I/I Assessment and Reduction Plan

City of Molalla
Oregon

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Oregon Department of Environmental Quality

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NPDES Permit #:101514

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FIGURES

APPENDICES

ACRONYMS

CCTV	Closed Circuit Television
DEQ	Oregon Department of Environmental Quality
EPA	Environmental Protection Agency
FTE	Full Time Employee
GIS	Geographic Information System
GPS	Global Positioning System
I/I	Infiltration and Inflow
MACP	Manhole Assessment and Certification Program
MGD	Million Gallons per Day
MGH	Million Gallons per Hour
NPDES	National Pollution Discharge Elimination System
PACP	Pipe Assessment and Certification Program
RII	Rainfall Induced Infiltration
SDC	System Development Charges
SSES	Sewer System Evaluation Study
SSO	Sanitary Sewer Overflow
WWTP	Wastewater Treatment Plant

SECTION 1 INTRODUCTION

1.1 Purpose

Like many wastewater collection systems, the City of Molalla's collection system was designed according to industry standards, but now appears to experience levels of inflow and infiltration (I/I) that exceed levels originally expected. Consequently, the City has developed its I/I Assessment and Reduction Plan to implement a consistent, long-term approach to utilizing the City's limited resources to efficiently address I/I within the City's collection system.

The goals of the City's I/I Assessment and Reduction Plan include:

- Minimization of infiltration, inflow and exfiltration, and maximum conveyance of wastewater to the wastewater treatment plant;
- Efficient use of allocated funds; and
- Identification, design and prioritization of ways to address I/I issues.

The intent of the City I/I Assessment and Reduction Plan is to optimize use of the City's limited human and material resources to effectively and efficiently address I/I. The City intends to establish its I/I Assessment and Reduction Plan as a matter of City policy.

The City's I/I Assessment and Reduction Plan complies with NPDES Permit No. 101514, Schedule D (July 1, 2014). Schedule D requires the City to develop an I/I plan within 180 days of the effective date of the NPDES permit. The NPDES permit requires the City's I/I program to address or include the following:

- Identification of all overflow points;
- Verification that sewer system overflows are not occurring up to a 24-hour, 5-year storm event or equivalent;
- Monitoring of all pump station overflow points;
- A process for identifying and removing inflow sources into the permittee's sewer system over which the permittee has legal control, including a time schedule for identifying and reducing inflow;
- If the permittee does not have the necessary legal authority to develop, operate and maintain an I/I reduction program, a strategy and schedule for putting in place the necessary legal authority to do so; and
- A process and schedule for identifying and removing inflow sources once legal authority has been obtained.

The City's I/I Assessment and Reduction Plan addresses each of these items. It also outlines a comprehensive, long-term approach to efficiently prioritizing the City's I/I assessment and reduction efforts.

Maintaining the value of the City's investment in its infrastructure is vital. The collection system represents a major capital investment for the community and it is one of the community's major capital assets. Equipment and facilities will deteriorate through normal use and age. Maintaining value of the capital asset is a major goal of the City's I/I Assessment and Reduction Plan.

The City's infrastructure provides crucial City's services and generates revenues. Proper reinvestment in capital facilities maintains the City's ability to provide those services at the lowest cost possible. It also helps ensure compliance with environmental requirements.

As a capital asset, the collection system and wastewater treatment plant require ongoing investment to ensure design capacity while maintaining existing facilities and equipment, as well as extending the life of the system. The City will use its I/I Assessment and Reduction Plan to, in part, manage its assets; in this case, the collection system itself.

1.2 Background

The City of Molalla currently operates and maintains approximately 29.3 miles of sanitary sewer. In addition, the City maintains 5 lift stations and one wastewater treatment facility. Eleven (11) basins encompassing 1157.7 acres contribute flow to the wastewater treatment facility (see **Figure 1A**).

In February, 1997, the City's Public Works Department completed an I/I Field Monitoring Summary (1997 I/I Report) to determine the general condition of the wastewater conveyance system at that time. The 1997 I/I Report evaluated areas of the City, specifically the older portions of the conveyance system where the pipes had been constructed mainly with concrete, AC and other materials that deteriorate with time. Flow metering was conducted at selected locations and data analysis was done utilizing a spreadsheet to calculate and organize the data. The 1997 I/I Report concluded that the following basins, as listed on the current Sewer Basin Map (**Figure 1**), appeared to have the highest I/I inputs: TL_A, TL_D, TL_F and BC_A.

More recently, when developing the 2013-14 fiscal budget, the City contracted with Curran-McLeod to complete an SDC Methodology and Sewer System Capital Improvement Plan (2013-14 Capital Improvement Plan). One component of the City's implementation of the 2013-14 Capital Improvement Plan targeted collection system I/I abatement and system expansion, trunk line upgrades and collection line upgrades.

In addition, over the past few years the City has worked toward improving collection system reliability and maintenance. The City has completed the following activities as part of this work:

1. In 2013, the City purchased a new sewer jetter and vacuum truck to clean sewer lines and remove debris from manholes. The City's Public Works Department has integrated this equipment into its regular collection system maintenance activities.

2. In the 2013-14 Fiscal Year, the City budgeted $75,000 for I/I investigation to study the current system and identify areas for future targeted maintenance and capital improvements. This budget has been set aside to fund planned field investigation work, including I/I flow monitoring, smoke testing, dye testing, manhole or pipe inspections, training and data analysis.
3. In October 2014, the City completed mapping the collection system with GPS coordinates and utilizing current GIS technology. The City's updated Sewer Basin Map (**Figure 1**) provides the most comprehensive, accurate and complete map of the collection system the City has ever had.

1.3 Legal Authority

The City has the legal authority necessary to regulate the volume of flow entering the collection system, including from residential and commercial properties. *See* Molalla Code Ch. 13.08 (available at http://qcode.us/codes/molalla). This includes I/I reduction.

The City maintains strict control over the connection of private sewer laterals to sewer mains. Molalla Code Ch. 13.08.270. Generally, in older collection systems, such private sewer lateral connections can have significant potential to be sources of infiltration. Standards for new connections are clearly specified. Molalla Code Ch. 13.08.420. The City's sewer use ordinance also contains provisions for inspection, approval of new connections, and a program to implement the requirements. Molalla Code Ch. 13.08.620-640, 68-770 (inspections); Molalla Code Ch. 13.08.330-470 (new connections); Molalla Code Ch. 13.08.710 (authority to require repair of leaks).

The City also prohibits stormwater connections to the sanitary sewer. Molalla Code 13.08.440 ("No person shall make connection of roof downspouts, exterior foundation drains, areaway drains, or other sources of surface runoff or groundwater to a building sewer or building drain which in turn is connected directly or indirectly to a public sanitary sewer.") (Ord. 2007-07 §1; Ord. 1976-2 Art. 4 §11)).

Direct stormwater connections to a separate sanitary sewer system are known as inflow. Inflow can severely impact the ability of the collection system to transport flows to the treatment plant during wet weather, leading to overflows and noncompliance with the wastewater treatment plant's NPDES permit. Generally, the City prohibits direct stormwater connections that could generate inflow. Consequently, the primary target of the City's I/I Assessment and Reduction Plan is infiltration.

1.4 Mapping

The City believes it crucial to develop and maintain accurate, current maps of the City's collection system. Efficient collection system maintenance and I/I identification requires functional maps. Collection system maps are also useful sources of information that City personnel use to carry out their assignments.

Prior to 2014, the City did not have a single unified map of sewer collection system

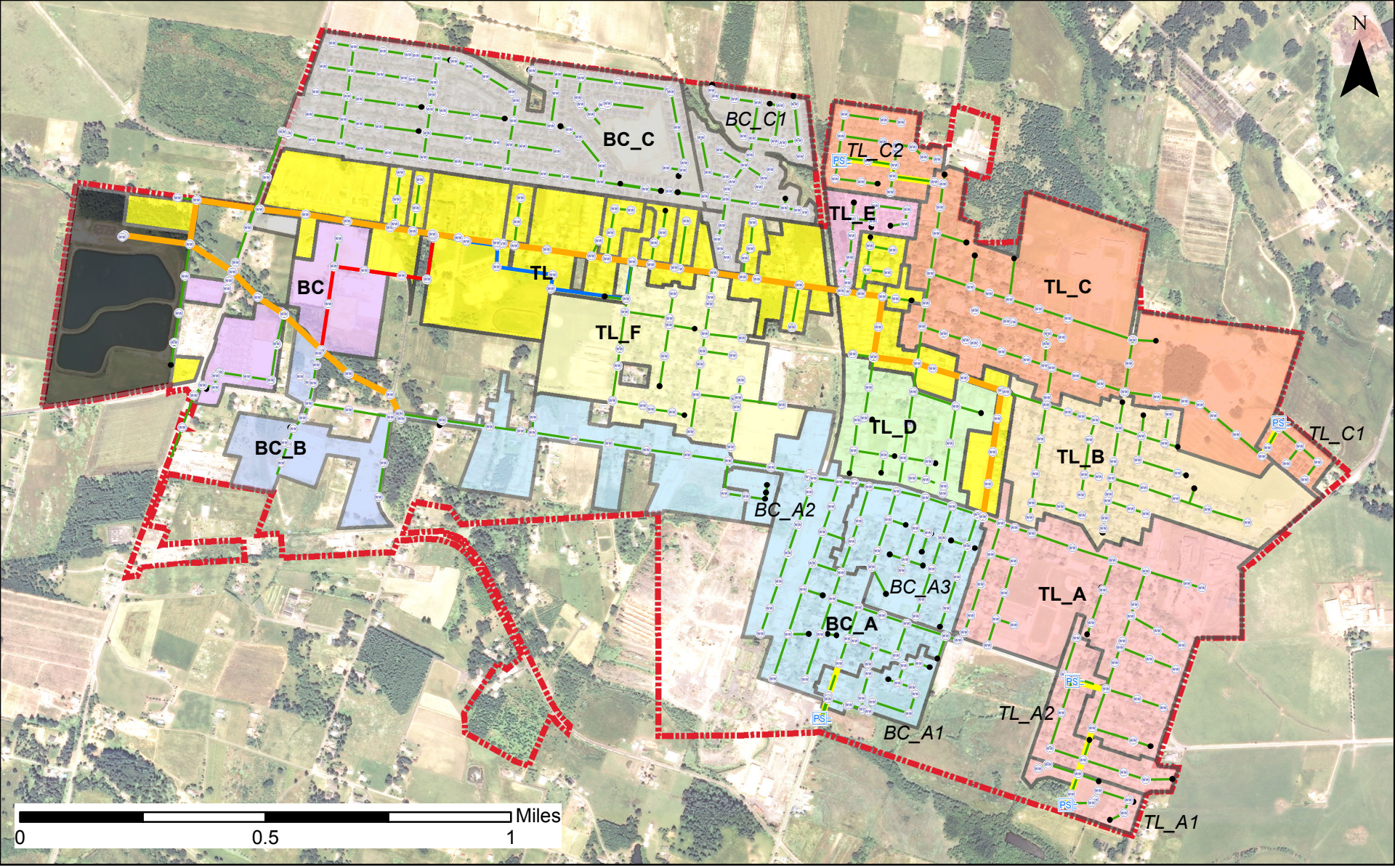
features. As part of the City's ongoing O&M and general sewer system management and upgrade program, the City developed a GIS-based map of sewer system features. That Sewer Basin Map is shown in **Figure 1**.

The Sewer Basin Map contains information on the following:

- Mains, trunk lines and force mains;
- The Tolliver Bypass;
- The Bear Creek Bypass;
- Lift Stations;
- Lampholes;
- Manholes;
- Sub-basins and the City boundary (service area boundary); and
- The Wastewater Treatment Plant.

The City intends to continue to update the information contained on the Sewer Basin Map. The City plans to collect and add information concerning the following:

- Laterals;
- Cleanouts;
- The properties served; and
- Other landmarks (roads, water bodies).



Sewer Features

- Manholes
- Lampholes
- Lift Stations
- Sub-Basins

Sewer Mains

- Mains
- Trunk Lines
- Force Mains
- Tolliver Bypass
- Bear Creek Bypass

Other Features

- City Boundary
- Wastewater Treatment Plant

Figure 1: Sewer Basin Map

Map Prepared by the City of Molalla
Data current to Nov, 2014

SECTION 2 SELECTION OF STUDY AREAS

2.1 No I/I Historical Sewer System Overflows

The City of Molalla has had no known historic sewer system overflows (SSOs) associated with or related to I/I since January 2006. (The City did report a September 8, 2014 sewer main blockage to DEQ, but this was not I/I related.) The City does not presently have concerns that I/I-related SSOs are likely nor has the Department of Environmental Quality expressed concern with the potential for I/I related SSOs in the City's collection system. In many Oregon cities, SSOs are a driver of I/I assessment and reduction programs because I/I often overwhelms the older collection systems present in many communities. Molalla does not have such a situation. The City's collection system and wastewater treatment plant is generally able to handle the wastewater quantities flowing into the wastewater treatment plant without any I/I related SSOs occurring.

2.2 Initial Prioritization of Sewer Basins

The City periodically evaluates the capacity of the sewer system in both wet and dry weather flows to ensure the capacity is maintained as it was designed. The City's I/I Assessment and Reduction Plan is intended to build upon ongoing activities and the everyday preventive maintenance that the City undertakes in the system.

The City's efforts as part of its I/I Assessment and Reduction Plan involve a number of components:

- Inventory and Prioritization;
- Flow Monitoring;
- Sewer System Testing;
- Identification of I/I Locations; and
- Sewer Rehabilitation Program

The City's assessment begins with an inventory of the current collection system and prioritization of areas for initial investigation. The City's collection system inventory includes the following basic information about the system:

- Population served;
- Total system size;
- Inventory of pipe length, size, material and age, and interior and exterior condition as available;
- Inventory of appurtenances such as bypasses, siphons, diversions, pump stations, tide or flood gates and manholes, etc., including size or capacity, material and age, and condition as available;
- Force main locations, length, size and materials, and condition as available;

- Pipe slopes and inverts; and
- Location of laterals.

The next step in the City's assessment is to identify the locations of significant I/I input to the collection system. These locations may warrant further investigation in the form of flow and rainfall monitoring and inspection procedures to identify and quantify the I/I issues associated with a particular location. The City's ultimate goal is to identify the major sources of I/I that contribute to the influent entering the WWTP.

The City's collection system is divided into Ten (10) sewer basins and Nine (9) sewer sub-basins. For the purpose of its I/I Assessment and Reduction Plan, the City has prioritized these basins and sub-basins for assessment using factors such as the age of the basin and sub-basin infrastructure, known backups that have occurred at a given location, and anticipated high I/I areas. Since excessive I/I from deteriorated pipes, pipe joints, manholes, and illegal connections by private homeowners normally occurs to a greater extent in older sewer systems, the City's assessment has been prioritized accordingly.

Figure 1A: Collection System Basins

Basin ID	Manhole Count	Lamphole Count	Mileage (lines)	Acres Serviced
Toliver Line Basins				
TL	**75**	**6**	**4.63**	**188.80**
TL_Sub-basins	*27*	*5*	*1.55*	*63.93*
TL_A	**50**	**9**	**3.04**	**143.24**
TL_A1	*10*	*3*	*0.41*	*10.05*
TL_A2	*8*	*3*	*0.61*	*22.27*
TL_B	**32**	**5**	**1.82**	**81.60**
TL_C	**63**	**8**	**3.32**	**182.44**
TL_C1	*7*	*0*	*0.27*	*8.08*
TL_C2	*18*	*1*	*0.82*	*23.75*
TL_D	**15**	**7**	**1.17**	**41.02**
TL_E	**10**	**3**	**0.4**	**12.92**
TL_F	**22**	**3**	**1.44**	**76.95**
Bear Creek Line Basins				
BC	**26**	**10**	**1.71**	**45.21**
BC_A	**87**	**24**	**5.67**	**184.43**
BC_A1	*15*	*3*	*0.6*	14.45
BC_A2	*2*	*3*	*0.18*	5.47
BC_A3	*21*	*12*	*1.56*	41.02
BC_A4	*5*	*0*	*0.31*	7.64
BC_B	**19**	**0**	**0.83**	**31.35**
BC_C	**122**	**16**	**5.96**	**170.86**
BC_C1	*36*	*4*	*1.33*	40.02
Total**	**522**	**91**	**29.99*****	**1158.82**

SECTION 3 SEWER SYSTEM EVALUATION STUDY

As part of the City's I/I Assessment and Reduction Plan, the priority basins and sub-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/EWRI Manuals and Reports on Engineering Practice No. 62, 2010).

The City's program consists of the following six (6) key components:

- Administration;
- Public Relations;
- I/I Quantification;
- I/I Identification;
- Source Flow Analysis; and
- Final Recommendations and Implementation Plan.

The City will assign existing personnel (FTEs) to take on the roles of collection system I/I inspector/technician. These FTEs will be involved in all field inspection and rehabilitation activities, and will be supplemented by other City staff as necessary. 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 the implementation plan will initially focus on critical areas identified during the investigation. These critical areas will be addressed first. Ultimately, the results of the investigation will be used to determine whether significant I/I is entering the collection system and to demonstrate whether I/I reductions can be achieved cost-effectively. The implementation plan will provide the projected costs of removing public sector I/I sources. Repairs that are shown to be cost effective will be compared with the costs of removing private sector (or laterals) I/I. The investigation will also determine whether private sector I/I is a significant source and, if so, how to cost-effectively address it.

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 door 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 potentially affected property owners will be provided via 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. A telephone number will 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

Fundamental information about the City's collection system can be obtained by flow monitoring. Flow monitoring provides information on dry weather flows as well as areas of the collection system potentially affected by I/I.

Flow measurements performed for the purpose of quantifying I/I are typically separated into three components: base flow, infiltration, and inflow. Base flow is generally taken to mean the wastewater generated without any I/I component. Infiltration is the seepage of groundwater into pipes or manholes through defects such as cracks, broken joints, etc. Inflow is the water which enters the sewer through direct connections such as roof leaders, direct connections from storm drains or yard, area, and foundation drains, the holes in and around the rim of manhole covers, etc. Many collection system owners or operators add a third classification: rainfall induced infiltration (RII). RII is stormwater that enters the collection system through defects that lie so close to the ground surface that they are easily reached. Although not from piped sources, RII tends to act more like inflow than infiltration.

In addition to the use of flow meters, other methods of inspecting flows will be employed such as visually monitoring manholes during low-flow periods to determine areas with excessive I/I. For a small system like Molalla's, this technique is often an effective and low-cost means of identifying problem areas in the system which require further investigation.

The City's goal is to efficiently identify locations of excessive I/I within its system. The program looks at the wastewater treatment plant, pump stations, flows, and rainfall

data to characterize peaking factors for the system.

For the flow monitoring portion of its investigation, the City plans to purchase and place eight (8) temporary flow meters within the collection system. The City calculated the flow meter study design using the flow meter assessment rule of thumb of 1 meter per 15,000-25,000 linear feet (LF). The City currently has 29.34 miles or 154,915 LF of existing collection lines. Thus, eight flow meters will provide sufficient data with which to assess flows in the system under wet and dry conditions.

The flow meters are area velocity flow modules with sensors. The flow meters record flow, velocity and depth readings every fifteen minutes. The collection system's response to wet-weather events will be monitored through the winter of 2015, with a monitoring period for 2 weeks in late summer to determine average dry weather flow.

The data collected with the flow meters will be used to determine the flows in each basin and sub-basin under wet and dry conditions.

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. Data collected from the rainfall gauge will be used in conjunction with flow monitoring data.

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; and
- Peak wet-weather total flows.

The results of the flow analysis will be used to rank basins and sub-basins on I/I contributions to the collection system and to refine the priority ranking described in Section 2.

3.4 Interviews

Prior to field inspections, the City will interview current and past staff about the existing sewer system. City staff who have worked with the collection system are the people who are most familiar with the system. The City expects that those staff may have information on defect locations and the history of the performance within areas of the system. The staff also may have 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 typically significant contributors of 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. Visual inspection of manholes and pipelines are the first line of defense in the identification of existing or potential problem areas. Visual inspections will take place on both a scheduled basis and as part of any preventive or corrective maintenance activity. Visual inspections provide additional information concerning the accuracy of system mapping, the presence and degree of I/I problems, and the physical state-of-repair of the system.

Manhole inspections will be accomplished using a two-person crew. Manholes will generally be inspected from the surface using survey rods, digital cameras, mirrors, and high-powered spot lights. Industry standard OSHA, NIOSH, 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 and analysis.

The following manhole components will be inspected for signs of I/I and for structural soundness per the NASSCO Manhole Assessment Certification Program (MACP) inspection guidelines. 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 sewer lines will be visually inspected by a pole mounted camera from accessible manholes. This procedure is called a visual pipe inspection and will be conducted in accordance with MACP guidelines. 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.

Prior to inspection, all Public Works crew members will attend an MACP/PACP and QC informational training on the standardized processes for inspection of manholes and collection pipes.

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 used 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; and
- Probing rods.

3.4.2 Smoke Testing

Smoke testing is a relatively inexpensive and quick method of detecting sources of inflow in sewer systems, such as down spouts, or driveway and yard drains and works best for detecting cross connections and point source inflow leaks.

The City will conduct smoke testing on various line segments located within the priority basins in order 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 with a handheld GPS unity to allow for efficient analysis and, as necessary, 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 private 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, and in basins identified by the Engineer to have high inflow potential from both public and private sources. 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 two people. One person will set up the smoke test for a segment while the other will walk around and note everywhere they see smoke, record the location with a hand held GPS unit, and take pictures of each emission. While one person from the crew is 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. A map created from the recorded locations of the handheld GPS unit of all visible smoke will be a description of the location (streets/cross-streets, address) with ties to this location (measurement from the corner of a building, house, survey marker, etc.). 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; and
- 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. Inspections will be conducted per the NASSCO Pipeline Assessment Certification Program (PACP). For each segment that is inspected, a form will be completed, data collected electronically and a videotape of the segment will be created.

A CCTV inspection crew will consist of two people full time. There will be one crew

member who will conduct the CCTV inspections. Before any CCTV inspections are conducted, a training of the inspection crew will be conducted. CCTV inspection forms (if necessary), controls and procedures will be explained.

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

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

The CCTV inspection will take place immediately following the field investigations, manhole inspection..

3.4.4 Dyed-Water Testing

Dyed-water testing is a rainfall simulation technique used to identify defects that can contribute significant I/I during a storm event. Dyed water testing may be used to establish the connection of a fixture or appurtenance to the sewer. It is often used to confirm smoke testing or to test fixtures that did not smoke. As is the case with smoke testing, it is not used on a routine basis but rather in areas that have displayed high wet weather flows. Dyed water testing can be used to identify structurally damaged manholes that might create potential I/I problems. This is accomplished by flooding the area close to the suspected manholes with dyed water and checking for entry of dyed water at the frame-chimney area, cone/corbel, and walls of the manhole.

Dyed-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 visually by inspectors or through CCTV, indicates infiltration.

A dyed-water testing crew will consist of two people. There will be one crew member who will conduct the dyed-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 dyed-water tested.

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

Fluorescent dyes will be used for dyed-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; and
- Traffic control equipment such as cones, signs, flags, etc.

The dyed-water testing will be conducted concurrently with Smoke or CCTV inspections, as potential I/I sources are identified.

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 the associated reduction options and associated costs to remove this I/I from the system. These costs will be used to conduct a cost effective analysis to determine the most effective and efficient use of the City's limited funds.

Recognizing that the observations of I/I during manhole inspections, CCTV, smoke testing, and dye-testing may not be truly representative of the I/I entering the system during peak wet-weather events, the flow monitoring data will be used to calibrate a hydrologic and hydraulic model that will "mimic" the City's collection system and predict the I/I from each basin.

Based on work done in numerous communities in the Willamette Valley, the City is initially contemplating a basin-wide approach to collection system rehabilitation for the purposes of I/I abatement. This may include both the public and private portions of the collection system, including private laterals. Pilot projects may be implemented to determine the cost-effectiveness of this approach.

Once modeling has been completed and basins have been prioritized based on leakage rates, 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.

3.6 Recommendations and Implementation Plan

The completed inspections forms, video, and photographs will be incorporated into a database and/or other Asset Management tool. 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 by these categories to better prioritize rehabilitation efforts. The field inspection forms for all field activities can be integrated. Once the data has been entered, QA/QC will be conducted to ensure all information was input correctly.

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 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; and
- Post-Rehabilitation Flow Monitoring.

The City has a sewer rehabilitation program, but it typically has addressed major problems when they occur, such as pipeline backups. The objective of the City's updated sewer rehabilitation program, as outlined in this I/I Assessment and Reduction Plan, is to maintain the overall viability of the City's collection system. This is done in three ways: (1) ensuring its structural integrity; (2) limiting the loss of conveyance and wastewater treatment capacity due to excessive I/I; and (3) controlling exfiltration from the pipe network. The rehabilitation program builds on information obtained from all forms of maintenance and observations made during O&M, as well as the specific investigative activities described in this Plan.

There are many rehabilitation methods which the City considers for particular issues. The City's choice of methods for addressing a given issue depends on pipe size, type, location, dimensional changes, sewer flow, material deposition, surface conditions, severity of I/I, and other physical factors, as well as cost-benefit ratio, available or anticipated funding and priority in comparison to other existing or anticipated O&M issues.

4.1 Priority 1 – Cost Effective Rehabilitation

Cost-effective rehabilitation 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 can consist of manhole, pipeline and public lateral rehabilitation, as well as closing off stormwater sources.

4.1.1 Manhole Rehabilitation

Cost-effective manhole rehabilitation is typically focused on the top-end of the manhole where higher I/I flows are usually found. Such rehabilitation can include the following:

- Replace Vented Covers Below Grade;
- Raise Manhole to Grade;
- Replace/Rehabilitate Frame/Seal; and/or
- Replace/Rehabilitate Chimney.

4.1.2 Pipeline Rehabilitation

Cost-effective pipeline rehabilitation may consist of the following methods:

- Point Repairs;
- Full Line Replacement;
- Full Line Rehabilitation;
- Abandon/Realign Pipeline;
- Defective Service Tap Rehabilitation;
- Disconnecting Direct Storm Connections; and/or
- 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:

- Replace/Rehabilitate Frame Seal;
- Replace/Rehabilitate Chimney;
- Rehabilitate Cone and Wall;
- Rehabilitate Bench and Invert; and/or
- 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; and/or
- Abandon/Realign Pipeline.

4.3 Preventative Maintenance

The City is currently developing a preventative maintenance and emergency maintenance plan to more explicitly describe the City's current O&M activities. The City will integrate preventative maintenance activities into its O&M activities to address those areas with identified I/I but which are lower on the priority scale.

4.4 Post-Rehabilitation Flow Monitoring

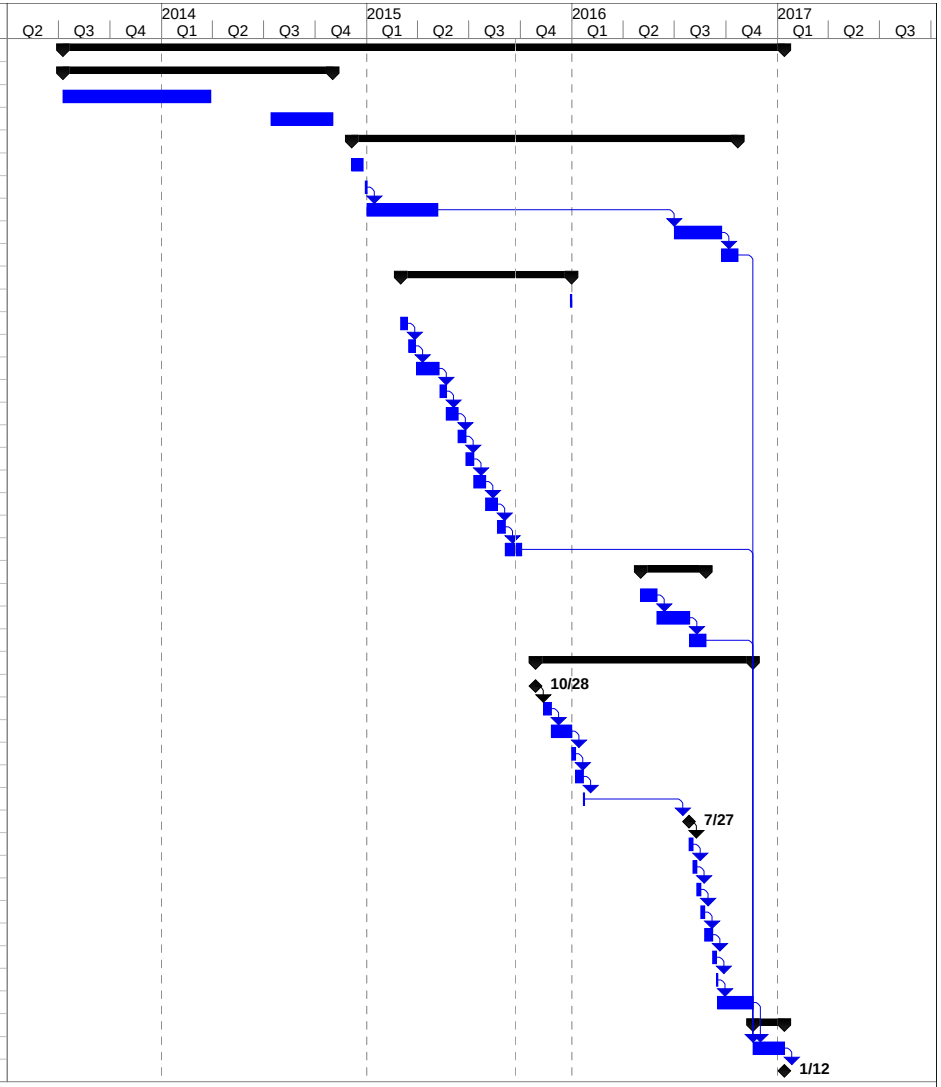
Following the rehabilitation of individual study areas, post-rehabilitation flow analysis will be conducted to measure the success of the program. Flow monitoring will be performed in the same locations as were monitored prior to rehabilitation. Flow data will then be compared to pre-rehabilitation flow 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 project 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-benefit 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.

The project schedule is constrained by weather and other uncontrollable factors. For example, smoke testing cannot be performed when the soil surrounding the pipes is saturated or frozen or during windy days. Inspections will only be conducted during working hours, excluding holidays, and weather permitting days.

ID	Task Name	Duration	Start	Finish	Predecessors
1	**City of Molalla I/I Removal Program - Characterization Phase**	**918 days**	**Tue 7/9/13**	**Thu 1/12/17**	
2	**Pre-Field Activities**	**344 days**	**Tue 7/9/13**	**Fri 10/31/14**	
3	Ordered Vac Truck	189 days	Tue 7/9/13	Fri 3/28/14	
4	Map Collection System	80 days	Mon 7/14/14	Fri 10/31/14	
5	**Flow Meters Analysis**	**491 days**	**Fri 12/5/14**	**Fri 10/21/16**	
6	Purchase Flow Meters/Training	14 days	Fri 12/5/14	Wed 12/24/14	
7	Install Flow Meters	3 days	Mon 12/29/14	Wed 12/31/14	
8	Bi-weekly Flow Readings	90 days	Thu 1/1/15	Wed 5/6/15	7
9	Hydrologic/Hydraulic Modeling	60 days	Fri 7/1/16	Thu 9/22/16	8
10	Flow Data Analysis Report	21 days	Fri 9/23/16	Fri 10/21/16	9
11	**Manhole Inspections**	**218 days**	**Mon 3/2/15**	**Wed 12/30/15**	
12	PACP/MACP Training	2 days	Tue 12/29/15	Wed 12/30/15	
13	Inspect Basin TL_A	10 days	Mon 3/2/15	Fri 3/13/15	
14	Inspect Basin TL_B	10 days	Mon 3/16/15	Fri 3/27/15	13
15	Inspect Basin TL_C	30 days	Mon 3/30/15	Fri 5/8/15	14
16	Inspect Basin TL_D & TL_E	9 days	Mon 5/11/15	Thu 5/21/15	15
17	Inspect Basin BC_A	15 days	Fri 5/22/15	Thu 6/11/15	16
18	Inspect Basin TL_F	10 days	Fri 6/12/15	Thu 6/25/15	17
19	Inspect Basin BC_C1	10 days	Fri 6/26/15	Thu 7/9/15	18
20	Inspect Basin BC_C	15 days	Fri 7/10/15	Thu 7/30/15	19
21	Inspect Basin BC_B & GEN	15 days	Fri 7/31/15	Thu 8/20/15	20
22	Inspect Basin TL	10 days	Fri 8/21/15	Thu 9/3/15	21
23	Manhole Inspection Data Only Report	21 days	Fri 9/4/15	Fri 10/2/15	22
24	**Smoke/Dye Testing**	**84 days**	**Mon 5/2/16**	**Thu 8/25/16**	
25	Notify Public/Fire Dept of Smoke Testing	21 days	Mon 5/2/16	Mon 5/30/16	
26	Smoke Testing/Dye Testing	42 days	Tue 5/31/16	Wed 7/27/16	25
27	Smoke/Dye Testing Analysis Report	21 days	Thu 7/28/16	Thu 8/25/16	26
28	**CCTV**	**277 days**	**Wed 10/28/15**	**Thu 11/17/16**	
29	Request Funding & RFP for CCTV Work F/Y 2015/16	0 days	Wed 10/28/15	Wed 10/28/15	
30	Inspect Main Trunk Lines (Bear Ck & Toliver)	10 days	Wed 11/11/15	Tue 11/24/15	29
31	Inspect Basin TL_A	26 days	Wed 11/25/15	Wed 12/30/15	30
32	Inspect Basin TL_B	5 days	Thu 12/31/15	Wed 1/6/16	31
33	Inspect Basin TL_C	10 days	Thu 1/7/16	Wed 1/20/16	32
34	Inspect WWTP Storm	2 days	Thu 1/21/16	Fri 1/22/16	33
35	Request Funding & RFP for CCTV Work F/Y 2016/17	0 days	Wed 7/27/16	Wed 7/27/16	34
36	Inspect Basin TL_D & TL_E	5 days	Wed 7/27/16	Tue 8/2/16	35
37	Inspect Basin BC_A (Excluding Trunk Line)	5 days	Wed 8/3/16	Tue 8/9/16	36
38	Inspect Basin TL_F	5 days	Wed 8/10/16	Tue 8/16/16	37
39	Inspect Basin BC_C1	5 days	Wed 8/17/16	Tue 8/23/16	38
40	Inspect Basin BC_C	10 days	Wed 8/24/16	Tue 9/6/16	39
41	Inspect Basin BC_B & GEN	5 days	Wed 9/7/16	Tue 9/13/16	40
42	Inspect Basin TL (Excluding Trunk Line)	2 days	Wed 9/14/16	Thu 9/15/16	41
43	CCTV Inspection Report	45 days	Fri 9/16/16	Thu 11/17/16	42
44	**Infiltration & Inflow Removal Analysis**	**40 days**	**Fri 11/18/16**	**Thu 1/12/17**	
45	I & I Cost Effective Analysis	40 days	Fri 11/18/16	Thu 1/12/17	43,27,23,10
46	Final I/I Report Complete	0 days	Thu 1/12/17	Thu 1/12/17	45



City of Molalla, Oregon
Figure 2

Task	External Tasks	Duration-only	External Tasks		
Split	External Milestone	Manual Summary Rollup	External Milestone		
Milestone	Inactive Milestone	Manual Summary	Progress		
Summary	Inactive Summary	Start-only	Deadline		
Project Summary	Manual Task	Finish-only			

Appendix A
Field Inspection Forms

MANHOLE INSPECTION FORM

Surveyor's name (1)	Certificate number (1a)	System Owner (2)	Survey Customer (3)

Drainage Area (4)	Sheet No. (5)	P.O. No. (6)	Date (CCYY/MM/DD) (8)

Time (9)	Location (No. & Name) (10)	Locality/City Name (10a)	Further Location Details (11)

Manhole Number (12)	Outgoing Rim to Invert (13)	Outgoing Grade to Invert (14)	Rim to Grade (15)

Use of Sewer (20)	Year Laid (31)	Year Rehabilitated (32)	Tape/Media Number (33)

Purpose (34)	Sewer Category (35)	Pre-Cleaning (36)	Date Cleaned (CCYY/MM/DD) (36a)

Weather (37)	Location Code (38)	Additional Information (39)	Manhole Surface Type (40)

Potential for Runoff (41)	Access Point Type (42)	Northing (43)	Easting (44)

Elevation (45)	Coordinate System (46)	Accuracy of GPS (47)	Inspection Status (48)

Evidence of Surcharge (49)	Image Reference (50)	Video Name (51)

SKETCH

MANHOLE COMPONENT OBSERVATIONS

Cover Shape	Cover Size/ Width		Cover Material	Cover Type	Vent Hole Diameter	# Vent Holes

Cover Bearing Surface Diameter/Width		Cover/Frame Fit	Cover Condition	Cover Insert Type	Cover Insert Condition

MH Adjustment Ring Type	MH Adjustment Ring Condition	MH Adjustment Ring Height

Frame Material	Frame Bearing Surface Width	Frame Bearing Surface Depth	Frame Clear Opening Diameter

Frame Condition	Frame Seal Condition	Frame Offset Distance	Frame Seal Inflow	Frame Depth	Chimney Material 1

Chimney Material 2	Int. Chim. Coating/Liner	Ext. Chim. Coating/Liner	Chimney I/I	Chimney Clear Opening	Chimney Depth

Cone Type	Cone Material	Int. Cone Coating/Liner	Ext. Cone Coating/Liner	Cone Depth	Wall Diameter (length/width)	

Wall Material	Int. Wall Coating/Liner	Ext. Wall Coating/Liner	Wall Depth	Bench Present?	Bench Coating/Liner

Bench Material	Channel Installed	Channel Material	Channel Type	Channel Exposure	# Steps

Step Material

PIPE CONNECTION FIELDS

Pipe Number	Pipe Clock Position	Rim to Invert	Pipe Direction	Pipe Material	Pipe Shape	Pipe Diameter	Pipe Width	Pipe Seal Condition	Pipe Special Condition	Connects to Access Point ID

Date: ____/____/____
Crew: _____
_____
_____

SMOKE TESTING

City of Molalla, Oregon

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	Footage (0=DS MH)	*Optional*: 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: _____
_____
_____
_____

Date: ____/____/____
Crew: _____
_____
_____

DYE TESTING

City of Molalla, Oregon

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

Public Works

117 N Molalla Avenue, PO Box 248, Molalla, Oregon 97038
Phone: (503) 829-6855 Ext. #218 Fax: (503) 829-3676
jcline@cityofmolalla.com

Date

Resident name _____
Address_____
_____

Re:

Dear Resident:

The City of Molalla 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 Molalla 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 503-829-6855.

Sincerely,

Public Works Director
City of Molalla, Oregon

City of Molalla, OR

ATTENTION

The City of Molalla 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 Molalla 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 503-829-6855

City of Molalla, OR

ATTENTION

The City of Molalla 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 _____.**

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If you have any questions, contact the City at 503-829-6855