Gravity Line Preventive Maintenance Program

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D. Wayne Loveday — 2.19.2009

D. Wayne Loveday — Date

KUB

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Partners Acting for a Cleaner Environment

A 10-year Program to Improve Our Waterways

Executive Summary

The Gravity Line Preventive Maintenance Program describes KUB's process for preventive cleaning of the wastewater system. This program will improve the operation, efficiency, and effectiveness of the system. It is divided into two components - the Blockage Abatement Program and the Comprehensive Hydraulic Cleaning Program. Root Control and Manhole Preventive Maintenance are components of both the Blockage Abatement Program and the Comprehensive Hydraulic Cleaning Program.

Blockage Abatement Program

Blockage Abatement (BA) is a preventive maintenance approach for addressing operational issues. It uses previous event history and condition assessment information to implement activities that prevent or reduce system disruptions. The BA Program has the following eight components:

1. Identification and provision of all personnel and equipment needed: To meet the program goals, KUB currently utilizes external resources to perform inspections, hydraulic cleaning, and/or root removal on a predetermined frequency. KUB has chosen to outsource this program through a multi-year contract that is described in Section 2.1 Resources.
2. Determination of the frequency: The frequencies that have been established for this program can be found in Section 2.2 Blockage Abatement Frequency. KUB has developed a BA frequency decision tool to assist in assigning a maintenance frequency for each BA line segment. This tool compares BA frequencies with influencing factors such as rate of blockage accumulation, time between two sanitary sewer overflow (SSO) events, and upstream flow considerations.
3. Establishment of procedures: Step-by-step procedures have been documented to assist the contractor in performing hydraulic cleaning. The hydraulic cleaning procedures are documented in Section 2.3 Hydraulic Cleaning Procedures.
4. Establishment of priorities for scheduling: The computerized BA Program has automated the scheduling of the BA line segments based on prescribed maintenance frequency. This scheduling practice is illustrated in Section 2.4 Priorities for Scheduling.
5. Development and implementation of standard forms: KUB has developed standard forms that will be used in the collection of field data. A description of these forms can be found in Section 2.5 Standard Forms-Maintenance on Internet.
6. Establishment of record-keeping requirements: The process by which KUB records field information is identified in Section 2.6 Record-Keeping.
7. Establishment of performance measures: KUB has identified several measures to evaluate the performance of the BA Program. Reports are automatically generated to summarize the program's performance. The performance measures KUB will use to determine if the goals of the program have been met are described in Section 2.7 Performance Measures.
8. Integration of all data collected under the program with KUB's IMS: The data that populates the reports includes information from the field data that is stored in KUB's Geographic Information System (GIS). A description of how KUB's Blockage Abatement Program data is integrated with other Information Management Systems can be found in Section 2.8 Information Management System.

Comprehensive Hydraulic Cleaning Program

KUB's Comprehensive Hydraulic Cleaning Program is a systematic, planned cleaning of the system to reduce debris and grease buildups, and root intrusions. It is based on preventing and reducing the initial occurrence of system disruptions and maintaining the original hydraulic capacity of the

collection system. This program also provides support to the Comprehensive Condition Assessment and Monitoring Program by removing any obstructions in the system that would prevent a comprehensive inspection. The Comprehensive Hydraulic Cleaning Program has the following eight components:

1. Identification and provision of all personnel and equipment needed: KUB personnel are responsible for implementing this program. A description of the resources allocated is detailed in Section 3.1 Resources.
2. Determination of the frequency: The goal of this program is to clean every line segment within the wastewater system in 12 years. The structured cleaning strategy employed incorporates directional cleaning of entire sub-basins at a time. This structured approach will decrease the potential for system disruptions. The maintenance frequency for this program is described in Section 3.2 Maintenance Frequency.
3. Establishment of procedures: The hydraulic cleaning procedures for the Comprehensive Hydraulic Cleaning Program are the same as described for the Blockage Abatement and are detailed in Section 3.3 Hydraulic Cleaning Procedures.
4. Establishment of priorities for scheduling: The prioritization for determining sub-basin cleaning schedules is based on a comprehensive sub-basin matrix. As compared to the BA Program, entire sub-basins are scheduled rather than individual line segments. KUB has established the priorities for scheduling cleaning activities in Section 3.4 Priorities for Scheduling.
5. Development and implementation of standard forms: Field data is collected using electronic forms. A description of standard forms used in collecting field information can be found in Section 3.5 Standard Forms.
6. Establishment of record-keeping requirements: The information gathered in the field is used to detail maintenance activities and evaluate system performance. This process by which this information is retained is discussed in Section 3.6 Record-Keeping.
7. Establishment of performance measures: KUB has identified several measures to evaluate the performance of the Comprehensive Hydraulic Cleaning Program. Reports are automatically generated to summarize the program's performance. The performance measures KUB will use to determine if the goals of the program have been met are described in Section 3.7 Performance Measures.
8. Integration of all data collected under the program with KUB's IMS: As similar to BA Program, field information will be stored in KUB's GIS. The method by which this data is integrated with other KUB systems is described in Section 3.8 Information Management System.

Root Control

Mechanical root control is discussed throughout the Blockage Abatement and Comprehensive Hydraulic Cleaning programs. The Chemical Root Abatement Program is a component of the Blockage Abatement Program and is described in Section 2.2.1 Chemical Root Abatement Program.

Manhole Preventive Maintenance

A component of KUB's Comprehensive Condition Assessment and Monitoring Program is manhole inspections. The details of the manhole inspection component will be described in the Continuing Sewer System Assessment Program. The procedures for cleaning or removal of debris from manholes are included in both the Blockage Abatement and Comprehensive Hydraulic Cleaning programs. The Comprehensive Condition Assessment and Monitoring Program will determine if any manhole rehabilitation or repair is necessary.

The 7 Elements of a Proper MOM Program
KUB's Gravity Line Preventive Maintenance Program

1. **Utility-Specific**
   Based on the needs of our service area and customer base, KUB's Gravity Line Preventive Maintenance Program serves as a guide to provide an efficiently maintained and operated sanitary sewer system and reduce the negative impact on the environment and hazards to public health.

2. **Purposeful**
   This program is designed to:
   - Maintain the hydraulic capacity of the wastewater collection system
   - Provide a structured and consistent response to prevent blockage-related SSOs from occurring or recurring
   - Identify structural or other system defects that require immediate attention (such as point repairs, short-line replacements, or pump repairs/replacements) or inclusion in the Blockage Abatement Program
   - Provide system assessment of existing infrastructure to identify areas with structural deficiencies, inflow and infiltration (I/I) sources, capacity issues, and to prioritize the associated rehabilitation or replacement
   - Extend the lifecycle of or replace system assets through rehabilitation or installation of system components
   - Reduce overflows caused by blockages and structural failures while also removing I/I entering the system through manhole and pipe defects.

3. **Goal-Oriented**
   KUB's Gravity Line Preventive Maintenance Program provides structured guidance for the operation, maintenance, and performance of the sanitary sewer system. It provides comprehensive and systematic maintenance including hydraulic cleaning to remove debris, roots, and grease on all manholes and gravity mains in the entire collection system. It also identifies additional maintenance requirements and provides a systematic approach to meet increased maintenance needs in the Blockage Abatement Program. The frequencies established for assessing and cleaning the gravity collection system are as follows:
   - Comprehensive Hydraulic Cleaning – Entire system cleaned in 12 years
   - Mechanical Root Abatement – As determined by condition assessment
   - Chemical Root Abatement – As determined by condition assessment
   - Blockage Abatement – As determined by condition assessment.

4. **Uses Performance Measures**
   KUB will evaluate the performance of the Gravity Line Preventive Maintenance Program by tracking performance of the following indicators:
   - Percent of gravity collection system cleaned annually
   - Adherence to Blockage Abatement schedule
   - Number of repeat blockage-related SSOs.

The 7 Elements of a Proper MOM Program
KUB's Gravity Line Preventive Maintenance Program, cont.

5. **Periodically Evaluated**
   KUB will review the Gravity Line Preventive Maintenance Program annually and amend it as appropriate. Modifications may be made to the program based on the review and assessment of previous years' performance in the following areas:
   - Number of blockage-related SSOs
   - Percent of gravity system cleaned
   - Number of linear feet mechanically root abated
   - Number of linear feet chemically root abated.

6. **Available in Writing**
   This program will be maintained and kept readily available as a reference for current staff and will be used to train new personnel to ensure program expectations and requirements are met.

7. **Implemented by Trained Personnel**
   The performance expectations for each component of the Gravity Line Preventive Maintenance Program are the same for internal and external resources. Internal resources receive a series of training components from confined space training to Sewer Overflow Response Training with a prescribed frequency for refresher courses. KUB employees are regularly introduced to new and improved techniques to improve safety and efficiency.

   Contractors selected to perform outsourced components of the Gravity Line Preventive Maintenance Program are held to the same performance expectations as KUB's internal staff. KUB's contracts for these outsourced projects contain written standards and specifications detailing KUB's approved requirements for physical system assessment and improvements of its wastewater system. Contractors performing work for these projects are contractually obligated to ensure the work site and the work of their employees meet federal, state, and local laws, statutes, and regulations, specifically including, but not limited to, safety requirements mandated by the Occupational Safety and Health Administration (OSHA).

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Section 1: Introduction

1.0 Introduction

KUB's maintenance activities focus on sustaining the sanitary sewer collection system's hydraulic capacity for conveying wastewater. Typically, two different classes of problems can reduce hydraulic capacity: operational and structural.

Most operational defects, such as roots, sediment, fats, oils, and grease, reduce the hydraulic capacity of the pipe. Sewer cleaning and source control activities are directed toward preventing or reducing the impacts of operational defects on the collection system.

Structural defects involve the degradation of the sewer pipe itself. Serious structural deficiencies can lead to pipe failure and cause sanitary sewer overflows (SSOs) and backups. Sewer repair and rehabilitation activities are focused on restoring the structural integrity of the pipe.

KUB addresses operational and structural defects through its Gravity Line Preventive Maintenance Program, Comprehensive Condition Assessment and Monitoring Program (CAMP), and Infrastructure Rehabilitation Program (IRP), and each program has several components.

1.1 Preventive Cleaning Maintenance Program

These are the key components of the Gravity Line Preventive Maintenance Program:

- **Blockage Abatement Program**
  Blockage Abatement (BA) is a preventive maintenance approach for addressing operational issues. It uses previous event history and condition assessment information to implement activities that prevent or reduce system disruptions. The BA Program uses previous SSOs or backups in the system to prevent dry weather blockages from recurring. Condition assessment of lines performed as part of the Continuing Sewer System Assessment Program may also indicate the need for regular hydraulic cleaning and inspection frequencies. The BA Program is discussed in greater detail in Section 2: Gravity Line PM-Blockage Abatement Program.

- **Comprehensive Hydraulic Cleaning Program**
  KUB's Comprehensive Hydraulic Cleaning Program is a systematic, planned cleaning of the system to reduce debris and grease buildups, and root intrusions. It is based on preventing and reducing the initial occurrence of system disruptions and maintaining the original hydraulic capacity of the collection system. This program also provides support to the CAMP by removing any obstructions in the system that would prevent a comprehensive inspection. The Hydraulic Cleaning Program is discussed in greater detail in Section 3: Gravity Line PM- Comprehensive Hydraulic Cleaning Program.

1.1.1 Comprehensive Condition Assessment and Monitoring Program (CAMP)

The CAMP identifies structural and operational defects affecting sewer system performance. The results of the inspections provide data for the BA and IRP programs. The CAMP will be discussed in greater detail in the Continuing Sewer System Assessment Program – Condition Assessment and Monitoring Program.

1.1.2 Infrastructure Rehabilitation Program (IRP)

The IRP is a corrective maintenance approach for implementing repairs or rehabilitation to remediate a known defect. The BA and the CAMP programs provide the information needed to prioritize and determine the scope of projects for the IRP. Projects under the IRP include those identified as part of the Corrective Action Plan/Engineering Report (CAP/ER) and required under the Consent Decree. The process for implementing repairs or rehabilitation to remediate a known defect will be discussed in greater detail in the IRP.

The above programs (BA, Comprehensive Hydraulic Cleaning, CAMP, and IRP) are supported by the following activities:

- Hydraulic cleaning using high-pressure flushing equipment
- Hydraulic cleaning and vacuum system debris removal using combination flushing/vacuum equipment
- Condition assessment using computer software, closed circuit television (CCTV) equipment, smoke testing, manhole inspection, etc.
- Root abatement and control
- Grease source and field control program
- Public education.

1.2 Purpose and Goals

The Gravity Line Preventive Maintenance Program is designed to:

- Maintain the hydraulic capacity of the wastewater collection system
- Provide a structured and consistent response to prevent blockage-related SSOs from occurring or recurring
- Identify structural or other system defects that require immediate attention (such as point repairs, short-line replacements, or pump repairs/replacements) or inclusion in the BA Program
- Provide system assessment of existing infrastructure to identify areas with structural deficiencies, inflow and infiltration (I/I) sources, capacity issues, and to prioritize the associated rehabilitation or replacement
- Extend the lifecycle of or replace system assets through rehabilitation or installation of system components
- Reduce overflows caused by blockages and structural failures while also removing I/I entering the system through manhole and pipe defects.

KUB has established the following goals for assessing and cleaning the gravity collection system:

Gravity Line Cleaning Goals	
Description	**Frequency**
Comprehensive Hydraulic Cleaning	Entire system cleaned in 12 Years
Mechanical Root Abatement	As determined by condition assessment program
Chemical Root Abatement	As determined by condition assessment program
Blockage Abatement	As determined by condition assessment program

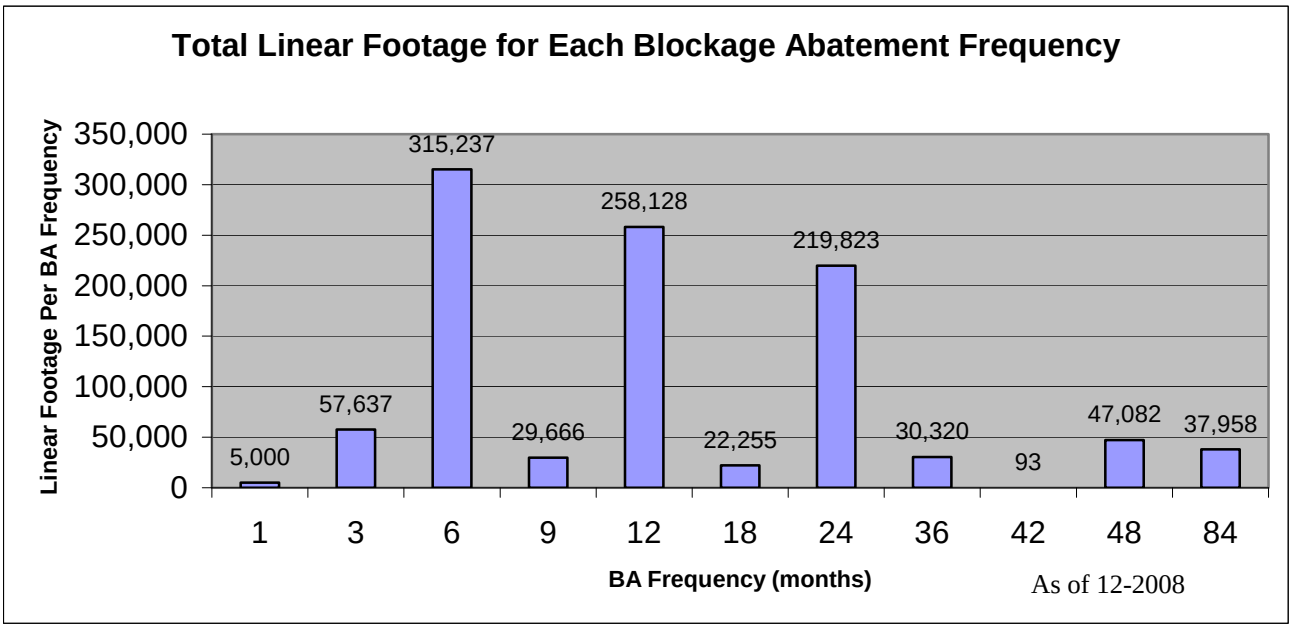
Section 2: Gravity Line PM – Blockage Abatement Program

2.0 Purpose and Goals

The primary objective of KUB's BA Program is to prevent blockages from causing recurring SSOs or backups in the system. To meet that objective, KUB performs inspections, hydraulic cleaning, and/or root removal on a routine frequency based on condition assessment by the field responder and basin engineer.

The assets included in this program are identified based on CCTV inspections, blockage-related SSOs, or backups experienced in the past. The frequency of the maintenance activity ranges from one month to 42 months. **Figure 2-1** illustrates the amount of linear footage allocated to each BA maintenance frequency as of the last update of this report. All line segments included in the BA Program are also included in the CAMP.

Figure 2-1



KUB's performance goal for this program is to conduct all scheduled abatement activities within the prescribed frequency. To ensure that goal is met, KUB will monitor the performance metrics described in this document and adjust resources accordingly.

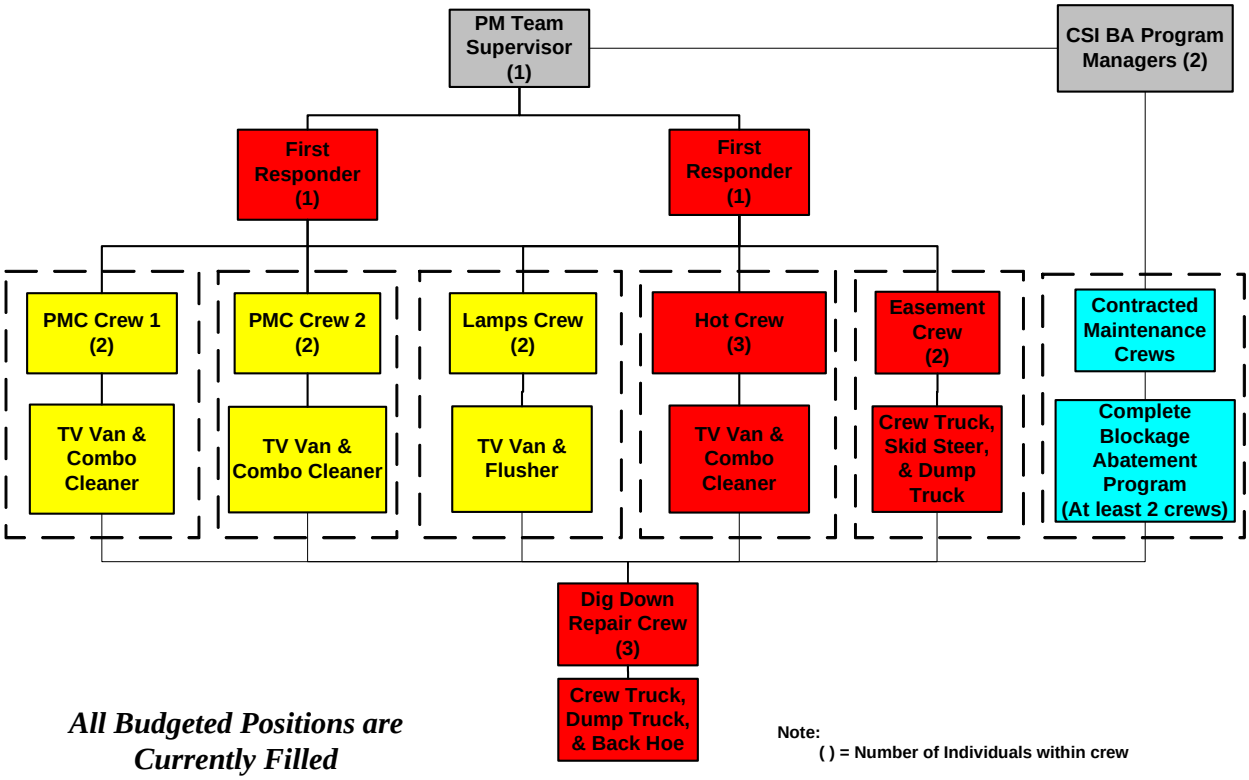
Assets are removed from the BA Program after upgrades or improvements alleviate the original reason for inclusion in the program. KUB will continue to maintain the asset as part of the CAMP.

2.1 Resources

The program includes a combination of internal and external resources. A team of KUB professionals will have the primary responsibility of addressing the preventive and corrective activities, and contractors will perform BA activities. **Figure 2-2** details the organizational structure of KUB's Management, Operation, and Maintenance (MOM) resources.

Figure 2-2

Management, Operations, and Maintenance (MOM)
Operation Organizational Resources



Description of allocated MOM Resources:

1. CSI BA Program Managers
   These members of the Collection System Improvement (CSI) Team manage, direct, and monitor the MOM programs. They work closely with KUB Underground Construction (UGC), other KUB departments, as needed, contractors, and consultants.

2. PM Team Supervisor
   The Preventive Maintenance (PM) Team Supervisor is a member of UGC and supervises day-to-day maintenance and repair of sanitary sewers.

3. PMC Crews
   The PMC Crews are members of UGC. They perform scheduled preventive maintenance activities, such as hydraulic cleaning and assessment.

4. Lamps Crew
   The Lamps Crew are members of UGC. They provide a reactive response to calls that result in a resolution of problem on property by inspecting private sewer laterals. The inspection is reviewed by CSIP to determine if repair or replacement is required under the Private Lateral Program.

5. First Responders
   The First Responders are members of UGC. They provide a reactive response to unscheduled requests for service. Examples of unscheduled requests include, but are not limited to,

implementing KUB's Sewer Overflow Response Plan (SORP), addressing customer requests, etc.

6. Hot Crew
   The Hot Crew is part of UGC. This crew has similar responsibilities as the First Responders with extended capabilities provided by hydraulic cleaning and CCTV equipment. The primary goal of this crew is to address unscheduled activities to allow the PMC Crews to remain dedicated to their scheduled activities.

7. Easement/MH Inspection Crew
   The Easement/Manhole Inspection Crew is a member of UGC. These crews inspect manholes and dedicated easements. They will provide assistance as needed to the First Responders and Hot Crew during SORP events and unscheduled responses. These crews will also backfill vacancies for the PMC Crews during absences due to vacations and illness.

8. Contracted Maintenance Crews
   The Contracted Maintenance Crews are an external resource used to implement the BA Program [see the blue highlighted portion of Figure 2-2]. Contract crews may also be used to supplement work performed by KUB crews including additional BA cleaning and inspection work. Contract Crews are also used extensively to perform IRP work. Contract work varies throughout the year making it difficult to quantify the number of Full Time Equivalents (FTEs) working on contracts. The CSI BA Program Managers will manage this contractual agreement.

A preventive maintenance program is a proactive activity that restores or maintains the intended function of an asset before failure. The maintenance activity is planned and scheduled periodically based on the asset condition to prevent blockage-related SSOs from occurring or recurring. KUB's preventive maintenance program is the BA Program. KUB has chosen to outsource the program through a multi-year contract that will be evaluated on an annual basis.

KUB personnel will perform corrective maintenance required to mitigate blockages. A corrective maintenance is a reactive activity that occurs in response to an asset failure characterized by the loss of the intended function. Corrective maintenance is event driven, i.e., a failure event occurs before any maintenance activity is scheduled. First Responders and the Hot Crew will have the primary responsibility for implementing KUB's SORP, addressing customer requests, removing system disruptions that could result in SSOs, making point repairs, and other unscheduled maintenance activities. The red highlighted portion of **Figure 2-2** illustrates these resources.

KUB has dedicated the following resources to the corrective component:
- CCTV Inspection Truck
- Combination Cleaner/Vacuum Truck
- Standard First Responder Trucks
- Pole Camera
- Dump Truck
- Backhoe and Trailer
- Crew Truck
- FTEs

KUB has and will continue to support or augment these responsibilities with other UGC Department resources.

2.2 Blockage Abatement Frequency

KUB adds a line segment to the BA Program when its cleaning frequency under the maintenance cycle proves insufficient to prevent overflows. Each line segment included in the BA Program is assigned a maintenance frequency more aggressive than it had under the CAMP. Also, prescribed maintenance activities determined by the nature of the system problem (i.e. roots, grease, debris, etc.) are assigned to the line segment.

Line segments are added to this program in two ways. The first provides short-term remediation following a blockage-related SSO, and the second is a result of a proactive assessment of the system. Blockage-related SSOs caused by debris, roots, and grease are placed on the BA Program. The intent is to prevent these issues from causing any future SSOs by maintaining the impacted line segments more frequently. The second way that a line segment is added to the BA Program is through the assessment of the system either by KUB crews or outside contractors. When obstructions are identified that could cause a potential SSO, this area is remediated immediately and added to the BA Program to reduce the risk that the blockage will re-establish in the future.

The initial BA frequency will be set at six months. The line segments with an initial frequency of six months will be televised prior to cleaning to determine the re-accumulation rate of the blockage over the last six months. For all other frequency schedules field crews will provide on-site recommendations based upon their evaluation of the existing frequency.

Figure 2-3: The Blockage Abatement Frequency Decision Tool provides evaluation guidelines for the CSI Team to:

- Determine the initial frequencies for BA line segments
- Review the frequencies of existing BA line segments
- Modify the frequencies of existing BA line segments.

This Decision Tool compares BA frequencies with influencing factors that would justify assigning a maintenance frequency to a particular BA line segment. The listed factors are intended to assist the decision maker in applying sound engineering judgment while considering the historical performance and the current condition of the wastewater system.

Figure 2-3
Blockage Abatement Frequency Decision Tool

Frequency (Months)	Frequency Determining Factors
1	• Extreme rate of blockage accumulation • Pending grease control enforcement action upstream • Upstream flow considerations-High Risk • Time between two SSO events less than 3 months
3	• High rate of blockage accumulation • Pending grease control enforcement action upstream • Time between two SSO events less than 6 months • Upstream flow considerations-Moderate to High Risk
6	• Medium rate of blockage accumulation • Pending grease control compliance action upstream • Upstream flow considerations • Require CCTV Follow-up before cleaning • Initial frequency following a blockage related SSO • Time between two SSO events less than 9 months

9	• Light rate of blockage accumulation • Pending grease control compliance action upstream • Upstream flow considerations • Time between two SSO events less than 12 months
12	• Slow rate of blockage accumulation • Pending grease control compliance action upstream • Upstream flow considerations • Time between two SSO events less than 18 months
18	• Slow rate of blockage accumulation • Pending grease control compliance action upstream • Upstream flow considerations • Time between two SSO events less than 24 months
24	• Slow rate of blockage accumulation • Pending grease control compliance action upstream • Upstream flow considerations • Time between two SSO events less than 36 months • Time span for initial chemical root abatement application
36	• Slow rate of blockage accumulation • Pending grease control compliance action upstream • Upstream flow considerations • Time between two SSO events less than 42 months • Large diameter pipe
42	• Slow rate of blockage accumulation • Pending grease control compliance action upstream • Upstream flow considerations • Time between two SSO events less than 144 months • Line segments upstream of siphons

When a blockage has been identified that could lead to a future SSO during the proactive assessment of the system, the impacted line segment(s) will be added to the BA program at a frequency of twelve months. The goal of each frequency is to avoid future system disruptions.

The BA Program is a short-term remediation activity conducted until the line segment can be rehabilitated or repaired. After the cause of the aggressive cleaning schedule has been remediated, the line segment will be addressed in the CAMP.

2.2.1 Chemical Root Abatement Program

Root intrusion into gravity sewer lines can significantly reduce transport capacity and lead to overflows. Roots alone can block sewer lines, and they can also allow debris and grease to accumulate. To address the potential for root intrusion-related overflows, KUB developed the Chemical Root Abatement Program. The goal of this program is to sufficiently limit root intrusion to prevent significant capacity reductions and overflows.

Root intrusion occurs primarily along sewer lines within sewer easements. Line segments beneath roadways and other concrete or asphalt surfaces are typically far enough removed from nearby trees to limit root intrusion. For that reason, line segments in streets require more widespread and frequent line cleaning to remove debris as compared to root control. Also, because the resources used to clean sewer lines are also equipped with root control devices, the KUB Chemical Root Abatement Program has been combined with the BA Program. The Chemical Root Abatement Program makes use of the

same Information Management System, forms, and performance measures as those described in the BA Program.

2.3 Hydraulic Cleaning Procedures
Typical hydraulic cleaning procedures are listed below.

2.3.1 Project Setup
Cleaning work will be assigned to each PMC Crew by the distribution of sub-basin collection system maps. An electronic form will be completed during the cleaning phase and incorporated into the information management database, and portions will be collected in the Knoxville Geographic Information System (KGIS). This process is discussed in more detail in Section 3.8 Information Management System.

Line segment cleaning will begin in the downstream manhole of that segment and move upstream.

2.3.1.1 Fill Truck Water Tank
The truck's water tank is usually filled using a fire hydrant. When operating a hydrant valve, the operator should use the supplied hydrant wrench. Operators will use backflow preventers and water meters during filling activities. When the tank is filled, close the valve slowly to prevent water hammer.

2.3.1.2 Set Up Traffic Control
Approved traffic control practices that conform to applicable statutes around the work site will be followed.

2.3.1.3 Set Up Over Manhole
The truck operator positions the cleaning hose reel over the manhole. When ready to begin, he attaches the appropriate cleaning nozzle to the hose. Various nozzle types are available for specialized cleaning tasks, such as removing a blockage.

2.3.1.4 Open Manhole
When the cleaning unit is set up, the operator opens the manhole and tests for "sewer gas." Procedures for gas testing and for what to do if high gas levels are present can be found in KUB's Standard Operating Procedures.

2.3.1.5 Position Nozzle for Cleaning
With the manhole open, start the truck's engine and lower the hose into the manhole. Use a roller or guide to shield the hose from the rough edges of the manhole. To begin cleaning, place the nozzle in the invert of the pipe pointed upstream.

2.3.2 Line Cleaning

2.3.2.1 Propel Cleaning Nozzle Up Line
To begin cleaning, turn on the water valve and start the high-pressure pump. An increase in pump speed will generate sufficient water velocity to move the nozzle up the sewer line.

2.3.2.2 Return Nozzle to Manhole
After propelling the nozzle a sufficient distance upstream, turn the reel directional control to the "in" position and increase the pump speed to achieve the proper water pressure. The nozzle should be reeled in until it is just outside the manhole.

Note: Experience will be the best guide for when to begin returning the nozzle to the manhole. Take care not to go so far that the debris returned in front of the nozzle creates a sewer blockage.

2.3.2.3 Repeat Steps 2.3.2.1 and 2.3.2.2
Steps 2.3.2.1 and 2.3.2.2 should be repeated until the nozzle is able to reach the upstream manhole and return to the downstream manhole with no debris present.

2.3.2.4 Collect Debris Using Vacuum Unit
When the nozzle has been returned to the downstream manhole, collect debris using the vacuum unit. To use the vacuum part of the combination truck, insert the vacuum tube into the manhole and turn the suction on to the appropriate level for the size of debris being removed. Continue working the vacuum tube around the manhole until all debris is removed. Next, remove the vacuum tube and return it to its proper secured position on the truck. While operating the vacuum unit, take care to avoid overhead obstructions, such as power lines.

2.3.3 Mechanical Root Abatement Procedures

2.3.3.1 Necessity of Performing Mechanical Root Abatement
Root intrusions may be discovered during line cleaning activities, such as flushing, or identified during CCTV inspection.

2.3.3.2 Select Root Cutter Blade
The appropriate size of the root cutter and blade will vary depending on the size of the line diameter and the severity of the root intrusion.

2.3.3.3 Position Root Cutter
With the manhole open, start the truck's engine and lower the hose into the manhole. Use a roller or guide to shield the hose from the rough edges of the manhole. To begin mechanical root abatement, the root cutter is laid in the invert of the pipe and pointed upstream.

2.3.3.4 Propel Cleaning Cutter up Line
To begin cutting, turn on the water valve and start the high-pressure pump. An increase in pump speed will generate sufficient water velocity to move the cutter up the sewer line.

2.3.3.5 Return Cutter to Manhole
After propelling the cutter a sufficient distance upstream, turn the reel directional control to the "in" position and increase the pump speed to achieve the proper water pressure. The nozzle should be reeled in until it is just outside the manhole.

Note: Experience will be the best guide for when to begin returning the cutter to the manhole. Take care not to go so far that the debris returned in front of the cutter creates a sewer blockage.

2.3.3.6 Repeat Steps 2.3.3.4 and 2.3.3.5
Steps 2.3.3.4 and 2.3.3.5 should be repeated until the cutter is able to reach the upstream manhole or beyond the root intrusion and return to the downstream manhole with no debris present.

2.3.3.7 Follow-up Cleaning
After the operator completes the mechanical root abatement, the line will be cleaned again (Refer to Section 2.3.2 for approved procedures).

2.3.3.8 Televise Line
Televise the line after the follow-up cleaning to ensure that root intrusions are no longer present.

2.3.3.9 Repeat Steps 2.3.3.6, 2.3.3.7, and 2.3.3.8
Steps 2.3.3.6, 2.3.3.7, and 2.3.3.8 should be repeated until root intrusions are no longer present.

2.3.4 Completion of Line Cleaning
After cleaning, return the hose to the reel. If the line will not be televised at this time, replace the manhole lid and remove any traffic control devices. When the debris collected by the vacuum unit fills the tank, take the truck to an approved site for dumping.

2.4 Priorities for Scheduling
The BA Program is an inventory of line segments within the collection system that requires maintenance more frequently than the proactive cleaning schedule provides. The scheduling of the line segment(s) is an automated process based upon the last maintenance activity and the prescribed frequency of the next maintenance activity.

The computerized BA Program assigns maintenance dates by adding the frequency to the last completed date to determine the next scheduled date. For example, if a line segment received maintenance on October 1, 2005 and the frequency is twelve months, then the next schedule date will be October 1, 2006. The internally developed Information Technology solution utilizes Microsoft Access, KUB's GIS, and the Internet to:

- Inventory all BA line segments
- Schedule maintenance activities
- Store maintenance field information
- Plan for repair and/or rehabilitation of cause of the blockages.

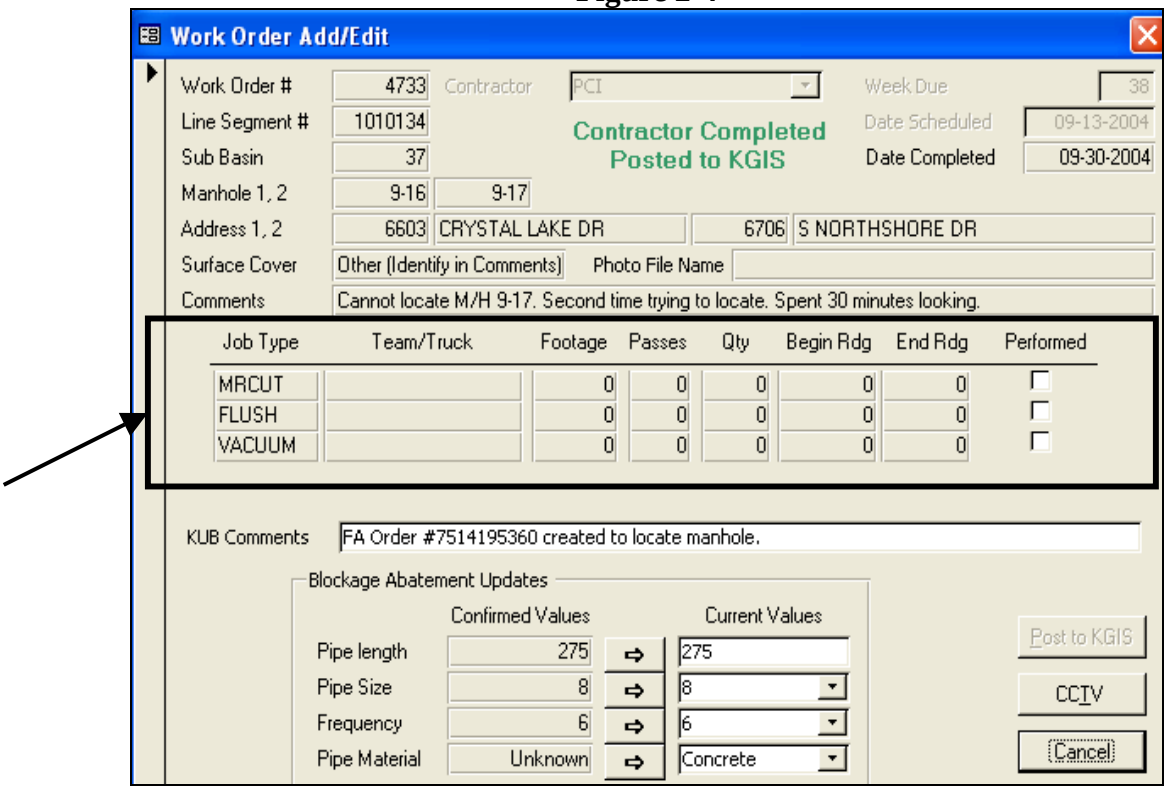
KUB has established a multi-year agreement with a contractor to perform work required by the BA Program. The contractor is able to focus only on completing the BA Program on schedule. This allows KUB internal resources to focus on proactive cleaning. Priority will always be given to meeting the BA schedule, therefore the contractor's or KUB's crews work schedules will be adjusted accordingly.

2.5 Standard Forms-Maintenance on Internet
Figure 2-4 is a screen shot of the standard form that the contracted field crew will use to receive and record new information pertaining to a BA line segment. As illustrated, the contractor is provided information regarding the location and required maintenance activity for the BA line segment and the scheduled date for completing the required activity.
For example, when the contractor is instructed to clean a line segment, they are provided:

- Upstream and downstream manhole numbers
- Upstream and downstream manhole street addresses
- Line segment length
- Pipe diameter or size
- Pipe material.

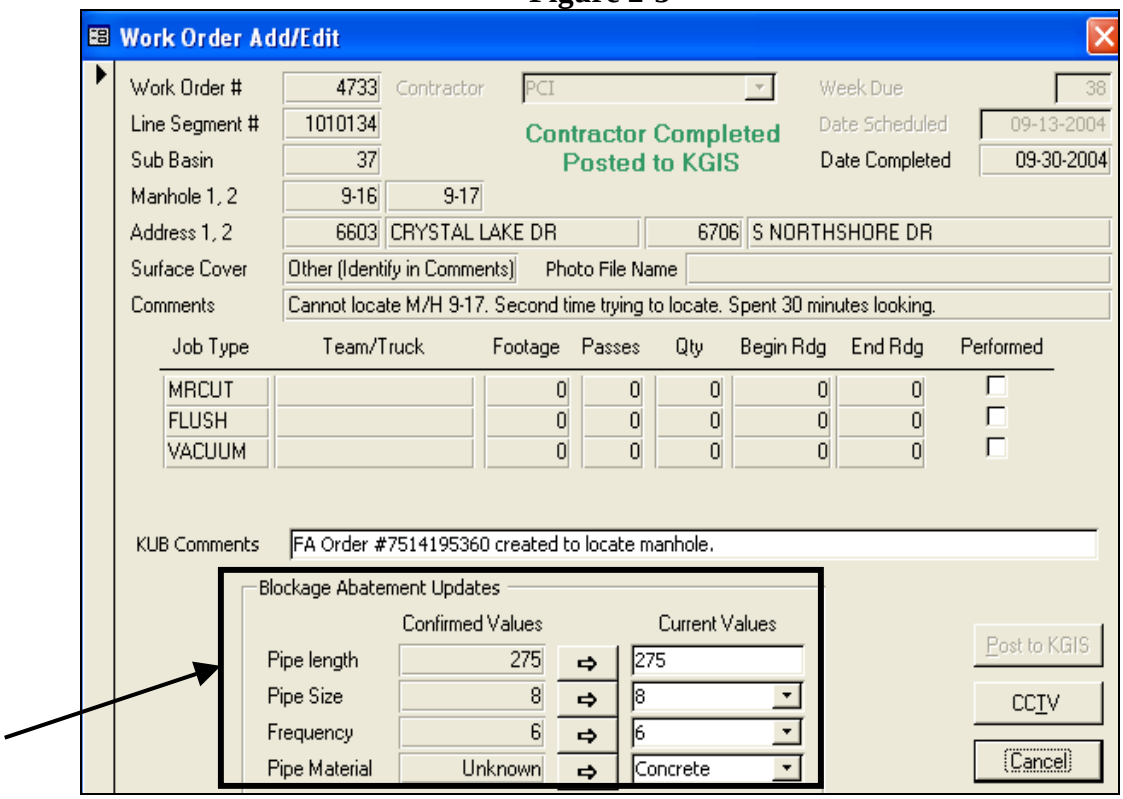
Within the Job Details portion of this form, the contractor will document what actions were accomplished, such as mechanical root cutting, flushing, and/or vacuuming.

Figure 2-4



As shown in **Figure 2-5**, this form also provides the contractor an opportunity to document other pertinent information relating to this line segment such as correcting the length, size, or material of the pipe. The CSI Team will validate this information and corrections, if any, will be updated in KUB's GIS inventory.

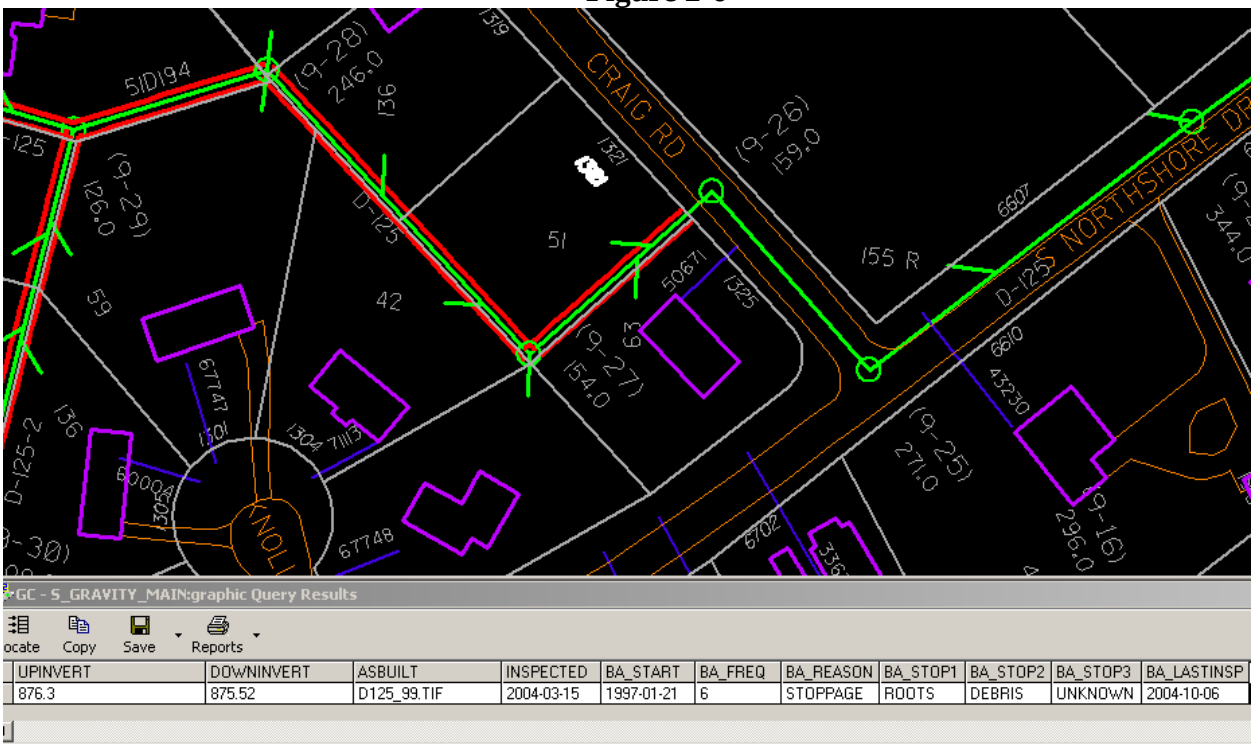
Figure 2-5



2.6 Record-Keeping

The BA Software allows the CSI Team to record maintenance information for each BA line segment. Typical information recorded for the BA Program includes the completion status of the work orders, the activity performed by field crews, and download status of the information into KUB's GIS.

Figure 2-6



UPINVERT	DOWNINVERT	ASBUILT	INSPECTED	BA_START	BA_FREQ	BA_REASON	BA_STOP1	BA_STOP2	BA_STOP3	BA_LASTINSP
876.3	875.52	D125_99.TIF	2004-03-15	1997-01-21	6	STOPPAGE	ROOTS	DEBRIS	UNKNOWN	2004-10-06

Various reports can be generated from the BA data stored as illustrated in Section 2.7.1 Report Generation. The information recorded in the field is capable of being accessed either from the KUB GIS, as shown above in **Figure 2-6,** or from the Microsoft Access database.

2.7 Performance Measures

2.7.1 Report Generation

KUB will evaluate the performance of the BA Program using the reports listed in **Figure 2-7**. The BA Program will automatically generate these reports. The data is also available for additional analysis and reporting, as needed.

Figure 2-7

Examples of Automatically Generated Blockage Abatement Program Performance Measures
Linear feet (LF) of lines flushed (basin)
LF of lines flushed (sub-basin)
LF of lines root cut (basin)
LF of lines root cut (sub-basin)
LF of lines chemically root abated (basin)
LF of lines chemically root abated (sub-basin)

Examples of Automatically Generated Blockage Abatement Program Performance Measures, cont.
Average cost per LF
Number of line segments added to BA Program
Amount of unique LF added to BA Program
Number of line segments removed from BA Program
Percent of line segments completed early
Percent of line segments completed on-time
Percent of line segments completed late

2.7.2 Evaluation of System Information

KUB uses the above information for several follow-up activities:

- Ensure that the prescribed BA schedule and activity is providing effective short-term remediation
- Identify line segments for inclusion in repair and rehabilitation projects such as short line replacement contracts
- Monitor the progress and quality of the contractor performing the BA contract.

2.8 Information Management System

KUB has developed an information management tool for the CSI Team to manage and monitor the performance of the BA Program. The software integrates an Access database with KUB's GIS to inventory information relating to the maintenance of the BA line segments, and uses the Internet as the information conduit with the contractor for sending and receiving data in the field. The marriage of these applications provides a comprehensive accountability and management asset for the CSI Team.

2.8.1 Data Integration

The contractor is provided a list of work orders via an Internet connection. The information provided to the contractor includes the location of the line segment, the required maintenance activity, and schedule for accomplishing the activity. After the prescribed activity is completed, the contractor will return the work order to KUB electronically. Once the data is downloaded from the field into the office and before it is stored in KUB's GIS, the CSI Team will validate the information received from the contractor before downloading it into KUB's GIS.

Section 2.7.1 Report Generation describes standard reports that will be generated for review by not only the MOM Coordinator but also for the Basin Managers and UGC Supervisors. These standard reports, as well as special requested reports, will serve as tools to judge the validity of the information being collected and reported.

Section 3: Gravity Line PM – Comprehensive Hydraulic Cleaning Program

3.0 Purpose and Goals

The purpose of the Comprehensive Hydraulic Cleaning Program is to maintain the operability and performance of and to support condition assessment of the wastewater collection system. This program provides comprehensive and systematic maintenance, including cleaning to remove debris, roots, and grease, on all manholes and gravity mains in the entire wastewater collection system.

The program will:

- Assess resource requirements, such as personnel and equipment
- Schedule the sub-basin cleaning using a sub-basin scoring analysis
- Update standard operating procedures to maximize allocated resources
- Provide seamless field data collection of information management systems
- Create performance reports to monitor progress and adherence to projected schedules.

The goal of the systematic program is to maximize the operational capacity of the wastewater collection system by reducing debris buildup, grease, and root intrusions.

Gravity Line Cleaning Goals	
Description	**Frequency**
Comprehensive Hydraulic Cleaning	Entire system cleaned in 12 Years
Mechanical Root Abatement	As determined by condition assessment program
Chemical Root Abatement	As determined by condition assessment program
Blockage Abatement	As determined by condition assessment program

3.1 Resources

Figure 2-2 in Section 2.1 details the organizational structure of KUB's MOM resources.

KUB uses internal resources to implement the Comprehensive Hydraulic Cleaning and CAMP programs. Three dedicated teams have been assigned to focus on wastewater collection system maintenance. The yellow highlighted portion of **Figure 2-2** represents those three PMC Crews.

KUB has dedicated the following resources to the component:

- CCTV Inspection Truck
- CCTV Inspection Trailer
- Combination Cleaner/Vacuum Trucks
- Hydraulic Flusher Truck
- FTEs

3.1.1 Comprehensive Condition Assessment and Monitoring Program

The CAMP identifies structural and operational defects affecting the entire sanitary sewer system. The primary difference between the BA Program and this program is the percentage of the system included in each program. The BA Program addresses only line segments that have experienced or have the potential of experiencing blockage-related SSOs, while the CAMP performs maintenance and assessment activities for the entire wastewater system. As mentioned, the CAMP is discussed in greater detail in the Continuing Sewer System Assessment-Condition Assessment and Monitoring Program.

3.2 Maintenance Frequency

The KUB wastewater collection system is divided into 10 drainage basins and 73 sub-basins. The structured cleaning strategy employed by the CSI Team is based on comprehensive cleaning of entire sub-basins. That approach allows KUB to incorporate directional cleaning techniques of the gravity line segments. The sub-basins are prioritized based on several weighted factors:

- Average number of dry-weather SSOs per mile
- Number of odor complaints
- Number of pipe failures
- Percentage of sub-basin currently on the Blockage Abatement (BA) schedule.

The cleaning frequency for each sub-basin will vary depending on the size of the sub-basin. Sub-basins range in size from 169 linear feet to 263,475 linear feet. Therefore, the time allotment for each basin will vary proportionally. KUB projects accomplishing the comprehensive cleaning cycle of the wastewater collection system in 12 years.

In the past, KUB crews have performed similar activities in a less structured approach referred to as "map work." KUB continues to supplement in-house efforts with outside contractors to perform maintenance.

3.3 Hydraulic Cleaning Procedures

The hydraulic cleaning procedures described in Section 2.3 Hydraulic Cleaning Procedures will also be used for the Hydraulic Cleaning Program.

3.4 Priorities for Scheduling

There are two KUB PMC Crews, one Lamps Crew, one KUB Hot Crew, one Easement Crew, and two First Responders. The PMC Crews' primary responsibility is to clean and assess the condition of the collection system on a scheduled basis. The Hot Crew and the two First Responders will perform all unscheduled maintenance activities, such as execution of the SORP and addressing customer requests, to reduce interruptions to the PMC Crews' efforts. These crews will occasionally supplement the efforts of the First Responders and the Hot Crew during critical or emergency situations.

KUB implements a comprehensive sub-basin maintenance matrix rather than scheduling maintenance on individual line segments spread across different sub-basins. This approach is an efficient system for ensuring preventive maintenance on all lines. Each sub-basin will receive a score based on several performance factors:

- Total linear footage of sub-basin
- Percentage of sub-basin currently on the BA Program
- Average number of total SSOs per mile
- Average number of dry-weather SSOs per mile
- Number of odor complaints
- Number of pipe failures
- Percentage of sub-basin rehabilitated in last three years
- Average Condition Assessment Rating.

KUB will use those factors, along with a weighted average for each performance factor, to derive a final sub-basin score. The sub-basin scores will be ranked with the highest scores receiving the highest priority. This scheduling program will be updated semi-annually to ensure that the sub-

basins that would benefit most are scheduled first in the comprehensive cleaning and condition assessment cycle.

3.5 Standard Forms

Field crews document hydraulic cleaning through an electronic form. The forms collect information used to detail maintenance activities and to evaluate system improvements.

Information to be recorded in the field on the electronic form includes:

- Date work accomplished
- Sub-basin number
- Manhole number
- Associated street address
- Employees performing work
- Man-hours
- Line number
- Type of work accomplished
- Number of flushing passes
- Unique footage cleaned
- Unique footage root cut
- Number of root cut passes
- Estimated volume vacuumed
- Type of material removed
- Needed follow-up activities

Figure 3-1

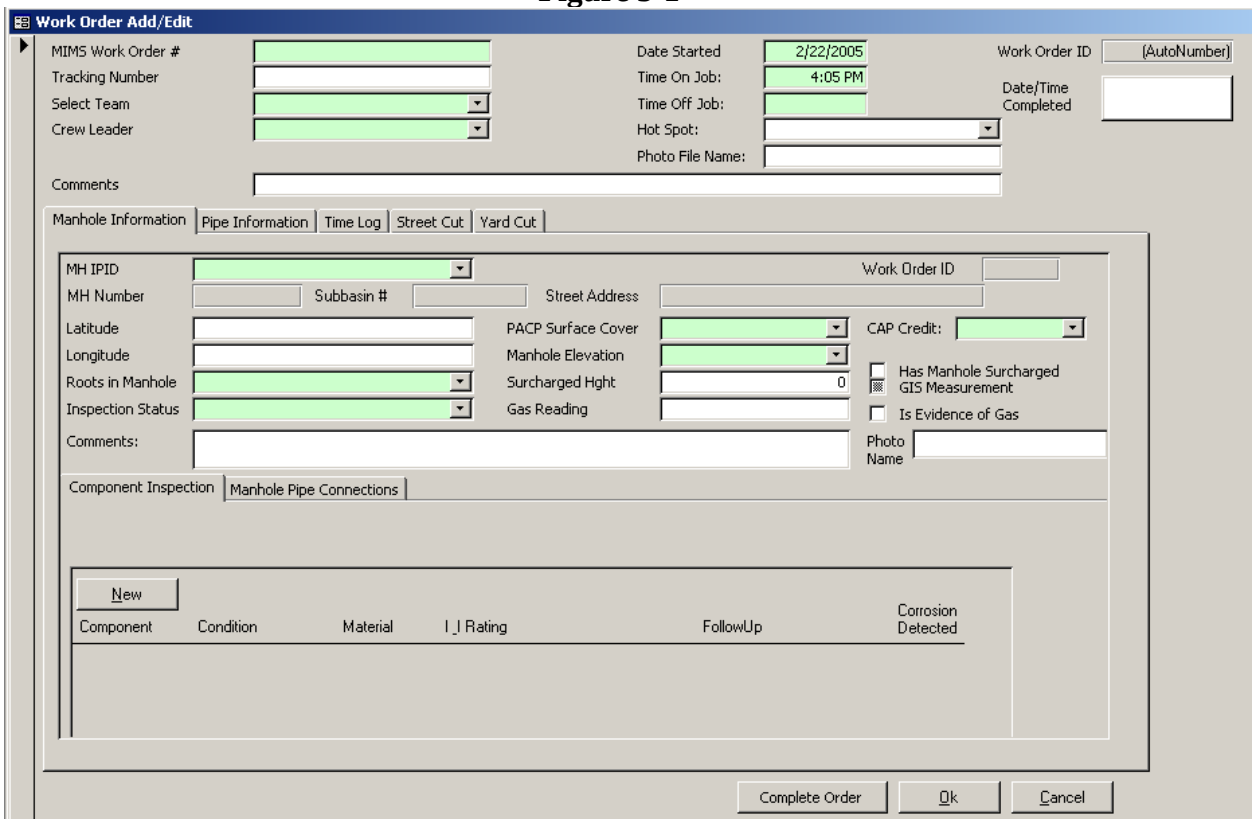


Figure 3-1 above includes several pull-down menus and data triggers to reduce the time required to complete the form and to standardize information that enhances the ability to search the KUB database for information. The electronic form also allows for use of the same format for many different activities.

3.6 Record-Keeping

3.6.1 Data Input

3.6.1.1 Electronic Download

To reduce data entry time and minimize data entry errors, all PMC Crews complete the electronic forms on their Mobile Data System (MDS) units. The MDS units provide the same reference and data entry capability as traditional office computers.

The information can be returned either by writeable CDs or by mobile hard drives. The data is downloaded when the crews return to the office. The information is automatically distributed to various databases across KUB, following an authentication process by the CSI Team.

3.6.1.2 Paper Scanning

To anticipate any computer malfunctions, the form is formatted so that it can be manually completed on a paper copy in the field. The completed paper copies would then be returned to the office and scanned by office personnel.

3.6.2 Data Integration

The hydraulic cleaning information obtained from field crews, KUB or contracted, will be collected and stored electronically. The information collected using a paper process will be scanned and stored electronically. The primary collection tool of data is the electronic Collection System Maintenance form. The original paper copy will be stored to serve as a contingency to collect information if computer errors are experienced in the field.

The quality and control process of the data collection will be a multi-phased process. The Collection System Maintenance Program has validation programs running as field crews enter data. If data is entered incorrectly or if all required fields are not entered, then the operator cannot close the order and will be prompted to the questionable data. This process provides the first level of accuracy assurance.

Once the data is downloaded from the field into the office and before it is stored in KUB's GIS, an additional validation program will be run on the database automatically to flag questionable data. This report will be submitted to the MOM Coordinator for review and intervention.

Section 3.7.1 describes standard reports that will be generated for review by not only the MOM Coordinator but also for the Basin Managers and UGC Supervisors. The standard reports, as well as special requested reports, will serve as tools to judge the validity of the information being collected and reported.

3.7 Performance Measures

3.7.1 Report Generation

The Information Management database will allow KUB to assess the performance of the program as well as of individual crews, and it will automatically produce the reports listed in **Figure 3-2**. The data is available for additional analysis and reporting.

Figure 3-2

Examples of Automatically Generated Maintenance Cleaning and Mechanical Root Abatement Performance Measures
Linear Footage (LF) of lines flushed (day/crew)
LF of lines flushed (basin)
LF of lines flushed (sub-basin)
LF of lines root cut (day/crew)
LF of lines root cut (basin)
LF of lines root cut (sub-basin)
Total man-hours flushed*
Total man-hours root cut*
Total man-hours cleaned (flushed + root cut)*
LF flushed/man-hour*
LF root cut/man-hour*
LF cleaned/man-hour*
Average cost per LF*
Number of line segments added to BA Program from PM Cleaning
Number of follow-up activities required*
Number of follow-up activities required (type)*
Number of follow-up activities completed*

*KUB crews only

3.7.2 Evaluation of Program Findings

KUB uses the information obtained from field crews for several follow-up activities:

- Create immediate follow-up work orders for in-house resources for such activities as dye-testing, point repair, additional CCTV, additional cleaning, etc.
- Include in maintenance rehabilitation contracts, such as in the short-line replacement contract, manhole rehabilitation contract, chemical root abatement contract, easement cleaning contract, etc.
- Include in KUB's IRP.

3.8 Information Management System

KUB uses integrated Information Management databases to prioritize sub-basin scheduling, provide information to field crews, receive input from the field, store data, generate reports, and evaluate the program and system.

3.8.1 Information Management Sources Used to Establish Sub-Basin Scores

3.8.1.1 Sanitary Sewer Overflow Evaluation Report (SSOER)

The information collected and reported in the SSOER is used to populate the various related fields. KUB's BA Program was implemented to reactively reduce or prevent future recurrence of SSOs due to dry weather causes.

The sub-basin scheduling uses the total average number of SSOs per mile and the average number of dry weather SSOs per mile over the last three years from the SSOER.

3.8.1.2 Blockage Abatement Program

The objective of the BA Program is to prevent blockages caused by debris, grease, roots, etc.,

from recurring. The ultimate goal is to transition those pipe segments (through point repairs, short-line replacements, and Capital Improvement Projects) from this program to the cleaning program.

The total footage of each sub-basin with the BA Program will also be used to determine the performance of the system.

3.8.1.3 Comprehensive Condition Assessment and Monitoring Program (CAMP)

The CAMP is a component of the Gravity Line Preventive Maintenance Program that occurs in concert with the Comprehensive Hydraulic Cleaning Program. The objective of the CAMP is to provide a comprehensive and systematic inspection program using CCTV, smoke testing, man-hole inspection, easement inspection, and flow monitoring. The fundamental goal of the program is to gather information related to the condition of the wastewater assets to make replacement/improvement decisions.

The information from this program used for sub-basin scheduling relates to the condition assessment rating. The Pipeline Assessment and Certification Program (PACP) score is a factor of the type, number, and severity of the defects identified in the system.

3.8.1.4 Underground Construction Job Tracker Database

The maintenance history on cleaning, repairs, and replacement of the wastewater collection system is stored in the UGC Job Tracker Database.

The information from this program, including the number of pipe failures and a portion of the percent rehabilitated and replaced over the last three years, is used to develop schedules and in the prioritization of the sub-basins.

3.8.1.5 Customer Information System (CIS)

The CIS maintains records of account numbers, premise details, and other customer information. It also generates work orders and facilitates workflow between departments and keeps a record of activities requested by a particular customer or group of customers.

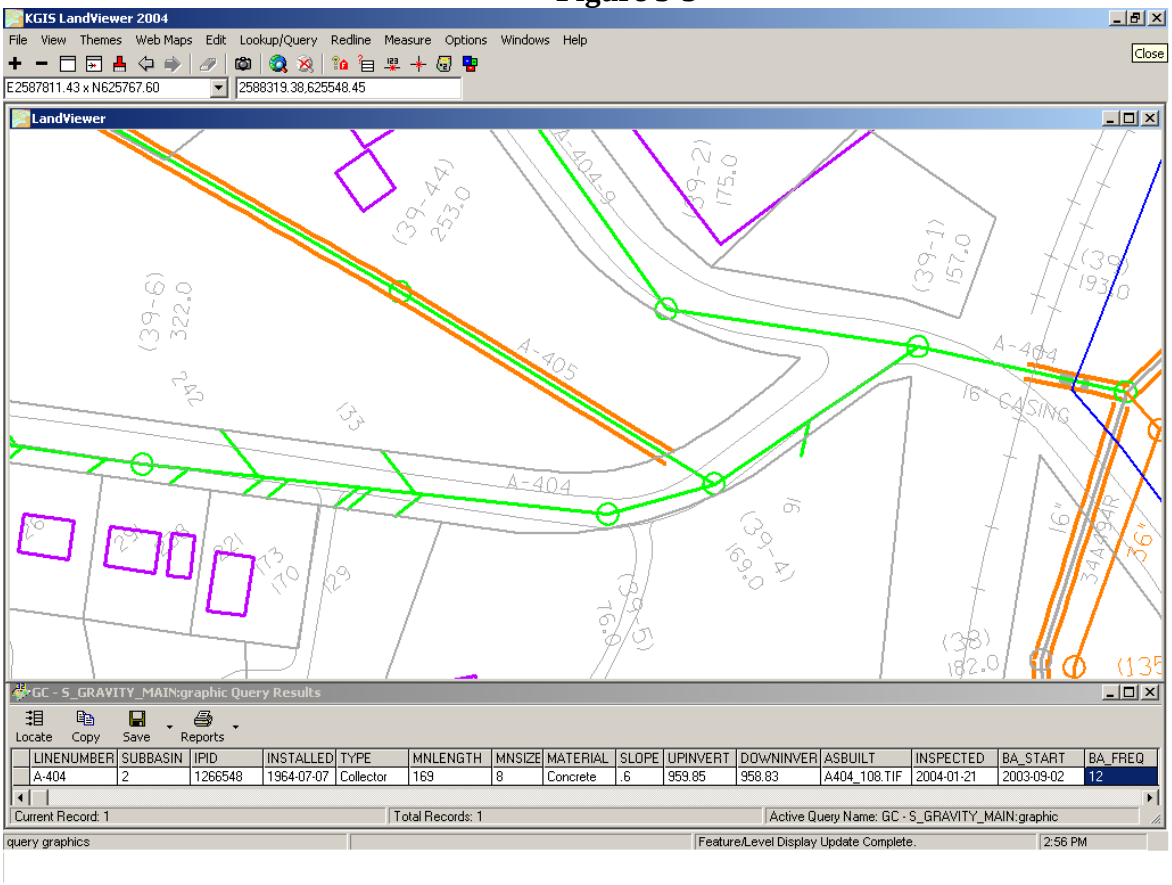
The information used for sub-basin scheduling is the number of odor complaints per sub-basin over the last three years.

3.8.2 System Mapping for Field Crews

3.8.2.1 Paper Collection System Maps

A field crew receives a collection system map (**Figure 3-3**) that contains the necessary information to properly maintain the system and to accurately report activities before beginning work in a sub-basin. The maps serve the same purpose as traditional work orders. In this case, each line segment on the map will represent a work order to be completed. The crews are given a timeline for completion of the sub-basin, and UGC and the CSI Team will monitor their progress and provide any support necessary to complete the sub-basin cleaning on schedule.

Figure 3-3



The map also provides information required to complete electronic forms. The map contains such system information as:

- Manhole number
- Line number
- Line diameter size
- Line segment length.

3.8.2.2 Landviewer

Field crews are equipped with MDS units in their vehicles. The MDS units will give the field crews access to the KGIS. Landviewer software allows the field crew to ascertain information on the manhole, line segment, etc., that is necessary to perform maintenance on the system and report on their activities.

Section 4: Gravity Line PM – Summary

4.0 Summary

Corrective Action Plan/Engineering Report

As required by the Consent Decree, KUB is in the process of developing and implementing a Corrective Action Plan to address both maintenance and rehabilitation needs in the KUB system. To develop this plan and engineering report for the gravity system, KUB is using the tools and methods described in this document.

Figure 4-1 depicts the workflow process KUB uses to carry out these tasks. KUB is using a mix of internal and external professionals including the following:

- Engineers
- System Operators and Technicians
- Other expert analysts.

The responsibility for managing this process belongs to the Director of Plants and Collection System.

Figure 4-1