safety cones, barricades, and flags.

8. Metal detector.

9. Pick and shovel.

10. Chain ladder or aluminum ladder.

11. Rain gear.

12. Inspection records and forms.

13. Safety equipment.

SAFETY EQUIPMENT

The safety of workers is of prime importance in any sewer maintenance program. Although safety guidelines and equipment will be discussed in some detail in Chapter 9, a partial list of important equipment is given here:

NOTE: All personal protective apparel, tools, devices, and equipment should meet all requirements and standards as outlined by such agencies as the Occupational Safety and Health Administration (OSHA), the National Institute for Occupational Safety and Health (NIOSH), and the American National Standard Institute (ANSI), etc.

1. Atmospheric testers. These are available as single purpose testers used to detect a specific gas such as carbon monoxide, methane, or hydrogen sulfide; dual purpose testers which detect either lack of oxygen or explosive conditions; and multi-purpose testers with interchangeable parts to allow for measurement of the concentration of several gases. Gas calibration cylinders should be kept to calibrate the meter.

2. Explosion-proof blowers to provide fresh air into confined spaces. These are available as portable or trailer mounted models. They should have a 25,000 cubic foot per minute capacity for projects involving large diameter sewers.

3. Self-contained breathing apparatus (SCBA). SCBA's contain a 30 minute oxygen supply. The air tank is carried on your back. These are used when a blower is not available, when it is questionable if the blower is working correctly, or for rescue operations.

4. Shoring equipment. This is important for projects requiring deep excavations. Hydraulic shoring is widely used, as it is lightweight, and safely and quickly installed and removed from above ground. Manual shoring with wooden timbers is more difficult and time consuming to install and is limited to excavations of small size and depth. Sheet shoring and trench boxes are suitable for loose or running soil conditions.

5. Traffic control equipment such as rotating, flashing beacons, traffic cones and warning signs, high level warning flags, and brightly colored safety vests.

6. Protective clothing including:

a. Coveralls which should be removed at the end of the working day to minimize contaminating the worker's car or family.

b. Steel toe safety shoes, with non-skid soles, steel shank and insulation.

c. Rubber boots for those working in raw wastewater. They should be equipped with safety toes, non-skid rubber soles, and a steel shank.

d. Rubber gloves to protect against infection and disease.

e. Leather gloves to protect against scrapes and cuts.

f. Eye protection such as safety goggles or face shields.

g. Hard hats.

h. Safety harnesses.

i. First aid kits.

j. Rain/chemical protective wear to protect against exposure to biological and industrial contaminants.

k. Hydrogen peroxide to clean hands with.

l. Antiseptic shampoo.

CONSTRUCTION AND REPAIR EQUIPMENT

Crews that participate in extensive repair operations or construction of new manholes or sewer lines may have need for the following equipment and materials:

1. Sewer pipe and fittings.
2. Manhole grade rings.
3. Manhole barrel sections.
4. Paving materials.
5. Aggregate and cement.
6. Road rock.
7. Sand.
8. Backhoes for projects of a significant size.
9. Dump trucks with a five-yard load capacity.
10. Water truck with a capacity of at least 1,000 gallons for dust control and clean-up.

11. Portable air compressors for the operation of jack hammers and other pneumatic tools.

12. Truck mounted hoist to lift manhole frames and covers, large pipes, manhole grade rings, and other portable equipment.

13. Internal tap cutters to combat protruding taps where excavation for removal is impractical.

14. Boring equipment.

15. Abrasive cutoff saws.

ACQUIRING EQUIPMENT

After analyzing the collection system and determining the equipment needs, it is necessary to acquire the equipment that is not already owned by the agency. The options available are renting, leasing, or purchasing equipment, or contracting jobs. Each has its own advantages and limitations, as follows:

Leasing/Renting

Advantages.

a. Expensive equipment is available without expending initial capital costs.

b. The problem of not being able to afford better equipment after making a purchase is eliminated.

c. Leases are usually on a one to three year basis, so equipment used won't become obsolete.

d. Leasing can be economically feasible for specialized equipment needed to complete one-time or seasonal programs.

e. Long term storage and maintenance are not required.

f. Leased equipment that breaks down can usually be replaced quickly.

Disadvantages.

a. The total cost of leasing may be greater than purchasing.

b. Staff must be hired and trained to use the equipment.

Purchasing

Advantages.

a. Agency will have standard equipment on hand that is used frequently.

b. The purchase of new equipment usually ensures better quality and longer life span.

Disadvantages.

a. Large initial capital investment.

b. Equipment must usually be kept and used for five to eight years in order to build up an adequate replacement fund.

c. It is difficult to obtain newer equipment that will do a better job until the older equipment wears out.

d. Equipment may require specially trained workers to operate and provide proper maintenance.

Contracting

Advantage.

a. Useful when the collection system agency does not have qualified staff to do a highly specialized job.

Disadvantage.

a. May be the most expensive alternative, but is satisfactory for a small job that can be done in a short time.

CHAPTER 9

SAFETY

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INTRODUCTION

The user should not assume that all safety measures are indicated in this manual or that other measures may not be required. The safety guidelines presented in this chapter are minimum standards only. Before commencing actual work the latest safety standards and laws should be checked and followed. It is the responsibility of each agency to follow current and comprehensive safety standards and laws at all times.

The contents of this chapter are not intended to be and should not be construed to be a standard of the Metropolitan Sanitary District of Greater Chicago or Metcalf & Eddy, Inc. No reference made in this chapter to any specific safety method, product, process, or service constitutes or implies an endorsement, recommendation or warranty thereof by the Metropolitan Sanitary District of Greater Chicago, or Metcalf & Eddy, Inc. The Metropolitan Sanitary District of Greater Chicago, and Metcalf & Eddy, Inc. make no representation or warranty of any kind, whether express or implied, concerning the accuracy, completeness, or suitability of any information, apparatus, product, or process discussed in this chapter, and assume no liability therefore. Anyone utilizing this information assumes all liability arising from such use, including but not limited to infringement of any patent or patents.

Worker's safety should be the responsibility of everyone involved in the operation and maintenance of a collection system. Good safety procedures are a result of proper planning. Proper planning ensures that tasks can be achieved in a safe working manner and that difficulties are reported and action taken by a designated person or persons. This ensures that slackness does not develop. Safety hazards which may be encountered during routine collection system operation and maintenance are addressed in this chapter. The National Institute for Occupational Safety and Health (NIOSH) and the Occupational Safety and Health Administration (OSHA) are two governmental organizations which offer booklets and guidelines for worker safety procedures. The National Association of Sewer Service Companies (NASSCO) offers safety training on request.

The best working conditions for operation and maintenance personnel of sewage collections systems includes provision and correct use of safety equipment, proper job instruction, frequent review of safety practices, adequate and competent supervision, and proper planning of a job through to completion. A high injury rate is not only undesirable for the obvious reason of human health care, but it also leads to a decrease in operating efficiency and an increase in operating costs.

SAFETY RESPONSIBILITIES

Agency

The agency under which the sewage collection system operates has the responsibility to develop safe working practices based on current and comprehensive safety standards for all jobs as well as to encourage and promote the implementation of these practices. The agency also has the responsibility of providing an organization which includes professional advisors, who recognize legal safety requirements and proper equipment and tools.

Management

Adequate training and education of employees is the responsibility of the management, who must communicate safety information to workers through safety meetings, in-service training classes and safety instruction booklets which are published by OSHA, NIOSH and other safety organizations. Management also has the responsibility of investigating hazardous work conditions, seeing that workers are fit to perform the work assigned, and maintaining accurate records of accidents and injuries.

Supervisors and foremen provide a link between management and workers. They must have a thorough knowledge of the safety program and see that it is followed by workers. Foremen should review their work for compliance with established safety regulations. They should also inspect the equipment and methods used for any problems which could lead to safety hazards.

Staff

All employees have a responsibility to themselves, their families, and their jobs to do everything they can to prevent personal injuries and accidents. This can be done by following established safety regulations, using the proper safety equipment required by any job, and keeping up to date with all current safety practices. In these ways, human error, the most significant cause of accidents, can be kept to a minimum.

In case an accident does occur, all employees should be familiar with the various routes to the nearest hospital. These routes can be marked on a map that is stored in each maintenance vehicle.

HAZARDS

There are six major categories of hazards that may be encountered when performing maintenance operations in a wastewater collection system. These hazards are discussed in order of frequency of accidents and deaths attributable to each. They are: atmospheric, physical injury (due to slips, falls, falling objects, sharp objects, bumps, and structural failures), infection and disease, insects, toxic exposure and drowning.

Atmospheric Hazards

Atmospheric hazards are of three major types: explosive or flammable, toxic, and oxygen deficient. These conditions are commonly found in confined spaces. The National Institute for Occupational Safety and Health (NIOSH) defines a confined space as a space which is characterized by any of the following:

1) Limited openings for entry and exit.
2) Unfavorable natural ventilation.
3) Not designed for continuous worker occupancy.

A confined space should NEVER be entered before the atmosphere is tested with the proper equipment for hazardous conditions. Table 9-1 summarizes common gases encountered in sewers and at sewage treatment plants.

Explosive or Flammable Atmospheres. Explosive or flammable atmospheres can develop at any time in the collection system. Flammable gases or vapors may enter a sewer system or manhole from a variety of legal, illegal or accidental sources. The principle causes of explosion are methane, gasoline, propane, other explosive fuel gases and grease solvents. Explosions can occur due to sparks from cars, tools, open flames, and cigarettes. Meters are available that measure the concentration of combustible gases. Check for combustible gases before lifting the manhole cover or before entering a manhole or sewer. Continue to meter for combustible gases for as long as workers are in the manhole or sewer.

Methane gas is one of the products of waste decomposition. This gas can be produced almost anywhere in the collection system. Methane is also the major flammable gas in the natural gas piped under streets by utility companies. Leaks in these pipes will saturate the soil around a sewer pipe, leading to seepage of the gas into the collection system. Since methane and other natural gases are lighter than air, some gas will diffuse or escape from a manhole if there is natural ventilation.

Explosive fuel gases, such as propane, gasoline, and grease solvents may be as much as four times heavier than air. This results in the accumulation of gases in deep manholes, underground structures, and sewers where ventilation is limited by venturi meters or sections flowing full.

Toxic Atmospheres. Toxic atmospheres (poisonous air) in wastewater collection systems are most often caused by sulfide, a gas produced by the decomposition of certain materials containing sulfur. Hydrogen sulfide mixes quickly with air and goes wherever the air goes. If there is no ventilation or air movement, hydrogen sulfide accumulates in the lower sections of the collection system. Hydrogen sulfide can also undergo a chemical reaction which results in the formation of sulfuric acid, a highly corrosive acid. Hydrogen sulfide can be identified by the smell of rotten eggs. However, the actual measurement of the hazard should be left to instruments that measure its concentration, because the human nose is unreliable. Other toxic gases that may be encountered include chlorine, carbon monoxide, and ammonia.

Other Sources. The combination of certain industrial wastes in the sewer system can result in the release of gases. Knowledge of the industrial discharges is important. Industrial wastes discharged within the collection system can constitute a major concern to worker health and safety. Further, due to the effects of undesirable discharge, either singularly or combined, major physical damage to the collection system, pumping and lifting stations, receiving treatment facility, and receiving waters can result.

TABLE 9-1. COMMON DANGEROUS GASES ENCOUNTERED IN SEWERS AND AT SEWAGE TREATMENT PLANTS*

Name of Gas	Chemical Formulae	Specific Gravity of Vapor Density** (Air=1)	Explosive Range (% by Vol. in air) Lower Limit	Upper Limit	Common Properties (Percentages below percent in air by volume)	Physiological Effects (Percentages below are percent in air by volume)	Most Common Sources in Sewers	Simplest and Cheapest Safe Method of Testing
Oxygen (in air)	O_2	1.1	Not flammable		Colorless, odorless, tasteless, non-poisonous gas. Supports combustion.	Normal air contains 20.93% of O2. Man tolerates down to 12%. Below 5% to 7% likely to be fatal.	Oxygen depletion from poor ventilation and absorption or or chemical consumption of available O2.	Oxygen deficiency indicator.
Gasoline	C_5H_{12} to C_9H_{20}	3.0 to 4.0	1.3	7.0	Colorless, odor noticeable in 0.03% Flammable. Explosive.	Anesthetic effects when inhaled. 2.43% rapidly fatal. 1.1% to 2.2% dangerous for even short exposure.	Leaking storage tanks, discharges from garages and commercial or home dry-cleaning operations	1. Combustible gas indicator. 2. Oxygen dificiency indicator for concentration C0 ampoules.
Carbon monoxide	C0	0.97	12.5	74.2	Colorless, odorless, non-irritating. Tasteless, flammable. Explosive.	Hemoglobin of blood has strong affinity for gas causing oxygen starvation. 0.2% to 0.25% causes unconsciousness in 30 minutes.	Manufactured fuel gas.	
Hydrogen	H_2	0.07	4.0	74.2	Colorless, odorless, tasteless, non-poisonous, flammable. Explosive. Propagates flame, very dangerous.	Acts mechanically to deprive tissues of oxygen. Does not support life. A simple asphyxiant.	Manfuactured fuel gas.	Combustible gas indicator.
Methane	CH_4	0.55	5.0	15.0	Colorless, tasteless, odorless, non-poisonous, flammable, explosive.	See hydrogen.	Natural gas, marsh gas, mfg. fuel gas, sewer gas.	Combustible gas indicator.

*From Water and Sewage Works - Van Kleeck - August 1953.
**Gases with a specific gravity less than 1.0 are lighter than air, those more than 1.0 are heavier than air.

TABLE 9-1. (Cont.) COMMON DANGEROUS GASES ENCOUNTERED IN SEWERS AND AT SEWAGE TREATMENT PLANTS*

Name of Gas	Chemical Formulae	Specific Gravity of Vapor Density** (Air=1)	Explosive Range (% by Vol. in air) Lower Limit	Upper Limit	Common Properties (Percentages below percent in air by volume)	Physiological Effects (Percentages below are percent in air by volume)	Most Common Sources in Sewers	Simplest and Cheapest Safe Method of Testing
Chlorine	C_{12}	2.5	Not Flammable Not explosive		Greenish yellow gas, or amber color liquid under pressure.	Respiratory irritant, irritating to eyes 30 ppm causes	Leaking pipe connections. Overdosage.	Odor, strong ammonia on swab gives off white
fumes.					Highly irritating and penetrating odor. Highly corrosive in presence of moisture.	coughing. 40-60 ppm dangerous in 30 minutes. 1000 ppm apt to be fatal in few breaths.		
Hydrogen Sulfide	H_2S	1.19	4.3	46.0	Rotten egg odor in small concentrations but sense of smell rapidly impaired. Odor not evident at high concentrations. Colorless. Flammable. Explosive. Poisonous.	Death in few minutes at 0.2%. Paralyzes respiratory center.	Petroleum fumes, sewer gas.	1. H_2S ampoules. 2. 5% by wt. lead acetate solution.
Carbon Dioxide	CO_2	1.53	Not flammable		Colorless, odorless, non-flammable. Not generally present in dangerous amounts unless there is already a deficiency of oxygen.	10% cannot be endured for more than a few minutes. Acts on respiratory nerves.	Issues from carbonaceous strata. Sewer gas.	Oxygen deficiency indicator.
Nitrogen	N_2	0.97	Not flammable		Colorless, tasteless, odorless. Non-poisonous. Principle constituent of air (about 79%).	See Hydrogen.	Issues from some rock strata. Sewer gas.	Oxygen deficiency indicator.
Ethane	C_2H_4	1.05	3.1	15.0	Colorless, tasteless, odorless, non-poisonous. Flammable. Explosive.	See Hydrogen.	Natural gas.	Combustible gas indicator.

*From Water and Sewage Works - Van Kleeck - August 1953.
**Gases with a specific gravity less than 1.0 are lighter than air, those more than 1.0 are heavier than air.

Due to the relative exposure it is critical to catalog, define, and develop appropriate safety job instructions and work measures to safely conduct required work within these areas.

Knowledge of industrial discharges should be obtained from such sources as; the local board of health, local right-to-know co-ordinator, local industrial waste officer, and regulatory agency personnel.

Oxygen Deficient Atmospheres. The amount of breathable oxygen present in a manhole or sewer can be decreased or eliminated by having the air mixed with or replaced by the entry of another gas. Meters are available that measure the concentration of oxygen in the atmosphere. It is extremely important to ventilate the manhole during occupancy. A manhole or other confined space where the atmosphere contains less than 19.5 percent or more than 21 percent oxygen is unsafe to work in. In this case, ventilation should be increased and the use of appropriate respiratory protection considered.

Physical Injury

Physical injuries during manhole work can occur from several causes. Working in manholes is often awkward due to the narrow space and uneven footing. This results in poor balance and decreased coordination which could lead to strained muscles, bruises, scrapes and cuts. Injuries can also occur due to slipping on ladder rungs and manhole benches. Care must also be taken in removing manhole covers. The cover should be removed with a hook or crowbar and dragged from the manhole frame. All loose debris and dirt should be cleaned from around the manhole opening to prevent the falling of such debris upon a worker below.

Corroded and otherwise unsafe manhole steps are also a potential source of injury. It is sometimes best to enter a manhole with the use of a portable window washer ladder. The use of heavy ladders should be avoided. Workers should not be in the manhole when ladders or other heavy objects are being moved. Access is impossible with standard ladders.

Dropping tools to workers in a manhole, and tossing them back out, have caused many injuries. A worker should avoid looking up and out of the manhole while inside it. This will decrease the chance for dust and debris to get in the eyes and for possible eye infection if the worker should wipe his eyes with a hand or glove that has been exposed to the wastewater environment. Tools should be lowered into and pulled out of manholes in a canvas bag or sling. Often, truck winches are used to lower a worker or tools into the manholes.

Protective eyewear must be used at all times. The use of spectacles or safety goggles in a manhole may be difficult because of their tendency to fog. These glasses can also become smeared by moisture in a manhole environment, resulting in decreased vision capacity by the wearer. Proper ventilation will reduce fogging problems. If a chipping gun or other tool is used to chip concrete or pipe, protection for the eyes must be worn. A helmet and clear face shield may be a better choice than safety goggles.

When working in a manhole, beware of sharp objects that can cut or penetrate your skin and cause a serious infection. Typical objects to look for include razor blades, pins, hypodermic needles, and pieces of broken glass and metal.

Infections and Disease

Workers who come in contact with wastewater are exposed to a number of viruses such as Hepatitis A, Polio and Reovirus. Exposure to the AIDS virus is also possible. However, the AIDS virus cannot survive outside the human body for more than a few seconds. Therefore, it is highly unlikely that the AIDS virus can be contracted from wastewater.

When working on the sewer system, protective clothing such as rubber surgical gloves, coveralls, and rubber boots become very important in reducing exposure to disease. Personal hygiene is also extremely important in reducing workers exposure to disease. Immunizations and inoculations for Typhoid, Paratyphoid, Polio, and Tetanus should be obtained by all workers. Specific state and local immunization requirements can be obtained from the Center for Disease Control, Atlanta, GA, NIOSH, Morgantown, W. VA, and state and local health officials.

Pests

Insects, rodents, and other pests, while less severe a danger to workers than infections and diseases, can be a source of danger. Many insect bites are associated with diseases. For example, mosquito bites can cause malaria. Always inspect a manhole for pests before entering. The following pests are found in manholes and should be avoided:

Stinging insects such as wasps, daubers, and bees.
Ticks.
Fleas.
Lice.
Mosquitoes.
Houseflies.
Blowflies.
Rats.
Snakes.
Roaches.

To remove pests and clean the manhole before entry, flush it with a water jet.

Toxic Exposure

Toxic acid, bases, and other hazardous liquid or solid chemicals can be discharged into the wastewater collection system either accidentally in spills or deliberately by industry or the public. This is always a potential health hazard. Proper boots and gloves are examples of protection against toxicants.

Drowning

With the trend toward larger regional wastewater treatment plants, intercepting sewers are being constructed that convey large flows. These large diameter sewers and flows increase the chance of a worker drowning from an accidental slip or fall into the flowing wastewater. Step carefully at all times, especially when working in or near large flows, to avoid drowning. Always wear a lifeline connected to the safety harness. Wear a life jacket if necessary. Make sure barricades, warning devices and signs are used.

SAFETY PRACTICES

All sewer system personnel should be aware of and use safety practices when working in or around the sanitary sewer system. Some of the more important safety practices are listed below.

To minimize the chance of injury due to asphyxiation or explosion the following safety practices must be used:

1. When entering a manhole where an atmospheric hazard is suspected to exist, there should be no smoking or open flames, workers should guard against sparks by using non-sparking tools and explosion-proof equipment. The atmosphere must be tested for hazards, including combustible gases, oxygen deficiency and hydrogen sulfide. If any hazard is detected, the sewer or manhole must be ventilated by natural or artificial means. Testing of the atmosphere must be repeated before entering the manhole.

2. Adequate ventilation must be maintained during work and tests must be conducted frequently.

3. Appropriate respiratory protection must be worn if adequate ventilation is not possible or practical.

4. Fire and explosion prevention is practiced through care in avoiding making sparks from shoes, tools, open flames, and even from the removal of manhole covers.

5. Appropriate personal protection and safety equipment must be used.

To minimize physical injuries, simple good housekeeping is very effective.

1. Tools should not be left near an open manhole and should be put away immediately after use.

2. Manhole covers should be replaced promptly after work is completed to guard against injury to workers and the public.

3. Sufficient help should be available whenever manhole entry is required. This calls for at least a three worker crew.

Some other very important, rules of safety are as follows:

1. Rubber gloves should be worn when handling wastewater or similar materials. Special precautions should be taken to prevent wastewater from coming in contact with open cuts or other injuries. Rubber boots or rubber shoe coverings should also be worn. Rinse any contaminated skin areas with hydrogen peroxide.

2. Emergency first aid must be given to all minor cuts or injuries. A doctor should treat all but the minor injuries. Instruction for first aid treatment is available from several sources including state health departments, the National Safety Council, and the American Red Cross.

3. Personnel must make a habit of frequently and thoroughly washing hands and face with antiseptic soap and hot water, especially before meals and smoking. Prior to leaving work, a shower and change of clothes is recommended to reduce the chance of transmitting infection to others. Leave work clothes in the yard. Nails should be kept short and clean to prevent the accumulation of any dirt or infectious materials. Dirty hands should be kept away from eyes and mouth.

4. In general, the highest injury rate is usually associated with workers that are very aggressive in their work habits. Workers should always, without exception, take the necessary time to:

   a. Review and understand approved instructions.

   b. Wear all of the necessary approved personal protective apparel.

   c. Properly use all required safety tools, devices, and equipment.

SAFETY EQUIPMENT

Using the proper safety equipment is critical for any sewer system operation and maintenance program. When entering confined spaces many vapors and gases which are toxic cannot be detected without the use of approved detection equipment. NEVER conduct entry into a confined space without the use of such devices. Several types of gas detection and oxygen deficiency indicators are available for analyzing the atmospheres of confined spaces. A portable oxygen/explosivity alarm unit should be the type that continuously withdraws a sample of the atmosphere from a manhole and tests it for the presence of explosive or flammable gases and the percentage of oxygen, or that is equipped with a sensor or probe that is lowered into the manhole. The device should have an audible and visible alarm that will warn when flammable gases (such as methane, etc.) exceed 20 percent of the lower explosive limit, or when the amount of oxygen drops below 19.5 percent. A device must also be available to test for hydrogen sulfide gas and other toxic gases that might be present. Battery operated units should also have an alarm to indicate low battery power before such power becomes inadequate to permit the equipment to function properly. These gas testing devices must be maintained and in proper operating conditions at all times. It is important that these devices receive regular preventive maintenance and calibration before and after entry inspections.

When ventilation is unable to provide a suitable atmosphere in a manhole or confined space, self-contained breathing apparatus (SCBA) are required to safely enter. This apparatus consists of a face mask respirator and hose to the air supply. Air may be supplied either from a tank on the worker's back, or from larger cylinders placed at a convenient location and not carried by the worker.

A ventilation blower is required to ventilate sewers and manholes. The blower must be on ten to fifteen minutes and the atmosphere tested before entry to the manhole. The blower hose outlet must be all the way down to the bottom of the manhole. A fan type blower should have between 750 and 850 cfm (cubic feet per minute) capacity for a standard manhole with a four foot diameter at the bottom. The standard unit will have a fifteen foot long hose, eight inches in diameter to conduct the blower air to the bottom of the manhole. Hose couplings and extensions must be available because some manholes are over twenty feet deep. Gasoline engine powered blowers are less desirable due to the high noise factor, and the possibility of producing undesirable fumes and gasoline leaks. Whether the blower is powered by a gas engine or an electronic motor, it should be explosion-proof. One problem encountered in using blowers is that blowing air into a manhole can create a pocket of gas. Ventilation can be improved by removing the nearest upstream or downstream manhole cover. If the manhole is washed with a jet stream immediately before entry, the air current from the jet will further remove any gases.

Another method is to draw air from the bottom of the manhole. If the downstream pipe is not flowing full, there is an air space in it and air can be exhausted or drawn from the downstream manhole. In this way, the person in the manhole is breathing fresh air from the manhole entrance. This method is acceptable if the new air that flows into the bottom of the manhole is satisfactory for breathing and does not contain flammable or toxic gases. When airflow is stopped, hazardous atmospheric conditions may once again result. Therefore, ventilation and atmospheric testing should be continuous.

Safety harnesses should be worn by all workers entering the manhole to guard against several serious injuries including asphyxiation. The harness should be a parachute type which prevents a limp body from falling out of it. The lifeline connection should attach at the shoulders to suspend a body in the upright position. Tilting or doubling over of a body can prevent its rapid removal through the 24 inch manhole opening, or cause injury to a person while being removed in the doubled over or tilted position. Approved lifting devices should be used, whether they be portable or fixed. When fixed to vehicles, make sure the exhaust pipe has an extension hose and discharges fumes downwind of the entrance.

The harness and lifeline may be used to lower a worker into a confined space. Whenever a worker is underground, at least two persons of ample strength to pull the other worker out must be topside of the manhole holding the lifeline and observing the actions of the worker in the harness. Do not tie the above ground lifeline to any object that could be hit by a careless driver, which could result in injury to the worker in the harness.

Fire extinguishers should be available at all times to maintenance personnel. All personnel should be familiar with their use and location. The most convenient location for these extinguishers would be at a common location in each vehicle. For example, mounted to the left or right of the rear window over the driver's seat in division trucks. The extinguishers should be checked periodically for operability and charge.

Safety equipment needed to guard against physical injury includes traffic signs, cones, barricades, and high level flags when working in areas where vehicle traffic is present. Where traffic is very heavy or road conditions are dangerous, traffic police may be desired or required. A utility truck is an effective barricade. A manhole cage, proper lighting, and a safety harness and rope are necessities to guard against personal injury.

No person should be allowed to enter a manhole without adequate head protection. The full strength hard hat is recommended. The brim should be adequate to protect the face, or a clear face shield should be used. Chin straps are recommended for work in confined quarters.

As much of a person's skin as possible should be covered with clothing that will prevent scrapes and abrasions. This includes proper shoes, gloves, and long sleeves. Leather gloves protect best against cuts and scrapes. The use of disposable rubber surgical gloves, used in combination with outer gloves, can further reduce exposure.

Physical injuries in pumping stations should also be prevented. This can be done by enclosing ladders with hoop cages and supplying long ladders with intermediate landings and safety straps. Sufficient day and night lighting is required. Warning signs should be posted near dangerous machines. Carbon dioxide and dry chemical extinguishers should be supplied in every pumping station.

PRECAUTIONS FOR MANHOLE ENTRY

NOTE: The safety guidelines presented here are minimum requirements only. It is the responsibility of each agency to follow current and comprehensive safety standards at all times.

Immunizations

Workers in a wastewater collection system should have current immunizations against illnesses and diseases which might be encountered in the collection system. Typhoid and tetanus shots with booster shots every five years is the policy for many agencies. Records on all employees should be kept indicating when more shots are required. Contact state and local health agencies to determine specific immunization and inoculation requirements.

Health Conditions of Workers

All workers entering a manhole should conform to the following rules at the time of entry:

1. Be in good health. If a worker is recovering from a recent illness or surgery, manhole work should not be performed until fully recovered.

2. Do not have a hangover or be under the influence of alcohol or drugs as these impair physical and mental ability.

3. Be in sound physical condition.

4. Have no open sores, skin irritations (including such things as poison ivy or poison oak), fungus infections (such as athlete's foot), or serious sunburn.

5. Workers who do not require corrective eyeglasses for manhole tasks are recommended for such work.

Other workers on the manhole entry or maintenance crew should also follow the above rules to help make any operation as safe as possible for all involved.

Confined Space Entry Permit

Every Agency should have a specific procedure that must be followed before a worker is allowed to enter a confined space. This will ensure that the workers are familiar with safety procedures associated with confined space entry. Part of this procedure may consist of an employee completing a Confined Space Entry Permit and Record form before being allowed to enter a confined space. Figure 9-1 shows an example Confined Space Entry Permit and Record form. Additionally a Safe Work Permit or a Safe Job Instructions Form could be filled out prior to performing potentially dangerous work. Figures 9-2 and 9-3 are example Safe Work Permit and Safe Job Instructions form respectively. These forms serve

LOCATION OF WORK: (Name of Plant, Name of Confined Space)

____

____

DESCRIPTION OF WORK: ______________________________

____

____

EMPLOYEES ASSIGNED: ______________________________

____

ENTRY DATE: ______________________________________

ISOLATION CHECKLIST:

- Blanking and/or Disconnecting Piping
- Electrical Lockout and Danger Tags
- Mechanical
- Other

HAZARDOUS WORK TO BE DONE:

- Burning
- Welding
- Brazing
- Open Flame, Sparks
- Cleaning (solvents, water blast, sandblast)
- Other

HAZARDS EXPECTED:

1. Restrictive Opening
2. Oxygen Deficiency, Enrichment
3. Flammable Materials
4. Toxic Materials
5. Corrosive Materials
6. Dusty Materials
7. Darkness (Inside, Outside)
8. Slippery Surfaces
9. Water (Standing, Flowing)
10. Inlet Drain Open
11. Bacteria, Vermin
12. Hot Surfaces
13. Low Headroom
14. Noise
15. Other

PERSONAL SAFETY:

1. Training (This Assignment)
2. Emergency Procedures (See Below)
3. Clothing
4. Head, Hand, Foot, Ear Protection
5. Respirators
6. Safety Line and Harness
7. Communications
8. Traffic Controls
9. Ventilation
10. Lighting
11. Ladder, Handlines
12. Personnel Hoist
13. Fire Extinguisher
14. Other

FIGURE 9-1. EXAMPLE CONFINED SPACE ENTRY PERMIT AND RECORD

ATMOSPHERIC TESTS (OXYGEN, FLAMMABLE, TOXIC)

TIME	TEST	READING	TIME	TEST	READING

Tests Performed By: ______________________________
Signature

EMERGENCY PROCEDURES

Standby Person(s) ______________________________

Telephone, Emergency Notification (To Whom? How?) ______________________________

____

____

____

Rescue Procedure (By? How?) ______________________________

____

____

AUTHORIZATION:

Plant Manager ______________________________ ______________
Signature Date

FIGURE 9-1 (Cont.). EXAMPLE CONFINED SPACE ENTRY PERMIT AND RECORD

HEADING

TYPE OF PERMIT: VESSEL ENTRY ☐ HOT WORK ☐ OTHER ☐ PERMIT NO.

GOOD ON THIS DATE ONLY: FROM: AM ☐ PM ☐ TO: AM ☐ PM ☐

LOCATION:

WORKERS AUTHORIZED ENTRY:	WORK MONITORS:	FIRE WATCH: (HOT WORK ONLY)
______	______	______
______	______	______
______	______	______
______	______	______

DESCRIPTION OF JOB OR SPECIAL PROCEDURES: ______

______

EMPLOYEE TRAINING AND PRE-ENTRY BRIEFING

1. SAFE ENTRY AND RESCUE TRAINING CONDUCTED ON: ______ (DATE)
2. MANDATORY PRE-ENTRY BRIEFING CONDUCTED ON: ______ (DATE)
3. DOES THE JOB REQUIRE SPECIAL TRAINING? YES ☐ NO ☐

CONTRACTOR NOTIFICATION

CONTRACTOR NOTIFIED OF: PERMIT CONDITIONS ☐ POTENTIAL HAZARDS ☐ N/A ☐

LIGHTING REQUIREMENTS	SPECIAL TOOLS/EQUIPMENT	COMMUNICATION DEVICES
______	______	______
______	______	______
______	______	______

1. ARE ALL ELECTRICAL DEVICES INTRINSICALLY SAFE? YES ☐ N/A ☐
2. HAVE ALL POWER CORDS AND TOOLS BEEN VISUALLY INSPECTED? YES ☐ N/A ☐

PRE-ENTRY ATMOSPHERIC TESTING	READING:	TIME:	INITIALS:
1. TEST FOR OXYGEN CONTENT:	______ %02	______	______
2. TEST FOR FLAMMABLE CONCENTRATION:	______ %LEL	______	______
3. TEST FOR TOXIC CONCENTRATION:	______ PPM OF ______ (TLV=)	______	______
4. TEST FOR HEAT STRESS HAZARD:	______ ^{o}F ☐ ^{o}C ☐ WBGT	______	______

EMERGENCY/RESCUE PROCEDURES

1. LOCATION OF WRITTEN EMERGENCY RESCUE PLAN ______
2. TYPE OF EMERGENCY RESCUE TEAM REQUIRED: ON-SITE ☐ OFF-SITE ☐ PHONE NO. ______

SAFETY EQUIPMENT

PERSONNEL PROTECTIVE EQUIPMENT REQUIRED:	AREA SAFETY EQUIPMENT REQUIRED:
______	______
______	______
______	______

1. SELF-CONTAINED BREATHING APPARATUS REQUIRED? YES ☐ NO ☐ TYPE ______
2. PORTABLE ATMOSPHERIC MONITOR REQUIRED? YES ☐ NO ☐ TYPE ______

PERMIT AUTHORIZATION

I CERTIFY THAT I HAVE INSPECTED THE WORK AREA FOR SAFETY AND REVIEWED ALL SAFETY PRECAUTIONS RECORDED ON THIS PERMIT.

PERMIT AUTHORIZED BY (SIGNATURE) ______

N/A = NOT APPLICABLE TO PRESENT JOB

FIGURE 9-2. EXAMPLE SAFE WORK PERMIT

TODAY'S DATE ______________________

DATE WORK WILL BE DONE ______________

WORK TO DO	MAJOR HAZARDS EXPECTED	PRECAUTIONS TO CONTROL HAZARDS

FIGURE 9-3. SAFE JOB INSTRUCTIONS SHEET

to remind the workers of potential dangers and safety practices before entering a confined space.

Equipment Test

Before leaving the maintenance yard at the start of each day, safety equipment must be carefully inspected and tested. Where functional capacities are doubtful, replacement equipment should be used while the defective or suspect equipment is repaired and further tested.

Disinfectants

In cases where a manhole that must be entered is located reasonably close to the discharge of a hospital, venereal treatment center, clinical laboratory, surgical facility, or a veterinarian's office and hospital, a disinfectant may be required in the manhole and the upstream line, one or two hours ahead of scheduled entry. While this action may result in other problems and strong odors in the manhole, this may be the recommended procedure, rather than risk exposure of workers to the diseases which are possible in such manholes. Because disinfectants are poisons, it is important to not enter a manhole when the odor of a disinfectant is present.

Most state and local health departments have laws and regulations that prevent the discharge of infectious wastes into wastewater collection systems until after they have been disinfected (usually in an autoclave that disinfects by using steam). Contact the medical officer in charge of any medical facility immediately upstream from manholes and sewers in which you must work. This person should be able to explain the disinfection procedures used by the medical facility, indicate if the threat to your health is significant, and recommend any special precautions or disinfectants that may be necessary.

Washdown

All manholes, but especially ones which are filthy, infested, contain slime or scum, or smell of hydrogen sulfide or insecticides, should be washed down with high velocity clearwater, preferably dosed with HTH, a disinfectant, before sending a worker down into the manhole. This wash is best done within an hour before entry.

Pesticides

Where insects have been a problem, and where rats or other vermin may occupy a collection system, or where epidemics of insect borne diseases may be present, spraying a manhole with pesticide is suggested. The poison solution should be water soluble, and leave a toxic residue to be effective against the next hatch of any insects present and breeding in the collection system. Spraying should be conducted at the time of manhole entry if insects or other problems are observed. The manhole should be ventilated so that the pesticide will not be inhaled by workers.

Tools, Materials, and Equipment

Prior to sending a worker into a manhole, a careful inventory and examination of the condition of all required tools, materials, and equipment needed for the work should be made. Exposure to injury is greatest while a worker is descending into, or climbing out of a manhole. Therefore, job organization and equipment requirements should be arranged to permit all work to be done with a single entry and exit of the manhole.

MANHOLE ENTRY PROCEDURES

The minimum sized crew for work requiring manhole entry is three workers. One worker enters the manhole, another acts as lifeline attendant, and the third stands by and assists on the surface. Both of these topside workers must be physically able to lift the worker out of the manhole in an emergency. The safety and other equipment is generally the responsibility of the entire crew. However, a support crew may be needed to direct traffic and provide other needed assistance. The following is a step-by-step procedure which should be followed for any manhole entry operation, or before entering any confined space:

1. Always organize and plan the work to be done before entering the manhole. Avoid prolonged stays in manholes.

2. Place markers and safety cones around the work area, and park trucks and vehicles to protect the working area from traffic. If necessary, place a cage enclosure around the manhole. An open manhole should always be attended.

3. The portable explosivity/oxygen alarm must be calibrated BEFORE removing the manhole cover. Test for combustible gas before removing the cover because removing the cover may ignite a spark which could cause an explosion. Test the manhole from top to bottom for oxygen deficiency, explosive, and toxic gases. Also, it is helpful to know conditions in the manhole before any ventilation occurs.

   If an explosive atmosphere is discovered in a manhole:

   a. Immediately notify the supervisor that an explosive condition has been discovered and provide as many details as possible, especially location of the hazard. Request notification of police and fire departments.

   b. Do not remove manhole cover.

   c. Turn off any running engines in the vicinity that could cause a spark.

   d. Inspect upstream and downstream manholes for explosive conditions to determine the extent of the problem.

   e. Route traffic off the street to reduce potential for explosion.

   f. Notify industrial waste inspectors and wastewater treatment plant operators.

   g. Attempt to locate the source of the problem and correct the situation.

   h. Cautiously and continuously ventilate the system with a large blower to eliminate the explosive hazard. Try ventilating from a safe upstream or downstream manhole in order to keep workers and equipment away from explosive conditions.

4. Use proper tools to remove the manhole cover. Never use only your hands.

5. Open manholes upstream and downstream from the work area to encourage natural ventilation of the sewer. Be sure all open manholes are properly barricaded and covered with grating.

6. Clean the area around the manhole opening, including the manhole ring and lid ledge, and remove all loose debris. Sweep the area before removing the manhole cover, and clean the ring ledge after the cover has been removed. Test for oxygen deficiency and toxics from top to bottom. Wash down manhole and rings with a water jet, preferably dosed with HTH.

7. Start the ventilation blower and purge the manhole atmosphere prior to entry. Locate the blower upwind of the manhole and at least ten feet from the manhole opening. If the blower has a gas driven engine the exhaust must be downwind from the manhole. Place the air intake to the blower from two to five feet above the ground surface, depending on conditions (higher for dusty ground surfaces). Some agencies prefer to exhaust or pull air from the downstream manhole if possible.

8. The person entering the manhole must put on all necessary personal protective apparel and use all necessary safety tools, devices, and equipment, including hard hat, safety harness with lifeline attached, gloves, etc. Another crew member or the foreman should inspect for proper fit and condition.

9. Before entry into the manhole, make sure the brickwork is sound and the steps are safe.

10. Continue to use the alarm system to test for the presence of an oxygen deficiency and explosive and toxic gases in the manhole atmosphere the entire time the worker is in the manhole.

11. Employees entering a manhole must not carry anything in their hands. Needed equipment must be lowered prior to entry by the employee when possible. Equipment should be lowered only when ordered and never dropped. Use a sling or material lift hoist.

12. Equipment and materials on the surface must be kept far enough away from the manhole so that they will not be accidentally kicked or dropped into the manhole.

13. The condition of employees in a manhole should be checked regularly by verbal communication.

14. Do not enter a confined space without a qualified stand-by assistant constantly stationed at the point of entry. AT NO TIME SHALL AN EMPLOYEE IN A MANHOLE BE LEFT UNATTENDED.

15. Before engaging in work in public rights-of-way, warning signs or traffic control devices must be placed in areas easily seen by approaching traffic, i.e. cones and flashing lights. Where further protection is needed, suitable barricades must be erected. When the nature of work and traffic requires it, a flagman must be stationed to warn traffic of the hazards.

16. When openings or obstructions are made in streets, side-walks, or on private property, danger signals, such as warning signs, cones and flags, must be

effectively displayed. At night warning lights must be prominently displayed. Excavations and openings must be enclosed with suitable barricades.

17. When working on private or public property, reasonable effort must be made to avoid creating hazards to persons or causing unnecessary property damage. Signs, barricades, tools, equipment and excess materials must be removed from the site when the job is completed.

18. When equipment or obstructions are left on a roadway overnight, the following precautions must be taken:

    a. Do not obstruct fire hydrants or entrances to parks, playgrounds, churches, houses or schools unless absolutely necessary;

    b. Lock, block or otherwise secure; and

    c. Place approved warning devices where needed.

19. The manhole safety enclosure (cage support with a winch) must be placed around the manhole.

20. Rescue procedures will vary, however, some general guidelines are:

    a. Call for help (oral, radio, and/or telephone).

    b. Qualified rescuers must put on self-contained air units, life lines, harnesses, and other necessary equipment before entering the confined space.

    c. Upon reaching the victim, assess the injury and the nature of the accident.

    d. Administer first aid and prepare to move the victim.

    e. Move the victim with care.

    f. There must always be a top person even during rescue attempts.

21. Before using power tools in confined spaces, test the working atmosphere. Use personal protective equipment, and utilize continuous atmosphere monitoring.

22. Do not use fuel-powered tools in confined spaces.

23. Facial hair that would interfere with proper sealing of a respirator is not allowed.

PRECAUTIONS WHEN WORKING IN TRAFFIC

When collection system maintenance work requires the disruption of traffic, safety precautions must be taken to ensure the safety of the workers, motorists, and pedestrians.

This is accomplished through proper planning, barricades, warning signs and flagmen, as appropriate.

When it is determined that traffic disruption will occur, the following procedure should be followed:

1. Determine if the road on which traffic will be disrupted is state, county, or locally owned.

2. Contact the proper state, county, or local authorities and indicate the date, location, and projected duration of the traffic disruption. A permit may be required so be sure to call in advance.

3. Determine proper safety and warning procedures for the specific job. This will depend on a number of factors such as:

   a. Type of maintenance work.
   b. Duration of maintenance work.
   c. Type of road.
   d. Speed limit on road.
   e. Traffic patterns.
   f. Location of work.

If excavation is required for the maintenance work, provisions for excavation equipment will be needed. Duration of maintenance work is very important for determining working procedures. Work completed in one day will not require night time warning systems such as electric lights.

The type of road can range from a residential street to a highway. The average traffic speed is a good indication of the potential hazard. Roads that have a high speed limit (35-55 mph) usually have more congested traffic patterns and, therefore, pose more potential hazards to workers due to the high speeds and heavy traffic. Roads with lower speed limits (up to 35 mph) tend to have less congested traffic patterns and pose less hazards to workers. Location of work is also important. Work in a traffic lane is more hazardous than shoulder work, and work in an easement beside the shoulder is even less hazardous.

Regardless of the degree of hazard involved with traffic disruption, safety precautions must be used. It is important that the traffic be warned of the work and that warning precautions are set up far enough in advance of the work site so that motorists have a chance to slow down, change lanes, and become alert to the situation. There are many types of warning devices, the ones most commonly used are listed below:

1. Barricades - should be reflectorized and stabilized (usually with sand bags).

2. Reflectors.

3. Reflectorized drums, usually 55 gallon size. The drums should not be weighted with sand or water to the point where they are a hazard to motorists. Weighting should be great enough so the barrel does not blow over, but not so great that it could cause a hazard in a collision.

4. Sandbags. If sandbags are used, they must be coated with reflectorized paint.

5. Cones. Cones should be bright orange.

6. Flags. Flags are usually used in conjunction with barricades, barrels, sandbags, or cones.

7. Caution, warning, and directional signs.

8. Warning lights. These are usually attached to reflectorized barricades or drums and must be used during dark hours at excavations, obstructions, or other hazards. Flashing lights should be used when barricades are used singly and steady lights should be used when barricades are used in series.

9. Flagmen.

All workers must wear orange vests when working in traffic to optimize their visibility to motorists. Using common sense when working in traffic can also reduce the number of potential hazards. Instructions on proper use of warning devices can be obtained from the state department of transportation.

SAFETY RECORDS

Unfortunately, accidents do happen in spite of the precautions taken. To prevent similar accidents from occurring, an accident report should be completed as soon as possible after the event. Complete accident reports also help if there is legal action. An example accident report is shown in Figure 9-4. When accidents do occur, emergency telephone numbers should be available and stored in a well known location. Emergency telephone numbers should be entered by each Agency into Table 9-2 for future reference.

Department: ______ Section: ______ Index No. ______

Name of Injured Employee: ______ Social Security No. ______

Home Address of Employee: ______ Phone: ______

Date of Birth: ______ Sex: M F Wage at Time of Accident: ______

No. of Hours Worked: Per Day: ______ Per Week: ______ No. of Days Per Week: ______

Classification: ______ Date of Hire: ______

Place of Accident: ______ City/Town: ______

Date of Accident: ______ Time: ______ Date Reported: ______ Time: ______

Did employee return to work on date of injury? ______ Lost Time: ______ Days/Hr.

Was employee off work beyond date of injury? ______

If so, last date worked: ______

Nature of injury (specify part of body injured?): ______

Was employee acting in regular line of duty when injured? ______

If No, Explain: ______

How did the accident occur? ______

Was first aid given? ______ By whom? ______

Doctor: ______ Address: ______

Hospital (If Any): ______ Address: ______

What machine, tool substance, or object was most closely connected with the accident? ______

Were mechanical guards or other safeguards provided? ______

Were mechanical guards or other safeguards used? ______

What, in your opinion, caused the accident? ______

Describe Any Unsafe Act: ______

Describe Any Unsafe Conditions: ______

What has been done to prevent a similar accident? ______

Witnesses: ______

Signed: ______
Date: ______
Phone: ______

For Further Particulars Please Use Reverse Side

FIGURE 9-4. EXAMPLE SUPERVISOR'S REPORT OF ACCIDENT

TABLE 9-2. LIST OF EMERGENCY TELEPHONE NUMBERS

	Phone Office	Phone Home
1. PHYSICIANS/AMBULANCE/HOSPITAL		
Dr. ______	______	______
Dr. ______	______	______
Ambulance ______	______	______
Ambulance ______	______	______
Hospital ______	______	______
Hospital ______	______	______
2. FIRE		
Department ______	______	______
Department ______	______	______
3. POLICE		
Town Police ______	______	______
County Sheriff ______	______	______
Deputy ______	______	______
State Police ______	______	______
Headquarters ______	______	______
4. POWER COMPANY		
Name ______	______	______
Name ______	______	______
5. TELEPHONE COMPANY		
Name ______	______	______
Name ______	______	______
6. GAS COMPANY		
Name ______	______	______
Name ______	______	______
7. ELECTRICIANS		
Name ______	______	______
Name ______	______	______
Name ______	______	______
8. PLUMBERS		
Name ______	______	______
Name ______	______	______
9. HEAVY EQUIPMENT OPERATORS		
Name ______	______	______
Type of Equipment Available ______		
Name ______	______	______
Type of Equipment Available ______		

TABLE 9-2 (Cont.). LIST OF EMERGENCY TELEPHONE NUMBERS

	Phone Office	Phone Home
10. EXTRA LABOR		
Name __________	__________	__________
Name __________	__________	__________
11. CONSULTING ENGINEER		
Name __________	__________	__________
Name __________	__________	__________
12. TOWN OFFICIALS		
Name __________	__________	__________
Name __________	__________	__________
Name __________	__________	__________
Name __________	__________	__________
13. COUNTY HEALTH DEPARTMENT		
Official __________	__________	__________
Official __________	__________	__________
14. ILLINOIS ENVIRONMENTAL PROTECTION AGENCY		
Name __________	__________	__________
Name __________	__________	__________
15. FEDERAL ENVIRONMENTAL PROTECTION AGENCY REGIONAL OFFICE		
Official __________	__________	__________
Official __________	__________	__________
16. AREA CIVIL DEFENSE		
Official __________	__________	__________
Official __________	__________	__________
17. OTHER		
__________	__________	__________
__________	__________	__________
__________	__________	__________
__________	__________	__________
__________	__________	__________
__________	__________	__________
__________	__________	__________
__________	__________	__________

CHAPTER 10

BUDGETING

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INTRODUCTION

Part of meeting the Metropolitan Sanitary District of Greater Chicago's requirement of developing a long-term operation and maintenance program is to insure that adequate funding is available each year to complete routine operations and preventive maintenance functions. Annual budgets must be developed by each agency which summarizes the anticipated expenses for performing the necessary tasks in the agency's accepted operation and maintenance program. The revenue available for each agency's sewer system operation and maintenance program must be adequate to cover the budgeted expenses.

When preparing an annual budget for the operation and maintenance of a sanitary sewer collection system, the scope of work required to carry out the yearly objectives of the planned operation and maintenance program must be defined. Alternate methods of accomplishing the planned objectives must be evaluated. After methods have been selected for completing the operation and maintenance functions, specific tasks to be performed need to be defined. The types and quantities of equipment, materials, and labor must then be estimated for each task. Costs are subsequently established for the equipment, materials, and labor needed to complete each task and the cost for each task in summed up to develop the overall budget.

When preparing a budget, records of past years labor, material, and equipment costs are essential to the supervisor preparing the budget. Accurate records detailing the current year's job tasks, costs, staff requirements, and productivity, provide the best support for the upcoming year's budget requests. All budgeting programs should be prepared to meet the needs of the agency and accomplish the objective of the operation and maintenance plan. The sanitary sewer system programs are normally competing for funds with other public service departments, so they should be documented well and with the care needed to show their importance.

Budgets will vary for each agency depending on factors such as the size and age of the collection system, the type of collection system, and the amount of equipment owned to maintain the collection system. The key is to budget enough money to be able to perform the maintenance tasks necessary to prevent the deterioration of the sanitary sewer collection system.

MONTHLY OPERATING AND MAINTENANCE COST REPORT

General

A summary of monthly operating and maintenance costs is essential for the management of a sanitary sewer collection system, especially during the preparation of a budget request. The collection system supervisor should be responsible for the preparation of the monthly operations and maintenance report and should submit it to his supervisor. The report should summarize all of the sewer system operation and maintenance activities completed during the month along with a summary of all costs. The costs can be summarized on a form similar to the example form shown in Figure 10-1. The example form can be revised to meet the needs of each agency tributary to the MSDGC facilities. The form can either be filled out manually each month or set up on a computer using one of the spread sheet type software packages currently available.

Routine Operating and Maintenance Costs

There are certain costs that can be normally expected for completing routine operation and maintenance activities in a wastewater collection system. These costs are those needed to complete day to day preventive maintenance activities and activities necessary to meet the requirements of a long-term operation and maintenance program aimed at reducing the quantity of infiltration and inflow entering the wastewater collection system. These costs include but are not limited to the following:

1. Lift Station operation and maintenance costs. Costs involved with operating and maintaining a lift station include:

   a. Labor. The direct labor costs will include costs associated with personnel assigned to inspecting and performing routine maintenance on each lift station.

COMMUNITY/AGENCY NAME ______________________________

MONTH ____________ YEAR ________

PREPARED BY ______________________ TITLE ______________

MONTHLY SEWER SYSTEM OPERATING AND MAINTENANCE COSTS

O&M TASK DESCRIPTION	UNIT OF MEASURE	UNITS THIS PERIOD		LABOR HOURS	LABOR COST	MATERIAL COST	EQUIPMENT COST	TOTAL COST	COMMENTS
		UNITS BUDGETED	UNITS ACTUAL						
ROUTINE O&M COSTS									
Lift Station O&M	Each								
Sewer Cleaning	Ln Ft.								
Roof Cutting	Ln. Ft.								
Minor Sewer Repairs	Ln. Ft.								
Manhole Repairs	Ln. Ft.								
Sewer System Inspections									
Sewer Pipe	Ln. Ft.								
Manholes	Each								
New Construction	Each								
Flow Monitoring	Ln. Ft.								
Response to Customer Complaints	Each								
Subtotal O&M Costs									
Overhead									
Vehicle/Equipment Maintenance	Hours								
Administration	Hours								
Supervision	Hours								
Insurance									
Vacation Leave	Hours								
Holiday Leave	Hours								
Sick Leave	Hours								
Workmen Compensation	Hours								
Training	Hours								
Subtotal Overhead Costs									
Total Routine O&M Costs									

FIGURE 10-1. EXAMPLE MONTHLY OPERATIONS AND MAINTENANCE COST FORM

O&M TASK DESCRIPTION	UNIT OF MEASURE	UNITS THIS PERIOD		LABOR HOURS	LABOR COST	MATERIAL COST	EQUIPMENT COST	TOTAL COST	COMMENTS
		UNITS BUDGETED	UNITS ACTUAL						
ABNORMAL O&M COSTS									
Engineering Studies	Each								
Outside Contracts	Each								
Consulting Services	Each								
New Equipment Purchases	Each								
Replacement Equipment	Each								
Total Abnormal O&M Costs									
TOTAL MONTHLY COSTS									

FIGURE 10-1 (Cont.). EXAMPLE MONTHLY OPERATIONS AND MAINTENANCE COST FORM

b. Materials. The material cost will include all items necessary to perform routine maintenance such as lubricants, cleaning supplies, paint, etc.

c. Equipment. The equipment costs will include any equipment rentals necessary to maintain the lift stations. One piece of equipment that may be rented would be a vacuum truck used to clean lift station wet wells.

2. Sewer cleaning costs.

3. Root cutting costs.

4. Sewer system inspection costs.

5. Periodic flow metering costs.

6. Minor sanitary sewer system repair costs for work items that can be typically planned for.

7. Costs associated with operating, maintaining, and repairing equipment such as inspection, cleaning, and flow metering equipment.

8. Costs associated with customer complaints.

9. Utility costs such as electric, telephone, water, and gas.

10. Map updating costs.

11. Overhead costs such as:

    a. Administration.
    b. Supervisory staff.
    c. Vacation/holiday leave.
    d. Sick leave.
    e. Other employee benefits.
    f. Workman's compensation.
    g. Staff training.
    h. Office supplies and equipment.
    i. Vehicle maintenance and repairs.
    j. Office or storage space rental.

<u>Abnormal Operating and Maintenance Costs</u>

At times the cost to operate and maintain a sanitary sewer collection system will include costs for items that are abnormal or not part of the normal operation and maintenance routine. These costs should still be included on the monthly operation and maintenance cost report. Some typical costs which would not be expected to be part of the normal operation and maintenance routine would be:

1. Costs for engineering studies possibly pertaining to the collection system capacity or system improvements.

2. Major system rehabilitation requiring help from outside contractors.

3. New equipment purchases.

4. Costs for replacing equipment and tools.

The monthly operating and maintenance cost report is developed using specific records such as employee time sheet, equipment usage tickets, purchase order forms, utility bills, invoices from outside contractors and consultants, and any other available cost records.

Employee Time Sheets

Employee time sheets should be coded so that time spent on specific tasks can be easily separated. Figure 10-2 shows an example employee time sheet.

Purchase Orders

Purchase order forms should be filled out in duplicate when ordering equipment, supplies, parts, etc. The first copy is sent to order the requested material; the second copy is filed for future reference. By tabulating the cost of materials purchased through these order forms, the supervisor can control expenses and include purchase order costs in budget figures.

When the items on the purchase orders are delivered, the purchase order information is to be reviewed to insure that all the materials requested have been received. Any discrepancies between the purchase order and the actual shipment should be noted and corrective action taken.

Figure 10-3 represents an example purchase order form.

ANNUAL REPORT

At the end of each calendar year, the supervisor should prepare an annual report for the sewage collection system. The report includes the costs of running the collection system for that year, the additions and changes made to the system during the year, and an evaluation of the sewage system performance.

The summary of annual operating and maintenance costs is an important tool to use when preparing the upcoming year's budget. Cost trends can be observed by reviewing annual cost summaries from the past several annual reports. An example annual cost summary form is shown in Figure 10-4. The monthly operating and maintenance cost report will be useful for preparing the annual cost summary report.

One way to present the annual cost to operate and maintain the sewage collection system is by the ratio of cost to sewage flow through the system. By determining the cost for each operation and maintenance item per volume of sewage, past costs can be compared to

___ /___ /___

WEEK ENDING

Hours Charged to an Account Must be Noted by Day

EMPLOYEE NUMBER

EMPLOYEE NAME

WEEKLY TIME SHEET

	SAT	SUN	MON	TUE	WED	THU	FRI	REGULAR HOURS	OT HOURS	ACCOUNT ABBREVIATION	PROJECT OR ACCOUNT	DEPT. NUMBER	TYPE OF WORK
HOLIDAY										HOLIDAY			
SICK LEAVE										SICK LEAVE			
VACATION										VACATION			
SPECIAL LEAVE										SPECIAL LEAVE			
TIME OFF OFFICE CLOSING										TIME OFF/OFFICE CLOS.			
TOTAL HOURS													

EMPLOYEE SIGNATURE

APPROVED BY SUPERVISOR

FIGURE 10-2. EXAMPLE EMPLOYEE TIME SHEET

Sample Index for Account Numbers, Department Numbers, and Type of Work Codes.

Project or Account No.	Account Abbreviation
XXXX	Sewer Cleaning
XXXX	Inspections
XXXX	Rehabilitation
XXXX	Budgeting
XXXX	Etc.
Dept. No.	
XXXX	Operation and Maintenance
XXXX	Civil Engineering
XXXX	Purchasing
XXXX	Etc.
Type of Work Codes	
XX	Administrative
XX	Training
XX	Technical Report Writing
XX	Sewer Balling
XX	Manhole Inspections
XX	Replacing Manhole Covers
XX	Etc.

FIGURE 10-2 (Cont.). EXAMPLE EMPLOYEE TIME SHEET

TO:

SHIP TO:

PURCHASE ORDER NUMBER: ____________________

WORK ORDER NUMBER: ____________________

DATE INITIATED: ____________________

DATE REQUIRED: ____________________

SHIP VIA: ____________________

F.O.B.: ____________________

TERMS: ____________________

____

____

DATE RECEIVED: ____________________

QUANTITY	STOCK NUMBER/DESCRIPTION	PRICE	PER	TOTAL

APPROVED BY: ____________________ DATE: ____________________

SHEET ______ OF ______

FIGURE 10-3. EXAMPLE PURCHASE ORDER FORM

Agency ____________ Prepared by ________________

19___ Month	Direct Labor S.T.	Overtime	Overhead	Utility Costs	New Equip. Purchases	Equip. Repair	Equip. Rental	Consultant Fees	Contractor Fees	Misc.	TOTAL
JAN											
FEB											
MAR											
APR											
MAY											
JUNE											
JULY											
AUG											
SEPT											
OCT											
NOV											
DEC											
TOTAL											

FIGURE 10-4. EXAMPLE ANNUAL COST SUMMARY FORM

present costs which will help when estimating future costs for each operation and maintenance task. An example of this concept is presented below:

Example:

Year	Equipment Repair Costs	Sewage Flow
1985	$ 3,500	85.2 million gallons
1986	$ 3,900	86.1 million gallons
1987	$ 4,500	87.2 million gallons

The annual cost for equipment repairs per million gallons of sewage flow is therefore:

1985	$ 3,500/85.2	=	$41.08 per mg
1986	$ 3,900/86.1	=	$45.30 per mg (10 percent increase)
1987	$ 4,500/87.2	=	$51.61 per mg (14 percent increase)

By comparing the repair costs to annual inflation rates, a conclusion can be made regarding the condition of the equipment. For example, if the annual cost to repair equipment increases more than the inflation rate it is possible that the equipment is wearing out and soon may need to be replaced.

BUDGET REQUEST REPORT

General

The annual budget request should be presented in a report form so that the request for sewage collection system operation and maintenance funds can be evaluated by agency officials along with budgets from other public works departments.

Each sewage collection system operating and maintenance task should have a scope of work defined for it, along with the desired objectives for performing the task.

The type and quantity of equipment, materials, and labor involved with each task must also be defined. The costs must be established for the involved labor, equipment, and materials. Normally at budget time the existing staff and equipment are evaluated to determine if they will be adequate for completing the upcoming years planned program.

Staff Requirements

Requesting additional staff for meeting increased system operating and maintenance needs is one of the most difficult budget items to present to management. Usually management will not accept a request for more staff when the request is based only on the supervisor's opinion or experience.

It is necessary for a supervisor to support the request for additional staff using data from the operating and maintenance records which are on file. Presentation of records covering several years can indicate a definite trend in activities. The trend observed may verify that the work load has increased and may continue to increase to a point where additional staffing could be justified.

Equipment Needs

The request to purchase additional or replacement equipment must also be justified in the budget request report. When requesting replacement equipment, age may not be the only factor for justifying replacement. Some equipment can be repaired over and over again so that it can be made to last almost forever. What must be considered though is the cost (time and money) to keep a piece of equipment operating. Other pieces of equipment may become outdated before they even need to be repaired. The newer versions of the outdated equipment may be much more productive which may be adequate justification for replacing a certain piece of equipment.

Replacement of sewage system equipment can create a strain on an annual budget when an expensive piece of equipment needs to be replaced and there is no replacement fund. A replacement fund is generally not included as part of an annual sewer system operating budget but should still be a part of the agency's overall budget. In order to determine an amount for the annual replacement fund, a periodic user rate study by a professional should be undertaken. User rate studies assist in determining and comparing the costs versus the revenues generated by the utility. Rates are then adjusted to offset costs and provide a replacement fund for equipment.

Justifying the need to purchase additional equipment will also be required in a budget request report. Records indicating the amount of time logged on a piece of equipment are essential for supporting the need for additional equipment. It is also possible that services previously provided by outside contractors will be incorporated into the agency's operation and maintenance program. Equipment formerly used by the outside contractor will need to be obtained by the agency. Often the need for additional equipment can be justified if more staff are also being requested in the same budget request report. The agency then must decide which option between purchasing, leasing, or renting is more beneficial.

Supplies

The best method to use when estimating the upcoming year's cost for supplies is to review past year's records. The trends observed in supply usage for each type of maintenance task should be reviewed to estimate the future demand for those same supplies.

Outside Contracting Services

When preparing the annual budget, the costs associated with outside contractors should be reviewed to determine if they have increased to the point where it may be more cost-effective to hire additional staff and purchase additional equipment to perform the same tasks in house.

CHAPTER 11

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INTRODUCTION

Scheduling preventive maintenance can be a time consuming and complex problem because of the detail involved. Some ideas will be presented in this chapter which should make planning scheduled maintenance a little easier.

The objective of any preventive maintenance program is to improve the operating conditions in problem areas by scheduling the absolute minimum amount of maintenance. An effective preventive maintenance program tries to predict what problems will be encountered and what measures must be scheduled to prevent the problems from occurring. Preventive maintenance schedules must be flexible and should be periodically revised based on their effectiveness and the ability to accomplish the maintenance objectives. An outline prepared by the ICAP Technical Advisory Panel of a suggested continuous sanitary sewer system maintenance program is included in Appendix D. The ICAP Technical Advisory Panel is an interagency committee consisting of members elected by local officials, sanitary districts, and utility companies tributary to the Metropolitan Sanitary District of Greater Chicago's facilities.

Several forms for keeping records of sewer maintenance activities have been included throughout this chapter and in other chapters of this manual. The forms should be modified as required to fit the needs of each agency. The forms contained herein are only guides to stimulate agencies in developing forms they feel most comfortable with.

RECORDS

General

Preventive maintenance activities cannot be scheduled effectively without the use of sewer system operation and maintenance records. Records are important because they document past work and provide a reasonable base for planning future needs. When reviewing past records of conditions requiring emergency attention, maintenance can be scheduled in time to prevent or reduce the number of emergency situations.

Types of Records

There are many types of records which when kept up to date and filed in useful categories can provide the information needed to schedule maintenance, predict personnel requirements, prepare budgets, estimate operating costs, and assess the performance of the sewer system. These records include the following categories:

1. Main Sewer Line.

    A. Inventory.

        1. Identification of each line segment.
        2. Size, length, and material of each line segment.
        3. Invert elevations at upstream and downstream manholes.

    B. Maintenance history.

        1. Date of maintenance activity.
        2. Type of equipment used for each maintenance activity.
        3. Labor required for each maintenance activity.
        4. Material required for each maintenance activity.
        5. Time required to perform maintenance tasks.
        6. Reason for the maintenance activity.

    C. Inspection history.

        1. Sewer lamping.
        2. Closed circuit television inspection.

    D. History of stoppages.

        1. Date.
        2. Reason for stoppage.

2. Manholes.

    A. Inventory.

        1 Identification of each manhole.
        2. Locations.
        3. Manhole data.

B. Maintenance history.

1. Date and type of maintenance activity.
2. Reason for maintenance activity.
3. Labor, equipment, and materials required for each maintenance activity.
4. Time required to perform maintenance tasks.

C. Inspection history.

3. Appurtenant Structures (siphons, junction chambers, etc.).

A. Inventory.

1. Identification of each structure.
2. Location.
3. Structure data.

B. Maintenance history.

1. Date and type of maintenance activity.
2. Reason for maintenance activity.
3. Labor, equipment, and material required for each maintenance activity.
4. Time required to perform maintenance tasks.

C. Inspection history.

4. Lift Stations.

A. Inventory.

1. Identification.
2. Location.
3. Lift station data.

B. Equipment.

1. Equipment operating logs.
2. Preventive maintenance requirements.

C. Maintenance history.

1. Date and type of maintenance activity.
2. Reason for the maintenance activities.
3. Labor, equipment, and material required for each maintenance activity.
4. Time required to perform maintenance tasks.

D. Inspection history.

E. Emergency situations.

5. Building Service Laterals and Related Plumbing.

A. Inventory.
B. Maintenance history.
C. Inspection history.
D. Illegal connections.

6. Miscellaneous Sewer System Inspections.

   A. Smoke testing.
   B. Dye water tests.

7. Equipment.

   A. Inventory.
   B. Depreciation records.
   C. Equipment operating logs.
   D. Preventive maintenance requirements.

8. Personnel.

   A. Employee file.
   B. Attendance file.
   C. Work assignments.
   D. Pay records.

9. Miscellaneous records.

   A. Accident reports.
   B. Emergency calls.
   C. Complaints.
   D. Safety training activities.
   E. Job related training.
   F. Budget request documentation.
   G. Sewer system maps.
   H. Engineering studies.
   I. Construction plans and specifications.
   J. Contracts
      1. Engineers.
      2. Contractors.

SCHEDULING MAINTENANCE

<u>General</u>

The outline for a continuous sewer system maintenance program prepared by the ICAP Technical Advisory Panel has been included in Appendix D of this manual. The outline provides suggested preventive maintenance frequencies for the various aspects of a preventive maintenance program. However, a large number of variables must be considered by each agency in order to develop the type of preventive maintenance program that works best for their system. Preventive maintenance scheduling will depend on several factors including but not limited to the:

1. Type of system users (residential, commercial, or industrial).

2. System age.

3. Construction methods used.

4. Quality of construction.

5. Past maintenance activities.

Since the characteristics of the sub-areas within an agency's system can be very different, many agencies may need to develop different preventive maintenance schedules for each sub-area. For example, an agency with both new sewer areas and old sewer areas may need to schedule sewer cleaning and closed circuit TV inspections more frequently in the older sewer area.

Long-term Planning

Because of the many variables that must be considered when preparing a preventive maintenance schedule, it is not likely that any two agencies will develop identical long-term maintenance schedules. Each agency must review and use past records to develop a long-term preventive maintenance program that schedules just enough maintenance to provide maximum protection against the entry of excessive infiltration and inflow, equipment failures, sewer line blockages, pavement collapse, and other emergency conditions.

As guidance to each agency, suggested long-term preventive maintenance schedules have been provided in Figures 11-1, 11-2, and 11-3 for a typical old, stable, residential community, a new, growing residential community and a mostly industrial and commercial community, respectively.

Unscheduled Maintenance

Certain types of maintenance activities cannot be scheduled into a long-term preventive maintenance program. Maintenance activities that fit into this category include responses to complaints and emergency situations such as sewer line blockages and equipment failures.

Scheduling specific repairs for deteriorated portions of the sewer system is also difficult to include in a long-term maintenance schedule. An effective preventive maintenance program allows for early detection of sewer system deterioration so that minor repair work can be completed as necessary instead of waiting for major repairs and full-scale sewer rehabilitation program. Effective preventive maintenance should also reduce but probably not eliminate the number of complaints and emergency situations that may occur. Therefore, unscheduled maintenance activities must be planned for each year and included as part of the annual budget.

Estimating sewer system repair requirements and the number of responses to complaints, sewer blockages, equipment malfunctions and other emergency situations may seem like a difficult task. However, when using past records as the basis for making the estimates, the "guess-work" can usually be relatively accurate.

Records should be kept for each occurrence of a complaint, equipment malfunction, and emergency condition. Figures 11-4, 11-5, and 11-6 are example forms that can be used to record the equipment malfunctions, emergency conditions, and complaints, respectively.

Type of Community: Old, Stable, Residential Community
Some Typical Characteristics Affecting
Long-term Sewer Maintenance Requirements:
- High Infiltration Potential
- Potential for Illegal Building Connections
- Little Potential for Sewer System Growth

MAINTENANCE TASK	SUGGESTED CYCLE	COMMENTS
Sewer Map Updating	1 year	- Very few if any changes to sewer maps each year. - Primarily changes will be related to sewer system rehabilitation.
Sewer Cleaning	1-5 years	- Problem areas may require more than 1 cleaning per year. - Areas recently rehabilitated may require less frequent cleaning than unrehabilitated areas. - Some areas may be "self-cleaning" allowing for a longer than 5-yr. cleaning cycle. - Frequency of sewer cleaning should be adjusted over time to provide minimum amount of cleaning necessary to prevent blockages. - Root removal or control may be necessary because of older sewer and established trees.
Inspections:		
Sewer Lamping	5 years	- Should be done in conjunction with manhole inspections. - Additional maintenance, such as TV inspections or sewer cleaning may be required as a result of the sewer lamping.

FIGURE 11-1. SUGGESTED LONG-TERM MAINTENANCE SCHEDULE FOR AN OLD, STABLE, RESIDENTIAL COMMUNITY.

MAINTENANCE TASK	SUGGESTED CYCLE	COMMENTS
Inspections:		
Manhole Inspections	5 years	- Should be done in conjunction with sewer lamping. - More frequent inspections may be required where manholes are located in heavily used roadways. - Defects should be noted and scheduled for repairs.
Exterior Private Building Inspections	5 years	- Inspections can be done in conjunction with manhole inspections and sewer lamping. - Building exteriors should be checked for downspouts that have been connected to below grade discharge. Overland sump pump discharges should be checked for evidence of operation. - Inspections may be initiated by observing excessive wet weather sewer flows.
Lift Stations	As Needed	- See Chapter 4 for some suggested cycles for lift station inspections. Inspection cycles can vary from daily inspections to annual inspections. - Follow the manufacturers recommendations for maintaining all lift station equipment.
Closed Circuit TV Inspections	10 years or as needed	- Overall condition of the sewer system and service connections should be assessed using CCTV at least every 10 years. - Should be done if sewer cleaning debris includes pieces of broken pipe. - Should be done more frequently in areas where flow metering indicates that an excessive infiltration problem exists.

FIGURE 11-1 (Cont.). SUGGESTED LONG-TERM MAINTENANCE SCHEDULE FOR AN OLD, STABLE, RESIDENTIAL COMMUNITY.

MAINTENANCE TASK	SUGGESTED CYCLE	COMMENTS
Inspections:		
Smoke Testing	As Needed	- Helpful for locating sources of inflow. Should be done if flow metering indicates an inflow problem.
Dye Water Tests	As Needed	- Can be done if flow metering indicates an inflow problem. - Can be used to confirm suspect private sector inflow sources such as sump pumps and down-spouts that discharge below ground.
Interior Private Building Inspections	5-10 years	- Interior plumbing can be inspected at changes in ownership. - Required in all homes with sump pumps. - More frequent inspections required in areas with known sump pumps when flow monitoring indicates increased wet weather flows.
Flow Monitoring:		
Manual Spot Checks	Several times per year at key manholes	- Several quick flow measurements should be taken for different dry weather and wet weather conditions each year. - When flows appear to increase excessively, spot checks should be followed up with continuous flow monitoring and/or system investigations as needed.

FIGURE 11-1 (Cont.). SUGGESTED LONG-TERM MAINTENANCE SCHEDULE FOR AN OLD, STABLE, RESIDENTIAL COMMUNITY.

MAINTENANCE TASK	SUGGESTED CYCLE	COMMENTS
Flow Monitoring:		
Continuous	10 years or as needed	- Continuous flow monitoring may be needed in isolated areas of the system if the manual spot checks indicate a potential problem. - The entire system should be monitored on a 10 year cycle to more accurately assess the effectiveness of the maintenance program.
Sewer System Repairs	As needed	- Common repairs for an older community can include: - Manhole replacement. - Manhole well repairs. - Manhole bench and channel repair. - Manhole frame sealing. - Manhole rim elevation adjustment. - Spot replacement of sewers. - Sewer grouting. - Sewer lining.

FIGURE 11-1 (Cont.). SUGGESTED LONG-TERM MAINTENANCE SCHEDULE FOR AN OLD, STABLE RESIDENTIAL COMMUNITY.

Type of Community: New, Growing, Residential Community
Some Typical Charateristics Affecting
Long-term Sewer Maintenance Requirements:

- Low potential for infiltration if construction was monitored adequately.
- Low potential for illegal building connections.

MAINTENANCE TASK	SUGGESTED CYCLE	COMMENTS
Sewer Map Updating	1 year	- Many changes may need to be made to the sewer maps each year. - Important to note changes on a working set of maps as the changes occur. - New updated maps should be reprinted at least once a year.
Sewer Cleaning	1-5 years	- Problem areas must be identified/ - Past records will not be available to use when scheduling sewer cleaning frequencies. Effective frequencies must be developed. - Newer sewers may require more frequent cleaning than older sewers if there is minimal I/I because I/I can flush solids from the sewer system during wet weather. - Less root intrusion expected for newer sewers.
Inspections:		
Sewer Lamping	5 years	- Should be done with manhole inspections. - Sewer lamping may reveal areas that require cleaning or internal TV inspections.

FIGURE 11-2. SUGGESTED LONG-TERM MAINTENANCE SCHEDULE FOR A NEW, GROWING RESIDENTIAL COMMUNITY.

MAINTENANCE TASK	SUGGESTED CYCLE	COMMENTS
Inspections		
Manhole Inspections	5 years	- Should be done with sewer lamping. - Newer manholes should not exhibit significant structural damage. - More frequent inspections may be required where manholes are located in the path of construction traffic.
New Construction	Before Acceptance of Work	- Verify that sewers pass infiltration tests. - Verify proper service connection construction. - Make sure rim elevations of manholes are correct. - Make sure all manholes can be located. - Verify performance of all lift station equipment. - Check buildings for illegal connections to the sanitary sewer.
Exterior Private Building Inspections	5 years	- Inspections can be done with manhole inspections and sewer lamping. - Downspouts and sump pump discharges should be checked for changes in discharge points from above ground to below ground.

FIGURE 11-2 (Cont.). SUGGESTED LONG-TERM MAINTENANCE SCHEDULE FOR A NEW, GROWING RESIDENTIAL COMMUNITY.

MAINTENANCE TASK	SUGGESTED CYCLE	COMMENTS
Inspections:		
Lift Stations	As needed	- See Chapter 4 for some suggusted cycles for lift station inspections. Inspection cycles can vary from daily inspections to annual inspections. - Follow the manufacturers recommendations for maintaining all lift station equipment.
Closed Circuit TV Inspections	10 years	- Overall conditions of the sewer system and service connections should be assessed using CCTV at least every 10 years. - More frequent TV inspections would be required if infiltration became excessive or if it was needed to verify a damaged section of the sewer system.
Smoke Testing	As Needed	- Can be done if flow metering indicates there is an inflow problem.
Dye Water Tests	As Needed	- Can be done if flow metering indicates there is an inflow problem. - Can be useful for verifying suspect private sector inflow sources such as sump pumps and downspouts that discharge below ground.

FIGURE 11-2 (Cont.). SUGGESTED LONG-TERM MAINTENANCE SCHEDULE FOR A NEW, GROWING RESIDENTIAL COMMUNITY.

MAINTENANCE TASK	SUGGESTED CYCLE	COMMENTS
Inspections:		
Interior Private Building Inspections	10 years	- Interior plumbing can be inspeced at changes in ownership. - Only necessary if sewer flows become excessive and flow reduction cannot be achieved through public sector maintenance work.
Flow Monitoring:		
Manual Spot Checks	Several times per year at key manholes	- Several quick flow measurements should be taken for different dry weather and wet weather conditions each year. - When flows appear to increase excessively, spot checks should be followed up with continuous flow monitoring and/or system investigations as needed.
Continuous	10 years or as needed	- Continuous flow monitoring may be needed in isolated areas of the sewer system based on manual spot check results. - The entire system should be monitored on a 10 year cycle to more accurately assess the effectiveness of the maintenance program.
Sewer System Repairs	As Needed	- Common repairs for a newer community can include: - Adjust manhole rim elevations. - Seal manhole frames. - Repair settled areas over pipe trenches.

FIGURE 11-2 (Cont.). SUGGESTED LONG-TERM MAINTENANCE SCHEDULE FOR A NEW, GROWING RESIDENTIAL COMMUNITY.

Type of Community: Established Industrial/Commercial Community
Some Typical Characteristics Affecting
Long-term Sewer Maintenance Requirements:

- More rapid sewer system deterioration expected when compared to residential areas.
- Infiltration potential high.

MAINTENANCE TASK	SUGGESTED CYCLE	COMMENTS
Sewer Map Updating	1 year	- For an established community, very few map changes are expected. Changes will primarily be related to sewer system rehabilitation.
Sewer Cleaning	1-5 years	- Make sure sewer cleaning chemicals do not react adversely with industrial or commerical discharges. - Frequency of cleaning can be determined by reviewing past records. - Problem areas may require more than one cleaning per year. - Grease may be a significant problem downstream of restau rants.
Inspections:		
Sewer Lamping	3-5 years	- Because sewer deterioration can occur at a faster pace in sewers carrying industrial discharges, more frequent sewer lamping may be necessary. - Sewer lamping may identify sewer sections in need of cleaning, TV inspections, or repair.

FIGURE 11-3. SUGGESTED LONG-TERM MAINTENANCE SCHEDULE FOR AN ESTABLISHED INDUSTRIAL/COMMERCIAL COMMUNITY.

MAINTENANCE TASK	SUGGESTED CYCLE	COMMENTS
Inspections:		
Manhole Inspections	3-5 years	- Should be done with sewer lamping. - More frequent inspections may be required in areas of heavy industrial traffic.
Lift Stations	As Needed	- See Chapter 4 for some suggested cycles for lift station inspections. Inspections can vary from daily to annual inspections. - Follow the manufacturers recommendations for maintaining all lift station equipment.
Closed Circuit TV Inspections	5-10 years	- In areas where industries discharge aggressive chemicals to the sewer system TV inspections should be perform on a 5 year cycle to assess the condition of the sewers. - TV inspection can be performed on a 10 year cycle in areas where industrial or commercial discharges are neutral and non-aggressive. - More frequent inspections may be required if flow monitoring indicates an excessive infiltration problem. - Should be performed if sewer lamping indicates possible structural damage to the sewers.

FIGURE 11-3 (Cont). SUGGESTED LONG-TERM MAINTENANCE SCHEDULE FOR AN ESTABLISHED INDUSTRIAL/COMMERCIAL COMMUNITY.

MAINTENANCE TASK	SUGGESTED CYCLE	COMMENTS
Inspections:		
Smoke Testing	As Needed	- Can be done if flow monitoring indicates an inflow problem.
Dye Water Tests	As Needed	- Can be done if flow monitoring indicates an inflow problem. - Can be used to confirm suspect private sector inflow sources such as sump pumps and down-spouts that discharge below ground. Can also be used to confirm illegal plumbing on loading dock trench drains.
Private Building Inspections	10 years	- Should be done more frequently if flow monitoring indicates an excessive inflow problem that cannot be accounted for in the public sector. - Interior and exterior plumbing on all buildings should be in-pected at changes in building ownership.
Flow Monitoring:		
Manual Spot Checks	Several times per year at key manholes	- Several quick flow measurements should be taken for dry weather and wet weather conditions each year. - When flow appear to increase excessively, spot checks should be followed up with continuous flow monitoring and/or system investigations as needed.

FIGURE 11-3 (Cont). SUGGESTED LONG-TERM MAINTENANCE SCHEDULE FOR AN ESTABLISHED INDUSTRIAL/COMMERCIAL COMMUNITY.

MAINTENANCE TASK	SUGGESTED CYCLE	COMMENTS
Flow Monitoring:		
Continuous	10 years	- More frequent continuous flow monitoring may be required in isolated areas where spot checking of flows resulted in higher than expected flows. - The entire sewer system should be accurately monitored for flow on a 10 year cycle in order to evaluate the overall effectiveness of the long-term maintenance activities.
Sewer System Repairs	As Needed	- Common repairs for an established industrial/commercial community can include: - Adjustment of manhole rims. - Manhole frame sealing. - Manhole wall repairs. - Manhole bench and channel repairs. - Sewer replacement. - Sewer lining.

FIGURE 11-3 (Cont). SUGGESTED LONG-TERM MAINTENANCE SCHEDULE FOR AN ESTABLISHED INDUSTRIAL/COMMERCIAL COMMUNITY.

EQUIPMENT NAME AND NUMBER	SERIAL NO.	LOCATION

DATE OF TROUBLE	TIME	REPORTED BY	SHIFT

INDICATION OF TROUBLE		WHEN DISCOVERED	CAUSE OF TROUBLE
☐ BROKEN PART	☐ DIRTY, FOULED	☐ STARTING	☐ HEAT/COLD/WEATHER
☐ WORN PART	☐ VOLTAGE	☐ STOPPING	☐ HUMIDITY/MOISTURE
☐ HEAT	☐ CURRENT	☐ DURING OPERATION	☐ FOREIGN OBJECT
☐ NOISE	☐ RESISTANCE	☐ DURING PREVENTIVE MAINT.	☐ SHOCK/VIBRATION
☐ SMELL	☐ FLOW RATE	☐ DURING CORRECTIVE MAINT.	☐ WEAR
☐ VIBRATION	☐ PRESSURE	☐ DURING OVERHAUL	☐ EQUIPMENT DEFECT
☐ LEAKING	☐ SPEED	☐ OTHER ______	☐ IMPROPER INSTALLATION
☐ OTHER ______			☐ IMPROPER LUBRICATION
			☐ IMPROPER OPERATION
			☐ OTHER ______

REMARKS AND RECOMMENDATIONS ______

CHECK IF EQUIPMENT WAS TAGGED OUT OF SERVICE ☐

FIGURE 11-4. EXAMPLE EQUIPMENT MALFUNCTION REPORT

DATE ______________________ OPERATOR ______________________

UNUSUAL CONDITION: CHECK (✓)

☐ EXPLOSION	☐ POWER FAILURE
☐ FLOODING	☐ FIRE
☐ VANDALISM	☐ LINE COLLAPSE OR BLOCKAGE
☐ EQUIPMENT FAILURE	☐ OTHER

REASON FOR CONDITION ______________________

DAMAGES, INJURIES, ETC. ______________________

ACTION TAKEN (WHO NOTIFIED, WHAT DONE) ______________________

REMARKS ______________________

SIGNED ______________________

OPERATOR ON DUTY

FIGURE 11-5. EXAMPLE EMERGENCY CONDITIONS REPORT

DATE ____________________ TIME ____________________

COMPLAINT BY ____

ADDRESS ____

TELEPHONE ____

LOCATION OF COMPLAINT ____

____

DETAILS OF COMPLAINT ____

CHECK (✓) COMPLAINT

SEWER SYSTEM COMPLAINTS

- ☐ MANHOLE COVER MISSING
- ☐ MANHOLE COVER LOOSE OR NOISY
- ☐ ODORS-GASES
- ☐ MANHOLE CAVE-IN
- ☐ LINE CAVE-IN
- ☐ MANHOLE FLOODED
- ☐ STREET FLOODED
- ☐ YARD FLOODED
- ☐ BUILDING FLOODED
- ☐ OTHER

LIFT STATION COMPLAINTS

- ☐ ODORS
- ☐ FLOODING
- ☐ STOPPAGES
- ☐ UNKEPT GROUNDS
- ☐ SPILLS
- ☐ OTHER

ACTION TO BE TAKEN:

- ☐ IMMEDIATE INSPECTION
- ☐ IMMEDIATE REPAIR
- ☐ OWNER'S REPAIR
- ☐ FUTURE REPAIR
- ☐ WATER DEPARTMENT NOTIFIED
- ☐ HEALTH DEPARTMENT NOTIFIED
- ☐ OTHER ____________________

COMPLAINT RECEIVED BY: ________________________________ DATE: ____________

FIGURE 11-6. EXAMPLE COMPLAINT FORM

Records from previous years can be reviewed and used to make the estimate necessary to plan for the probable number of unscheduled maintenance activities for a given year.

SCHEDULING ANNUAL MAINTENANCE

In order to prepare an annual budget or make a determination if the current level of personnel is adequate to carry out the preventive maintenance program for the upcoming year, an annual schedule must be developed at the beginning of each year which identifies the maintenance tasks and the estimates of the manhours required to complete the tasks. Preventive maintenance activities that will be done by outside contractors should also be included on the annual schedule so they can be included in the budget.

When preparing the annual schedule, the long-term maintenance schedule should be used to determine which scheduled work items need to be done for a particular year. Work items that can definitely be scheduled include activities such as lift station inspections, routine maintenance on lift station equipment, routine sewer cleaning, manhole inspections, sewer lamping, closed circuit television inspections, flow monitoring, and sewer map updating to name a few.

Past records should be examined to determine the quantity of unscheduled maintenance activities that must be planned such as sewer system repairs, smoke testing, dye water tests, and emergency responses.

Figure 11-7 shows an example form which can be used to summarize all of the expected annual preventive maintenance activities. The example form has been filled out as it would appear for a typical small established residential community with a population of 1100. There are 24,000 linear feet of public sector sewers in the community along with 64 manholes. There are also 3 lift stations which require periodic maintenance. It is apparent from looking at Figure 11-7 that a form of this type can be very helpful for preparing the annual budget or determining if the current staff level is adequate for completing the annual program.

One type of record that can be used to assign the productivity rates to the different types of work is a daily progress report. An example daily progress report is shown in Figure 11-8. The daily progress report summarizes all work completed in one day and the number of hours spent by the work crew for completing each task.

SCHEDULING PREVENTIVE MAINTENANCE WORK USING A CARD SYSTEM

Introduction

A card system can be a very effective way to organize a preventive maintenance program if implemented properly. The purpose of a card system is to make sure maintenance work is completed on schedule and that accurate records of the work are kept.

Organization

A card system can be organized in many different ways. The following is a suggested format for organizing a card system. Each agency should customize their format to their

Annual Preventive Maintenance Schedule

Year: ____________________

Prepared by: ____________________

Approved by: ____________________

0 & M Activity	Total System Quantity	Scheduled Work J F M A M J J A S O N D	Productivity Rate	Total Mandays Required
Sewer Mapping:				
Updating	1 Set	1 Set	80 hrs/set	10.0
Flow Metering:				
Spot Checks	3 Key MH	72 Spot Checks	0.5 hr/MH	4.5
Continuous	6 Key MH	2 Key MH	80 hrs/MH	20.0
Inspections:				
Manholes	64	16 MH	0.5 hr/MH	1.0
Sewer Lamping	24,000 LF	6000 LF	0.0025 hr/LF	1.9
Private Bldg.	300	30	0.75 hr/Bldg.	2.8
TV Inspections	24,000 LF	2000 LF	0.03 hrs/LF	7.5
Dyed Water	24,000 LF			
Smoke Testing	24,000 LF	1000 LF	0.024 hrs/LF	3.0
Lift Stations	3	156 Inspections/YR	2.0 hrs/Insp.	39.0
Inv. Siphons	1	12 Inspections/YR	2.0 hrs/Insp.	3.0
Junction Chamb.	0			
Div. Structures	0			
New Const.	—			
Sewer Cleaning	24,000 LF	8000 LF	0.024 hrs/LF	24.0
Rehabilitation:				
Manholes:				
Replace	64	2	24 hrs/MH	6.0
Seal Frame	64	6	12 hrs/MH	9.0
Replace Cover	64			
Seal Walls	64			
Pipe Seal	64			
Sewers:				
Grout	24,000 LF	1000 LF	Contract Out	0
Replace	24,000 LF	800 LF	Contract Out	0
Line	24,000 LF			
Service Repairs	300	2	Contract Out	0
Lift Station Main.	3	36 Maint. Visits/YR	10 hrs/Visit	45.0
Emergency Response:				
Complaints	—	5/YR	8 hrs/comp.	5.0
Blockages	—	2/YR	24 hrs/blck.	6.0
Equip. Fail.	—	2/YR	32 hrs/Fail.	8.0
TOTAL				195.7

FIGURE 11-7. EXAMPLE ANNUAL PREVENTIVE MAINTENANCE SCHEDULE

NAME ______________________ DAY __________ DATE __________ 19 __

	NAME	PRODUCTION	STAND BY	FIELD REPAIR	TRAVEL	SHOP	OTHER	HRS	TOTAL
CREW CHIEF									
SECOND MAN									
THIRD MAN									
FOURTH MAN									
TOTAL HOURS									

WEATHER CONDITIONS ______________________________

WORK PHASE	DISTRICT	MANHOLE REACH	EQUIPMENT USED	MILEAGE	TIME SPENT

SIGNED ______________________

FIGURE 11-8. EXAMPLE DAILY PROGRESS REPORT collection system. In this format the card system is used in conjunction with maintenance forms. The card system ensures that maintenance work is scheduled in a timely manner. The maintenance forms ensure that accurate records are kept for future reference.

Using this format a maintenance card is filled out for each component of the sewer system. This means that every manhole, sewer segment, lift station, junction chamber, siphon, building, etc. is assigned a card. In addition, a maintenance card for each piece of sewer equipment and a card for sewer map updating will need to be developed. It is recommended that 2 identical cards be filled out for each sewer system component, so that 2 sets of cards can be stored in separate filing systems. One set of cards should be filed chronologically with respect to the next scheduled maintenance date. The other set of cards should be filed by sewer system categories in order of component identification number. For example, all manhole cards would be filed together in either increasing or decreasing order according to the manhole identification numbers. The purpose of the second set of cards is to enable the supervisor to locate a sewer system component card without knowing when it is scheduled next for maintenance. The importance of both card files can be illustrated by the following example. Three homeowners call the Public Works Department to report that they have sewage backing up in their basements. All of the homeowners who call live in the same general area. The sewer system supervisor assumes that there is a blockage or a partial blockage in one of the sewer lines in the vicinity of where the complaints came from. The supervisor will want to schedule these lines immediately for lamping and cleaning to locate and relieve the problem. Since it would be difficult to quickly find the maintenance cards for the sewer line segments near the complaining homeowners in the card system filed chronologically by next scheduled maintenance date, the supervisor can go directly to the card system filed in categories by component number. By referencing the sewer map the supervisor will be able to identify which sewer segments are in the area of the blockage. The cards for these sewer segments can be pulled and the next scheduled maintenance date which appears at the top right-hand corner will indicate where in the chronologically ordered file the duplicate card is located. This card can be pulled from the chronologically ordered file and scheduled for immediate maintenance. After the sewer blockage is cleared, a future maintenance task for the sewer segment that was blocked will be scheduled. The future maintenance date will be placed in the upper right-hand corner of both cards. Both cards will then be re-filed in their respective filing systems.

It should be noted that setting up the card system can be a labor intensive process, especially for large collection systems. A detailed sewer map and an equipment listing can be useful tools when filling out the cards. Each card will serve as a record for all inspection, maintenance, and rehabilitation work performed on the sewer system component. The maintenance form will serve as detailed records of the work completed.

Some suggestions for information that should appear on the cards are:

1. Top, right-hand corner should be reserved for the next scheduled maintenance date. The date should be written in pencil so it can be erased and re-entered, or typed on stickers so that stickers can be placed on top of the previous sticker to indicate the next maintenance date.

2. Component name (i.e. sewer segment, manhole, lift station, siphon, equipment name, etc.).

3. Component location, installation date, and material. Sewer segments should be identified as stretches between manholes. The manholes can be identified by street address and/or unique identification number. Installation date will

provide information regarding the age of the component. The component material is important when deciding what type of rehabilitation method to use.

4. Date maintenance work was scheduled.

5. Date maintenance work was completed.

6. Type of work completed. Examples of different types of work which could be applicable for the item to be maintained appear at the bottom of the card. If the work completed is not listed at the bottom of the card, write-in the type of work completed in the "type of work" or "work completed" column on the card.

7. Specific information that is important for the component. For example, for sewer segments and manholes the type of equipment used for the maintenance work is important for future reference in scheduling more maintenance work.

8. Comments/Recommendations. Each card should have a column for comments and recommendations. This column is very important for recording unusual conditions or observations. It is also important that a recommendation be made in this column for additional work or a change in maintenance frequency on the component if necessary.

   Maintenance forms for record keeping should be developed for each type of maintenance work that is listed at the bottom of the cards. For example, maintenance forms for sewer segment cleaning, lamping, televising, and rehabilitation should be developed. Examples of these forms and other forms are referenced in the following example of how to use the card system. The data shown on the example cards is for informational purposes only. Each agency may find that different types of data are more useful for implementing their own preventive maintenance program.

<u>How to Use the Card System</u>

1. Initially all cards are marked with a date which indicates when maintenance is next scheduled to be performed. An agency's long term maintenance schedule should be used to determine the next scheduled maintenance date on each card.

2. One set of cards are arranged in chronological order with respect to scheduled maintenance, a second set of cards is arranged by component with respect to component number. Next scheduled maintenance dates are indicated on both sets of cards.

3. At the beginning of each week all cards for the week are removed from both sets of files.

4. The maintenance chief or supervisor writes out work orders for each work item scheduled for the week as indicated on the cards and distributes the work orders to the appropriate maintenance crews.

5. Crews complete the work and return the work slips and the associated maintenance forms to the supervisor.

6. The supervisor records the required data on both sets of cards and based on recommendations made by the crews, will schedule additional work for a given component or change the frequency that maintenance is completed on it if necessary. A new date is then placed in the top right-hand corner of both cards indicating the next date when the sewer system component should be maintained again.

7. The cards are then re-filed in the respective card filing system; chronologically with respect to the next scheduled maintenance date, or by component with respect to component number.

8. The maintenance forms are filed chronologically in a separate filing system by category.

Example Card System Setup

An Example of how cards can be used to schedule maintenance is presented on the following pages. The example hypothetical community is Beachwood, Illinois. A sanitary sewer map for Beachwood is presented as Figure 11-9.

Beachwood has a separate sanitary sewer system consisting of 2,700 feet of 8 inch vitrified clay pipe. There is one lift station located 175 feet north of manhole No. 7. There is also one inverted siphon where the sewer crosses under Black Creek. All components of the system were installed in 1951. No construction or major repairs have occurred on the system since then. In this example all the components of the system have been identified and the cards formatted as previously outlined under "Organization."

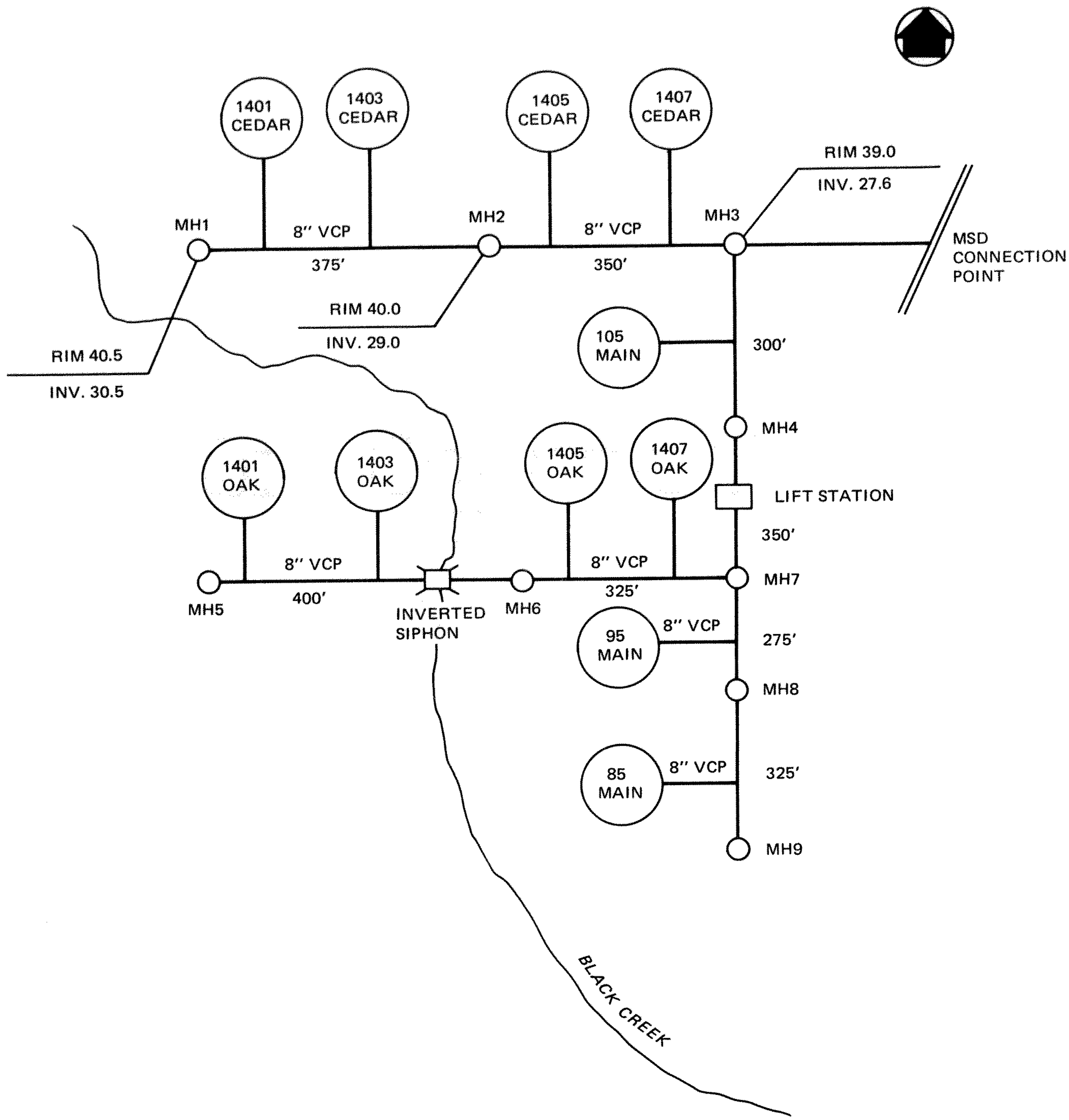
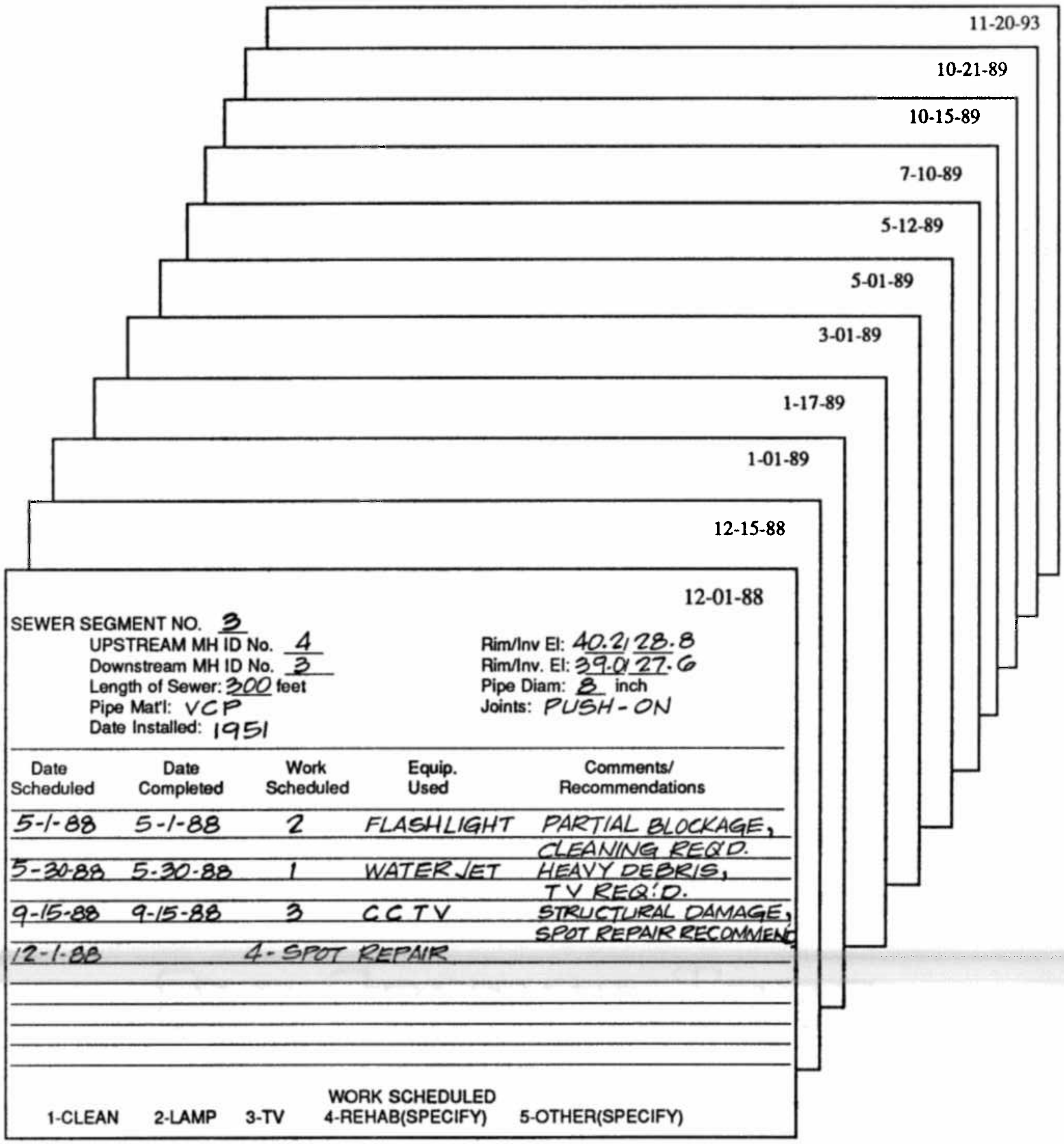
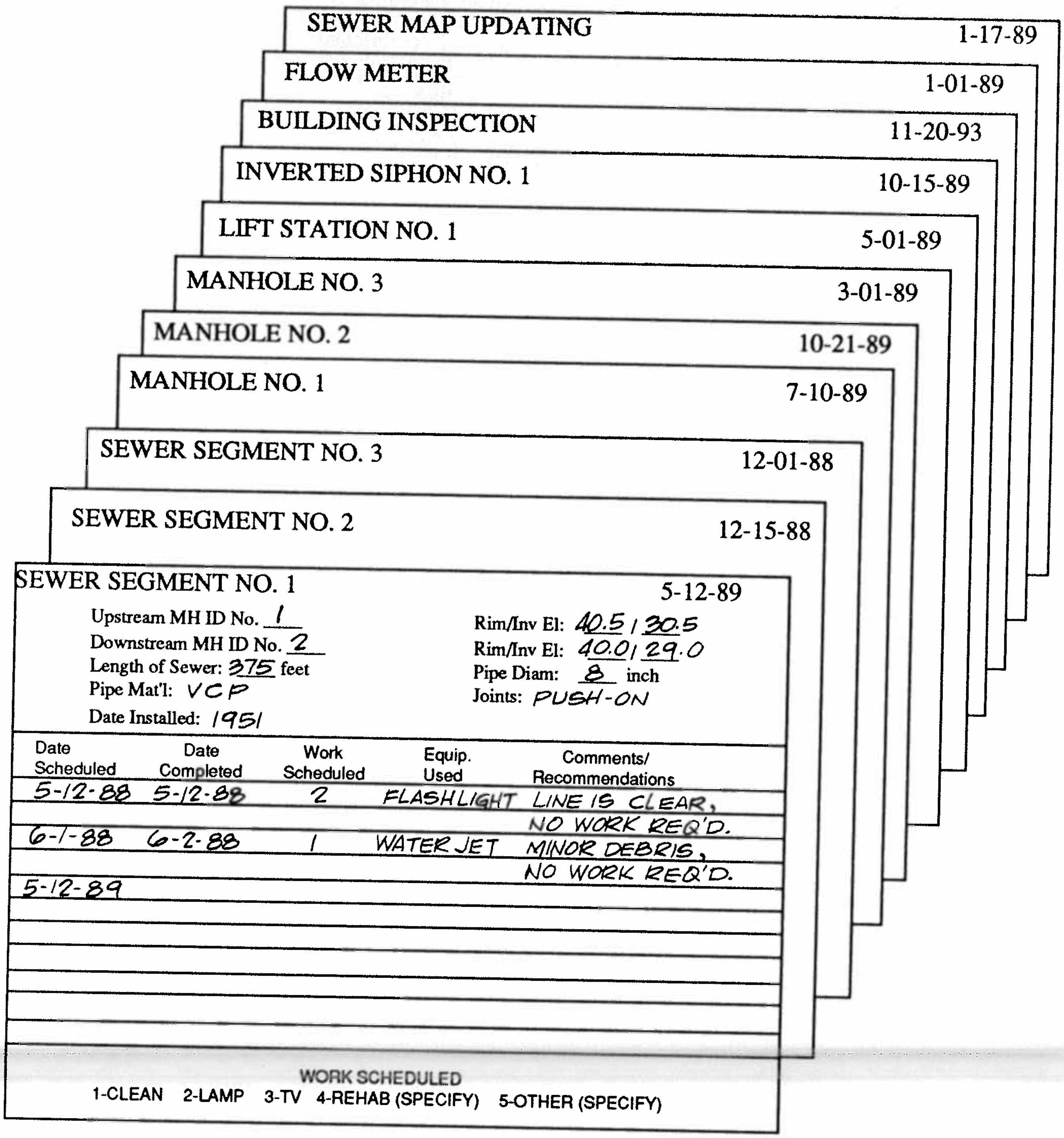


FIGURE 11-9. BEACHWOOD SANITARY SEWER MAP

One set of cards are placed in chronological order with respect to scheduled maintenance. For a new maintenance program the initial maintenance dates can be assigned from a rough long-term maintenance schedule. If some type of preventive maintenance program existed prior to implementing the card system, then initial maintenance dates for the cards can be based on the previous maintenance program. When the cards are all assigned dates and put in chronological order, they should be filed and look like this:



The second set of cards should be filed by component with respect to comonent number. For this example, the second set of cards would like like this:



The building inspection cards can be filed by street address. The equipment maintenance cards can be filed alphabetically.

Example Maintenace Task No. 1:

SEWER SEGMENT NO. 3 | 12-1-88

Upstream MH ID No. 4 — Rim/Inv El: 40.2 / 28.8

Downstream MH ID No. 3 — Rim/Inv El: 39.0 / 27.6

Length of Sewer: 300 feet — Pipe Diam: 8 inch

Pipe Mat'l: VCP — Joints: PUSH-ON

Date Installed: 1951

Date Scheduled	Date Completed	Work Scheduled	Equip. Used	Comments/ Recommendations
5-1-88	5-1-88	2	FLASHLIGHT	PARTIAL BLOCKAGE, CLEANING REQ'D.
5-30-88	5-30-88	1	WATER JET	HEAVY DEBRIS, TV REQ'D.
9-15-88	9-15-88	3	CC TV	STRUCTURAL DAMAGE, SPOT REPAIR RECOMMENDED
12-1-88		4 - SPOT REPAIR		

WORK SCHEDULED

1-CLEAN 2-LAMP 3-TV 4-REHAB (SPECIFY) 5-OTHER (SPECIFY)

According to this example the next component of the sewer system scheduled for maintenance is Sewer Segment Number 3. It is scheduled for work on December 1, 1988. Sewer segment number 3 is located between manholes numbered 3 and 4 (refer to the sewer map, Figure 11-9). Sewer Segment number 3 consistes of 300 feet of 37-year old 8 inch diameter vitrified clay pipe with push-on joints. The work scheduled for December 1, 1988 is rehabilitation, as indicated by the number 4 in the "work scheduled" column. The rehabilitation is specified as "spot repair". When the work is complete the "date completed" will be entered in addition to "equipment used" and any comments of recommendations for additional work. In addition, a maintenance form will be completed for the type of work that was scheduled. An example sewer rehabilitation form is shown in Figure 11-10. An example sewer rehabiltation form is schown in Figure 11-10. Other types of work commonly scheduled for sewer segments are: cleaning, televising, lamping, dye water flooding and smoke testing. Example maintenance forms for this work appear as figures 11-11, 4-3, 4-4, 4-6, and 4-7 respectively.

The history of Sewer Segment Number 3 is apparent by reviewing the work previously completed on the sewer sement and the recommendations made by the crew for additional work. Lamping was completed on this section on May 3, 1988. A partial blockage was observed and cleaning of the line was recommended. Cleaning by water jet was scheduled for May 30, 1988. Cleaning the line removed heavy debris and therefore, the line was recommended for televising. Closed circuit televising was scheduled for and completed on September 15, 1988. Structural damage to the pipe was observed which was recommended for repair. The repair method recommended was sewer pipe spot replacement. The spot replacement was then scheduled for December 1, 1988 and the card was filed in chronological order with respect to other scheduled maintenance tasks. The maintenance form, upon completion, should be filed chronologically in a separate file.

DATE:________________

Sewer Segment No.__________

Upstream MH ID No.________ Rim/Inv El:_______/_____

Downstream MH ID No._______ Rim/Inv El:_______/_____

Length of Sewer ________ feet Pipe Material:____________

Pipe Diameter________inch Joints:________________

Date Installed:__________________

Type of Rehabilitation Completed:

- ☐ Service Connection Repair
- ☐ Spot Replacement
- ☐ Sewer Grouting (indicate number of joints) Sliplining
- ☐ Inversion Lining
- ☐ Manhole-to-Manhole Replacement
- ☐ Other ____

Exact location of work:______________________________________

Crew Size Used: ____

Manhours Used:____

Equipment Used:____

Replacement/Repair Materials Used:________________________________

____

Comments:____

____

____

FIGURE 11-10. EXAMPLE SEWER SEGMENT REHABILITATION FORM

DATE:________________

Sewer Segment No.__________

Upstream MH ID No. __________ Rim/Inv El:_______/_____

Downstream MH ID No. ________ Rim/Inv El:_______/_____

Length of Sewer__________feet Pipe Material:___________

Pipe Diameter____________inch Joints:_______________

Date Installed:___________________

Cleaning Equipment Used: ____

____

Debris Severity Observed:_________

Types of Debris Observed:

- ☐ Grit
- ☐ Grease
- ☐ Roots
- ☐ Broken Pipe
- ☐ Other ____

Comments: ____

____

____

Debris Severity

0 - None 1 - Minor 2 - Moderate 3 - Severe 4 - Blockage

FIGURE 11-11. EXAMPLE SEWER CLEANING FORM

Example Maintenance Task No. 2:

SEWER SEGMENT NO. 2 — 12-15-88

Upstream MH ID No. 2 — Rim/Inv El: 40.0/29.0

Downstream MH ID No. 3 — Rim/Inv El: 39.0/27.6

Length of Sewer: 350 feet — Pipe Diam: 8 inch

Pipe Mat'l: VCP — Joints: PUSH-ON

Date Installed: 1951

Date Scheduled	Date Completed	Work Scheduled	Equip. Used	Comments/ Recommendations
5-20-88	5-20-88	2	FLASHLIGHT	PARTIAL BLOCKAGE, CLEANING RECOMMENDED
6-15-88	6-15-88	1	WATER JET	CLEARED BLOCKAGE, LAMP MORE FREQ.
12-15-88		2		

WORK SCHEDULED

1-CLEAN 2-LAMP 3-TV 4-REHAB (SPECIFY) 5-OTHER (SPECIFY)

Lamping of Sewer Sement No. 2 is scheduled for December 12, 1988. This is the next scheduled maintenance item following the repair of Sewer Segment No. 3. A Sewer Lamping Data Sheet should be filled out for this work. Figure 4-4 shows an Example Sewer Lamping Data Sheet.

The history of Sewer Segment No. 2 indicates that this line segment is subject to block-ages. More Frequent lamping has been recommended in order to monitor how fast debris builds up in the pipe. Televising or more frequent cleanings may be recommended based on observations from additional lamping.

Example Maintenance Task No. 3:

FLOW METER 1-1-89

Model: INSTA-FLO

Manufacturer: XYZ MANUFACTURERS

Serial No.: AB-1234 CD

Date Purchased: 1988

Date Scheduled	Date Completed	Maintenance Completed	Comments
1-1-88	1-1-88	CALIBRATION CHECK	O.K.
6-1-88	6-1-88	CLEAN, CALIBRATION CHECK	O.K.
1-1-89		CLEAN, CALIBRATION CHECK	

The next scheduled maintenance item following the lamping of Sewer Segment No. 2 is the cleaning and calibration of the flow monitoring equipment. The scheduled maintenance date is January 1, 1988. This equipment maintenance card is for an XYZ INSTA-FLO flow meter which is used for manually spot checking sewer flow rates. A Maintenance Work Order Form (Figure 11-12) would be completed for this work along with an Equipment Service Record Card (Figure 11-13).

DATE	REQUESTED BY	REQUIRED COMPLETION DATE
EQUIPMENT NAME AND NUMBER	SERIAL NO.	LOCATION

INDICATION OF TROUBLE		WORK TO BE DONE	CAUSE OF TROUBLE
☐ BROKEN PART	☐ DIRTY, FOULED	☐ INSPECT	☐ HEAT/COLD/WEATHER
☐ WORN PART	☐ VOLTAGE	☐ REPAIR	☐ HUMIDITY/MOISTURE
☐ HEAT	☐ CURRENT	☐ REPLACE	☐ FOREIGN OBJECT
☐ NOISE	☐ RESISTANCE	☐ SERVICE	☐ SHOCK/VIBRATION
☐ SMELL	☐ FLOW RATE	☐ OVERHAUL	☐ WEAR
☐ VIBRATION	☐ PRESSURE	☐ PAINT	☐ EQUIPMENT DEFECT
☐ LEAKING	☐ SPEED	☐ OTHER ______	☐ IMPROPER INSTALLATION
☐ OTHER ______			☐ OTHER ______

WORK REQUESTED ______

ESTIMATED COSTS
LABOR ______
PARTS ______
CONTRACTOR ______
TOTAL ______

ESTIMATED DOWN TIME

APPROVED BY	DATE	JOB NO.

MAINTENANCE WORK RECORD RECAP

DESCRIBE WHAT WAS WRONG AND HOW IT WAS FIXED	OUTSIDE CONTRACTOR USED
RECOMMENDATIONS FOR AVOIDING REPEATED FAILURE	REASON

EQUIPMENT STATUS AT COMPLETION	SPARE PARTS AVAILABILITY	ACTUAL COSTS
☐ FULLY OPERATIONAL	☐ IN STOCK	LABOR ______
☐ NON-OPERATIONAL	☐ OBTAINED LOCALLY	PARTS ______
☐ REDUCED CAPABILITY	☐ DELAY IN PROCURING	CONTRACTOR ______
☐ AWAITING SPARE PARTS	☐ LENGTH	TOTAL DOWN TIME

WORK COMPLETED	WORK APPROVED
DATE ______ NAME ______	DATE ______ REQUESTOR ______

FIGURE 11-12. EXAMPLE MAINTENANCE WORK ORDER

EQUIPMENT NO. ____________________

DATE	MECHANICS NAME	REQ. HRS.	OT HRS.	PARTS OR MATERIALS	MANUFACTURER AND CATALOG NO.	COST

FIGURE 11-13. EXAMPLE EQUIPMENT SERVICE RECORD CARD

Example Maintenance Task No. 4:

		1-17-89
SEWER MAP UPDATING Date of Original Map: 1951 Prepared By: E. REINER & CO. Type of Map: AREA MAP		
Date	Summary of Changes Made	Prepared by:
1-17-88	NONE	——
1-17-89		

Every January the sewer map for Beachwood is updated. This is the next scheduled work item. The map updating card indicates that no changes were made to the sewer map in 1988. Sewer map revisions are required when new construction is completed on the existing collection system. New construction could consist of extending the collection system, spot replacements, new service connections, manhole replacement, lift station installation, etc. Any new construction should be indicated on the sewer map. The scheduling cards and maintenance forms should be referenced for the details regarding new construction during the previous year.

Example Maintenance Task No. 5:

3-1-89

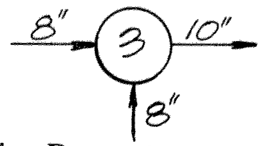
MANHOLE NO.: 3

Rim/Inv El: 39.0 / 27.6

Location: CEDAR & MAIN

Manhole Type: PRECAST CONCRETE

Cover: STANDARD



Installation Date: 1951

Date Scheduled	Date Completed	Work Scheduled	Equip. Used	Comments/ Recommendations
10-13-88	10-13-88	1	ATMOS. TESTER	VANDALIZED, RECOM. BOLT DOWN COVER
3-1-89		3- REPLACE COVER		

WORK SCHEDULED

1-INSPECTION 2-VISUAL FLOW CHECK 3-REHAB (SPECIFY)

The next scheduled maintenance item is to replace the manhole cover at Manhole Number 3 with a bolt down cover. This was recommended after the inspection on October 13, 1988 indicated that the manhole was being vandalized. A manhole rehabilitation form should be filled out when this work is completed. An Example Manhole Rehabilitation Form is shown as Figure 11-14. Example maintenance forms for Manhole Inspection and Visual Flow Checks are included as Figures 4-2 and 11-15, respectively.

The manhole identification number should be consistent with manhole numbers shown on the sewer system map. The street address or the location and the rim and invert elevations of the manhole should also be shown. In this example Manhole Number 3 is located at the intersection of Cedar and Main. The manhole construction is precast concrete and it currently has a standard cover.

Following the installation of the bolt down cover on March 1, 1989, the cover type will change from "standard" to "bolt down." The manhole was installed in 1951 and a diagram of the sewer pipes entering and leaving the manhole is indicated in the top center of the card. The different types of work that are commonly scheduled at a manhole are listed at the bottom of the card.

DATE:________________

Manhole ID No.______________

Rim/Inv El:_________/_________

Street Address/Location:____

Manhole Type:________________________

Cover Type:___________________________

Installation Date:______________________

Type of Rehabilitation Completed:

- ☐ Cover Replacement
- ☐ Frame Seal
- ☐ Wall Repairs
- ☐ Pipe Connection Repair
- ☐ Replacement
- ☐ Bench and Channel Repairs

Equipment Used:____

Crew/Contractor:____

Time Required to Complete:____

Replacement/Repair Materials Used:____

Comments: ____

____

____

FIGURE 11-14. EXAMPLE MANHOLE REHABILITATION FORM

DATE:________________

Manhole ID No.____________

Rim/Inv El:__________/_________

Street Address/Location:____

Manhole Type:________________

Cover:______________________

Installation Date:_______________

Sketch of Inlet and Outlet Piping:

N ↑

Flow Measuring Equipment:

- ☐ Dip Stick
- ☐ Weir
- ☐ Flume
- ☐ Flow Monitor (specify type)

Flow Measurement:____________ gpd

Time of Reading:_____________________ Weather:_____________________

Indicate weather conditions on the 3 days prior to this measurement:

____

Comments:____

____

____

FIGURE 11-15. EXAMPLE VISUAL FLOW CHECK FORM

Example Maintenance Task No. 6:

LIST STATION NO. 1 | 5-1-89

Pump Manufacturer: A B C PUMPS, INC.
Type of Pumps: SUBMERSIBLE
No. of Pumps: 2
Date Built: 1951

Date Scheduled	Date Completed	Work Scheduled	Specific Work Completed	Comments/ Recommendations
11-1-88	11-1-88	3	LUBRICATE BEARINGS	NO PROBLEMS
5-1-89		1-ANNUAL		

WORK SCHEDULED

1-INSPECTION 2-REHAB (SPECIFY) 3-MAINTENANCE

On May 1, 1989, Lift Station Number 1 is scheduled for its annual inspection. This is the next maintenance item following the cover change on Manhole Number 3. The upper area of the card indicates the location of the pump station, the pump manufacturer, pump type, number of pumps, and the date the pump station was built. The bottom of the card indicates types of work which are commonly scheduled.

Example Lift Station Maintenance Forms for daily, weekly, monthly, and annual inspection appear as Figures 11-16, 11-17, 11-18, and 11-19, respectively.

DATE:________________

Lift Station No.__________

Location:____

Pump Manufacturer:______________________________________

Type of Pumps:____

No. of Pumps:____________

Date Lift Station was Built:___________

Inspector(s):____

Time Arrived:____________________ Time Departed:________________

TASK		COMPLETED
1.	Check that electric power is on.	______
2.	Make sure no circuit breakers have been tripped.	______
3.	Read and record values on counters and timers.	______

Pump No.	Running Time
1	______
2	______
3	______

4.	Inspect, clean, and lubricate motors and rings.	______
5.	Inspect and clean wet well level sensor electrodes and bubbler tubes.	______
6.	Inspect and clean motor starters and relays.	______
7.	Check the operation of the gland water pump motors and electric valves.	______
8.	Inspect and clean all automatic gate controls.	______
9.	Check kilowatt meters and charts and record data.	______
10.	Check the motor, heating elements and belts on auxiliary equipment. Replace any broken or worn parts. Parts Replaced ____________________	______
11.	Check the float switches and motors on lift station sump pumps.	______

FIGURE 11-16. EXAMPLE DAILY LIFT STATION INSPECTION FORM

DATE:________________

Lift Station No.__________

Location:____

Pump Manufacturer:____

Type of Pumps:____

No. of Pumps:___________

Date Lift Station was Built:__________

Inspector(s):____

Time Arrived:_____________ Time Departed:_______________

TASK	COMPLETED
1. Check all equipment, piping and valves for leakage.	
2. Operate each wastewater pump in the "manual" or "hand" position and inspect the pump and motor for excessive noise or vibration.	
3. Check all motors for excessive temperature increases.	
4. Check all pressure and vacuum gauges.	
5. Inspect and clean sump pump wells if necessary.	
6. Clean the wet well of accumulated grease, floating debris, and grit.	
7. Clean and reposition floats and level sensor electrodes in the wet well.	
8. Inspect wet well piping and ladders.	
9. Mow the lift station yard if necessary.	
10. Wipe down all equipment.	
11. Replace recording charts as required.	
12. Exercise standby equipment to dry out water, redistribute lubricant and ensure operational readiness.	
13. Check operation of all lift station alarm systems.	

Comments:____

____

FIGURE 11-17. EXAMPLE WEEKLY LIFT STATION INSPECTION FORM

DATE:__________

Lift Station No.________

Location:____

Pump Manufacturer:____

Type of Pumps:____

No. of Pumps:___________

Date Lift Station was Built:___________

Inspector(s):____

Time Arrived:______________ Time Departed:_________________

TASK	COMPLETED
1. Operation all flow control gates and valves to prevent them from seizing.	________
2. Remove the pump casing inspection plates and remove any debris that has accumulated.	________
3. Check calibration and recalibrate flow meters.	________
4. Clean all ventilation openings.	________
5. Check first aid supplies.	________
6. Take inventory of spare parts. Verify that depleted parts have been ordered.	________
7. Check the condition of paint both inside and outside the lift station.	________

Comments:____

____

____

FIGURE 11-18. EXAMPLE MONTHLY LIFT STATION INSPECTION FORM

TASK		COMPLETED
12.	Inspect and clean bar screen or communitor controls.	____________
13.	Inspect indicating lights on all equipment and telemetry equipment controls.	____________
14.	Inspect pumps and bearings. Lubricate and repack if needed.	____________
15.	Inspect and lubricate line shaft bearings.	____________
16.	Inspect and lubricate gland water pumps and bearings.	____________
17.	Make sure the pump packing is not leaking too much water and is not too tight.	____________
18.	Inspect check valves and verify that they are not stuck either open or partially closed.	____________
19.	Inspect sump pump floats and all discharge piping and valves.	____________
20.	Check the position and operation of all flow control gates.	____________
21.	Check the drives and screens on all mechanically cleaned bar screens.	____________
22.	Inspect communitors for proper operation.	____________
23.	Inspect, clean, and lubricate all air compressors.	____________
24.	Manually clean bar screens.	____________
25.	Make sure all vent fans and lights are operating properly.	____________
26.	Enter any observed problems into the lift station log books.	____________
27.	Pick up all debris inside and outside of the facility.	____________
28.	Before leaving the facility make sure it is secure.	____________
29.	Plow snow if necessary.	____________

Comments:____

____

____

FIGURE 11-16 (cont.). EXAMPLE DAILY LIFT STATION INSPECTION FORM

DATE:__________

Lift Station No.__________

Location:____

Pump Manufacturer:____

Type of Pumps:____

No. of Pumps:______________

Date Lift Station was Built:____________

Inspector(s):____

Time Arrived:__________________ Time Departed:__________________

TASK	COMPLETED
1. Dismantle the wastewater pumps to inspect the impellers, shafts, and shaft sleeves.	________
2. Inspect and clean all components of the ventilating fans, heaters, sump pumps, and dehumidifiers.	________
3. Inspect the condition of all electrical equipment.	________
4. Paint areas both inside and outside of the lift station as needed.	________
5. Inspect the inlet and outlet piping at the lift station. Clean the piping if needed.	________
6. Check flowmeter calibration and recalibrate if necessary.	________

Comments:____

____

____

FIGURE 11-19. EXAMPLE ANNUAL LIFT STATION INSPECTION FORM

Example Maintenance Task No. 7:

SEWER SEGMENT NO. 1 | 5-12-89

Upstream MH ID No. 1 | Rim/Inv El: 40.5 / 30.5

Downstream MH ID No. 2 | Rim/Inv El: 40.0 / 29.0

Length of Sewer: 375 feet | Pipe Diam: 8 inch

Pipe Mat'l: VCP | Joints: PUSH-ON

Date Installed: 1951

Date Scheduled	Date Completed	Work Scheduled	Equip. Used	Comments/ Recommendations
5-12-88	5-12-88	2	FLASHLIGHT	LINE IS CLEAR, NO WORK REQ'D.
6-1-88	6-2-88	1	WATER JET	MINOR DEBRIS, NO WORK REQ'D.
5-12-89				

WORK SCHEDULED

1-CLEAN 2-LAMP 3-TV 4-REHAB (SPECIFY) 5-OTHER (SPECIFY)

The next card indicates that Sewer Segment Number 1 is scheduled for lamping on May 12, 1989. The Sewer Lamping Data Sheet (Figure 4-4) should be completed at the time of the inspection.

Example Maintenance Task No. 8:

MANHOLE NO. : 1

7-10-89

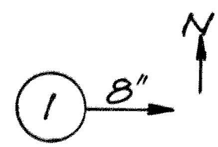
Rim/Inv El: 40.5/30.5

Location: 1400 CEDAR

Manhole Type: PRECAST CONCRETE

Cover: STANDARD

Installation Date: 1951



Date Scheduled	Date Completed	Work Scheduled	Equip. Used	Comments/ Recommendations
7-10-88	7-15-88	1	ATMOS. TESTER	O.K., NO WORK RECOMMENDED
7-10-88		1		

WORK SCHEDULED

1-INSPECTION 2-VISUAL FLOW CHECK 3-REHAB (SPECIFY)

This card indicates that Manhole Number 1 is scheduled for an inspection on July 10, 1989. A Manhole Inspection Form should be filled out during the inspection. Figure 4-2 shows an Example Manhole Inspection Form.

Example Maintenance Task No. 9:

INVERTED SIPHON NO. 1 — 10-15-89

Type: DOUBLE BARREL
Location: 100' WEST OF MH 6 (1404 OAK)
Length: 50 FT.
Pipe Material: DUCTILE IRON — Pipe Diam's: 3"/6"
Pipe Invert: 32.1 FT. — Date Installed: 1951

Date Scheduled	Date Completed	Work Scheduled	Specific Work Completed	Comments/ Recommendations
10-15-89		1		

WORK SCHEDULED

1-INSPECTION 2-REHAB (SPECIFY) 3-CLEANING

Inverted Siphon Number 1 is scheduled for an inspection on October 15, 1989. It is a double barreled siphon 50 feet long. The pipe diameters are 3 inch and 6 inch and the pipe material is ductile iron. An Example Inverted Siphon Inspection Form is shown as Figure 11-20. Sewer Segment Rehabilitation and Cleaning Forms (Figures 11-10 and 11-11, respectively) can be used when cleaning or rehabilitating the inverted siphon.

DATE:________________

Inverted Siphon No.____________

Type:______________________ Pipe Diameters:

Location:____________________ Pipe No. 1:_____inch

Length:_____________________ Pipe No. 2:_____inch

Pipe Material:________________ Date Installed:__________

Pipe Inverts:________________

Inspectors:____

Time Arrived:________________ Time Departed:__________

Atmospheric Testing Results:

Inlet Structure:____

Outlet Structure:_______________________________________

Flow measurement upstream of siphon:____________ gpd

Flow measurement downstream of siphon:____________ gpd

TASK		COMPLETED
1.	Mechanical parts inspected for debris.	________
2.	Check that hatches to inlet and outlet structures are secure.	________
3.	Check that air vent piping between inlet and outlet structures is working properly.	________
4.	Exercise slide gates.	________

FIGURE 11-20. EXAMPLE INVERTED SIPHON INSPECTION FORM

Example Maintenance Task No. 10:

10-21-89

MANHOLE NO. : 2

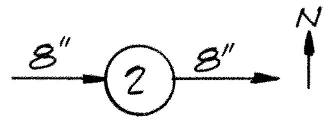
Rim/Inv El: 40.0 / 29.0

Location: 1404 CEDAR

Manhole Type: PRECAST CONCRETE

Cover: STANDARD

Installation Date: 1951



Date Scheduled	Date Completed	Work Scheduled	Equip. Used	Comments/ Recommendations
7-15-88	7-15-88	1	ATMOS. TESTER	FRAME NEEDS SEALING
10-21-88	10-21-88	3-FRAME SEAL	BUTYL RUBBER SEAL	
10-21-89		1		
10-21-89		2		

WORK SCHEDULED

1-INSPECTION 2-VISUAL FLOW CHECK 3-REHAB (SPECIFY)

This card indicates that Manhole Number 2 is scheduled for an inspection and a visual flow check with a V-notch weir on October 21, 1989. A Manhole Inspection Form (Figure 4-2) and Visual Flow Check Form (Figure 11-15) both should be completed.

Example Maintenance Task No. 11:

BUILDING INSPECTION 11-20-93

Building Address: 1401 CEDAR

Building Type:

Residential

single family

duplex

apartment/condo

Commercial/Industrial

Crawl Space: YES NO

Basement: YES NO

Sump Pump: YES NO

Year Built: 1940

Date	Violation?	Violation Type	Reinspection Date
8-20-88	YES	S	11-20-88
11-20-88	NO		11-20-93
11-20-93			

VIOLATION TYPE

S-SUMP PUMP D-DOWNSPOUT D-AREA DRAIN X-OTHER (SPECIFY)

The last maintenance item scheduled for this examle is a building inspection at 1401 Cedar Road. The inspection is scheduled for November 20, 1993. The building has a basement and a sump pump and has previously had one violation. When the inspection is complete a "reinspection date" will be assigned to the building. This reinspection date will be placed in the upper right-hand corner of the card and the card will be refiled in the filling system with respect to other scheduled maintenance work.

A Building Inspection Form should be filled out at the time of the inspection. An Example Building Inspection Form is shown in Figure 4-5.

OTHER TYPES OF MAINTENANCE SCHEDULING SYSTEMS

The card system for scheduling and keeping records of maintenance activities which was just described in the previous section is just one of many methods that can be used to help remind sewer system supervisors of the maintenance work required and when the work should be done. Other methods that can be used for scheduling maintenance include using sewer maps, bar charts, and commercially available computer software packages.

Sewer maps can be used effectively to schedule maintenance if an area map showing the entire community's sewer system can be clearly marked up each year to show specific maintenance requirements. The area maps are most effective if they are enlarged and attached to a wall in the supervisors office. Each type of maintenance activity can then be requested on the map by highlighting the area of the sewer system scheduled for a specific type of maintenance using a specific color. For example, sections of the sewer system scheduled for sewer cleaning can be highlighted in yellow and the sewers scheduled for closed circuit TV inspection can be highlighted in blue. Colored tape can be used to highlight the sewer sections so that when a maintenance activity has been completed, the tape can be removed from the map. At the end of the year no areas of the sewer system on the map should be highlighted with colored type if all of the scheduled maintenance has been completed.

Bar charts can also be used as a reminder of the maintenance activities that have been scheduled. The bar chart needs to include a list of all the annual maintenance activities and when they are scheduled to begin and end. As the maintenance activities are actually completed, the bar chart can be marked up to represent that the maintenance activities have been completed.

Another method for scheduling maintenance and storing records that is growing in popularity because of the increasing use of personal computers is the use of commercially available computer software packages specifically designed for the operation and maintenance of wastewater collection systems. Providing a description of the various software packages currently available for scheduling sewer system maintenance is beyond the scope of this manual. Information regarding the commercially available software packages can be found in Microcomputers In Public Works, published by the American Public Works Association, 1313 East 60th Street, Chicago, Illinois 60637.

APPENDIX A

RESOURCE BIBLIOGRAPHY

APPENDIX A

RESOURCE BIBLIOGRAPHY

NOTE: The following reference listing is organized by sewer operation and maintenance categories. The category titled "General" includes general references that cover more than one specific operation and maintenance category.

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APPENDIX B

THE METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO SEWER PERMIT ORDINANCE

NOTE: The Metropolitan Sanitary District of Greater Chicago Sewer Permit Ordinance is subject to periodic changes. It is the responsibility of each agency to insert the most updated version of the Ordinance into Appendix B of this O&M Manual.

APPENDIX C

THE METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO MANUAL OF PROCEDURES FOR ADMINISTRATION OF THE SEWER PERMIT ORDINANCE

NOTE: The Metropolitan Sanitary District of Greater Chicago Manual of Procedures for Administration of the Sewer Permit Ordinance is subject to periodic changes. It is the responsibility of each agency to insert the most updated version of the Manual of Procedures for Administration of the Sewer Permit Ordinance into Appendix C of this O&M Manual

APPENDIX D

OUTLINE OF A CONTINUOUS SANITARY SEWER SYSTEM MAINTENANCE PROGRAM

NOTE: The following outline was prepared by the ICAP Technical Advisory Panel to summarize the components of a continuous sanitary sewer system maintenance program. The ICAP technical Advisory Panel is an inter-agency committee made up of members elected by local officials, sanitary districts and utility companies. The program outline is provided as a reference to be used for scheduling periodic maintenance tasks.

OUTLINE

CONTINUOUS SANITARY SEWER SYSTEM MAINTENANCE PROGRAM

GOAL: Institute a continuous preventive maintenance program for the proper maintenance and operation of the local sanitary sewer system. The program should ensure the proper and satisfactory state of repair and performance level of the local sewer system at all times. The purpose is to prevent basement sewage backups, adverse surcharging and water pollution.

PROGRAM COMPONENTS

1. Mapping - A map of the sewer system should be completed and updated on an annual basis. The map should contain the location of all sewer pipes, manholes, lift stations and other structures. Rim, invert and other appropriate elevations should be shown wherever possible.

2. Inspections - A continuous inspection program should be implemented where approximately 20% of the system is visually inspected each year. In general, the complete system should be inspected every 5 years.

    a. Manholes - They should be visually inspected for defects and needed repairs.

    b. Sewers - Lamping should be performed on the 5 year cycle. TV inspection should be performed if visual inspection warrants it.

    c. Appurtenances - Any lift stations, junction chambers, siphons, etc., should receive periodic maintenance work as required.

    d. Private Sector - The local agency should inspect the private sector to identify and correct new illegal connections or reconnection of old sources. The following alternatives are suggested:

        1. Spot check subsystems by flow monitoring and inspect structures when excessive flows indicate a private sector I/I problem.

        2. Include inspections as a requirement for certificates of occupancy both for new construction and change of ownership.

        3. Inspect all buildings on a five year cycle except for those subsystems which demonstrate there are no private sector I/I problems.

    e. Flow Monitoring - When visual or other inspections indicate possible excess flow problems in certain subsystems, flow monitoring should be performed at key manholes. Smoke testing, dye testing and excavation may be required in some subsystems where complaints or backup causes are difficult to locate.

3. Rehabilitation and Maintenance Work - The rehabilitation work found necessary from the inspection program should be performed as soon as possible. Contemporary methods and materials should be utilized wherever possible when performing such work as: sealing of manhole covers, manhole frame adjustment or

repair, manhole wall repair, sewer pipe and sewer joint grouting or chemical sealing, pipe replacement, routine cleaning, etc.

4. Personnel - Sufficient staffing with own forces or subcontracting of work should be provided to carry out the necessary inspection and rehabilitation work. All personnel should be well trained. Periodic schedules of training for purposes of review and updating should be provided. Joint training and regional meetings with building departments and public works departments should be conducted.

5. Material and Equipment - Proper material and equipment shall be provided and maintained at all times. Periodic inspections should be made to assure an adequate supply in a workable condition.

6. Safety - Of prime importance is a well developed safety program. Training of personnel in all aspects of safety related to rehabilitation work and the furnishing of the necessary equipment cannot be over emphasized. Equipment shall include such items as: man-lifts, safety harnesses, gas detectors, ventilation equipment, traffic cones, hard hats, outer wear, etc.

7. Budgeting - Sufficient funds must be included in the budget each year to adequately carry out the scheduled work for maintaining the sewer system. Costs should not be co-mingled with other public works costs if possible. Separate line items are recommended for sewer maintenance costs. A user charge system could be developed.

8. A resource bibliography for sources of training shall be included.

APPENDIX E

WET WEATHER FLOW REQUIREMENTS FOR AGENCIES TRIBUTARY TO MSDGC FACILITIES

APPENDIX E

WET WEATHER FLOW REQUIREMENTS FOR AGENCIES TRIBUTARY TO MSDGC FACILITIES

WET WEATHER COMPLIANCE FLOW RATES

150 GPCPD Option

The communities that have elected the 150 gallons per capita per day (gpcpd) option are required to maintain their sewer system adequately to prevent wet weather flows from exceeding 150 gpcpd. For compliance monitoring in the 150 gpcpd option communities, the Metropolitan Sanitary District defines wet weather flow as the peak 24 hour flow resulting from a minimum rainfall of 1 inch in 24 hours and a maximum rainfall of 3.12 inches in 24 hours. In the Chicagoland area, 3.12 inches of rainfall in 24 hours corresponds to a 3 year recurrence storm.

ICAP Option

The communities that have elected the Infiltration/Inflow Corrective Action Program (ICAP) option cannot allow their sewer systems to deteriorate beyond their ICAP cost-effective wet weather flow limit which is defined as the peak 4 hour flow for a 3 year recurrence storm of 2 hours or less duration which remains in the sanitary sewer collection system after cost-effective defects have been repaired. In addition, ICAP communities will not be permitted to allow new subsystems and developments constructed after January 1, 1987 to deteriorate beyond a peak 24 hour flowrate of 150 gpcpd for any rainfall up to a 3 year recurrence storm with a 24 hour duration.

CONTINUOUS FLOW MONITORING REQUIREMENTS

Continuous flow monitoring in each agency system should be conducted in the entire system at the suggested frequency of once every 10 years. The purpose of a continuous flow monitoring program is to evaluate the effectiveness of each agency's preventive maintenance program and to demonstrate compliance with the MSDGC Sewer Permit Ordinance.

The continuous flow metering program should include at least 30 days of continuous flow metering during periods when groundwater conditions are typically high. In the Cook County area of Illinois, groundwater levels are normally elevated in the spring and fall. Therefore, the acceptable dates for monitoring flows for the purpose of demonstrating compliance are April 15 through June 30 and September 1 through November 15. The flow metering program should include all subsystems tributary to the MSDGC interceptor system. At least one significant rainfall event of 1 inch or more in a 24 hour period should be captured during the flow metering period. If a storm equivalent to a 3 year recurrence storm is not captured during the continuous flow monitoring period, the actual measured sewer flows must be projected to the 3 year storm flow. A rain gage shall be installed within the community during the flow metering program.

Records of the continuous flow monitoring program should be retained and used for scheduling preventive maintenance and for verification of compliance with the MSDGC Sewer Permit Ordinance.

APPENDIX F

COMPILATION OF DUPLICATE FORMS

INDEX OF DUPLICATE FORMS

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Weekly Lift Station Inspection Form F-34

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Inverted Siphon Inspection Form F-37

MANHOLE INSPECTION FORM

MH # ______________________ LOCATION ______________________

INSPECTOR ______________________ DATE ______________________

RAIN: NONE____ LIGHT____ HEAVY____ / SNOW: NONE____ FROZEN____ MELTING____

1. Surface at Manhole: Gravel Turf Concrete Blacktop Other
2. Subject to Ponding/Flooding: YES NO
3. Cover: Standard __________ Watertight __________
   Pickhole Size __________ Number of Holes __________
4. Atmospheric Conditions in Manhole prior to Ventilation: ______________________
   ____
5. Manhole Diameter __________ inches
6. Frame alignment and Seal: Good Fair Poor
7. Construction Type: Brick Block Precast Other
8. Structural condition: Good Fair Poor
9. Rim/Invert Elevations: ______________________
10. Evidence of Infiltration: Leaks Stains None
11. Frame Grade: Above Below Flush
12. Manhole Steps: None Corroded Loose Other Safe ________ Unsafe ________
13. Bench: Flat Steep None Condition ______________________
14. Invert: Shaped Properly __________ Shaped Improperly ______________________
15. Number and Sizes of Sewers Entering Manhole Number ________ Sizes ________
16. Direct Service Connections Entering Manhole Number ________ Direction: N S E W
17. Equipped with Groundwater Gauge: YES NO
18. Groundwater Level Above Sewer Invert ________ inches
19. Surcharge Evidence: Waterline Height ________
20. Debris: None Minor Needs Cleaning
21. Describe Debris: ______________________
22. Manhole Type: Standard Drop
23. a) Seal at Manhole Frame: GOOD NEEDS REPAIR
    b) Seal at Riser Joints: GOOD NEEDS REPAIR
    c) Seal at Bench: GOOD NEEDS REPAIR
24. Remarks ______________________
    ____

DATA SHEET FOR MANHOLE INSPECTIONS

VIDEO TAPE NO. __________

COMMUNITY ______________________________ DATE: __________

PIPE LOCATION ______________________________

SURFACE OVER SEWER: ASPHALT CONCRETE GRASS OTHER __________

PIPE SIZE / DEPTH / MAT'L ______ / ______ / ______

WEATHER: SUNNY RAIN SNOW TEMP: __________

CLEANING: NONE JET ROOT CUTTING OTHER __________

IN CONJUNCTION WITH DYE-FLOODING: YES NO

CREW CHIEF: ______________________________

MH# MH#

0 · · · · · · · 0

DIRECTION OF FLOW __________

DIRECTION OF CAMERA __________

N

FOOTAGE	SERVICE CONNECTIONS	REMARKS	I/I (gpm)

EXAMPLE REMARKS:

Brick demortared, but still intact
Brick missing, backfill showing
Camera blocked; unable to proceed
Camera submerged
Crack in pipe - lateral
Crack in pipe - transverse
Corrosion (indicate severity)
Collapsed pipe
Damage (specify type)
Debris accumulated in invert
Distorted shape
Flow depth
Infiltration flow rate
Inflow rate
Grease accumulation
Invert damage (specify)
Offset joint
Separated joint
Leakage observed
Mineral deposits
Root intrusion
Sagged line
Abandoned tap
Protruding tap
Tap with roots
Structural damage (spalled concrete, loose bricks)

SEWER INSPECTION DATA SHEET

F-4

COMMUNITY: ____________________

INSPECTION CREW: ____________________

WEATHER: TEMP: ____________________ SUNNY RAIN SNOW

DATE	SECTIONS LAMPED (MH TO MH, LIN. FT.)	OBSERVATIONS

SEWER LAMPING DATA SHEET

DATE: ______________________ VIOLATION: YES NO ENTRY REFUSED

COMMUNITY: ______________________ INSPECTOR: ______________________

BUILDING TYPE: RESIDENTIAL COMMERCIAL INDUSTRIAL

ADDRESS: ______________________ OWNER: ______________________

BASEMENT: YES NO CRAWL SPACE:

SUMP PUMPS:

TYPE	DISCHARGE TO	SUMP BOTTOM SEALED?	TYPE	DISCHARGE TO
			A. SANITARY	SANITARY SEWER
			B. STORM	STORM SEWER
			C. COMBINED	OUTSIDE SURFACE
			D. NONE	UNKNOWN

IF TWO OR MORE SUMPS EXIST, ARE THEY PIPED TOGETHER?

INFLOW SOURCE	NUMBER	DISCHARGE TO:
Foundation Drains		
Window Wells		
Stairwell Drain		
Floor Drain		
Downspout		Underground
Downspout		Surface
Yard Drains		
Driveway Drains		
Other (Specify)		

How long has owner lived there?

Have they experienced any sewer backups?

REMARKS:

BUILDING INSPECTION DATA SHEET

DATE: ____________

COMMUNITY: ____ JOB NO. ____________

SET-UP LOCATION: ______________________________________

START/END TIME: _____/_____ CREW: ____________

TYPE OF SET UP: STORM SEWER DIA. ____________________ CATCH BASIN ______

DITCH ____________________

PRIVATE SECTOR TEST: DOWNSPOUT ____________________ DRIVEWAY DRAIN ____

WINDOW WELLS ____________________ OTHER ____________

TEST(MH/MH): _____/_____________________________________

FLOW DEPTH BEFORE FLOOD (MH/TIME/DEPTH): ____/____/____ INCH

FLOW DEPTH FOLLOWING DYE OBSERVATIONS (MH/TIME/DEPTH): ____/____/____ INCH

CONCENTRATION OF DYE OBSERVATION: TRACE MEDIUM HEAVY

NO DYE OBSERVED (MH/TIME): _____/_____

SKETCH	SKETCH OF SET UP
LEGEND SANITARY SEWER STORM SEWER CATCH BASIN FIRE HYDRANT FL FILLING LOCATION X PLUG	

REMARKS: ____

____

____

DYED WATER TESTING DATA SHEET

COMMUNITY: ______________________________ DATE: ____________

CREW NAMES: ____

Set-Up Information: Pipe Size Smoked: ____________

Length of Pipe/MH to MH: ______ft./ MH No. ________ to MH No. ________

Type of Smoke Bomb Used: ______ 3 min. ______ 5 min. ______ other ____________

LEGEND		SKETCH OF SET-UP
●	Sanitary MH	
○	Storm MH	
———	Sanitary Sewer	
....	Storm Sewer	

Source of Smoke	Description of Source of Smoke (address/other)	Surface Type/Area Drained by Source of Smoke	Address Where Vent Pipes Showed No Smoke	Photo No.

POTENTIAL SOURCES OF SMOKE

01 Downspout
02 Roof Drain
03 Yard Drain
04 Catch Basin
05 Storm Sewer Manhole
06 Manhole Frame
07 Cracked Pavement
08 Lateral
09 Surface Over Sewer
10 Sump Pump
11 Foundation Wall
12 Driveway Drain
13 Other - Describe

Additional Observations: ____

____

SMOKE TESTING DATA SHEET

LOCATION OF WORK: (Name of Plant, Name of Confined Space)

____

____

DESCRIPTION OF WORK: ______________________________

____

____

EMPLOYEES ASSIGNED: ______________________________

____

ENTRY DATE: ______________________________________

ISOLATION CHECKLIST:

- Blanking and/or Disconnecting Piping
- Electrical Lockout and Danger Tags
- Mechanical
- Other

HAZARDOUS WORK TO BE DONE:

- Burning
- Welding
- Brazing
- Open Flame, Sparks
- Cleaning (solvents, water blast, sandblast)
- Other

HAZARDS EXPECTED:

1. Restrictive Opening
2. Oxygen Deficiency, Enrichment
3. Flammable Materials
4. Toxic Materials
5. Corrosive Materials
6. Dusty Materials
7. Darkness (Inside, Outside)
8. Slippery Surfaces
9. Water (Standing, Flowing)
10. Inlet Drain Open
11. Bacteria, Vermin
12. Hot Surfaces
13. Low Headroom
14. Noise
15. Other

PERSONAL SAFETY:

1. Training (This Assignment)
2. Emergency Procedures (See Below)
3. Clothing
4. Head, Hand, Foot, Ear Protection
5. Respirators
6. Safety Line and Harness
7. Communications
8. Traffic Controls
9. Ventilation
10. Lighting
11. Ladder, Handlines
12. Personnel Hoist
13. Fire Extinguisher
14. Other

CONFINED SPACE ENTRY PERMIT AND RECORD

ATMOSPHERIC TESTS (OXYGEN, FLAMMABLE, TOXIC)

TIME	TEST	READING	TIME	TEST	READING

Tests Performed By: ______________________________
Signature

EMERGENCY PROCEDURES

Standby Person(s) ______________________________

Telephone, Emergency Notification (To Whom? How?) ______________________________

____

____

____

Rescue Procedure (By? How?) ______________________________

____

____

AUTHORIZATION:

Plant Manager ______________________________ ______________
Signature Date

CONFINED SPACE ENTRY PERMIT AND RECORD (Cont.)

HEADING

TYPE OF PERMIT: VESSEL ENTRY ☐ HOT WORK ☐ OTHER ☐ PERMIT NO.

GOOD ON THIS DATE ONLY: FROM: AM ☐ PM ☐ TO: AM ☐ PM ☐

LOCATION:

WORKERS AUTHORIZED ENTRY: ______ WORK MONITORS: ______ FIRE WATCH: (HOT WORK ONLY) ______

DESCRIPTION OF JOB OR SPECIAL PROCEDURES: ______

EMPLOYEE TRAINING AND PRE-ENTRY BRIEFING

1. SAFE ENTRY AND RESCUE TRAINING CONDUCTED ON: ______ (DATE)
2. MANDATORY PRE-ENTRY BRIEFING CONDUCTED ON: ______ (DATE)
3. DOES THE JOB REQUIRE SPECIAL TRAINING? YES ☐ NO ☐

CONTRACTOR NOTIFICATION

CONTRACTOR NOTIFIED OF: PERMIT CONDITIONS ☐ POTENTIAL HAZARDS ☐ N/A ☐

LIGHTING REQUIREMENTS	SPECIAL TOOLS/EQUIPMENT	COMMUNICATION DEVICES

1. ARE ALL ELECTRICAL DEVICES INTRINSICALLY SAFE? YES ☐ N/A ☐
2. HAVE ALL POWER CORDS AND TOOLS BEEN VISUALLY INSPECTED? YES ☐ N/A ☐

PRE-ENTRY ATMOSPHERIC TESTING

	READING:	TIME:	INITIALS:
1. TEST FOR OXYGEN CONTENT:	______ %02		
2. TEST FOR FLAMMABLE CONCENTRATION:	______ %LEL		
3. TEST FOR TOXIC CONCENTRATION:	______ PPM OF ____ (TLV=)		
4. TEST FOR HEAT STRESS HAZARD:	______ °F ☐ °C ☐ WBGT		

EMERGENCY/RESCUE PROCEDURES

1. LOCATION OF WRITTEN EMERGENCY RESCUE PLAN ______
2. TYPE OF EMERGENCY RESCUE TEAM REQUIRED: ON-SITE ☐ OFF-SITE ☐ PHONE NO. ______

SAFETY EQUIPMENT

PERSONNEL PROTECTIVE EQUIPMENT REQUIRED: ______

AREA SAFETY EQUIPMENT REQUIRED: ______

1. SELF-CONTAINED BREATHING APPARATUS REQUIRED? YES ☐ NO ☐ TYPE ______
2. PORTABLE ATMOSPHERIC MONITOR REQUIRED? YES ☐ NO ☐ TYPE ______

PERMIT AUTHORIZATION

I CERTIFY THAT I HAVE INSPECTED THE WORK AREA FOR SAFETY AND REVIEWED ALL SAFETY PRECAUTIONS RECORDED ON THIS PERMIT.

PERMIT AUTHORIZED BY (SIGNATURE) ______

N/A = NOT APPLICABLE TO PRESENT JOB

TODAY'S DATE ______________________

DATE WORK WILL BE DONE ______________

WORK TO DO	MAJOR HAZARDS EXPECTED	PRECAUTIONS TO CONTROL HAZARDS

SAFE JOB INSTRUCTIONS SHEET

Department: ____________ Section: ____________ Index No. ____________

Name of Injured Employee: ____________ Social Security No. ____________

Home Address of Employee: ____________ Phone: ____________

Date of Birth: ____________ Sex: M F Wage at Time of Accident: ____________

No. of Hours Worked: Per Day: ________ Per Week: ________ No. of Days Per Week: ________

Classification: ____________ Date of Hire: ____________

Place of Accident: ____________ City/Town: ____________

Date of Accident: ________ Time: ________ Date Reported: ________ Time: ________

Did employee return to work on date of injury? ____________ Lost Time: ________ Days/Hr.

Was employee off work beyond date of injury? ____________

If so, last date worked: ____________

Nature of injury (specify part of body injured?): ____________

Was employee acting in regular line of duty when injured? ____________

If No, Explain: ____________

How did the accident occur? ____________

Was first aid given? ____________ By whom? ____________

Doctor: ____________ Address: ____________

Hospital (If Any): ____________ Address: ____________

What machine, tool substance, or object was most closely connected with the accident? ____________

Were mechanical guards or other safeguards provided? ____________

Were mechanical guards or other safeguards used? ____________

What, in your opinion, caused the accident? ____________

Describe Any Unsafe Act: ____________

Describe Any Unsafe Conditions: ____________

What has been done to prevent a similar accident? ____________

Witnesses: ____________

Signed: ____________
Date: ____________
Phone: ____________

For Further Particulars Please Use Reverse Side

SUPERVISOR'S REPORT OF ACCIDENT

	Phone Office	Phone Home
1. PHYSICIANS/AMBULANCE/HOSPITAL		
Dr. ______	______	______
Dr. ______	______	______
Ambulance ______	______	______
Ambulance ______	______	______
Hospital ______	______	______
Hospital ______	______	______
2. FIRE		
Department ______	______	______
Department ______	______	______
3. POLICE		
Town Police ______	______	______
County Sheriff ______	______	______
Deputy ______	______	______
State Police ______	______	______
Headquarters ______	______	______
4. POWER COMPANY		
Name ______	______	______
Name ______	______	______
5. TELEPHONE COMPANY		
Name ______	______	______
Name ______	______	______
6. GAS COMPANY		
Name ______	______	______
Name ______	______	______
7. ELECTRICIANS		
Name ______	______	______
Name ______	______	______
Name ______	______	______
8. PLUMBERS		
Name ______	______	______
Name ______	______	______
9. HEAVY EQUIPMENT OPERATORS		
Name ______	______	______
Type of Equipment Available ______		
Name ______	______	______
Type of Equipment Available ______		

LIST OF EMERGENGY TELEPHONE NUMBERS

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		Phone	
		Office	Home
10.	EXTRA LABOR		
	Name ______	______	______
	Name ______	______	______
11.	CONSULTING ENGINEER		
	Name ______	______	______
	Name ______	______	______
12.	TOWN OFFICIALS		
	Name ______	______	______
	Name ______	______	______
	Name ______	______	______
	Name ______	______	______
13.	COUNTY HEALTH DEPARTMENT		
	Official ______	______	______
	Official ______	______	______
14.	ILLINOIS ENVIRONMENTAL PROTECTION AGENCY		
	Name ______	______	______
	Name ______	______	______
15.	FEDERAL ENVIRONMENTAL PROTECTION AGENCY REGIONAL OFFICE		
	Official ______	______	______
	Official ______	______	______
16.	AREA CIVIL DEFENSE		
	Official ______	______	______
	Official ______	______	______
17.	OTHER		
	______	______	______
	______	______	______
	______	______	______
	______	______	______
	______	______	______
	______	______	______
	______	______	______
	______	______	______

LIST OF EMERGENCY TELEPHONE NUMBERS (Cont.)

COMMUNITY/AGENCY NAME ______________________

MONTH ____________ YEAR ________

PREPARED BY ______________________ TITLE ____________

MONTHLY SEWER SYSTEM OPERATING AND MAINTENANCE COSTS

O&M TASK DESCRIPTION	UNIT OF MEASURE	UNITS THIS PERIOD		LABOR HOURS	LABOR COST	MATERIAL COST	EQUIPMENT COST	TOTAL COST	COMMENTS
		UNITS BUDGETED	UNITS ACTUAL						
ROUTINE O&M COSTS									
Lift Station O&M	Each								
Sewer Cleaning	Ln Ft.								
Roof Cutting	Ln. Ft.								
Minor Sewer Repairs	Ln. Ft.								
Manhole Repairs	Ln. Ft.								
Sewer System Inspections									
Sewer Pipe	Ln. Ft.								
Manholes	Each								
New Construction	Each								
Flow Monitoring	Ln. Ft.								
Response to Customer Complaints	Each								
Subtotal O&M Costs									
Overhead									
Vehicle/Equipment Maintenance	Hours								
Administration	Hours								
Supervision	Hours								
Insurance									
Vacation Leave	Hours								
Holiday Leave	Hours								
Sick Leave	Hours								
Workmen Compensation	Hours								
Training	Hours								
Subtotal Overhead Costs									
Total Routine O&M Costs									

MONTHLY OPERATIONS AND MAINTENANCE COST FORM

O&M TASK DESCRIPTION	UNIT OF MEASURE	UNITS THIS PERIOD		LABOR HOURS	LABOR COST	MATERIAL COST	EQUIPMENT COST	TOTAL COST	COMMENTS
		UNITS BUDGETED	UNITS ACTUAL						
ABNORMAL O&M COSTS									
Engineering Studies	Each								
Outside Contracts	Each								
Consulting Services	Each								
New Equipment Purchases	Each								
Replacement Equipment	Each								
Total Abnormal O&M Costs									
TOTAL MONTHLY COSTS									

MONTHLY OPERATIONS AND MAINTENANCE COST FORM (CONT.)

____ / ____ / ____

WEEK ENDING

Hours Charged to an Account Must be Noted by Day

EMPLOYEE NUMBER

____

EMPLOYEE NAME

WEEKLY TIME SHEET

SAT	SUN	MON	TUE	WED	THU	FRI	REGULAR HOURS	OT HOURS	ACCOUNT ABBREVIATION	PROJECT OR ACCOUNT	DEPT. NUMBER	TYPE OF WORK

						REGULAR HOURS	OT HOURS	ACCOUNT ABBREVIATION	PROJECT OR ACCOUNT	DEPT. NUMBER	TYPE OF WORK
HOLIDAY								HOLIDAY			
SICK LEAVE								SICK LEAVE			
VACATION								VACATION			
SPECIAL LEAVE								SPECIAL LEAVE			
TIME OFF OFFICE CLOSING								TIME OFF/OFFICE CLOS.			
TOTAL HOURS											

____________________ EMPLOYEE SIGNATURE

____________________ APPROVED BY SUPERVISOR

EMPLOYEE TIME SHEET

Sample Index for Account Numbers,
Department Numbers, and Type of
Work Codes.

Project or Account No.	Account Abbreviation
XXXX	Sewer Cleaning
XXXX	Inspections
XXXX	Rehabilitation
XXXX	Budgeting
XXXX	Etc.
Dept. No.	
XXXX	Operation and Maintenance
XXXX	Civil Engineering
XXXX	Purchasing
XXXX	Etc.
Type of Work Codes	
XX	Administrative
XX	Training
XX	Technical Report Writing
XX	Sewer Balling
XX	Manhole Inspections
XX	Replacing Manhole Covers
XX	Etc.

EMPLOYEE TIME SHEET (Cont.)

TO:

SHIP TO:

PURCHASE ORDER NUMBER: ____________

WORK ORDER NUMBER: ____________

DATE INITIATED: ____________

DATE REQUIRED: ____________

SHIP VIA: ____________

F.O.B.: ____________

TERMS: ____________

____

____

DATE RECEIVED: ____________

QUANTITY	STOCK NUMBER/DESCRIPTION	PRICE	PER	TOTAL

APPROVED BY: ____________ DATE: ____________

SHEET ______ OF ______

PURCHASE ORDER FORM

Agency ____________ Prepared by ____________

19___ Month	Direct Labor S.T.	Overtime	Overhead	Utility Costs	New Equip. Purchases	Equip. Repair	Equip. Rental	Consultant Fees	Contractor Fees	Misc.	TOTAL
JAN											
FEB											
MAR											
APR											
MAY											
JUNE											
JULY											
AUG											
SEPT											
OCT											
NOV											
DEC											
TOTAL											

ANNUAL COST SUMMARY FORM

EQUIPMENT NAME AND NUMBER	SERIAL NO.	LOCATION

DATE OF TROUBLE	TIME	REPORTED BY	SHIFT

INDICATION OF TROUBLE

- ☐ BROKEN PART
- ☐ WORN PART
- ☐ HEAT
- ☐ NOISE
- ☐ SMELL
- ☐ VIBRATION
- ☐ LEAKING
- ☐ DIRTY, FOULED
- ☐ VOLTAGE
- ☐ CURRENT
- ☐ RESISTANCE
- ☐ FLOW RATE
- ☐ PRESSURE
- ☐ SPEED
- ☐ OTHER ____________

WHEN DISCOVERED

- ☐ STARTING
- ☐ STOPPING
- ☐ DURING OPERATION
- ☐ DURING PREVENTIVE MAINT.
- ☐ DURING CORRECTIVE MAINT.
- ☐ DURING OVERHAUL
- ☐ OTHER ____________

CAUSE OF TROUBLE

- ☐ HEAT/COLD/WEATHER
- ☐ HUMIDITY/MOISTURE
- ☐ FOREIGN OBJECT
- ☐ SHOCK/VIBRATION
- ☐ WEAR
- ☐ EQUIPMENT DEFECT
- ☐ IMPROPER INSTALLATION
- ☐ IMPROPER LUBRICATION
- ☐ IMPROPER OPERATION
- ☐ OTHER ____________

REMARKS AND RECOMMENDATIONS ____________

CHECK IF EQUIPMENT WAS TAGGED OUT OF SERVICE ☐

EQUIPMENT MALFUNCTION REPORT

DATE ______________________ OPERATOR ______________________

UNUSUAL CONDITION: CHECK (✓)

- ☐ EXPLOSION
- ☐ FLOODING
- ☐ VANDALISM
- ☐ EQUIPMENT FAILURE
- ☐ POWER FAILURE
- ☐ FIRE
- ☐ LINE COLLAPSE OR BLOCKAGE
- ☐ OTHER

REASON FOR CONDITION ______________________

DAMAGES, INJURIES, ETC. ______________________

ACTION TAKEN (WHO NOTIFIED, WHAT DONE) ______________________

REMARKS ______________________

SIGNED ______________________

OPERATOR ON DUTY

EMERGENCY CONDITIONS REPORT

DATE ____________ TIME ____________

COMPLAINT BY ____________

ADDRESS ____________

TELEPHONE ____________

LOCATION OF COMPLAINT ____________

____

DETAILS OF COMPLAINT ____________

CHECK (✓) COMPLAINT

SEWER SYSTEM COMPLAINTS

- ☐ MANHOLE COVER MISSING
- ☐ MANHOLE COVER LOOSE OR NOISY
- ☐ ODORS-GASES
- ☐ MANHOLE CAVE-IN
- ☐ LINE CAVE-IN
- ☐ MANHOLE FLOODED
- ☐ STREET FLOODED
- ☐ YARD FLOODED
- ☐ BUILDING FLOODED
- ☐ OTHER

LIFT STATION COMPLAINTS

- ☐ ODORS
- ☐ FLOODING
- ☐ STOPPAGES
- ☐ UNKEPT GROUNDS
- ☐ SPILLS
- ☐ OTHER

ACTION TO BE TAKEN:

- ☐ IMMEDIATE INSPECTION
- ☐ IMMEDIATE REPAIR
- ☐ OWNER'S REPAIR
- ☐ FUTURE REPAIR
- ☐ WATER DEPARTMENT NOTIFIED
- ☐ HEALTH DEPARTMENT NOTIFIED
- ☐ OTHER ____________

COMPLAINT RECEIVED BY: ____________ DATE: ____________

COMPLAINT FORM
F-24

METCALF & EDDY

NAME ____________________ DAY __________ DATE __________ 19 ___

	NAME	PRODUCTION	STAND BY	FIELD REPAIR	TRAVEL	SHOP	OTHER	HRS	TOTAL
CREW CHIEF									
SECOND MAN									
THIRD MAN									
FOURTH MAN									
TOTAL HOURS									

WEATHER CONDITIONS ____

WORK PHASE	DISTRICT	MANHOLE REACH	EQUIPMENT USED	MILEAGE	TIME SPENT

SIGNED ____________________________

DAILY PROGRESS REPORT

DATE:________________

Sewer Segment No.________

Upstream MH ID No.________ Rim/Inv El:_______/______

Downstream MH ID No.________ Rim/Inv El:_______/______

Length of Sewer ________ feet Pipe Material:____________

Pipe Diameter________inch Joints:________________

Date Installed:________________

Type of Rehabilitation Completed:

- ☐ Service Connection Repair
- ☐ Spot Replacement
- ☐ Sewer Grouting (indicate number of joints) Sliplining
- ☐ Inversion Lining
- ☐ Manhole-to-Manhole Replacement
- ☐ Other ____

Exact location of work:____

Crew Size Used: ____

Manhours Used:____

Equipment Used: ____

Replacement/Repair Materials Used:____

____

Comments:____

____

____

SEWER SEGMENT REHABILITATION FORM

DATE:________________

Sewer Segment No.__________

Upstream MH ID No. __________ Rim/Inv El:______/_____

Downstream MH ID No. _________ Rim/Inv El:______/_____

Length of Sewer__________feet Pipe Material:___________

Pipe Diameter___________inch Joints:________________

Date Installed:___________________

Cleaning Equipment Used: ____

____

Debris Severity Observed:_________

Types of Debris Observed:

- ☐ Grit
- ☐ Grease
- ☐ Roots
- ☐ Broken Pipe
- ☐ Other ____

Comments: ____

____

____

Debris Severity

0 - None 1 - Minor 2 - Moderate 3 - Severe 4 - Blockage

SEWER CLEANING FORM

DATE	REQUESTED BY	REQUIRED COMPLETION DATE

EQUIPMENT NAME AND NUMBER	SERIAL NO.	LOCATION

INDICATION OF TROUBLE

- ☐ BROKEN PART
- ☐ WORN PART
- ☐ HEAT
- ☐ NOISE
- ☐ SMELL
- ☐ VIBRATION
- ☐ LEAKING
- ☐ DIRTY, FOULED
- ☐ VOLTAGE
- ☐ CURRENT
- ☐ RESISTANCE
- ☐ FLOW RATE
- ☐ PRESSURE
- ☐ SPEED
- ☐ OTHER ____________

WORK TO BE DONE

- ☐ INSPECT
- ☐ REPAIR
- ☐ REPLACE
- ☐ SERVICE
- ☐ OVERHAUL
- ☐ PAINT
- ☐ OTHER ____________

CAUSE OF TROUBLE

- ☐ HEAT/COLD/WEATHER
- ☐ HUMIDITY/MOISTURE
- ☐ FOREIGN OBJECT
- ☐ SHOCK/VIBRATION
- ☐ WEAR
- ☐ EQUIPMENT DEFECT
- ☐ IMPROPER INSTALLATION
- ☐ OTHER ____________

WORK REQUESTED ____________

ESTIMATED COSTS

LABOR ____________

PARTS ____________

CONTRACTOR ____________

TOTAL ____________

ESTIMATED DOWN TIME

APPROVED BY	DATE	JOB NO.

MAINTENANCE WORK RECORD RECAP

DESCRIBE WHAT WAS WRONG AND HOW IT WAS FIXED	OUTSIDE CONTRACTOR USED
RECOMMENDATIONS FOR AVOIDING REPEATED FAILURE	REASON

EQUIPMENT STATUS AT COMPLETION

- ☐ FULLY OPERATIONAL
- ☐ NON-OPERATIONAL
- ☐ REDUCED CAPABILITY
- ☐ AWAITING SPARE PARTS

SPARE PARTS AVAILABILITY

- ☐ IN STOCK
- ☐ OBTAINED LOCALLY
- ☐ DELAY IN PROCURING
- ☐ LENGTH

ACTUAL COSTS

LABOR ____________

PARTS ____________

CONTRACTOR ____________

TOTAL DOWN TIME

WORK COMPLETED

DATE ____________ NAME ____________

WORK APPROVED

DATE ____________ REQUESTOR ____________

MAINTENANCE WORK ORDER

EQUIPMENT NO. ______________

DATE	MECHANICS NAME	REQ. HRS.	OT HRS.	PARTS OR MATERIALS	MANUFACTURER AND CATALOG NO.	COST

EQUIPMENT SERVICE RECORD CARD

DATE:________________

Manhole ID No.______________

Rim/Inv El:_________/_________

Street Address/Location:____

Manhole Type:________________________

Cover Type:__________________________

Installation Date:______________________

Type of Rehabilitation Completed:

- ☐ Cover Replacement
- ☐ Frame Seal
- ☐ Wall Repairs
- ☐ Pipe Connection Repair
- ☐ Replacement
- ☐ Bench and Channel Repairs

Equipment Used:____

Crew/Contractor:____

Time Required to Complete:____

Replacement/Repair Materials Used:______________________________________

Comments: ____

____

____

MANHOLE REHABILITATION FORM

DATE:______________

Manhole ID No.____________

Rim/Inv El:__________/_________

Street Address/Location:____

Manhole Type:________________

Cover:______________________

Installation Date:______________

Sketch of Inlet and Outlet Piping:

N ↑

Flow Measuring Equipment:

- ☐ Dip Stick
- ☐ Weir
- ☐ Flume
- ☐ Flow Monitor (specify type)

Flow Measurement:___________ gpd

Time of Reading:____________________ Weather:____________________

Indicate weather conditions on the 3 days prior to this measurement:

____

Comments:____

____

____

VISUAL FLOW CHECK FORM

DATE:________________

Lift Station No.__________

Location:____

Pump Manufacturer:____

Type of Pumps:____

No. of Pumps:____________

Date Lift Station was Built:___________

Inspector(s):____

Time Arrived:____________________ Time Departed:_______________

TASK	COMPLETED
1. Check that electric power is on.	____________
2. Make sure no circuit breakers have been tripped.	____________
3. Read and record values on counters and timers.	____________

Pump No.	Running Time
1	____________
2	____________
3	____________

4. Inspect, clean, and lubricate motors and rings.	____________
5. Inspect and clean wet well level sensor electrodes and bubbler tubes.	____________
6. Inspect and clean motor starters and relays.	____________
7. Check the operation of the gland water pump motors and electric valves.	____________
8. Inspect and clean all automatic gate controls.	____________
9. Check kilowatt meters and charts and record data.	____________
10. Check the motor, heating elements and belts on auxiliary equipment. Replace any broken or worn parts. Parts Replaced ________________________	____________
11. Check the float switches and motors on lift station sump pumps.	____________

DAILY LIFT STATION INSPECTION FORM

TASK	COMPLETED
12. Inspect and clean bar screen or communitor controls.	______
13. Inspect indicating lights on all equipment and telemetry equipment controls.	______
14. Inspect pumps and bearings. Lubricate and repack if needed.	______
15. Inspect and lubricate line shaft bearings.	______
16. Inspect and lubricate gland water pumps and bearings.	______
17. Make sure the pump packing is not leaking too much water and is not too tight.	______
18. Inspect check valves and verify that they are not stuck either open or partially closed.	______
19. Inspect sump pump floats and all discharge piping and valves.	______
20. Check the position and operation of all flow control gates.	______
21. Check the drives and screens on all mechanically cleaned bar screens.	______
22. Inspect communitors for proper operation.	______
23. Inspect, clean, and lubricate all air compressors.	______
24. Manually clean bar screens.	______
25. Make sure all vent fans and lights are operating properly.	______
26. Enter any observed problems into the lift station log books.	______
27. Pick up all debris inside and outside of the facility.	______
28. Before leaving the facility make sure it is secure.	______
29. Plow snow if necessary.	______

Comments:____

____

____

DAILY LIFT STATION INSPECTION FORM (CONT.)

DATE:________________

Lift Station No.__________

Location:____

Pump Manufacturer:______________________________________

Type of Pumps:____

No. of Pumps:___________

Date Lift Station was Built:__________

Inspector(s):____

Time Arrived:_____________ Time Departed:________________

TASK	COMPLETED
1. Check all equipment, piping and valves for leakage.	________
2. Operate each wastewater pump in the "manual" or "hand" position and inspect the pump and motor for excessive noise or vibration.	________
3. Check all motors for excessive temperature increases.	________
4. Check all pressure and vacuum gauges.	________
5. Inspect and clean sump pump wells if necessary.	________
6. Clean the wet well of accumulated grease, floating debris, and grit.	________
7. Clean and reposition floats and level sensor electrodes in the wet well.	________
8. Inspect wet well piping and ladders.	________
9. Mow the lift station yard if necessary.	________
10. Wipe down all equipment.	________
11. Replace recording charts as required.	________
12. Exercise standby equipment to dry out water, redistribute lubricant and ensure operational readiness.	________
13. Check operation of all lift station alarm systems.	________

Comments:____

____

WEEKLY LIFT STATION INSPECTION FORM

DATE:___________

Lift Station No.________

Location:____

Pump Manufacturer:____

Type of Pumps:____

No. of Pumps:___________

Date Lift Station was Built:___________

Inspector(s):____

Time Arrived:______________ Time Departed:_________________

TASK	COMPLETED
1. Operation all flow control gates and valves to prevent them from seizing.	___________
2. Remove the pump casing inspection plates and remove any debris that has accumulated.	___________
3. Check calibration and recalibrate flow meters.	___________
4. Clean all ventilation openings.	___________
5. Check first aid supplies.	___________
6. Take inventory of spare parts. Verify that depleted parts have been ordered.	___________
7. Check the condition of paint both inside and outside the lift station.	___________

Comments:____

____

____

MONTHLY LIFT STATION INSPECTION FORM

DATE:__________

Lift Station No.__________

Location:____

Pump Manufacturer:____

Type of Pumps:____

No. of Pumps:______________

Date Lift Station was Built:____________

Inspector(s):____

Time Arrived:__________________ Time Departed:__________________

TASK	COMPLETED
1. Dismantle the wastewater pumps to inspect the impellers, shafts, and shaft sleeves.	________
2. Inspect and clean all components of the ventilating fans, heaters, sump pumps, and dehumidifiers.	________
3. Inspect the condition of all electrical equipment.	________
4. Paint areas both inside and outside of the lift station as needed.	________
5. Inspect the inlet and outlet piping at the lift station. Clean the piping if needed.	________
6. Check flowmeter calibration and recalibrate if necessary.	________

Comments:____

____

____

ANNUAL LIFT STATION INSPECTION FORM

DATE:____________

Inverted Siphon No.____________

Type:____________

Location:____________

Length:____________

Pipe Material:____________

Pipe Inverts:____________

Pipe Diameters:

Pipe No. 1:_____inch

Pipe No. 2:_____inch

Date Installed:____________

Inspectors:____________

Time Arrived:____________ Time Departed:____________

Atmospheric Testing Results:

Inlet Structure:____________

Outlet Structure:____________

Flow measurement upstream of siphon:____________ gpd

Flow measurement downstream of siphon:____________ gpd

	TASK	COMPLETED
1.	Mechanical parts inspected for debris.	
2.	Check that hatches to inlet and outlet structures are secure.	
3.	Check that air vent piping between inlet and outlet structures is working properly.	
4.	Exercise slide gates.	

INVERTED SIPHON INSPECTION FORM