I/I Assessment and Reduction Plan

Cameron, Missouri

Prepared For:
Missouri Department of Natural Resources

Prepared By:
HDR | Archer

HDR Project No. 136952

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FIGURES

APPENDICES

ACRONYMS

CCTV	Closed Circuit Television
EPA	Environmental Protection Agency
GIS	Geographic Information System
GPS	Global Positioning System
I/I	Infiltration and Inflow
In	Inches
MDNR	Missouri Department of Natural Resources
MGD	Million Gallons per Day
MGH	Million Gallons per Hour
NPDES	National Pollution Discharge Elimination System
SSES	Sewer System Evaluation Study
SSO	Sanitary Sewer Overflow
WWTP	Wastewater Treatment Plant

SECTION 1 INTRODUCTION

1.1 Purpose

On July 28, 2009, the Missouri Department of Natural Resources (MDNR) conducted a Municipal Sanitary Sewer Overflow Compliance Inspection of the City of Cameron (City) sanitary sewer collection system. The purpose of the inspection was to assess compliance with the Missouri Clean Water Law. On December 31, 2009, the City received the Municipal Sanitary Sewer Overflow Compliance Inspection Report, NPDES Permit Number MO-0104299 (Inspection Report).

A required action of the Inspection Report is that the City develop and submit an Inflow and Infiltration (I/I) Assessment and Reduction Plan (Plan). The purpose of this Plan is to document the steps necessary to identify sources of I/I and create a comprehensive plan to reduce them. The Plan includes the following components:

- Prioritization of sewer basins based upon the age of the system and known problem areas
- Explanation of field activities that will serve to identify sources of I/I
- Method of determining cost-effective I/I rehabilitation
- Prioritizing of corrective action for each source identified
- Schedule for inspecting the priority areas and completing rehabilitation

1.2 Background

The City of Cameron currently operates and maintains approximately 48 miles of sanitary sewer. In addition, the City maintains thirteen pump stations and one wastewater treatment facility (NPDES MO-0104299). Twenty-three (23) basins encompassing 3,200 acres contribute flow to the water treatment facility (see Figure 1).

In March, 2009 the City completed a Preliminary Engineering Report (HDR|Archer, 2009) for improvements to the wastewater conveyance system. This report looked at areas of the City that have high I/I, specifically the northern part of the system served by Pump Stations 1 and 2 (basins F and E, respectively). Flow metering was conducted at the influent lines to these pump stations; flow metering data show that Basin F (Pump Station 1) sees a peak I/I rate of 9.2 times the average daily flow rate, and Basin E (Pump Station 2) sees a peak I/I rate of 14.6 times the average daily flow rate. The study looked at potential costs for reducing I/I in these basins.

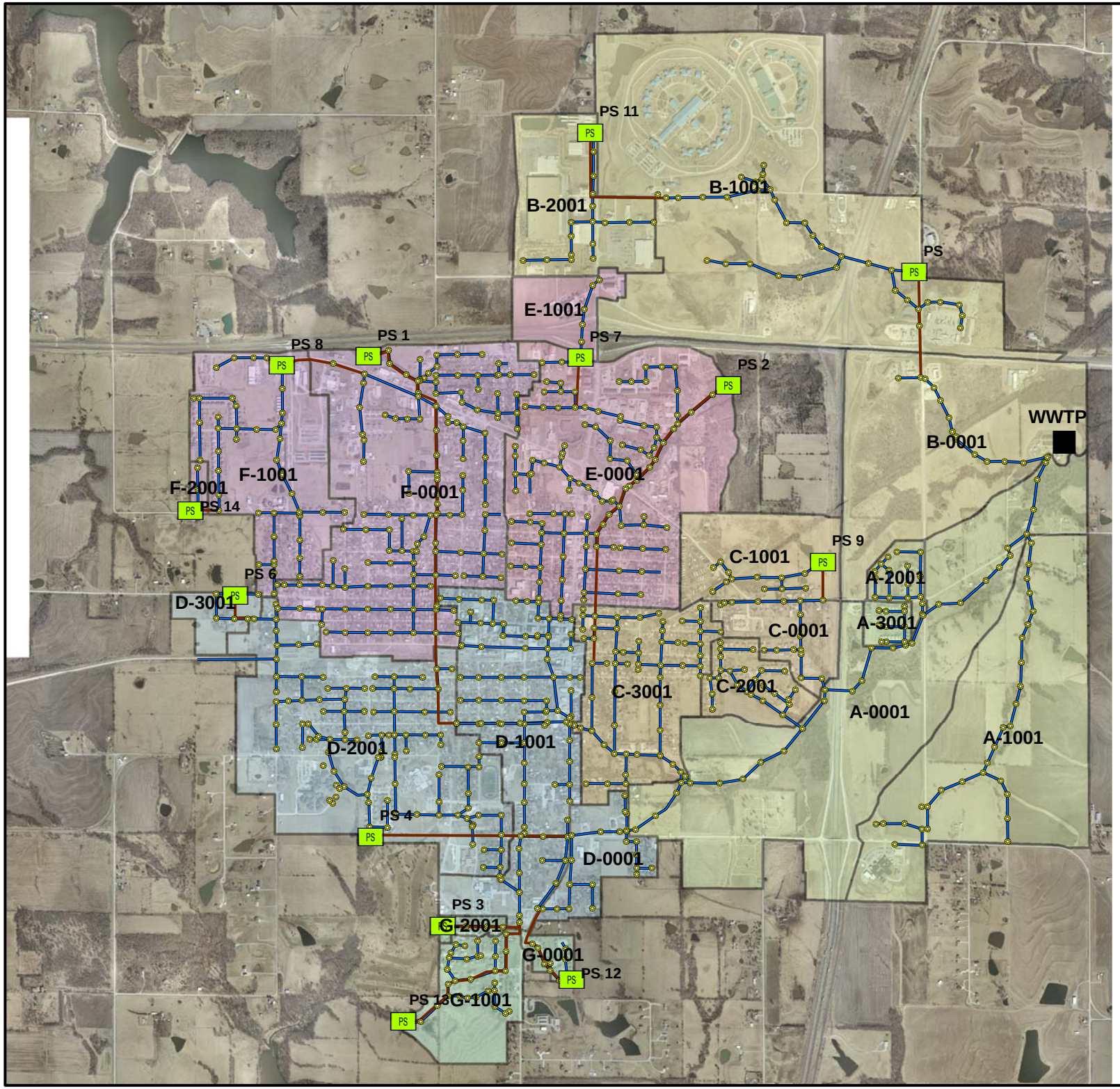
In addition this study assessed the condition of Pump Stations 1 and 2 and determined that the equipment has exceeded its useful life and should be replaced. Improvements planned for these pump stations include constructing new cast-in place concrete, submersible pump stations adjacent to the existing pump stations and new, larger force mains downstream of the pump stations to carry flow directly to the wastewater

treatment facility. An excess flow holding basin is also planned at the wastewater treatment facility to store flows that exceed the hydraulic capacity of the plant.

The Wastewater Conveyance Facility Improvements Preliminary Engineering Report is herewith submitted for review and approval.

Over the past few years, the City has worked toward improving collection system reliability and maintenance. The following are efforts the City has completed as part of this work:

1. In 2007 and 2008 the City purchased a new sewer jetter and vacuum unit to clean sewer lines and remove debris from manholes.
2. On May 1, 2006, the City developed a Sewer Overflow Response Plan and a companion document for basement backups.
3. The City purchased a new push-type camera system for smaller sewer lines.
4. Efforts to control fats, oils, and greases (FOG) in the collection system were stepped up. An initial inspection of all known food service establishments in the City was conducted. These facilities were given best management practices on controlling FOG.
5. The collection system maintenance supervisor has increased use of bio-blocks at some manholes to help in the grease reduction effort. Root cutting efforts have also been increased.
6. The City has been reporting infiltration/inflow and system maintenance efforts to MDNR semi-annually as part of the conditions of the permit renewal.
7. The City purchased two flow meters and rain gauges in 2008. These flow meters initially monitored pump stations #1 and #2, but have more recently been used to monitor other locations in the system.
8. The City budgeted $15,000 for manhole repairs/relining and have evaluated current technology for these repairs, as well as developments in the area of point repairs that can be done in-house.


PS 11
B-2001
B-1001
PS
E-1001
PS 8
PS 1
PS 7
PS 2
WWTP
B-0001
F-1001
E-0001
F-2001
F-0001
PS 14
PS 9
C-1001
PS 6
A-2001
D-3001
A-3001
C-0001
C-3001
C-2001
A-0001
A-1001
D-2001
D-1001
PS 4
D-0001
PS 3
G-2001
G-0001
PS 12
PS 13
G-1001
CITY OF CAMERON
I/I Assessment and Reduction Plan
Cameron, MO
Figure 1
Sewer Basin Map
Legend
Pump Station
Manhole
Sanitary Sewer Pipes
Force Main
Gravity
Sub-Basin Boundary (Sub-basins of the same color represent the same basin)
N
0 1,000 2,000 Feet
HDR | Archer

SECTION 2 SELECTION OF STUDY AREAS

2.1 Historical Sewer System Overflows

SSOs that occur at manholes within the system are reported to MDNR as they occur. The City has reported twenty-seven (27) SSO's or backups in the past two years.

- One SSO occurred at Pump Station 1 due to a broken force main
- Seven SSOs occurred at Pump Station 2; six of these are due to wet weather events and one is due to a broken force main
- One SSO occurred at Pump Station 4 due to wet weather
- Two SSOs occurred in the system at 8th and Harris due to wet weather
- Three SSOs occurred in the system at Walnut and Cornhill due to wet weather
- One SSO occurred in the system at Highway 69 and Dugan due to wet weather
- One SSO occurred in the system at Walnut and Prairie due to wet weather
- Six other SSOs occurred at unspecified locations in the system; these were due to a broken manhole barrel, grease blockages, a broken force main, and wet weather
- Six SSOs occurred at the wastewater treatment facility due to wet weather

The work subsequent to this plan that is described in Section 3 will identify the wet weather SSOs and private property backups that occur during the course of the work. These locations will be mapped out and included within the report. The maps will be used in the field during the inspections to locate historical problem areas and conduct interviews with property owners.

2.2 Initial Prioritization of Sewer Basins

The collection and conveyance system is divided into seven (7) sewer basins and twenty-three (23) sewer sub-basins that are prioritized for evaluation based upon factors such as the age of the system, known SSOs or backups, and anticipated high I/I areas. Since excessive infiltration and inflow from deteriorated pipes, pipe joints, manholes, and illegal connections by private homeowners, normally occurs to a greater extent in older sewer systems, the investigations will be prioritized accordingly. Not all of the sanitary sewer will be inspected as the study initially focuses on areas that are 15 years and older. Basin G (sub-basins G-0001, G-1001, and G-2001) was identified as a basin newer than 15 years and is not included initially as a priority area.

The basins are initially prioritized according to the following:

1. Sub-basin F-0001 – there have been three SSOs in this sub-basin, including one at Pump Station 1. This basin includes a portion of the original town area. This area is prioritized as the most important due to its upstream location to the City's drinking water intake.
2. Basin E (sub-basins E-0001 and E-1001) – there have been six SSOs in this basin (all at Pump Station 2). This basin includes a portion of the original town area.
3. Sub-basins D-0001 and D-1001 – there have been five SSOs in these sub-basins. These sub-basins drain to Basin C and include portions of the original town area.
4. Sub-basins D-2001 and D-3001 – there has been one SSO in these sub-basins. These sub-basins drain to Pump Station 4 and include portions of the original town area.
5. Sub-basins F-1001 and F-2001 – there have been no reported SSOs in these sub-basins.
6. Basin C (sub-basins C-0001 through C-3001) – there have been no reported SSOs in these sub-basins.
7. Basin A (sub-basins A-0001 through A-3001) –there have been no reported SSOs in these sub-basins other than the SSOs reported at the WWTP, which are not believed to be caused directly by Basin A.
8. Basin B (sub-basins B-0001 through B-2001) – there have been no reported SSOs in these sub-basins.

SECTION 3 SEWER SYSTEM EVALUATION STUDY

As part of this Plan, the priority basins identified in Section 2 will be studied to identify and assess the extent of I/I. All studies will generally follow the guidelines established in the Existing Sewer Evaluation & Rehabilitation, (WEF Manual of Practice FD-6 and ASCE Manual and Report on Engineering Practice No. 62, 1994). The program consists of the following six (6) key components:

- Administration
- Public Relations
- I&I Quantification
- I&I Identification
- Source Flow Analysis
- Final Recommendations and Implementation Plan

The City will hire an individual to take on the role of collection system I/I inspector/technician. This person will be involved in all field inspection and rehabilitation activities and will be supplemented by other City staff in these efforts. An engineering consultant will assist with field inspections and will complete analysis of flow and rainfall data, quantify I/I flows based on field inspections, complete cost-effective analysis, and provide final recommendations for rehabilitation improvements.

The field inspections (I/I identification), source flow analysis, and subsequent implementation plan will initially focus on public sector I/I only. Sub-basin F-0001, which is the first sub-basin to be completed, will be used as a pilot study to demonstrate whether the necessary I/I reductions can be achieved with only public sector I/I removal. For this pilot study the costs of removing public sector I/I sources that are not shown to be cost effective will be compared with the costs of removing private sector I/I in order to achieve the overall required reductions. The need to remove private sector I/I will be re-evaluated upon conclusion of this pilot study.

3.1 Administration

Progress meetings will be held regularly to review the project goals, objectives, and schedule. Public hearings and Council meetings will be conducted to discuss the project and answer questions from the public and/or City.

3.2 Public Relations

Field inspection notification letters will be sent at least one week prior to any investigations. The notification letter will explain the field inspections that will be taking place and the reasons for these inspections. A press release will also be printed in the City paper describing field inspections. In the event that manhole structures identified for inspection are located on inaccessible private property, a door notification will be left for the property owner. The notification will contain an explanation of the need to conduct an inspection of the structure along with a telephone number enabling

residents to contact the City for more information and to schedule a convenient time for the inspection.

Forty-eight hours (48) prior to smoke testing, a notification to affected property owners will be completed by placement of door hangers on homes and businesses. This notice will include general information about the testing; including instructions to fill infrequently used plumbing traps with water to prevent smoke from entering buildings via service lines. Telephone numbers shall be provided enabling residents to contact the City for more information or with any special needs and concerns they may have.

3.3 I&I Quantification

Dry weather and wet weather flow rates measured in the system are a good indicator as to which priority areas experience significant I/I entering the system. The results of flow monitoring will be used to refine the priority ranking described in Section 2 so that the City can concentrate the assessment efforts on the areas that exhibit high rates of I/I.

3.3.1 Flow Monitoring

As discussed previously, the City has two flow meters that have been used to measure flow into Pump Station 1 (Basin F) and Pump Station 2 (Basin E) in the past. This data will be used as initial flow monitoring data in these basins. More recently the City has used the flow meters they own other locations in the system. The City may purchase additional temporary flow meters to aid in the evaluation of the collection system. The temporary flow meters are area velocity flow modules with sensors. The flow meters record flow, velocity and depth readings every fifteen minutes. The average dry weather flow should be determined based upon a minimum of three months of data.

3.3.2 Rainfall Monitoring

Rainfall monitoring will be conducted concurrently with flow monitoring activities. A rainfall gauge will be placed near the center of town to be used in conjunction with flow monitoring data.

3.3.3 Flow Data Analysis

The flow and rainfall data collected will be analyzed for the following:

- Average daily and peak hourly dry-weather flows
- Peak high groundwater infiltration flows
- Peak wet-weather inflows
- Peak wet-weather total flows

The results of the flow analysis will be used to rank basins on I&I contribution to the system and refine the priority ranking described in Section 2.

3.4 I&I Identification

Prior to the commitment of field inspections, the City will interview staff about the existing sewer system. The staff members are the most familiar with the system and have information on defect locations and the history of the performance within areas of the system. The staff also has information on private property problems within the system. In areas with previously reported backups, residents will be interviewed during the field inspection process to determine the history of the problems. The information collected from staff members and residents will be noted and special attention given in the field to the areas with historical problems.

3.4.1 Manhole and Visual Pipe Inspections

Defective manholes are major contributors of excessive I/I in a sanitary sewer system. Manhole inspections are used to locate these sources of I/I, assess the conditions and the state of deterioration inside manholes, and to determine the need for repair or replacement.

Manhole inspections will be accomplished using a two-person crew. Manholes less than 15 feet deep and their connecting pipe sections will be inspected from the surface using survey rods, digital cameras, mirrors, and high-powered spot lights. Inspections of manholes greater than 15 feet deep will be accomplished by man entry into the manhole. Industry standard OSHA, NIOSH, ODSH, and NASSCO confined space entry policies and practices will be followed to ensure safe entry and egress of all confined spaces.

Manhole inspection forms and visual pipe inspection forms will be completed for each manhole. Example forms are contained in Appendix A. The forms include a field sketch of the plan view of each manhole to verify sewer line configurations. Digital photographs of each manhole and the connecting pipe sections will be taken during manhole inspections. All photos shall be taken north-facing to ensure consistency and provide a standard point of reference for viewing.

The following manhole components will be inspected for signs of I/I and for structural soundness: the manhole cover, cover-to-frame fit, the manhole frame, the frame-to-chimney seal, the chimney condition, the corbel condition, the wall condition, the step condition, the bench, the invert, and each of the pipe seals. Digital photographs will also be taken of noted I/I defects and other non-I/I related defects such as roots, debris, or structurally deteriorated steps.

Each field crew will use metal detectors and probing rods where necessary to assist in locating manholes. If a manhole cannot be located during a 15-minute time period, the manhole shall be placed on a "Can Not Locate" list and provided to the City with a general map of the position for location services at a later time. If a manhole is found to be buried, the approximate location of the manhole will be identified in the field and submitted to the City. New manholes found by field crews shall be assigned a temporary manhole number consisting of the last known downstream manhole number followed by a T1, T2, T3, etc., as applicable. If located on public sewer mains, these

manholes will be inspected and location details for the manhole will be provided to the City.

In addition to manhole structure inspections, the incoming and outgoing sanitary sewers can be visually inspected by a pole mounted camera from accessible manholes. This procedure is called a visual pipe inspection. This pipe inspection will be used to identify sections of pipe that are structurally defective or require some form of maintenance. Data from the visual pipe inspection will be used to identify defects near the manhole structure and to select lines for further investigation through CCTV inspections.

Before any manhole or visual pipe inspection begins, a training workshop with inspection crews will be conducted. Manhole and visual pipe inspection forms and procedures will be explained. A sample manhole will be inspected to instruct the field crews on how to fill out the inspection forms and the types of defects that will be observed.

The manholes will be labeled according the City's manhole ID numbers. The size, type, depth and condition of the manhole and pipes will be collected. Photos will be taken and recorded on each inspection form. All of the information collected will be used to estimate the amount of rehabilitation work required for each manhole. The typical defects found in manholes are: broken/cracked covers, broken/cracked frames, deteriorated frame seals, deteriorated frame adjustments, defective cones, defective walls, defective or deteriorated steps, deteriorated troughs or inverts, deteriorated pipe seals, and deteriorated benches.

The following equipment will be needed to perform the manhole and visual pipe inspections:

- Manhole pick and shovel to open the manholes
- Wrench to open bolted down manholes
- Flashlight
- Camera mounted on a bar
- Hand held camera
- Traffic control equipment such as cones, signs, flags, etc.
- Metal detector
- Probing rods

3.4.2 Smoke Testing

Smoke testing will be conducted on all line segments located within the priority basins to detect I/I sources, to locate manholes not identified on the City's existing map, and to obtain a lineal footage of the sewer line segments for the system inventory. Smoke sources will be photographically documented and precisely located to allow for efficient repair. Although the initial purpose of the testing will not be to identify private sources of I/I the smoke testing will likely identify some of these sources. These sources will be recorded and the City will request that the homeowner remove any illicit connections identified through smoke testing.

Smoke testing will be used to augment the manhole and visual pipe inspections. Prior to any smoke testing, the fire department will be notified and door hangers will be placed at each property. An example notification letter/door hanger is provided in Appendix B.

Smoke testing will be completed by blowing white smoke into an isolated line segment with high-capacity blowers. Blowers will be placed over an isolated line segment and three five-minute smoke bombs will be inserted into the blower intake to blow smoke into the sewer. Smoke emissions from sewer mains, storm sewers, and manholes indicate possible leaks and cross connections.

Every sewer segment within the study scope will be attempted. Before any smoke testing is conducted a training workshop with the inspection crew will be conducted. Smoke testing forms and procedures will be explained. A smoke testing crew will consist of three people. One person will set up the smoke test for a segment while the other two will walk around and note everywhere they see smoke, sketch the location of the smoke, and take pictures of each emission. While two people from the crew are setting up for the next segment, the other person will be filling out the smoke testing form from the previous smoked segment. There will be one smoke testing crew.

The segment of main that will be smoked will be identified by an upstream and downstream manhole ID. The sketch for all visible smoke will be a description of the location (house address) with ties to this location (measurement from the corner of a house). The smoke will be rated as light, medium, or heavy and the area that drains to this leak will be estimated and photographs will be taken. An example smoke testing form is provided in Appendix A.

The following equipment will be needed to perform the smoke testing:

- Blower
- Sandbags
- Smoke bombs
- Flags
- Hand held cameras
- Tape measure
- Manhole pick and shovel
- Wrench for bolt down manhole lids
- Flashlight
- Traffic control equipment such as cones, signs, flags, etc.

3.4.3 CCTV

The CCTV utilizes a closed circuit television camera to observe the conditions on the sewer mains and detect any defects. For each segment that is CCTV'd, a form will be completed and a videotape of the segment will be created. An example CCTV

inspection form is provided in Appendix A. A CCTV inspection crew will consist of two people. There will be one crew who will conduct the CCTV inspections.

Line segments recommended for cleaning and CCTV inspections will be based on the results from manhole/visual pipe inspections and smoke testing. Necessary cleaning and root cutting will be performed prior to the television inspections to allow passage of the camera to offer the best view of the interior of the lines for evaluating structural conditions and identifying potential I/I sources.

Before any CCTV inspections are conducted a training workshop with the inspection crew will be conducted. CCTV inspection forms and procedures will be explained.

The equipment that will be needed for the testing is as follows:

- Equipment required to clean sewer main segments
- Equipment required to conduct CCTV inspections of sewer main segments

CCTV will be conducted at the same time as the dye-water testing. The CCTV inspection will take place immediately following the field investigations, manhole inspection and smoke testing.

3.4.4 Dye-Water Testing

Dye-water testing is a rainfall simulation technique used to identify defects that can contribute significant I/I during a storm event. Dye-water testing is done in conjunction with CCTV testing.

Dye-water will be deposited into the storm sewers, streams, ditches, or driveway, stairwell, or area drains that are suspected to be connected to, or leaking into, the sewer system. The presence of dye-water in the adjacent downstream manhole, or within the sewer main, observed through CCTV, will indicate infiltration.

A dye-water testing crew will consist of two people. There will be one crew who will conduct the dye-water testing and CCTV inspections. Only suspected cross connections, or leakage into the sewer system, identified through manhole, visual pipe, and smoke testing within the priority areas will be dye-water tested.

Before any dye-water testing is conducted a training workshop with the inspection crew will be conducted. Dye-water testing forms and procedures will be explained. An example dye-water test form is included in Appendix A.

Fluorescent dyes will be used for dye-water testing. The equipment that will be needed for the testing is as follows:

- Equipment required to carry water to the site
- Fluorescent dye
- Sand bags to block sewer segments
- CCTV equipment if required

- Manhole pick and shovel
- Wrench for bolt down manhole lids
- Flashlight
- Traffic control equipment such as cones, signs, flags, etc.

The dye-water testing will be conducted concurrently with the CCTV inspections.

3.5 Establishing Source Flows and Costs

Once the field inspections for a priority area have been completed, the data collected will be analyzed to determine how much I/I was identified (in terms of flow rates) and what the associated costs to remove this I/I from the system are. These costs will be used in the cost effective analysis.

Determining the amount of I/I identified, or I/I quantification, is the process of assigning flow rates to individual defects identified and projected from the various field activities. Assigning individual flow rates is an approximation since many of the defects will not actually be observed leaking but will only show evidence of leakage. The flow rates assigned will, therefore, be based on a physical observation of the defect and typical flow rates based on experience. In most cases, classes of defects will be assigned the same rate. For example, all manhole walls rated fair will have the same estimated leakage unless, on an individual basis, there is a reason to assign a higher or lower rate. The sum of all defect flow rates should not exceed the monitored flow values. The quantification of sources will be based on a balance of monitored flows, individual area characteristics, and any other reported flow rates.

Unit flow rates for manhole and pipe defects will be based on estimated leakage rates for "good", "fair", or "poor" conditions as will be reported from the inspections, except those defects that depend on tributary area. Source flows that are determined based on tributary area include ponding at manhole covers or may include indirect or direct cross connections that would have high I/I flow rates. In these cases, the tributary area, depth of ponding, and smoke test intensity will be used to estimate flow rates.

Once all of the defects have been identified, quantified, and grouped, a cost effective analysis will be completed. This cost effective analysis will first determine what sources are the most cost effective to remove and how this cost compares to the cost of transporting and treating the I/I.

A cost for the elimination of each I/I source will be determined. A total correction cost for each group of defects will then be determined. Engineering, administration, and contingency will be added to the total correction costs for each group. The total accumulative cost against the total accumulative flow rate will be plotted on a chart and a curve will be drawn that passes through all points. The cost to transport and treat the I/I against the total flow rate will be plotted on this same chart. These two curves will then be added together and plotted on this same chart as a composite cost curve. The minimum cost along the composite cost curve will be located and a straight line parallel to the cost axis will be drawn until it intersects on the cost curve for rehabilitation. This intersecting point will represent the optimal point for sewer rehabilitation.

The analysis of the collected data and the cost effect analysis will be completed as each field inspection is completed. As each priority area is completed, the data shall be analyzed to allow improvements to begin in one area while another is undergoing field inspection.

3.6 Recommendations and Implementation Plan

The completed inspections forms, video, and photographs will be incorporated into Microsoft Excel. Through field inspections, it may be found that most of the defects are located on mains of a certain age or within certain areas. These mains can be grouped in Microsoft Excel by these categories to better prioritize rehabilitation efforts. The field inspection forms for all field activities can be integrated into Microsoft Excel. Once the data has been entered into Microsoft Excel, it will be quality controlled to ensure all information was input.

During field inspections, immediate attention items and maintenance items will be identified as work orders or scheduled maintenance. This will help to ensure that these items get repaired in a timely fashion.

A final report for each sewer basin will be provided in a clear and concise format summarizing the findings and recommendations for the field investigations and data analysis. The following information will be included in the reports:

- Executive Summary – highlights all tasks performed, conclusions, recommendations, and costs.
- Background Information – describes the problem statement, previous studies and rehabilitation work within the study area.
- Sewer Map – delineates sub-basins monitoring locations, and sewer sizes.
- Field Data Analysis – tabulates the results of the field activities and quantifies I/I flows per source.
- Recommendations – lists the recommended activities for each basin, including cost and finalized implementation schedule.
- Appendix – includes a complete bound copy of written inspection forms and a CD containing scanned images of the inspection forms and a digital inspection photos.

SECTION 4 I/I REDUCTION

The I/I Reduction Plan to manage and control peak wastewater flows will consist of public sector I/I reduction/elimination. I/I reductions will be divided into the following categories:

- Priority 1 – Cost Effective Rehabilitation
- Priority 2 – Structural Rehabilitation
- Preventative Maintenance
- Post-Rehabilitation Flow Monitoring

4.1 Priority 1 – Cost Effective Rehabilitation

Cost-effective rehabilitation is based on recommendations from the SSES and are those repairs that remove I/I and meet the lowest costs as determined by the composite cost curve method described in Section 3.5. Cost effective rehabilitation consists of both manhole and pipeline rehabilitation.

4.1.1 Manhole Rehabilitation

Cost-effective manhole rehabilitation may consist of the following methods which are focused on the top-end of the manhole where higher I/I flows are found:

- Replace Vented Covers Below Grade
- Raise Manhole to Grade
- Replace/Rehabilitate Frame/Seal
- Replace/Rehabilitate Chimney

4.1.2 Pipeline Rehabilitation

Cost-effective pipeline rehabilitation may consist of the following methods which may include immediate structural repairs if discovered during field inspections:

- Point Repairs
- Full Line Replacement
- Full Line Rehabilitation
- Abandon/Realign Pipeline
- Defective Service Tap Rehabilitation
- Disconnecting Direct Storm Connections
- Disconnecting Indirect Storm Connections

4.2 Priority 2 – Structural Rehabilitation

Additional defects that exhibited enough structural deterioration to warrant rehabilitation but may not be classified as cost effective will be recommended for further evaluation and possible repair. Structural rehabilitation also consists of both manhole and pipeline rehabilitation.

4.2.1 Manhole Rehabilitation

Structural manhole rehabilitation may consist of the following methods which may include additional top-end manhole repairs:

- Replace/Rehabilitate Frame Seal
- Replace/Rehabilitate Chimney
- Rehabilitate Cone and Wall
- Rehabilitate Bench and Invert
- Rehabilitate Pipe Seals

4.2.2 Pipeline Rehabilitation

Structural pipeline rehabilitation may consist of the following methods:

- Point Repairs
- Full Line Replacement
- Full Line Rehabilitation
- Abandon/Realign Pipeline

4.3 Preventative Maintenance

The City is currently developing an Inspection and Maintenance Program in accordance with the Municipal Sanitary Sewer Overflow Compliance Inspection Report. This plan will address preventative maintenance and emergency maintenance.

4.4 Post-Rehabilitation Flow Monitoring

Following the rehabilitation of individual study areas, post-rehabilitation flow analysis will be conducted to measure the success of the program. Flow monitoring will be performed in the same locations as were monitored prior to rehabilitation. Flow data will then be compared to pre-rehabilitation flow monitoring. Results will be evaluated to determine the success of the rehabilitation program and whether future rehabilitation methods should be altered.

SECTION 5 PROJECT SCHEDULE

A proposed schedule for completion of the SSES and related I/I reduction improvements is presented in Figure 2. Each basin will be studied separately and is divided into five categories: initial flow monitoring; completion of the SSES, including the cost-effective analysis and preparation of the final report; design and bidding of the selected I/I rehabilitation improvements; construction of the selected I/I rehabilitation improvements; and post-rehabilitation flow monitoring.

Manhole inspections cannot be performed when snow cover is on the ground. Smoke testing cannot be performed when the soil surrounding the pipes is saturated or frozen. Smoke testing during windy days can cause the smoke to blow away quickly, making the smoke less accurate to detect. This leaves approximately four to five months of the year in which to perform the inspections. Inspections will only be conducted during working hours, excluding holidays, and weather permitting days. The schedule assumes that field activities can be conducted beginning April 1 of each year followed by data analysis.

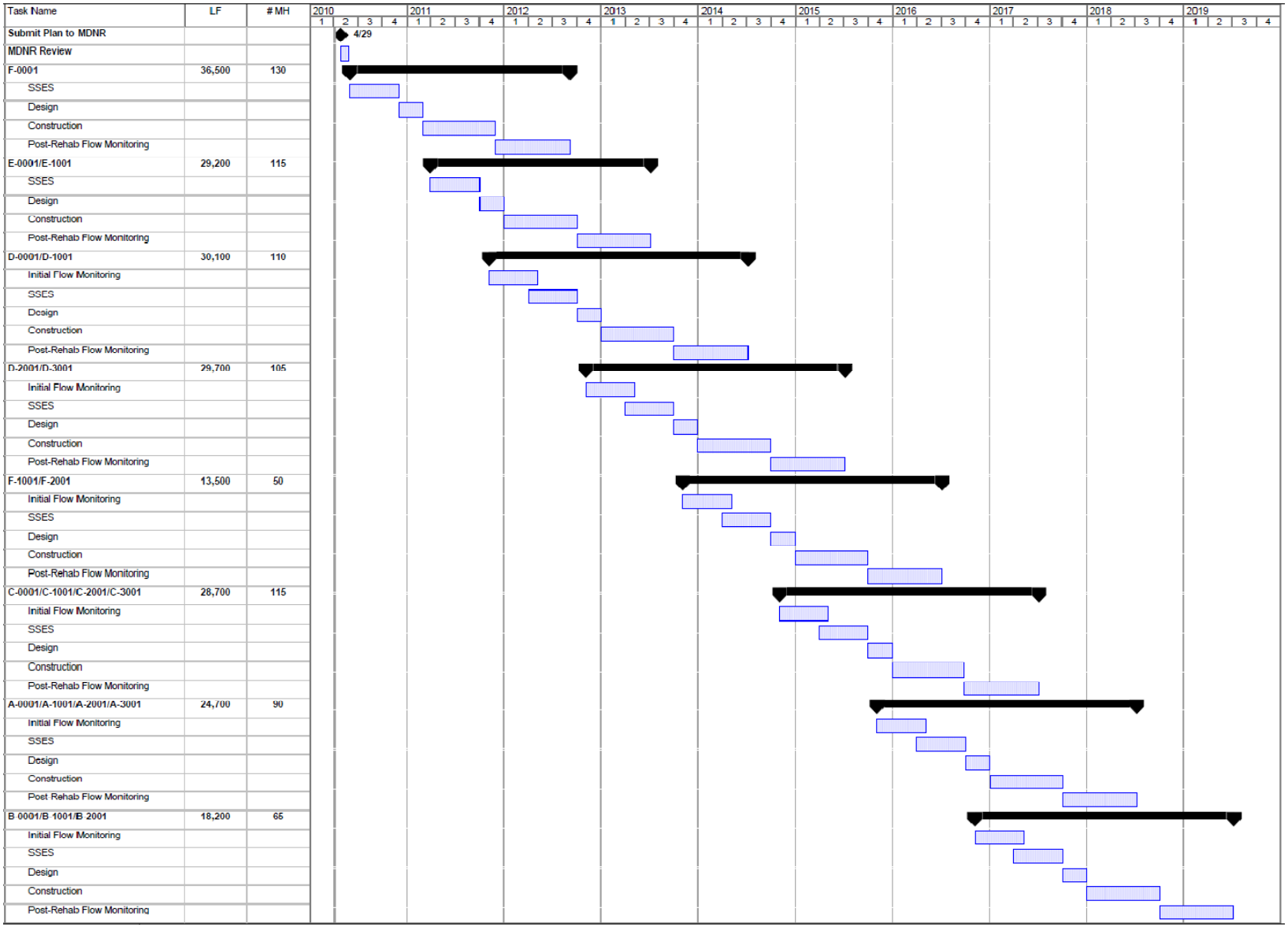


Figure 2: Proposed Schedule for I/I Assessment and Reduction Activities

Appendix A
Field Inspection Forms

MANHOLE INSPECTION

Date: ___ / ___ / ___

Crew: _____, _____, _____

City of Cameron, Missouri

Project No. _____

Manhole No. ( ) _____

Address: House No. _____

Street: _____

Locality: _____

Map No.: _____

Precipitation: _____
1 = None, 2 = Light Rain, 3 = Heavy Rain, 4 = Snow

Ground Conditions: _____
1 = Dry, 2 = Damp, 3 = Wet, 4 = Standing Water

Downstream Pipe Length: _____ (ft.)

o **Inspected**

Reason Not Inspected: _____

1 = C.N.L.
2 = D.N.E.
3 = Buried
4 = Haz/Atmos.
5 = Unsafe
6 = Sealed Lid
7 = Traffic
8 = Dog
9 = Other

Location Code: _____

1 = Paved Street
2 = Unpaved Street
3 = Paved Intersection
4 = Unpaved Intersection
5 = Alley
6 = Sidewalk
7 = Parking Lot
8 = Backyard
9 = Ditch
10 = Curb/Gutter
11 = Easement
12 = Private Residence

Manhole Diameter: _____.____(ft.)

Manhole Depth: _____.____(ft.)

o **Subject to Ponding**

Ponding Depth: _____.____(ft.)

Tributary Area: _____ (sq. ft.)

Grade Elevation Code: _____

1 = Even

2 = Above _____ (in.) no decimal

3 = Below _____ (in.) no decimal

Structure Type Codes:

1 = Brick
2 = Precast
3 = Block
4 = Clay Pipe
5 = Concrete Pipe
6 = Poured
7 = Rehab Coating
8 = Cast Iron
9 = PVC
10 = PVC-coated
11 = Rebar
12 = None
13 = Bitumastic
14 = Grout
15 = Other

See Attachment "A" for General Observation Codes.

	Type	Condition	I/I (gpm)	General Obs.	Comments
Cover: ……		G F P		____,____,____,____	_____

a. Diameter: ____.____ (in.)

b. Thickness: ____.____ (in.)

c. Type Code: _____

1=Light Duty, 2=Heavy Duty
3=Bolt Down, 4=Locking

d. o Vented Cover

e. No. of Vents: _____

f. Vent Dia.: ____.____(in.)

_____ MH Area Photo	_____ MH Photo Topside (N)
_____ MH Defect Photo	_____ MH Defect Photo
_____ MH Defect Photo	_____ MH Defect Photo

	Type	Condition	I/I (gpm)	General Obs.	Comments
Cover-to-Frame Fit: ……		G F P	____	____,____,____,____	_____
Frame: ……..		G F P	____	____,____,____,____	_____
a. Inside Dia.: ____.____(in.)					
b. Outside Dia.: ____.____(in.)					
c. Dwell: ____.____ (in.)					
d. Height: ____.____ (in.)					
Frame-to-Chimney Seal:	_____	G F P	____	____,____,____,____	_____
Chimney: ……..	_____	G F P	____	____,____,____,____	_____
a. Height: ____.____ (in.)					
Corbel: ……..	_____	G F P	____	____,____,____,____	_____
Wall: ……..	_____	G F P	____	____,____,____,____	_____
Bench: ……...	_____	G F P	____	____,____,____,____	_____
Invert: ……...	_____	G F P	____	____,____,____,____	_____
Steps: …….	_____	G F P	____	____,____,____,____	_____

a. No. Missing: _____

Pipe Seal: **Condition I/I (gpm)**

Seal #1. G F P _____

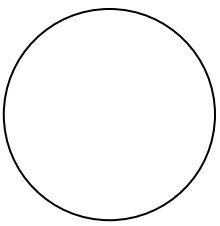
Seal #2. G F P _____

Seal #3. G F P _____

Seal #4. G F P _____

Seal #5. G F P _____

Seal #6. G F P _____



o **Evidence of Surcharge**

Surcharge Depth: _____.____ (ft.)

Comments: _____

MANHOLE INSPECTION
ATTACHMENT "A" GENERAL OBSERVATION

Observation Codes

1. Needs immediate attention
2. Collapsed
3. Structurally unsound
4. Surcharged: unable to inspect
5. I/I staining: not active
6. Cracks: minor
7. Cracks: moderate
8. Cracks: major
9. Root intrusion: minor
10. Root intrusion: moderate
11. Root intrusion: major
12. Broken
13. Missing
14. Deteriorated
15. Missing Bitumastic Seal
16. Offset
17. Missing/broken bolts on cover
18. Cover in bottom of manhole
19. Cover insert: good condition
20. Cover insert: poor condition
21. Cover gasket: good condition
22. Cover gasket: poor condition
23. Vent holes plugged
24. Cover sealed with asphalt
25. Cover sealed with sealing compound
26. Cretex boot: good condition
27. Cretex boot: poor condition
28. Missing grout/mortar
29. Missing bricks/blocks
30. Leaking joints
31. Leak around step
32. Leak at lift-hole
33. Minors chat
34. Previous rehabilitation coating
35. Previous partial replacement
36. Previous structural lining
37. Bench-to-wall seal: fair condition
38. Bench-to-wall seal: poor condition
39. Raised bench
40. Depressed bench
41. Bench-to-invert seal: fair condition
42. Bench-to-invert seal: poor condition
43. Deposition: silt
44. Deposition: sludge
45. Deposition: debris
46. Notched
47. Located in asphalt pavement surface
48. Located in concrete pavement surface
49. Flat bench
50. Moderate honeycomb
51. Severe honeycomb
52. Mineral deposit
53. Groundwater
54. Unexposed invert
55. Flattop

Recommendation Codes

81. Expose Invert
82. Reshape Invert
83. Chimney Rehabilitation
84. Seal Precast Joints
85. Plug Lift Holes/Plug Holes
86. Grade Adjustment
87. Replace Steps
88. Coat Pipe Seal
89. Grout Pipe Seal
90. Complete Manhole Replacement
91. Replace Bench and Trough
92. Bench and Trough Rehabilitation
93. Wall Rehabilitation
94. Corbel Replacement
95. Corbel Rehabilitation
96. Replace Frame Seal/Chimney
97. Replace Cover/Frame/Frame Seal/Chimney
98. Replace Frame Seal Only
99. Replace Cover/Frame/Frame Seal

VISUAL PIPE INSPECTION

City of Cameron, Missouri

Date: _____ / _____ / _____ **Project No._____**

Crew: _____, _____, _____ **Observation Manhole No. ( ) _____**

Lamping Direction	**DS #1**	**US #2**	**US #3**	**US #4**	**US #5**
To Manhole:	( )	( )	( )	( )	( )
Service	●	●	●	●	●
Rim-To-Invert Elevation (nearest tenth of a foot)	__ __ . __	__ __ . __	__ __ . __	__ __ . __	__ __ . __
Drop	●	●	●	●	●
Drop Type: 1=Const. Ext.; 2=Const. Int. 3=Not Constructed	_____	_____	_____	_____	_____
Pipe Diameter: (dia. in inches – no decimals)					
Type of Pipe: 1=VCP 4=RCP 7=OBG 2=PVC 5=CMP 8=Other 3 = DIP 6=CIP 9=Truss					
Pipe Shape: 1=Circular 3=Elliptic 2=Rectangular 4=Other					
Depth of Flow: (in.)	__ __ __ . __ __	__ __ __ . __ __	__ __ __ . __ __	__ __ __ . __ __	__ __ __ . __ __
Velocity of Flow: (ft./sec.)	__ __ . __	__ __ . __	__ __ . __	__ __ . __	__ __ . __
Roots: 1=Light 2=Medium 3=Heavy	___ @ _____ (ft)	___ @ _____ (ft)	___ @ _____ (ft)	___ @ _____ (ft)	___ @ _____ (ft)
Deposition: 1=Medium 2=Heavy					
Grease	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)
Mineral Deposit	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)
Longitudinal Cracks	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)
Circular Cracks	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)
Broken Pipe	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)
Collapsed Pipe	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)
Joint Infiltration	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)
Offset Joint: 1=Minor 3=Severe 2=Moderate	___ @ _____ (ft)	___ @ _____ (ft)	___ @ _____ (ft)	___ @ _____ (ft)	___ @ _____ (ft)
Protruding Tap	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)
Line Grade Poor	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)
Abandoned	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)
Permanent Plug	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)	● @ _____(ft)
Estimated Observed Length	__ __ __ (ft)	__ __ __ (ft)	__ __ __ (ft)	__ __ __ (ft)	__ __ __ (ft)
Photo Identification Nos.					

Comments: _____

_____

_____

_____

Date: _____/_____/_____

Crew: _____

_____

_____

SMOKE TESTING

City of Cameron, Missouri

Project No. _____

Sub-Basin _____

Line Segment: (**) _____ To (** **) _____**

Upstream **Downstream**

Weather Conditions: _____
1 = 110-90°, 2 = 90-80°, 3 = 80-70°, 4 = 70°-below

Ground Conditions: _____
1 = dry, 2 = moist, 3 = wet, 4 = saturated

Precipitation: _____
1 = dry, 2 = drizzle, 3 = rain

Last Rain Event: ____/____/____

Pipe Length (ft.): _____

Pipe Diameter (in.): _____

Status Code: _____

Measure Code: _____

Status Code:
1=C.N.L. 4=Line too long
2=D.N.E. 5=Diameter too large
3=Buried 6=Complete

Measure Code:
1=Scaled from Map 4=Total Station
2=Walking Wheel 5=Estimated
3=Tape Measure

PART A: PRIVATE SECTOR

Smoke Defect No.	Bldg. Defect No.	Address	Defect Type	*Optional*: Footage (0=DS MH)	Offset (L/R)	Offset Footage	Smoke Intensity	Photo ID
A	____	_____	_____	_____	____	_____	_____	_____
B	____	_____	_____	_____	____	_____	_____	_____
C	____	_____	_____	_____	____	_____	_____	_____
D	____	_____	_____	_____	____	_____	_____	_____
E	____	_____	_____	_____	____	_____	_____	_____
F	____	_____	_____	_____	____	_____	_____	_____
G	____	_____	_____	_____	____	_____	_____	_____
H	____	_____	_____	_____	____	_____	_____	_____
I	____	_____	_____	_____	____	_____	_____	_____
J	____	_____	_____	_____	____	_____	_____	_____

Defect Type:
1 = Downspout
2 = Uncapped Cleanout
3 = Driveway Drain
4 = Stairwell Drain
5 = Foundation Drain
6 = Area Drain
7 = Service Lateral
8 = Window Well
9 = Plumbing Defect

Smoke Intensity:
1 = Light
2 = Medium
3 = Heavy

PART B: PUBLIC SECTOR

Defect No.	Defect Type	*Optional*: Footage (0=DS MH)	Offset (L/R)	Offset Footage	Smoke Intensity	Photo ID	Comments
S	____	_____	_____	_____	_____	_____	_____
T	____	_____	_____	_____	_____	_____	_____
U	____	_____	_____	_____	_____	_____	_____
V	____	_____	_____	_____	_____	_____	_____
W	____	_____	_____	_____	_____	_____	_____
X	____	_____	_____	_____	_____	_____	_____
Y	____	_____	_____	_____	_____	_____	_____
Z	____	_____	_____	_____	_____	_____	_____

Defect Type:
1=Curb Inlet
2=Area Drain
3=Line Defect
4=Indirect Storm
5=Manhole Defect
6=Drainage Crossing
7=Water Valve
8=Direct Storm

Smoke Intensity:
1=Light
2=Medium
3=Heavy

Additional Comments: _____

_____

_____

_____

TELEVISION INSPECTION

City of Cameron, MO

Crew: ______________________
____
____

Project No: _______________
Priority Area: _____________

Line Segment: (   ) ______________________ To (   ) ______________________
Upstream — Downstream

Date Televised: ______/______/______
Pipe Diameter: ___________________
TV Tape No: ___________________

Date Reviewed: ______/______/______
Invert Depth: ____________________
Counter Start: __________________

Location: ________________________
____
Pipe Material: ___________________
1=vcp, 2=pvc, 3=dip, 4=rcp, 5=cmp, 6=CIP, 7=Obg, 8=Other
Counter Stop: __________________
Total Footage: __________________

Surface Condition: _____
1=Open Field
2=Street (Paved)
3=Street (Unpaved)
4=Sidewalk
5=Front Yard
6=Back Yard
7=Side Yard
8=Building, Structure
9=Street ROW
10=Other _________

Measurement: _________
1=Estimated
2=Scaled From Map
3=Tape Measure
4=Total Station
5=Walking Wheel

Maintenance Required: _____
1=Flush
2=Jet Flush
3=Power Rod
4=Root Cutter
5=Vapor Rooter
6=Bucket
7=Vacuum
8=Other __________

Frequency: ____________
1=Monthly
2=Quarterly
3=Semi-Annual
4=Annual
5=Every Two Years
6=Every Five Years
7=Once Only

PRIORITY LEVEL:
(Circle One; 1=Highest, 5=Lowest)

1 2 3 4 5

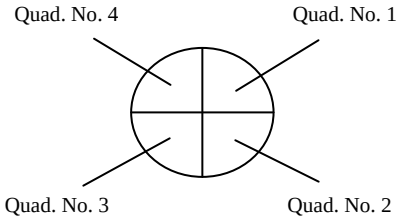
OBSERVATIONS:

Footage:	Measurement from Up/Down: (U/D)	Observation Code: 1	2	3	4	Comments:

Diagram:

TV OBSERVATION CODES

1. Camera Begin
2. Camera End
3. Camera Stuck
4. Left
5. Right
6. Crown
7. Quadrant 1
8. Quadrant 2
9. Quadrant 3
10. Quadrant 4
11. Camera Lens Sub
12. Camera Lens Emg
13. Long. Cracks Begin
14. Long. Cracks End
15. Circular Cracks
16. Broken Pipe Begin
17. Broken Pipe End
18. Broken Pipe
19. Missing Pipe-Partial
20. Missing Pipe Begin
21. Missing Pipe End
22. Debris in Invert
23. Collapse – Part. Blockage
24. Collapse – Comp. Blockage
25. Sag Begin
26. Sag End
27. Deformed Pipe
28. Joint w/Infiltration
29. Offset Joint-Minor
30. Offset Joint-Moderate
31. Offset Joint-Major
32. Separated Joint
33. Cracked Joint
34. Grade Change Up
35. Grade Change Down
36. Angle Left
37. Angle Right
38. Wye Connection
39. Tap-Flush
40. Tap-Protruding
41. Infiltration in Service
42. Infiltration at Seal
43. Light Roots Serv.
44. Mod. Roots Serv.
45. Heavy Roots Serv.
46. Light Roots
47. Moderate Roots
48. Heavy Roots
49. Grease Begin
50. Grease End
51. Deposition Begin
52. Deposition End
53. Mineral Deposit
54. Service Lateral Active
55. Service Lateral Dry
56. Service Lateral In Use
57. Service Lateral Dead
58. Evidence of Infiltration Light
59. Evidence of Infiltration Medium
60. Evidence of Infiltration Heavy
61. Leak at Joint
62. Reverse Setup
63. Begin Reverse Setup
64. End Reverse Setup
65. Begin Shattered Pipe
66. End Shattered Pipe
67. ¼ Diameter Water
68. ½ Diameter Water



Date: _____/_____/_____

Crew: _____

_____

_____

DYE TESTING

City of Cameron, Missouri

Project No.: _____

Sub-Basin: _____

Manhole No. ( ) _____

Address: **House No.** _____

Street: _____

Locality: _____

Precipitation: _____
1 = None, 2 = Light Rain, 3 = Heavy Rain, 4 = Snow

Ground Conditions: _____
1 = Dry, 2 = Damp, 3 = Wet, 4 = Standing Water

Downstream Pipe Length: _____ (ft.)

PART A: PRIVATE SECTOR

Drain No.	Type	Positive Y	Positive N	Suspect	Comments
A	_____	☐	☐	☐	_____
B	_____	☐	☐	☐	_____
C	_____	☐	☐	☐	_____
D	_____	☐	☐	☐	_____
E	_____	☐	☐	☐	_____
F	_____	☐	☐	☐	_____
G	_____	☐	☐	☐	_____
H	_____	☐	☐	☐	_____
I	_____	☐	☐	☐	_____
J	_____	☐	☐	☐	_____

Type:

1 = Downspout
2 = Uncapped Cleanout
3 = Driveway Drain
4 = Stairwell Drain
5 = Foundation Drain
6 = Area Drain
7 = Service Lateral
8 = Window Well

PART B: PUBLIC SECTOR

Defect No.	Defect Type	Footage (0=DS MH)	Positive Y	Positive N	Suspect	Comments
S	_____	_____	☐	☐	☐	_____
T	_____	_____	☐	☐	☐	_____
U	_____	_____	☐	☐	☐	_____
V	_____	_____	☐	☐	☐	_____
W	_____	_____	☐	☐	☐	_____
X	_____	_____	☐	☐	☐	_____
Y	_____	_____	☐	☐	☐	_____
Z	_____	_____	☐	☐	☐	_____

Defect Type:

1=Curb Inlet
2=Area Drain
3=Line Defect
4=Indirect Storm
5=Manhole Defect
6=Drainage Crossing
7=Water Valve
8=Direct Storm

Additional Comments: _____

_____

_____

_____

Appendix B
Example Notification Letter and Door Hanger

Date

Resident name _____
Address_____
_____

Re:

Dear Resident:

The City of Cameron will soon be implementing field inspection activities as part of the City's ongoing efforts to improve the sanitary sewer system. These improvements are intended to eliminate excess stormwater and groundwater from entering the sanitary sewer system. This excess stormwater and groundwater overloads the sanitary sewers causing basement flooding and sewer back-ups during and after periods of heavy rainfall. These field inspections will lead to improvements to the sanitary sewer system.

The field inspection activities include conducting smoke testing activities during the summer months. The purpose of "SMOKE TESTING" is to locate obstructions and defects in the sanitary sewer collection system. The smoke that you see coming from the vent stacks on houses or holes in the ground is: **NON-TOXIC, HARMLESS, HAS NO ODOR, AND CREATES NO FIRE HAZARD.**

The smoke should not enter your house unless you have defective plumbing or dry drain traps. If this occurs, you should consult your licensed plumber. In any event, the smoke can enter through faulty plumbing. The potential, likewise, exists for dangerous sewer gases to enter your home or establishment. Should smoke enter your building, you may contact a member of the smoke testing crew working in your neighborhood. If you have any seldom used drains, such as floor drains in basements, please pour water in the drain to fill the trap, which will prevent smoke from entering there. Drain traps should always be filled with water to prevent sewer gases or odors from entering the building. Additionally, washing machine drain pipes do not have traps. To help prevent smoke from entering your building around the washing machine drain pipe, tie a damp rag around the drain opening.

About 72 hours before smoke testing begins, door hangers will be distributed at each residence providing information regarding the procedure and names and phone numbers of personnel to contact for more information. During the smoke testing activities, personnel will be identifying defects that are revealed when smoke escapes through them. Locations for defects may include roof downspouts, uncapped cleanouts, driveway drains, stairwell drains, yard or area drains, window well drains, foundation-perimeter drains and defective service pipes. Smoke testing is anticipated to begin in early April and continue through the summer and fall months.

Thank you for your cooperation and assistance in helping the City of Cameron in its effort to improve the quality of service to all of our customers. Additional information concerning these activities may be found at either _____.

If you have any questions or require additional information, please contact the City at 816-632-2177.

Sincerely,

City of Cameron, Missouri

City of Cameron, MO

ATTENTION

The City of Cameron is implementing field inspection activities as part of the City's ongoing efforts to improve the sanitary sewer system. These improvements are intended to eliminate excess stormwater and groundwater from entering the sanitary sewer system. This excess stormwater and groundwater overloads the sanitary sewers causing basement flooding and sewer back-ups during and after periods of heavy rainfall.

The field inspection activities include smoke testing. **The smoke testing will occur in your area during the week of _____.**

The smoke should not enter into buildings unless leaks or plumbing defects exist. The smoke that you see coming from the vent stacks on houses or from holes in the ground is: **NON TOXIC, HARMLESS, HAS NO ODOR, AND CREATES NO FIRE HAZARD.** Please make sure that traps for all basement floor drains and other sink traps and plumbing fixtures are full of water by pouring approximately 24 ounces of water into each drain. Smoke may also enter your building around the wax ring, if faulty, at the base of the toilet.

Should you detect smoke in your building, the room should be ventilated through an open window or door. Leave the area and ventilate well to dissipate the smoke. Also, please notify the field technicians who are conducting the test should smoke enter your building.

Thank you for your cooperation and assistance in helping the City of Cameron in its effort to improve the quality of service to all of our customers. Additional information concerning these activities may be found at either _____

If you have any questions, contact the City at 816-632-2177

City of Cameron, MO

ATTENTION

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