Continuing Sewer System Assessment Program

Second Revised Version Placed in the Public Document Repository on February 19, 2009

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D. Wayne Loveday — 2-19-2009

D. Wayne Loveday — Date

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A 10-year Program to Improve Our Waterways

Executive Summary

The primary function of the Continuing Sewer System Assessment Program (CSSAP) is to provide decision-support information for implementation of the Corrective Action Plan/Engineering Report (CAP/ER), Capital Improvement Plan (CIP) and Infrastructure Rehabilitation Program (IRP). The CAP/ER and IRP are required components of the Consent Decree; while the CIP addresses other system improvements not related to SSO mitigation or infrastructure upgrades (i.e., wastewater collection and transmission system (WCTS) extensions, Supervisory Control and Data Acquisition (SCADA) improvements, etc.).

The CAP/ER is a capital improvement program focused on improvements to the WCTS. It consists of both capacity improvements (relief sewers, sewer replacement with larger sewer pipe, pump station expansion, and storage facilities) and existing system rehabilitation. Flow monitoring data and the hydraulic models are the primary tools for providing and analyzing system information to support decision-making for the CAP/ER. Follow-up smoke testing and closed-circuit television (CCTV) are also used in areas targeted for sewer rehabilitation.

As KUB moves forward, components of the CSSAP other than flow monitoring and modeling will play an increasingly important role in supporting asset management decision-making under the IRP. Increasing emphasis will be placed on a variety of information sources and decision-support tools as the CSSAP matures to make prudent infrastructure management decisions to prevent component failure due to structural deterioration or insufficient capacity.

KUB's objectives are to

1. Develop decision-support processes as part of the IRP to guide cost-effective repair/replacement decisions using data obtained under the CSSAP
2. Use cost-effective CSSAP technologies to gather condition and performance-related data to support decisions
3. Maintain a cost-effective mix of self-performed and contracted work to obtain data through CSSAP components.

The CSSAP is not a stand-alone program. It requires unique resources or planning activities for each of the program elements. Program elements of CSSAP are described below.

<u>Manhole Condition Assessment</u>

KUB's Manhole Condition Assessment evaluates the structural condition and operational performance of sanitary sewer manholes. This inspection practice uses visual inspections of the manholes, as described in Section 2.1.3 Routine Manhole Inspection and smoke testing as described in Section 2.1.6 Smoke Testing.

KUB uses a component methodology to inspect manholes. Each component of the manhole is inspected independently and required information is recorded on an electronic form described in Section 3.2 Collection System Maintenance (CSM) Program.

Gravity System Condition Assessment
KUB's Gravity System Condition Assessment evaluates the structural condition and operational performance of the sanitary sewer main lines and private laterals. This inspection practice uses several assessment tools including

- Flow monitoring as described in Section 2.1.4 Flow Monitoring/Flow Modeling
- Smoke testing as described in Section 2.1.6 Smoke Testing
- Dye testing as described in Section 2.1.1 Dye Testing/Dyed Water Flooding
- CCTV inspection as described in Section 2.1.5 CCTV Inspection.

Private Lateral Condition Assessment
KUB's Private Lateral Condition Assessment evaluates the structural condition and operational performance of the sanitary sewer service laterals. This inspection practice uses several assessment tools including

- Smoke testing as described in Section 2.1.6 Smoke Testing
- Dye testing as described in Section 2.1.1 Dye Testing/Dyed Water Flooding
- CCTV inspection as described in Section 2.1.5 CCTV Inspection.

Pump Station Performance Assessment
KUB's Pump Station Performance Assessment evaluates the adequacy of existing pump stations to provide reliable pumping capacity for dry and wet weather flows. This assessment includes evaluation of dry and wet weather flow conditions using flow monitoring data, hydraulic models, historical records of system performance (upstream SSOs, building backups, etc.), pump operating times, records of pump and pump station outages, and other related information as described in Section 2.1.7 Pump Station Performance and Adequacy.

Force Main Condition Assessment
KUB's Force Main Condition Assessment evaluates the condition of existing force mains to identify corrosion impacts through periodic inspection of WCTS components. This assessment includes corrosion defect identification as described in Section 2.1.2 Corrosion Defect Identification.

Program Assessment Tools
The following inspection tools, which are listed with their corresponding sections, provide various options for KUB to analyze the WCTS:

- *Dye Testing/Dyed Water Flooding***,** Section 2.1.1 Dye Testing/Dyed Water Flooding
- *Corrosion Defect Identification,* Section 2.1.2 Corrosion Defect Identification
- *Routine Manhole Inspection,* Section 2.1.3 Routine Manhole Inspections
- *Flow Monitoring and Flow Modeling***,** Section 2.1.4 Flow Monitoring/Flow Modeling
- *CCTV Inspection,* Section 2.1.5 CCTV Inspection

- *Smoke Testing,* Section 2.1.6 Smoke Testing
- *Pump Station Performance and Adequacy,* Section 2.1.7 Pump Station Performance and Adequacy.
- *Private Lateral Inspection Analysis,* Section 2.1.8 Private Lateral Inspection Analysis

The inspection tools are used to target specific system defects or provide information to improve the performance of a portion of the WCTS.

Priorities and Scheduling

KUB prioritizes assessment schedules based on a comprehensive sub-basin matrix, as described in Section 1.3.1 Sub-Basin Priority Decision Tool. KUB employees a comprehensive sub-basin maintenance matrix rather than scheduling maintenance and assessment on individual line segments spread across different sub-basins. This comprehensive approach develops priorities and schedules utilizing several factors described in the above-referenced section.

Resources (Manpower and Equipment)

To meet the program goals, KUB currently uses external and internal resources to perform inspections. A description of the allocated resources is detailed in Section 1.4 Resources.

Implementation Plan

KUB has initiated all of the CSSAP elements described; however some aspects of the program are still in development. Specifically, those aspects are as follows:

1. KUB's asset management system has the capability to perform Root Cause Failure Analysis (RCFA) for pump stations, but this functionality has not yet been established. It will take 365 days from CSSAP approval to fully develop the RCFA capability.
2. KUB is currently converting to new CCTV software and replacing field equipment with new cameras. The conversion should be completed by mid-2005.

The 7 Elements of a Proper MOM Program
KUB's Continuing Sewer System Assessment Program

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

2. **Purposeful**
   This program is designed to
   - Assess the structural condition and operational performance of the WCTS
   - Assess resource requirements, such as personnel and equipment
   - Schedule sub-basin assessments based on a structured decision matrix
   - Update Standard Operating Procedures to maximize allocated resources
   - Provide seamless field data collection for information management systems
   - Create performance reports to monitor progress and adherence to projected schedules
   - Develop performance measures to assess the progress of each component
   - Conduct flow monitoring and analyze hydraulic data to quantify flow and assess capacity
   - Support decision-making and prioritization of CAP/ER and IRP projects including
     - Sewer rehabilitation
     - Storage
     - Relief sewers
     - Pumping system improvements
     - Additional treatment capacity, if required
   - Assist in directing the physical assessment of portions of the system.

3. **Goal-Oriented**
   - KUB's CSSAP provides structured guidance for the operation, evaluation, and performance of the sanitary sewer system. It provides a comprehensive and systematic assessment plan to evaluate the entire sewer system within 12 years.

4. **Uses Performance Measures**
   The performance measures established for assessing the WCTS are as follows:
   - Manhole Assessment – Every manhole assessed in 12 years
   - Gravity Sewer Assessment – Entire gravity system assessed in 12 years
   - Private Lateral Assessment – Every lateral assessed in 12 years
   - Pump Station Performance Assessment – Every pump station assessed in one year and then monitored every two years
   - Force Main Performance Assessment – Every force main assessed in two years and then monitored every two years.

5. **<u>Periodically Evaluated</u>**
KUB will review the CSSAP 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 SSOs related to structural failures
   - Progress in achieving performance measures for each program element.

6. **<u>Available in Writing</u>**
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. **<u>Implemented by Trained Personnel</u>**
Internal resources receive a series of training components. KUB employees are regularly introduced to new techniques designed to improve safety and efficiency.

   Contractors selected to perform outsourced components of the CSSAP are held to the same standards 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 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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1.0 Introduction/Overview

The CSSAP is a systematic evaluation of the entire WCTS, including manholes, pump stations, and conveyance lines. It also assesses the capacity of the WCTS to support prioritization of the CAP/ER and IRP, including on-going hydraulic modeling and flow monitoring.

The CSSAP will

- Assess the structural condition and operational performance of the WCTS
- Assess resource requirements, such as personnel and equipment
- Schedule sub-basin assessments based on a structured decision matrix
- Update Standard Operating Procedures to maximize allocated resources
- Provide seamless field data collection for information management systems
- Create performance reports to monitor progress and adherence to projected schedules
- Develop performance measures for the progress
- Conduct flow monitoring and analyze hydraulic data
- Support decision-making and prioritization of CAP/ER and IRP projects including
- Sewer rehabilitation
- Storage
- Relief sewers
- Pumping system improvements
- Additional treatment capacity, if required
- Assist in directing the physical assessment of portions of the system.

The CSSAP is not a stand-alone program. It requires unique resources or planning activities for each of the program components. The Hydraulic Cleaning Program is a compliment to the CSSAP. For example, the mains and manholes will be assessed during hydraulic cleaning. Therefore, the sub-basin scheduling program as described in Section 1.3 Prioritization Procedures apply to Hydraulic Cleaning and the CSSAP. The other CSSAP components are typically not accomplished in conjunction with the Hydraulic Cleaning Program.

1.2 Program Elements

The CSSAP consists of five key program elements, which are described in **Table 1-1.** Each program element includes a method for setting priorities for determining where assessments are to be performed, a list of the tools and methods to be used to conduct assessments, and a performance measure to track progress. KUB performs most assessments using in-house resources.

Table 1-1. CSSAP Elements

Program Elements	Priority Criteria	Assessment Tools
Manhole Condition Assessment	Sub-Basin Prioritization	Manhole Inspections Smoke Testing
Gravity Sewer Condition Assessment	Sub-Basin Prioritization Flow Monitoring (R Value) SSO Reports Capacity Assurance Program Maintenance Records	Flow Monitoring Smoke Testing Dye Testing CCTV
Private Lateral Condition Assessment	Flow Monitoring (R Value) Maintenance Records	Flow Monitoring Smoke Testing Dye Testing CCTV
Pump Station Performance Assessment	Capacity Assurance Program	Pump Station Performance and Adequacy
Force Main Performance Assessment	Corrosion Defect Potential Analysis Program	Corrosion Defect Identification

Performance goals for the CSSAP elements are summarized in **Table 1-2**.

Table 1-2. Performance Goals for CSSAP Elements

Description	Period for one complete cycle of system
Manhole Condition Assessment	12 Years
Gravity Sewer Condition Assessment	12 Years
Private Lateral Condition Assessment	12 Years
Pump Station Performance Assessment	2 Years
Force Main Performance Assessment	2 Years

1.2.1 Manhole Condition Assessment

The structural condition and operational performance of sewer manholes are evaluated using physical inspection and during smoke testing. The physical inspection is accomplished during site visits. Inspections may be done with or without a pole camera, depending on the depth and other characteristics of the manhole. Smoke testing will identify the presence of inflow and infiltration (I/I) into the system.

The schedule for manhole condition assessment is established using the sub-basin prioritization matrix that is based on a priority ranking score for each sub-basin.

1.2.2 Gravity System Condition Assessment

KUB evaluates structural condition and operational performance of gravity main lines using several assessment tools. Flow monitoring indicates if extraneous water is entering the system; then KUB uses additional assessment tools to identify the particular source(s). Smoke testing and dye testing identify the presence of (I/I) into the system. CCTV inspections provide a video survey of the line to locate defects. KUB uses the Gravity System Condition Assessment program to prioritize the IRP and the CIP projects.

1.2.3 Private Lateral Condition Assessment

The primary goal of the Private Lateral Condition Assessment Program is to evaluate both the structural condition and operational performance of private sewer laterals. Laterals are inspected through smoke testing, visual inspection, and CCTV inspection.

Scheduling for private lateral inspections will be based on the sub-basin prioritization matrix and a review of historical maintenance records. Section 1.3 Prioritization Procedures provides additional information describing the scheduling of sub-basin assessment and cleaning activities.

1.2.4 Pump Station Performance Assessment

The Pump Station Performance Assessment addresses the ability of existing pump stations to provide reliable pumping capacity for dry and wet weather flows. The assessment includes evaluation of dry and wet weather flow conditions using flow monitoring data, hydraulic models, historical records of system performance (upstream SSOs, basement backups, etc.), pump operating times, records of pump and pump station outages, and other related information.

The goal of this continuing assessment is to determine if each pump station’s design features are adequate to reliably meet the specified service conditions required by the Capacity Assurance Program (CAP) (i.e. providing reliable capacity to pump peak flows). The Pump Station Performance and Adequacy component of CSSAP makes this assessment.

1.2.5 Force Main Condition Assessment

Force mains constructed of steel, cast iron, and ductile iron pipe are susceptible to corrosion damage in locations where air (i.e., oxygen) is introduced. That can occur if air is entrained by the pumps (not a common occurrence), if pipes are near air release valves, vacuum valves, or combination air release/vacuum valves, and in gravity flow segments at the discharge end of a force main.

Although the trend is to use corrosion-resistant PVC or ABS pipe for new force mains, corrosion of air release valves, vacuum valves, and combination air release/vacuum valves continues to be a concern. Failure of one of those valves could result in an SSO. Failure could also result in the following:

- Air binding resulting in reduced pumping capacities potentially causing an SSO at or upstream of a pump station
- Collapse of the pipe, which would result in significant SSOs at the failure location and/or upstream of the pump station.

KUB has developed a Force Main Condition Assessment Program to identify corrosion impacts and that information is used to schedule appropriate maintenance activities to prevent failures and to identify locations needing corrosion control. KUB's program consists of the following elements:

- Corrosion defect potential analysis to identify WCTS components that may be affected by corrosion
- Periodic inspection of WCTS components.

Long force mains are difficult to inspect for several reasons, including

- There are typically no access points to install a camera, except at the discharge end
- It is difficult to take them out of service for long periods of time
- Many are only four-inch or six-inch diameter.

The Corrosion Defect Identification component of the CSSAP will be used to conduct this assessment. Consideration will also be given to using CCTV to inspect the discharge end of force mains. For those force mains that feature a long descending leg to the discharge point, consideration will be given to installing a manhole for CCTV access at the high point where the force main effectively becomes a gravity sewer.

1.3 Prioritization Procedures

The CSSAP identifies structural and operational defects affecting sewer system performance. The results of the inspections and analyses provide data for the Blockage Abatement and Infrastructure Rehabilitation programs.

The CSSAP

- Schedules the sub-basin assessment and cleaning using a sub-basin scoring analysis
- Incorporates systemwide information into planning
- Assesses resource requirements, such as personnel and equipment.

1.3.1 Sub-Basin Priority Decision Tool

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

- Total linear footage of sub-basin
- Percentage of sub-basin currently on Blockage Abatement
- 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
- I/I impact represented by rainfall dependent inflow/infiltration (RD I/I).

KUB has used those factors, along with a weighted average for each performance factor, to derive a final sub-basin score. The sub-basin scores have been ranked with the highest scores receiving elevated priority. This scheduling program is updated semi-annually to ensure that the sub-basins that would most benefit are scheduled first in the comprehensive cleaning and condition assessment cycle. The following programs/IMSs are used as sources for sub-basin scoring.

1.3.1.1 Sanitary Sewer Overflow Evaluation Report (SSOER)

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. KUB's Blockage Abatement (BA) Program was implemented to reactively reduce or prevent future recurrence of SSOs due to dry weather causes.

1.3.1.2 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 CIP projects) from this program to the cleaning program.

The total sewer footage of each sub-basin in the BA Program is also used to assess the performance of the system.

1.3.1.3 CSSAP

The information obtained from CSSAP activities is used as a ranking factor for the prioritization program. For example, flow monitoring evaluation and Pipeline Assessment and Certification Program (PACP) scores are used for comparing the condition of additional assessment between sub-basins. The information from this program used for sub-basin scheduling relates to the condition assessment rating. The PACP score is a factor of the type, number, and severity of the defects identified in the system.

1.3.1.4 Underground Construction Job Tracker Database

The maintenance history on cleaning, repairs, and replacement in the WCTS is stored in the Underground Construction Job Tracker Database.

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

1.3.1.5 Customer Information System (CIS)

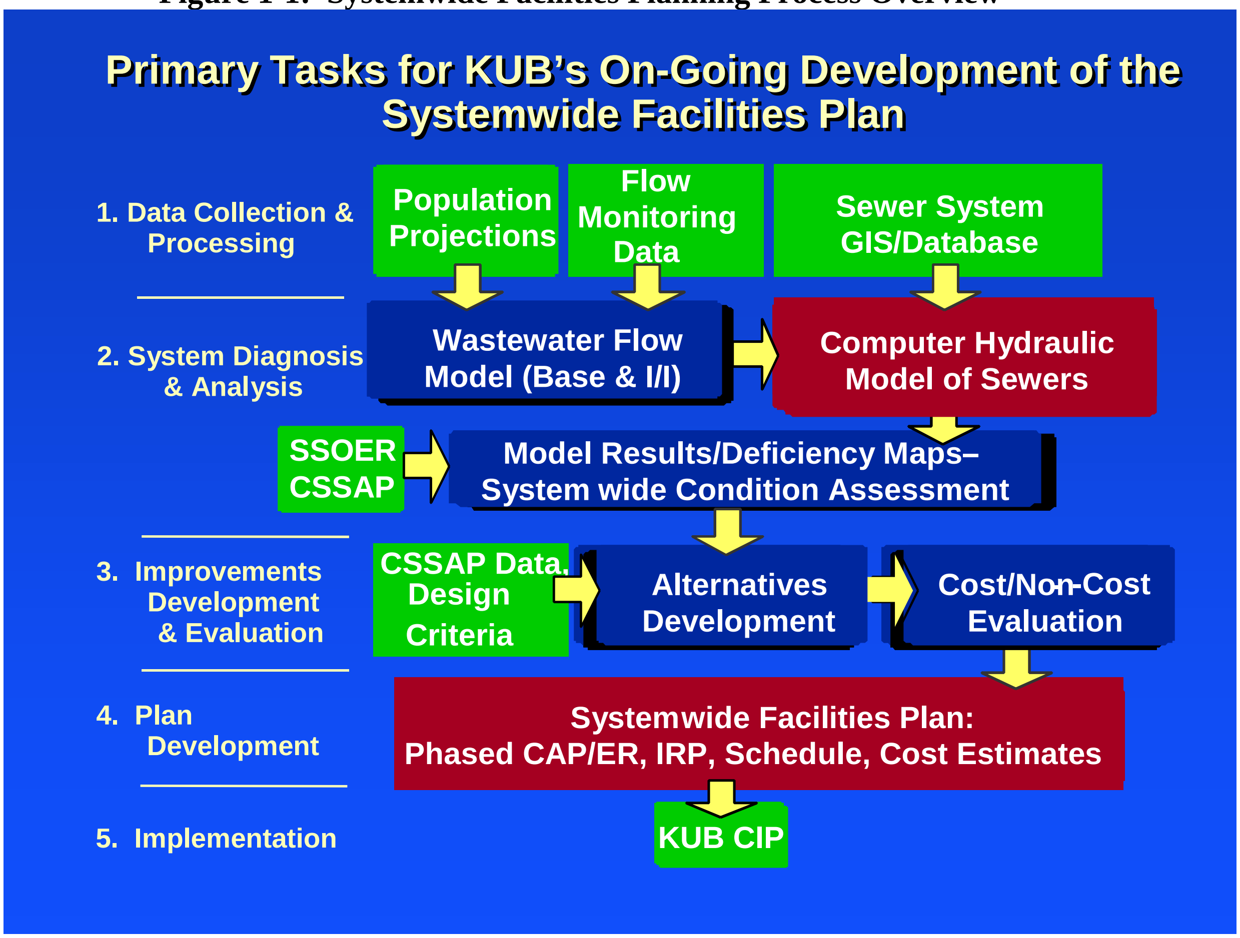
The CIS maintains records of account numbers, premise details, and other customer information. It also generates work orders, facilitates workflow between departments, and keeps a record of activities requested by a particular customer or group of customers.

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

1.3.2 Systemwide Facilities Planning Process

The CSSAP supports development of the Systemwide Facilities Plan that consists of the phased CAP/ER, CIP, and IRP as illustrated in **Figure 1-1**. It is periodically updated as additional information becomes available. It supports KUB's annual budget and five-year planning process for capital improvements in the IRP. The major tasks for the Systemwide Facilities Planning Process are illustrated in **Figure 1-1**.

Figure 1-1: Systemwide Facilities Planning Process Overview



The following are descriptions of primary tasks illustrated in **Figure 1-1:**

Primary Task 1-Data Collection and Processing
The two purposes of the data collection and processing task are to develop a wastewater flow model for dry and wet weather conditions and a dynamic hydraulic model of the trunk sewer system. Current and future population projections for traffic analysis zones (TAZ) are obtained from the Metropolitan Planning Commission. Temporary mini-basin flow monitoring data along with data from systemwide permanent flow monitors are used, along with population projections to develop the dry and wet weather flow models. The data is used to evaluate the severity of RD I/I and sub-basins are then ranked accordingly for subsequent CSSAP activities. These models are subsequently used for flow input to the hydraulic model.

The hydraulic model selected for systemwide use is MIKE-SWMM, a dynamic model that is based on the EXTRAN block of EPA's Stormwater Management Model (SWMM). KUB's GIS database is used as a source of sewer attributes for model development. The model is calibrated at specific locations for dry and wet weather conditions using flow monitoring data.

Primary Task 2-System Diagnosis and Analysis
The hydraulic model uses input flow hydrographs through a series of connected manholes and pipes to compute a time history of flows and heads at each node (i.e., manhole). The model, along with observed system performance, is used to develop dry and wet weather hydraulic deficiency maps, which indicate potential overflow locations and volumes, surcharged sewer segments, and peak WWTP and pump station influent flows. (Note: Observed system performance factors include the location and relative volumes of overflows during dry weather and specific wet weather events and the SSOER.)

Primary Task 3-Improvements Development and Evaluation
The deficiency maps (*see Task 2, above*) are used to focus evaluation efforts, specifically traditional CSSAP activities, including, but not limited to, manhole inspections, temporary flow monitoring, smoke testing, CCTV inspection, and dye testing.

The wet weather flow monitoring data is analyzed to develop an R-value for each mini-basin, where R is the percentage of rainfall that enters the system as RD I/I. Mini-basins with the highest R-values are prioritized for subsequent follow-up CSSAP activities for RD I/I source detection and condition assessment. Some CSSAP activities, specifically the manhole inspection and CCTV inspections, are performed as part of KUB's routine continuing sewer system assessment that covers the entire system. This information is critical for determining the extent of sewer rehabilitation needed and the appropriate methods. The information is also used to estimate effectiveness in RD I/I removal and to determine structural integrity and related rehabilitation requirements.

The model is then used to evaluate alternative improvement scenarios that feature various sewer rehabilitation methods (i.e., RD I/I removal, off-line storage, and/or increased transmission/treatment capacity).

Primary Task 4-Plan Development
After the improvements are developed and evaluated using the hydraulic model, KUB creates a Systemwide Facilities Plan. KUB integrates the proposed improvements into an overall schedule and develops cost estimates for each improvement. KUB uses a structured decision matrix to prioritize each improvement. Currently, KUB is developing the CAP/ER, a companion program of its IRP, using this protocol.

Primary Task 5-Implementation
Implementing the Systemwide Facilities Plan consists of developing schedules and budgets, defining project scopes, creating contract documents, acquiring easements (if necessary), construction of the improvement, and inspection and record-keeping during the construction to ensure that the improvement is installed according to KUB's specifications.

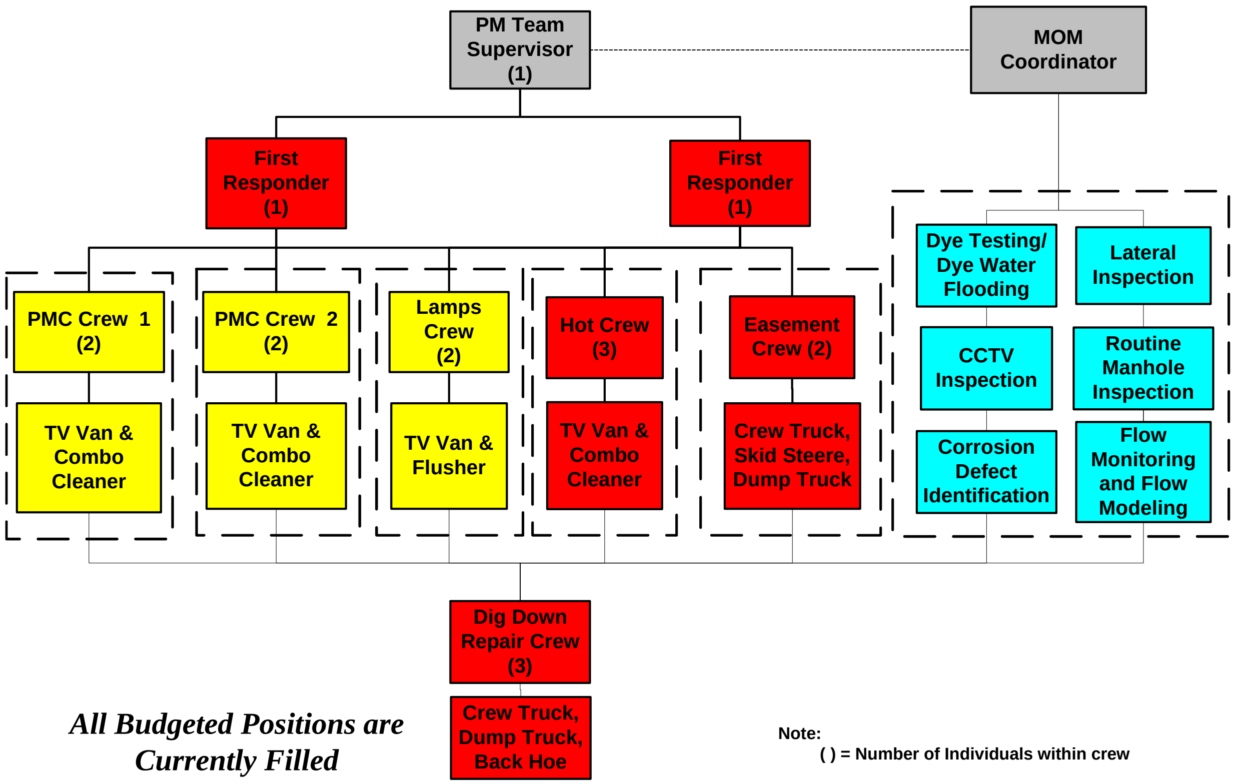
1.4 Resources

KUB's MOM programs described in this document include a combination of internal and external resources.

Underground Construction
A team of internal professionals has the primary responsibility of addressing the preventive and corrective activities, and contractors will address predictive maintenance. **Figure 1-2** summarizes the organizational structure of KUB's CSSAP resources. As mentioned in Section 1.0 Introduction/Overview, the resources that perform the CCSAP and Hydraulic Cleaning Programs overlap. Therefore, the same resources accomplish both programs.

Figure 1-2

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



All Budgeted Positions are Currently Filled

Note:
( ) = Number of Individuals within crew

Description of allocated MOM Resources:

1. Collection System Improvement (CSI) BA Program Managers
   These members of the Collection System Improvement Team manage, direct, and monitor the MOM programs. They work closely with KUB Underground Construction (UGC), other KUB departments, contractors, and consultants.
2. Preventive Maintenance (PM) Team Supervisor
   The 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 condition assessment.
4. Lamps Crew
   The Lamps Crew are members of UGC. They utilize the launch camera to inspect main lines in response to wastewater trouble calls and private laterals where wastewater trouble calls are determined to be a problem on property.
5. First Responders
   The First Responders are members of UGC. They provide a reactive response to unscheduled requests for service. Examples of unscheduled requests would 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/Manhole (MH) Inspection Crew
   The Easement/MH Inspection Crew is a member of UGC. The crew inspects manholes and dedicated easements. This crew will provide assistance as needed to the First Responders and Hot Crew during SORP events and unscheduled responses. This crew also backfills vacancies for the PMC crews during absences due to vacations and illness.
8. MOM Coordinator
   The MOM Coordinator oversees the planning, scheduling, and completion of the functions in the CSSAP. The CSSAP functions are fulfilled either by internal or contracted resources. (See the blue highlighted portion of Figure I-1). The MOM Coordinator manages CSSAP contractual agreements.

KUB has assigned three dedicated teams to focus on WCTS maintenance. The yellow highlighted portion of **Figure 1-2** represents those three PMC Crews.

KUB has dedicated the following equipment to the component:

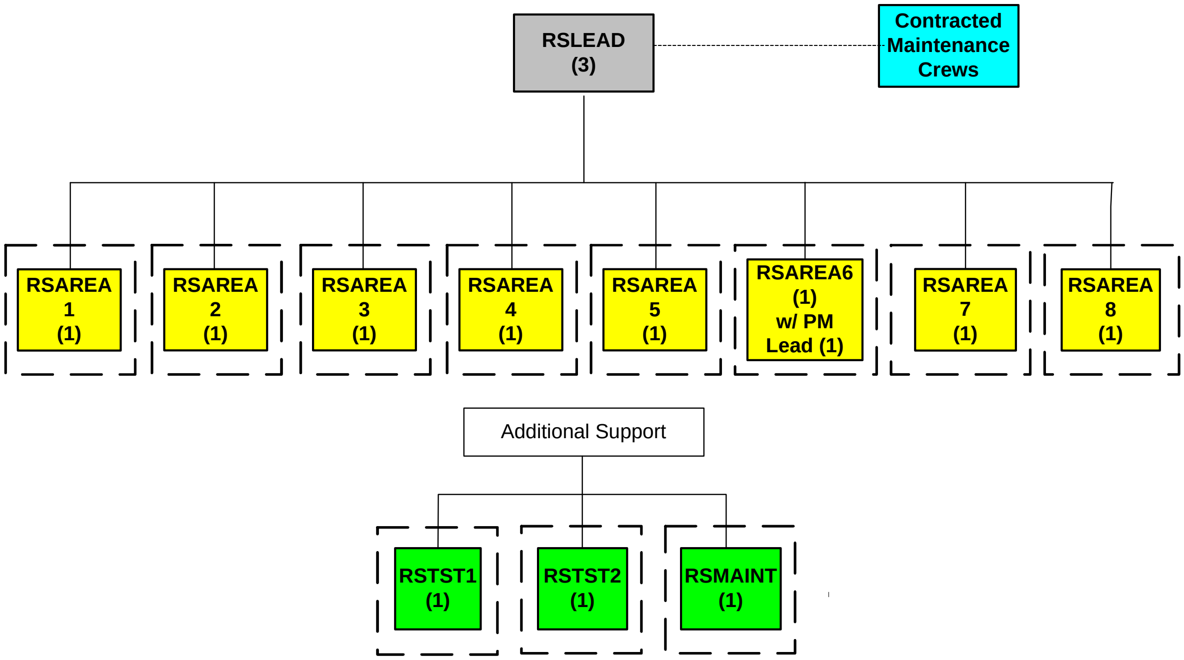
- CCTV Inspection Truck
- CCTV Inspection Trailer
- Combination Cleaner/Vacuum Trucks
- Hydraulic Flusher Truck
- Full-Time Equivalents.

If current resources prove insufficient, KUB will either use a contractor or assign additional resources to the CSSAP.

<u>System Operations</u>

Internal and external resources perform predictive, corrective, and preventive maintenance activities. First Responders and area personnel have primary responsibility for implementing KUB's Pump Station Performance and Adequacy Program, SORP, addressing customer requests, and performing other scheduled and unscheduled maintenance activities. **Figure 1-3** details the organizational structure of KUB's MOM resources.

**Figure 1-3: Management, Operations, and Maintenance (MOM)
SMSP Operation Organizational Resources
Lift Station Preventive Maintenance**



All Budgeted Positions are Currently Filled

Note:
( ) = Number of Individuals within crew

Description of allocated Station Management Services Pipes (SMSP) - MOM Resources:

1. RSLEAD:
   The RSLEAD manages and supervises the day-to-day work activities, capital upgrades and new installations, and manages budgeting allocations.
2. The RSMAINT and RSTST Crews are members of SMSP. They provide area support and perform scheduled preventive maintenance activities such as facility inspections, vibrations analysis, pump efficiency, etc.
3. RSAREA1:
   The RSAREA1 is responsible for the operation and maintenance of the facilities located within the area 1 geographical location.
4. RSAREA2:
   The RSAREA2 is responsible for the operation and maintenance of the facilities located within the area 2 geographical location.
5. RSAREA3:
   The RSAREA3 is responsible for the operation and maintenance of the facilities located within the area 3 geographical location.
6. RSAREA4:
   The RSAREA4 is responsible for the operations and maintenance of the facilities located within the area 4 geographical location.
7. RSAREA5:

The RSAREA5 is responsible for the operation and maintenance of the facilities located within the area 5 geographical location.

8. RSAREA6 w/ PM Lead:
   The RSAREA6 is responsible for the operation and maintenance of the facilities located within the area 6 geographical location.
   a. SMSP Preventive Maintenance (PM) Lead:
      This member of the SMSP Team manages, directs, and monitors the Lift Station Preventive Maintenance program. SMSP works closely with other KUB departments, contractors, and consultants as needed.
9. RSAREA7:
   The RSAREA7 is responsible for the operation and maintenance of the facilities located within the area 7 geographical location.
10. RSAREA8:
    The RSWEST is responsible for the operations and maintenance of the facilities located within the area 8 geographical location.
11. RSTST1:
    The RSTST1 is responsible for SCADA, electrical and technical maintenance, and area support.
12. RSTST2:
    The RSTST2 is responsible for SCADA, electrical and technical maintenance, and area support.
13. RSMAINT:
    The RSMAINT is responsible for general maintenance on a facilities and area support.
14. Contracted Maintenance Crews
    The Contracted Maintenance Crews are an external resource used to assist with any PM activities deemed necessary.

If current resources prove insufficient, KUB will either use a contractor or assign additional resources to the CSSAP.

2.1 System Defect Analysis and Associated Standard Procedures

KUB continues to employ various system analysis techniques to determine the operability and condition of the WCTS. The following inspection tools provide various options for KUB to analyze the collection system:

- Dye Testing/Dyed Water Flooding
- Corrosion Defect Identification
- Routine Manhole Inspection
- Flow Monitoring and Flow Modeling
- Closed-Circuit Television (CCTV) Inspection
- Smoke Testing
- Pump Station Performance and Adequacy
- Private Lateral Inspection.

These inspection tools are used to target specific system defects or to provide information to improve the performance of a portion of the WCTS. For example, smoke testing will determine if sump pumps, roof drains, or other prohibited connections are connected to the sewer system while CCTV will pin-point structural defects in main lines. Individually, these tools provide only a portion of the entire picture. Therefore, these tools are not typically used independently but in conjunction with the other described assessment tools. Information obtained from all of the assessment tools provides a clearer understanding of the condition of the sewer system.

2.1.1 Dye Testing/Dyed Water Flooding

Dye testing is used to confirm rain or ground water entry points into the WCTS. Dyed water is introduced into roof drain leaders, driveway drains, or area drains. After the dyed water is introduced, the downstream sanitary sewer manhole or a cleanout, if available, is checked for dyed water.

Dye testing can help identify inappropriate connections. For instance, if dye is introduced into a catch basin and the dye is then observed in the sanitary sewer downstream from that point, that indicates the catch basin may be directly or indirectly connected to the WCTS. The unwanted stormwater can impact the capacity of the WCTS, causing overflows or backups.

Dyed water flooding can be used to analyze the impact of surface water on the WCTS. For example, bodies of water or isolated water ponding can be dyed to determine if it is reaching the sewer system as well as identify the entry point into the system. In general, dye testing and dyed water flooding will be used in conjunction with other program assessment tools such as smoke testing or CCTV inspection.

2.1.2 Corrosion Defect Identification

Corrosion in the WCTS can lead to material failures that often result in excessive infiltration (groundwater and RD I/I). In addition, corrosion can result in catastrophic failures such as force main or sewer cave-ins that result in SSOs. Internal corrosion is typically a result of hydrogen sulfide produced by biological reduction of sulfate to sulfide by anaerobic bacteria that reside in anoxic wastewater and on slime layers that accumulate on pipe, concrete structure, and sediment surfaces. The resulting sulfide is transformed into hydrogen sulfide (H_2S) gas, which is then converted to sulfuric acid (H_2SO_4) by aerobic bacteria that reside above the water line in the WCTS. The acid can result in severe corrosion of metals, reinforced concrete and mortar. It is KUB's experience that the most severe corrosion problems occur in the vicinity of pump station force main discharges.

Residential wastewater contains sufficient quantities of sulfates to create a problem if they become anoxic, as they often do after initial wetwell storage followed by force main residence time without opportunities for aeration. Hydrogen sulfide gas is released as soon as an air-water interface and turbulence occur, such as downstream of vacuum valves in force mains and at discharge locations in a gravity sewer. Odor complaints are often the telltale sign of a potential corrosion problem at force main discharge locations.

KUB manages corrosion damage using a Corrosion Defect Identification Program with the following elements that are focused on force mains and force main discharge locations:

- Procedure to identify WCTS components subject to potential corrosion damage
- WCTS inspection program to identify and analyze corrosion defects
- Management of corrosion-related information.

Other corrosion impacts to the WCTS (manholes and pipes, not in the vicinity of force main discharges) will be identified and addressed under other components of KUB's CSSAP. A detailed description of each program component is provided in the following sections.

2.1.2.1 Procedure to Identify WCTS Components Subject to Potential Corrosion Damage and Analysis of Potential Defects

During Year 1, KUB will identify potential sites for corrosion damage resulting from force main discharges, classify force main discharge locations based on estimated time of travel, maintain a record of odor complaints and corrosion problems, etc. A representative cross section of sites will also be visited to determine if corrosion is a problem.

Critical pump station flow conditions (minimum diurnal dry weather flows, pump cycle times, and pumping rates) will be determined as part of KUB's CAP. That information will be used to compute travel times in the force mains.

For each force main of concern, KUB will

- Take grab samples and analyze for dissolved oxygen, dissolved sulfides, pH, and temperature. One sample each will be taken at the pump station wetwell and at the force main discharge. Discharge sampling will be staggered in time to account for the anticipated travel time in the force main.

- Install Odolog hydrogen sulfide analyzers for a one to two week period to measure hydrogen sulfide levels for force mains that exhibit high dissolved sulfides at the outlet or have corroded outlet manholes.
- Use data acquired from the field tests, along with critical flow data, to input/calibrate a hydrogen sulfide generation predictive model. The model will then be used to replicate various flow and temperature conditions. Annual wastewater temperature ranges will be taken from the WWTP monthly reports.

The model will be developed for at least 10 locations during Year 1. Based on results, KUB will determine whether additional sites should be analyzed with the model during Year 2.

For those sites where corrosion could result in a catastrophic failure subsequently causing SSOs, or where odors must be abated, KUB will evaluate alternative control technologies, including but not limited to, chemical addition, aeration, and replacement or armoring of materials subject to corrosion damage. KUB will prioritize existing corrosion defects and potential defects based on their potential to result in a short-term failure and the results of such failure.

2.1.2.2 WCTS Inspection Program to Identify and Analyze Corrosion Defects

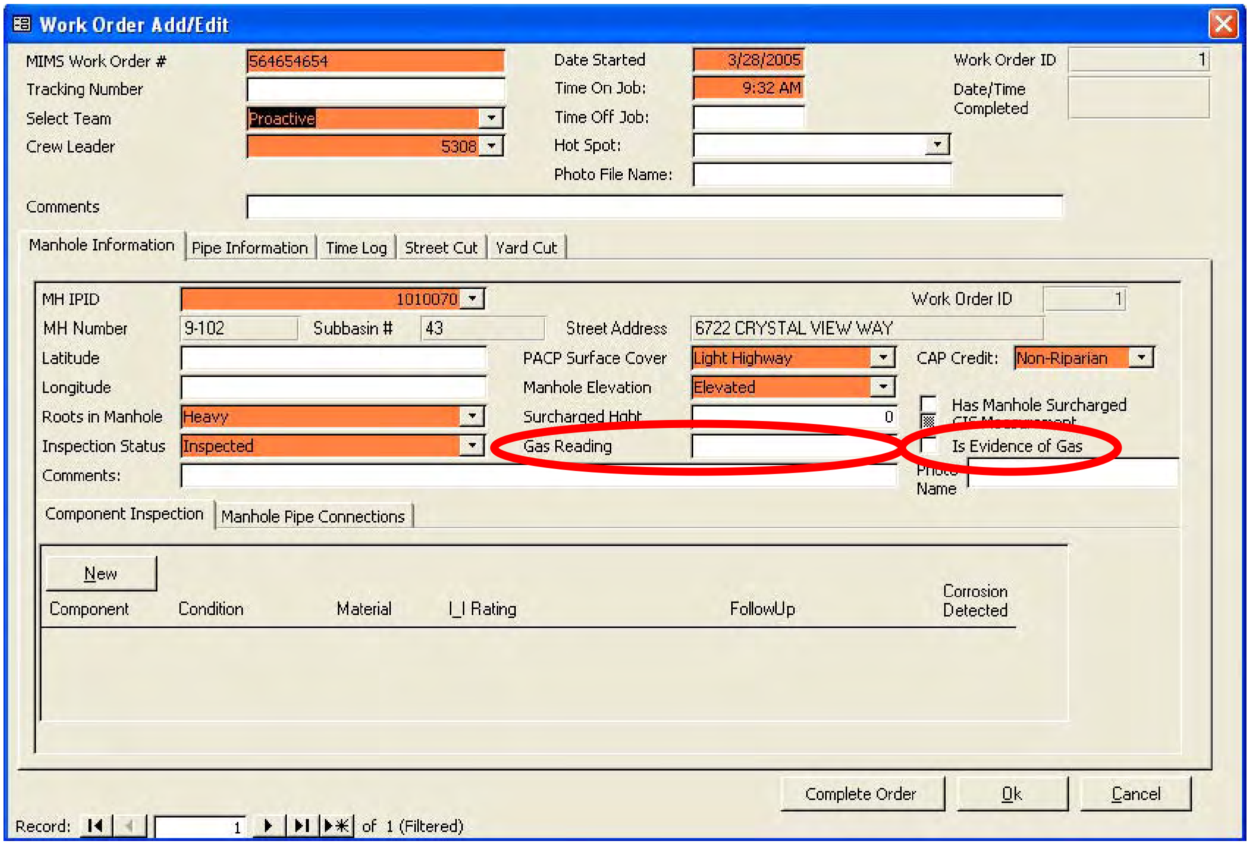
The corrosion defect identification process will include standard procedures for inspecting and identifying sewer infrastructure that is either corroded or at risk of corrosion and a system for prioritizing repair of corrosion defects, corrosion identification forms, and procedures for corrosion defect analysis.

Periodic inspections of all potential WCTS components subject to corrosion damage failure will include

- Force main air release valves, vacuum valves, and combination air release/vacuum valves
- Manholes where force mains discharge
- Gravity sewer segments downstream from force main discharges.

The Collection System Maintenance (CSM) Program, described in Section 3: Information Management System, records pertinent information obtained during inspections. A sample form is provided in **Figure 2-1**.

Figure 2-1 Collection System Screen Shot (Corrosion Detection)



Corrosion defects will be classified using a two-part identification and rating system as follows:

Component identification:

- D – Discharge Structure (including downstream gravity sewer)
- FM – Force Main
- V – Valve

Ratings:

- 1 – Imminent or short-term (less than one year) failure potential
- 2 – Long-term failure potential
- 3 – No apparent corrosion failure potential

2.1.2.3 Management of Corrosion Related Information

KUB will develop a database of all WCTS components subject to potential corrosion damage associated with pump stations. Results of initial analysis and all field inspections will be maintained in the database so that KUB can monitor the progress of corrosion damage and take action before a failure.

In addition, KUB will develop a GIS application to manage all WCTS corrosion-related information, including all pump stations, force mains, force main valves, discharge locations, materials of construction, odor complaints, identified corrosion defects, corrosion defect repairs, and related information.

2.1.2.4 Implementation Plan

KUB's performance goals for this program are as follows:

Year 1 **–** Develop and implement corrosion defect potential analysis program, including corrosion information management system and site inspection of highest priority discharge locations (additional sites will be done in Year 2 if deemed necessary).

Annually Thereafter **–** Inspect all force main discharge sites determined to have high potential for corrosion damage, including air, vacuum, and combination air/vacuum valve locations.

Every Two Years Thereafter **–** Inspect all other force main discharge locations and all air release, vacuum, and combination air release/vacuum valve locations not included in the annual inspection program.

2.1.3 Routine Manhole Inspection

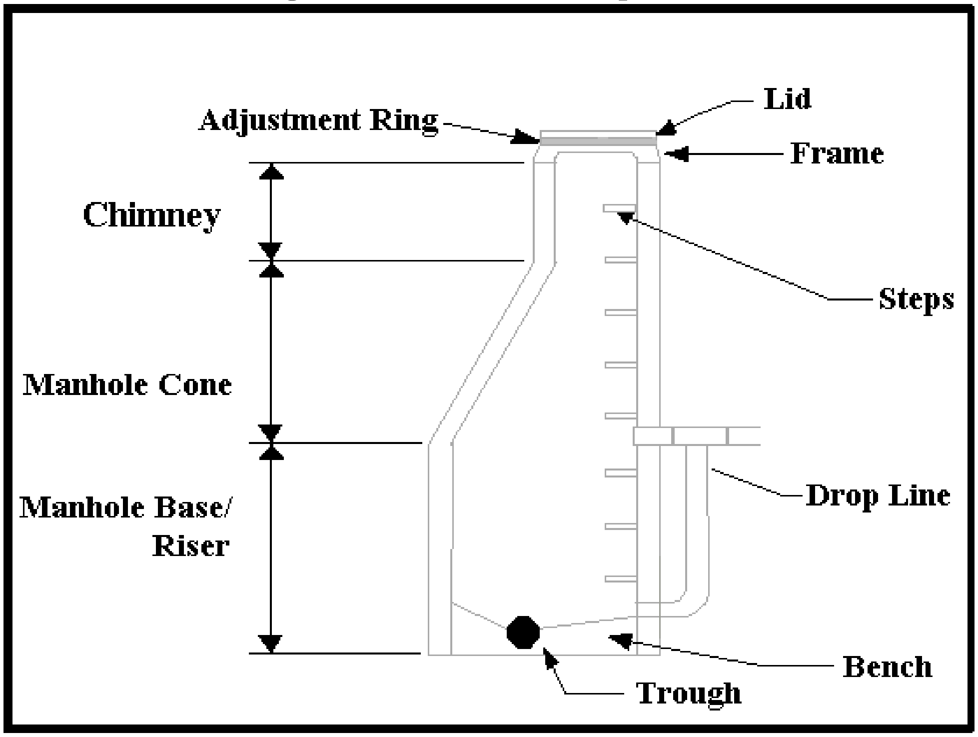
The primary purpose of the routine manhole inspection program is to identify I/I sources into the collection system manholes as well as other associated structural defects. A secondary purpose is to ensure that system manholes do not present a safety hazard.

KUB personnel open many manholes every week for a variety of reasons. The manhole inspection program ensures that every time a manhole is opened, regardless of reason, data regarding its condition is recorded into our information management system. Data entered into this system is highlighted in Section 3.2 Collection System Maintenance (CSM) Program.

Manhole inspections are performed by visually inspecting the internal condition of the manhole. The manhole lid is removed and each part of the manhole is inspected and documented. The general characteristics of the manhole are recorded and used to update system records, including GIS. If defects are located, the field professional will investigate in more detail. The data assessment is returned for further analysis.

The inspection of the manhole uses a component approach. The manhole is comprised of several smaller components that are inspected individually, as illustrated in **Figure 2-2**.

Figure 2-2: Manhole Components



As defects are identified in the manhole inspection process and recorded in the CSM Program, the appropriate improvements are scheduled in the CAP/ER, IRP, short-line replacement program, or point repair. The standardized assessment of manholes enables the CSI Team to prioritize the improvement schedule of the manholes.

The other significant benefit of the manhole inspection program is the continuous updating of KUB's inventory. The manhole inspection program not only provides defect analysis but also provides other useful information including

- Manhole size
- Manhole depth
- Number of pipe connections
- Location of pipe connections
- Size of pipe connection.

Either KUB or contracted field crews inspect the manholes visually. Depending on several factors, including depth or location of manhole, these assessors will inspect the manhole by standing above looking into the manhole, entering the manhole, or by using a pole camera inserted into the manhole to determine the necessary information.

The manhole inspections are collected in the CSM software described in Section 3: Information Management System (IMS).

2.1.4 Flow Monitoring/Flow Modeling

Flow monitoring is used to manage wastewater flows in the WCTS. The first step in managing the WCTS is flow measurement. A flow monitoring program can consist of a single meter at the treatment facility or a complex system of permanent ultrasonic monitors that transmit data to a central process control center.

The flow monitoring data is used in several ways to analyze system performance, diagnose problems, and support capital improvement planning. First, the data is used to identify areas in the WCTS that should receive the highest priority for CSSAP and rehabilitation. Second, the data is also used to support a hydraulic analysis of the trunk sewers in each of the monitored basins. The purpose of the hydraulic analysis is to identify trunk sewers or pump stations that need an increase in capacity during dry or wet weather conditions. The flow data is used to develop the wastewater design flows and to calibrate the models. Third, the data will be used to help quantify the amount of I/I that is reduced by sewer rehabilitation in selected areas. Finally, the data from permanent flow meters is used for hydraulic model calibration and for flow trending analyses.

The two types of flow monitoring approaches used are permanent and temporary, also known as short-term. Permanent monitors are generally used where there are merging sewer sub-basins and a need to monitor the long-term effectiveness of a comprehensive sewer rehabilitation program, I/I trends, or impacts from upscaled sewer maintenance programs. As the name suggests, these monitors are used to provide a consistent historical record of a particular point in the system and are not normally relocated.

Temporary or short-term flow monitoring uses portable wastewater flow monitors at pre-selected locations for a sufficient period of time to capture desired data. That period will vary depending on the program objective with 60 days being the minimum period.

In both approaches, flow meters are located within the sewer system to monitor the amount of water passing through selected locations. The data collected from the meters is transmitted to the office via telephone or cell phone. The information is studied to develop trends and evaluate system performance.

KUB initiated temporary flow monitoring programs in 1991, 2003, 2004, and 2005 as part of an ongoing capital improvement program for the WCTS. The purpose of permanent and temporary flow monitoring is to collect wastewater flow data and to evaluate quantities of flow and changes in flow during dry weather and wet weather conditions.

2.1.4.1 Rainfall Data Collection

Rainfall gauges are also used with flow monitoring to determine if the flows within the sewer system change during rain events of various sizes. The flow monitors are able to establish a base line or dry weather flow, the flow during non-rain events. This dry weather flow can be compared to the wet weather flow, the flow during the rain events, to determine the amount of rainwater or groundwater entering the sewer system.

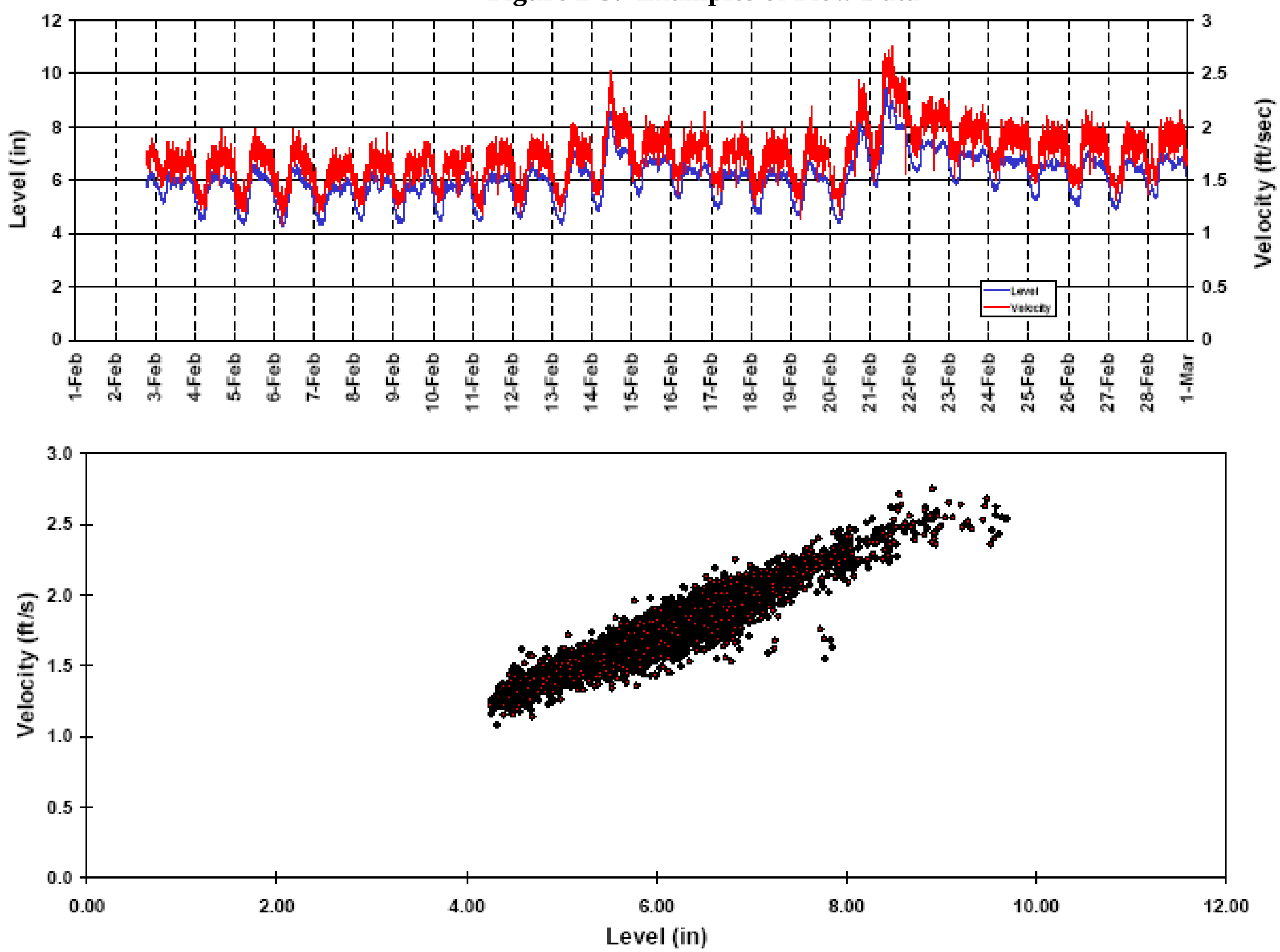
2.1.4.2 Permanent Flow Monitoring Program

Permanent monitors are generally used where there are merging sewer districts and a need to monitor the long-term effectiveness of a comprehensive sewer rehabilitation program, I/I trends, or impacts from enhanced sewer maintenance programs. As the name suggests, these monitors are used to provide a consistent historical record of a particular point in the system and are not usually relocated. Permanent flow meters have been installed throughout the system and provide continuous information.

2.1.4.3 Data Quality Review

After the data is collected, it is reviewed to ensure that only quality data are used in the analysis. The flow data are plotted over time to ensure that there are no unjustified changes in base wastewater flow and to ensure that the base flow is of sufficient quantity to be measured by the flow monitor. The velocity and level data recorded are used to make scatter plots (**Figure 2-3**).

Figure 2-3: Examples of Flow Data



The cluster of data points in the scatter plot gives information as to the quality of the data and the hydraulic conditions of the site. A cluster of data that appears flat can indicate that a downstream blockage may exist. A tight cluster of data could indicate that the hydraulics of the site is creating flow conditions that the monitor cannot interpret properly.

For the 2005 flow monitoring program, data were collected and reviewed weekly. Decisions could be made more quickly on whether the flow monitor was collecting data of sufficient quality to use on the analysis. Monitors that were not collecting quality data were checked to make sure they were operating correctly. In some cases, monitors were moved to a site that was more hydraulically suitable for collecting quality data.

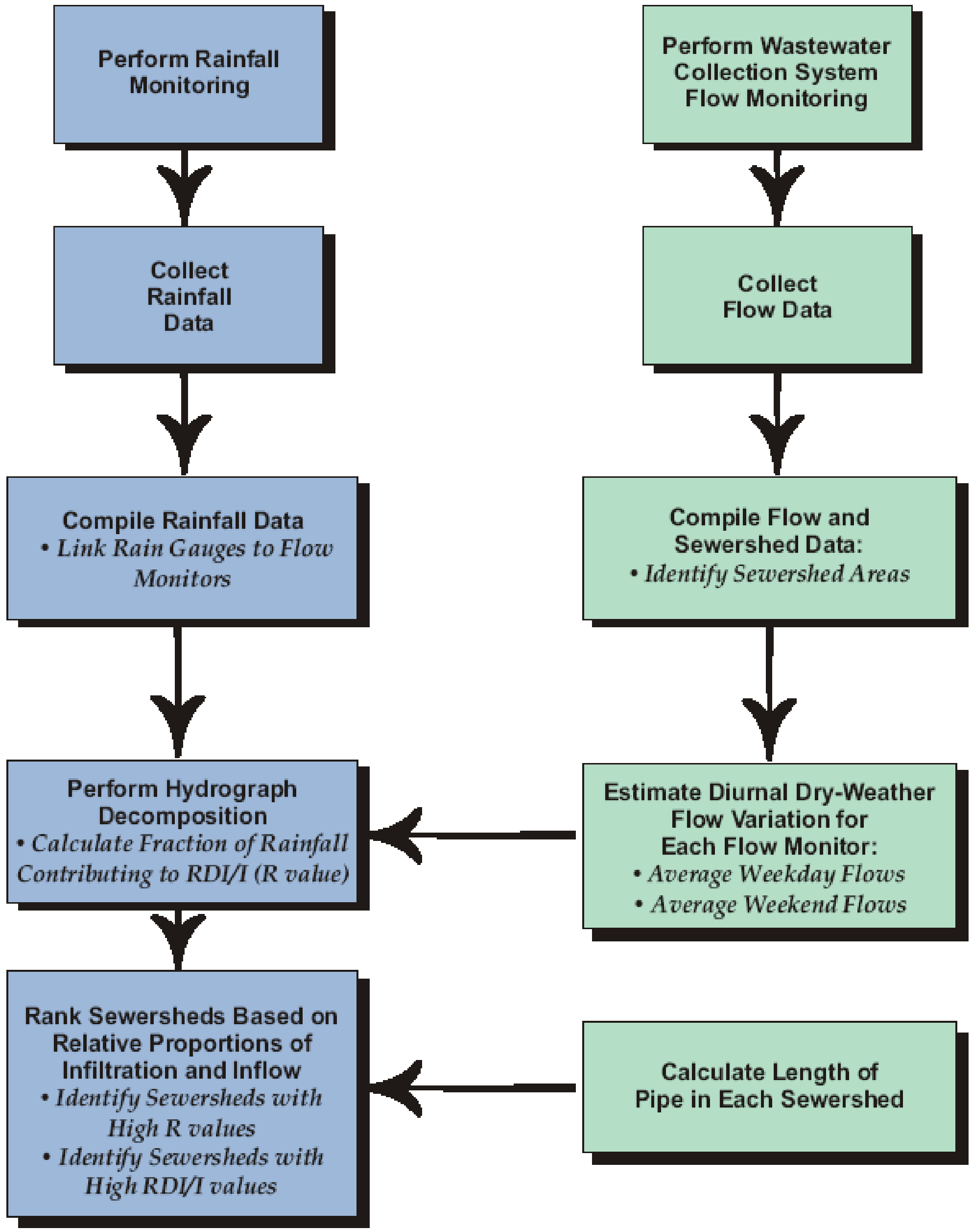
2.1.4.4 Data Analysis Approach

After the flow monitoring and rainfall data are collected, the data are analyzed with the purpose of prioritizing areas for CSSAP and using the flow data to update the hydraulic models. The data analysis approach includes

- **Components of Flow Monitoring Data**
  In general, wastewater flows can be divided into three components: base wastewater flow (BWWF), groundwater infiltration (GWI), and RD I/I. The wet-weather component (i.e. RD I/I) is of particular importance because it is the increased portion of flow that occurs during a rainfall event. Consequently, hydrograph decomposition is performed to identify BWWF and to determine the portion of the flow hydrograph attributed to RD I/I. Results of the hydrograph decomposition are utilized to evaluate existing conditions within the basins.

Figure 2-4 illustrates the flow monitoring data analysis process.

Figure 2-4 Flow Monitor Data Analysis



- **Decomposition of Flow Monitoring Data**
  The three flow components (BWWF, GWI, and RD I/I) make up a total flow hydrograph that shows the quantities of wastewater over a period of time. Hydrograph decomposition is a method of estimating the different components of flow and is used to analyze flow monitoring data to estimate BWWF, GWI, and RD I/I flow components. Camp Dresser and McKee (CDM) has developed

a computer software program to assist in separating measured wastewater flows into base flow (including groundwater infiltration) and RD I/I components. The computer program develops an average base flow hydrograph for a typical weekday and weekend day from the recorded data for dry-weather conditions.

2.1.4.5 Data Uses

The flow monitoring data is used to prioritize areas for CSSAP and rehabilitation activities, determine design flows for the hydraulic models, calibrate the hydraulic models, and evaluate the effectiveness of sanitary sewer rehabilitation. The following bullets describe in more detail how the flow monitoring data is used for each of these activities.

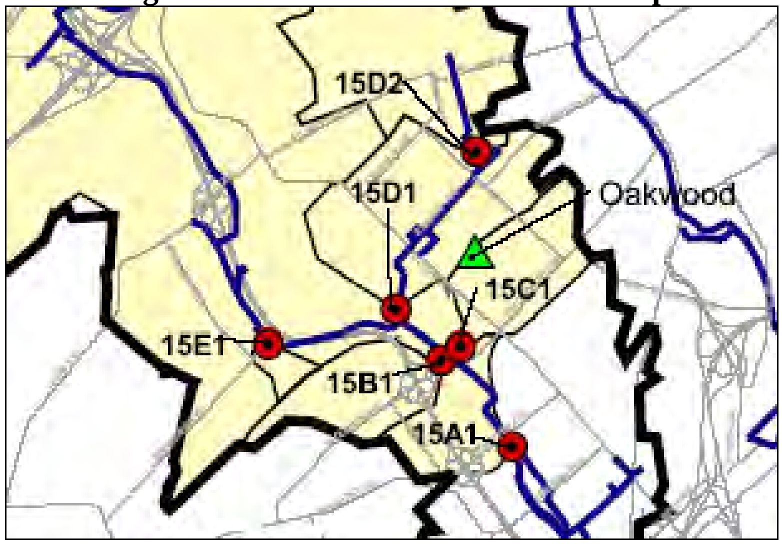
- **Prioritizing Areas for CSSAP**

  Areas are prioritized for CSSAP and sewer rehabilitation by ranking the areas in terms of their contribution of RD I/I per linear foot of sewer. Areas that have the highest volume of rainfall infiltration per foot of sewer receive a higher priority for further investigation and rehabilitation. This threshold will become lower as KUB's program advances. The following paragraphs describe how the volume of RD I/I per foot of sewer is calculated.

  Separate R-values are computed for significant storm events for which quality flow monitoring data is available. The R-values for each monitor are then used to calculate a rainfall-weighted average R-value. This rainfall-weighted R-value gives a greater weight to storms with a large volume of rainfall.

  It is important to note that the R-values are calculated from RD I/I volumes recorded at each flow monitor and represent the total area upstream of each monitor. For example, the flow monitor in mini-basin 15D1 records flow from upstream mini-basin 15D2. As a result, the R-values reported for 15D1 do not represent the incremental flows from 15D1 only, but rather the total flow from mini-basins 15D1 and 15D2 as shown in **Figure 2-5**.

Figure 2-5 Sub-basin 15 Mini-basin Map



Separate calculations are then performed to estimate R-values for these incremental areas in order to prioritize areas for CSSAP and rehabilitation.

$$R_2' = \frac{R_2 A_2 - R_1 A_1}{A_2'}$$

In general, an area-weighted R-value for the incremental area was calculated as follows:

A_1, A_2 = Drainage areas to Flow Monitors 15D1 (A_2) and 15D2 (A_1) (acres).

A_2' = Drainage area of incremental area between Flow Monitor 15D1 and upstream meter (acres).

R_1, R_2 = Rainfall-weighted average R-values for Flow Monitors 15D1 (R_2) and 15D2 (R_1) based on entire upstream drainage area.

R_2' = Average R-value for incremental area between Flow Monitors 15D1 and 15D2.

The area-weighted R-value for each sub-basin is used to calculate the volume of RD I/I contributed by each incremental sub-basin for a two-year design storm event. The volume of RD I/I calculated is the volume resulting from the hypothetical 2-year storm event. It is the volume of RD I/I that will enter the sewer if adequate capacity is available on average once every two years during the critical time period for GWI (i.e. December to May).

The sub-basins are prioritized for CSSAP work based on the gallons of RD I/I per linear foot of sewer. The most cost-effective means of reducing RD I/I volumes is to perform CSSAP work and rehabilitation in areas with high volumes of RD I/I per linear foot of pipe. Initially, sub-basins with values higher than 50 gallons of RD I/I per linear foot are targeted.

- **Use of Data for Modeling**

1. Flow Modeling

   CSSAP will feature the use of a dynamic hydraulic model (MIKE-SWMM) based on flow monitoring to analyze WCTS capacity performance. KUB's CSI Team will implement this program with hydraulic modeling assistance from CDM.

   The hydraulic modeling feature includes

   - Flow monitoring to determine existing wet and dry weather flows, I/I rates, and other flow information.
   - Modeling of the sewer system to verify current flows and predict future flows. Models start out with estimations but usually are modified as flow measurement information becomes available.
   - Determining remaining capacity in the sewer system that can be allocated for new development.
   - Rationing of the remaining capacity using an established procedure. This is usually an interim measure until SSOs can be addressed. As projects are completed, capacity in the system is restored and available for allocation to new customers.

   Flow modeling is a mathematical analysis of the sanitary sewer system using flow monitoring data and population information obtained from the Metropolitan Planning Commission. Simply put, the flow model uses information about the current flows within the system and the anticipated flows into the system and compares it to the existing capacity of the wastewater collection system. That analysis provides information regarding available capacity and areas that may need improvement.

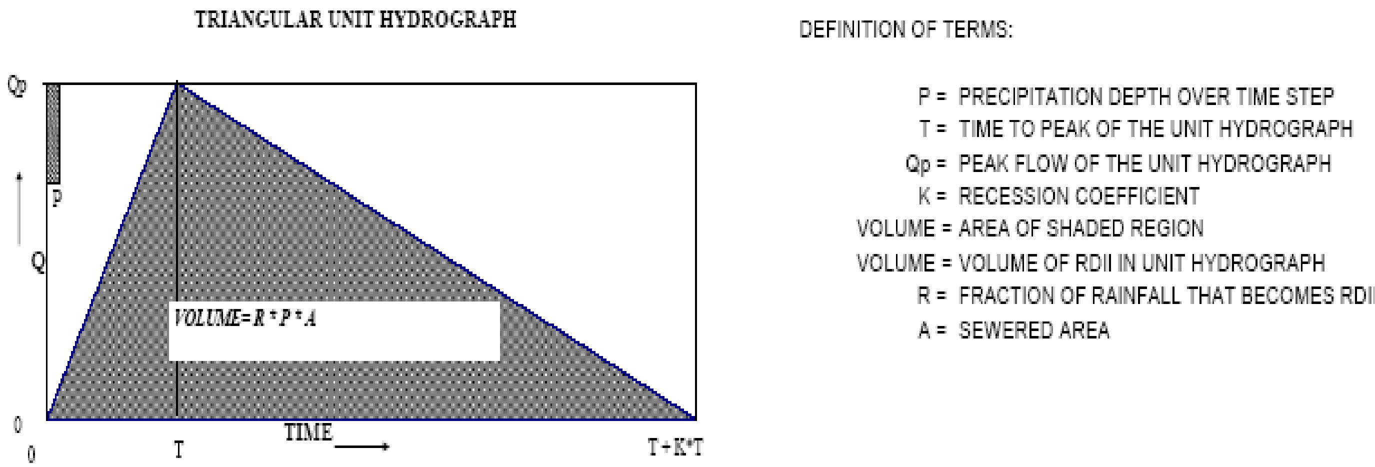
   That approach will help evaluate the success of the condition assessment and monitoring and the infrastructure rehabilitation programs. In other words, the condition assessment and monitoring program identifies sources of I/I, while the IRP will remediate the system defects. The flow modeling and hydraulic analysis of the system will determine if these programs are successfully identifying and removing sources of rainwater and groundwater to restore capacity. The model is also used to evaluate alternate capacity enhancement projects.

2. Unit Hydrograph Methodology

   The hydraulic analysis of KUB's sanitary sewer system is based on a relatively large storm event that occurs once every two years, on average (has a two-year return period). Therefore, a method is needed to predict flows from a large storm event, such as a two-year storm event. Because a dynamic hydraulic model (EXTRAN) is employed for this study, the method must predict flows for the entire duration of the event, including the peak flow and the total volume of RD I/I entering the system from the event.

The method is based on fitting three triangular unit hydrographs to an actual RD I/I hydrograph. A unit hydrograph is defined as the flow response that results from one unit of rainfall during one unit of time. A unit of time is defined as one 15-minute time-step. This methodology has two basic steps, and is illustrated in **Figure 2-6**.

Figure 2-6: Hydrograph Analysis



3. <u>Predicting Model Hydrographs</u>
   By computing flows from planning storm hydrographs using R-values representative of average high-groundwater conditions, and average antecedent moisture conditions and adding dry-weather flows such that peak RD I/I flow combined with average dry-weather flow, the design flow condition simulated from a two-year rainfall event will, as closely as possible, be representative of flows and hydraulic conditions that would occur once, on average, every two years.

- **Other Uses of Flow Monitoring Data**

1. <u>Determining the Effectiveness of Rehabilitation</u>
   Another use of the temporary flow monitoring data is to evaluate the effectiveness of sewer rehabilitation in removing RD I/I. One way to do this is to perform flow monitoring in the area to be rehabilitated before and after the rehabilitation is performed. The R-values before and after the sewer rehabilitation are then compared to see if there was a decrease in the volume and peak flows of rainfall that is entering the sewer system. The goal of this evaluation is to confirm the assumptions that were made in the facility plan for the basin.
2. <u>Permanent Flow Monitoring Data</u>
   KUB currently has 30 permanent flow monitors and seven rain gauges throughout the WCTS. By 2010, a total of 45 permanent flow monitors will be in place. The data obtained from these monitors will be used to periodically calibrate the hydraulic models. In addition, the data will be used to determine changes in dry and wet weather flow patterns, and to support the CAP.

2.1.5 CCTV Inspection

CCTV uses a television camera mounted on a remotely controlled, self-propelled robotic device that is connected to a video monitor. The robotic system is placed directly into the sewer through a manhole. Once inside the sewer line, the remote-controlled device moves through the sewer and allows the operator to examine the pipeline between manholes.

The CCTV system relays live footage to the mobile survey unit, typically a truck or van. The inspection is electronically recorded. If defects are located, the operator will stop and investigate in more detail. An electronic footage counter is connected to the camera, enabling the operator to identify the location of the defect. The CSI Team and other appropriate groups, such as KUB's Engineering Department and outside consultants will review the information during the planning for system improvements.

To standardize the information obtained from the condition assessment of the sewer pipe from a structural, maintenance, and physical dimension perspective, KUB has adopted the PACP. PACP allows the various KUB and external inspection crews to use standard codes and data management practices. That practice allows the condition of the deterioration of the pipe, if any, to be measured as well as allow for benchmarking with other utilities using PACP.

The Information Technology (IT) management software KUB uses to collect CCTV information is PACP based. The software allows KUB to

- Capture electronic condition assessment data from the field
- Store the field data on a centralized server so various KUB operational entities can access it
- Produce assessment reports to ascertain the condition of the WCTS.

2.1.6 Smoke Testing

Smoke testing is a very effective method for locating sources of I/I in the collection system. I/I occur when groundwater or rainwater enters the sewer lines through cracks, breaks, and/or areas not intended to drain into the sewer system. The unwanted stormwater can impact the capacity of the sanitary sewer system, causing overflows or backups.

The "smoke" will locate places where stormwater and other surface waters enter the sanitary sewers. Smoke testing is conducted by placing a blower over a manhole and forcing non-toxic smoke-filled air through a sewer line. With the pressure of the blower, smoke will fill the sewer line, plus any connections, then follow the path of any leaks to the surface of the ground, quickly revealing potential sources of I/I. The non-toxic "smoke" will be noticeable wherever there is a leak in a sanitary sewer pipe, such as a crack in a pipe, a cross-connection between a storm sewer and the sanitary sewer, a roof drain connected to the sanitary sewer, a broken cleanout cap/cover, or a defective or damaged manhole.

The procedure consists of blowing large volumes of air and smoke through the sewer lines. The smoke follows the path of the intruding water to the surface of the ground, revealing the source of the problem in a very short period of time.

Types of defects identified during smoke testing include

- Leaks permitting storm/surface water intrusion (inflow)
- Roof and cellar drains connected to the sanitary sewer
- Cross-connected sanitary and storm sewers
- All connected lines, including abandoned and supposedly unconnected lines
- Leaking manholes
- Yard and foundation drains
- Sump pumps.

Currently, KUB uses a stand-alone database to capture the results of the smoke testing inspections. KUB is in the process of combining this database into the CSM Program described in Section 3: Information Management System (IMS). The consolidation of these databases is intended to improve data analysis and system performance.

A structured communication plan is required for smoke testing to ensure that customers and emergency responders are aware of these activities. Smoke from the tests can enter residences, so an aggressive communication plan is required to reduce confusion and concern. KUB has implemented a detailed communication plan to address the CSSAP that includes a smoke testing component. Customers receive a written letter prior to the smoke testing, and door hangers are also placed on every door before testing.

2.1.7 Pump Station Performance and Adequacy

KUB's Pump Station Performance and Adequacy Program provides routine assessment of the performance of each pump station in the WCTS to determine if it is capable of providing reliable service for design operating conditions. In accordance with Tennessee Department of Environment and Conservation (TDEC) standards, every new wastewater pump station should be designed to pump peak flows with the largest pump out of service.

For that reason, KUB determined that it is critical to keep all pumps operable through routine assessment of performance data and implementation of appropriate preventive and predictive maintenance activities, until such time that additional pumping capacity is provided, or peak flows are reduced through sewer rehabilitation projects.

Pump operating time is a key factor in assessing pump station performance and adequacy. However, pump-operating time itself is not a factor in the design of a pump station. Factors affecting pump-operating time include

- Influent flow rates (maximum, minimum, average)
- Number of pumps and capacity of each, singularly and in parallel
- Wetwell volume and pump operating set points

- Use of constant or reversible speed pumps.

Typically, pump station design is based on using influent flow rates to select the number and capacity of pumps and wetwell operating volume to achieve minimum operating cycles at any combination of inflow and pumping. For small pump stations with constant speed pumps, cycle time is a concern because frequent motor starts can result in damage to motor windings. In larger pump stations, variable speed pumps are often used, and they are typically designed so that one pump operates continuously, or nearly continuously, and they typically feature pumps of different capacities. Therefore, a single criterion for establishing a baseline average daily pump operating time (i.e. Nominal Average Pump Operating Time, or NAPOT) cannot be applied uniformly to all sizes and types of pump stations.

This program will focus on acquisition and analysis of pump performance data. Specifically, KUB will use the following data sources:

- Monitored flow and estimated influent flow rates, along with estimated pumped volumes
- Pump draw down-testing data (for major pump stations) to confirm pumping capacities
- Pump operating time from SCADA (or run time meters and/or pump start counters)
- Records of pump and pump station failures.

This information will be analyzed and used to

- Identify capacity and/or reliability improvements required
- Conduct root cause failure analyses
- Schedule preventive and predictive maintenance activities.

2.1.7.1 Pump Station Adequacy

Under the CAP, KUB will develop and maintain a database for all WCTS pump stations including the following information:

- Pump station name
- Number of pumps and nominal capacity of each
- Results of draw down testing (major pump stations only) to confirm single and multiple pump capacities
- Current minimum, average, and maximum influent flow rates (as determined by flow monitoring, hydraulic model, or estimated from service area statistics with appropriate peaking factor)
- Future minimum, average, and maximum influent flow rates after completion of any planned CAP/ER project(s)
- Determination if reliable peak flow capacity is provided, currently, and on completion of CAP/ER project(s)
- Back-up power supply (second source from different substation, on-site generator, or provision for portable generator)
- Provisions for portable pumping equipment
- SCADA availability
- Suitability for emergency hauled waste pumping
- Root cause of historical pump or pump station failures
- Other information (wetwell dimensions, duration test results, etc.).

This information will be used to support the development components of CSSAP.

2.1.7.2 Pump Operations

For each pump station, KUB will develop and maintain a database to track average pump starts, average cycle time, and average daily operating hours. A trend analysis will monitor changes in these parameters over time. Any significant adverse change (i.e. an increase in any of these parameters) will warrant an investigation. For example, an increase in any of these parameters could be a result of increased flows due to I/I, decreased pumping capacity due to pump wear, clogging of pump(s) or piping, or air binding in the force main.

Pump starts and time of operation will also be used as triggers for conducting preventive and predictive maintenance activities such as pump rebuilding, vibration analyses, pump efficiency testing, and thermography of mechanical and electrical equipment.

For small pump stations that are not modeled with the hydraulic model, KUB will use NAPOT as an indicator of pump station adequacy. These pump stations typically contain two constant speed pumps and are used as load points for the hydraulic model analyses.

NAPOT is defined as the daily average pump operating time for the previous 12 months divided by one less than the total number of pumps installed in the pump station.

The concept of using NAPOT is explained below:

ADF = average daily flow
PDF = peak day flow
PF= Peaking factor = PDF ÷ ADF
Maximum Allowable PF = 24÷ NAPOT

Example: NAPOT = 8 (average daily operation hours for one pump in a two pump station)

In this example, one pump can handle average daily flow in 8 hours of operation. Therefore one pump can also handle a peak day flow of 3 times the average flow (i.e. 24 ÷ 8).

Conversely, if peaking factor is set, then maximum allowable NAPOT can be set (i.e. 24 ÷ PF). In this case, if PF is set at 3, the maximum allowable NAPOT is 24 ÷ 3 = 8.

For small pump stations, a peaking factor for peak day flows has been set at 2.4, which provides for a maximum allowable NAPOT of 10 (i.e. 24 ÷ 2.4 = 10).

Average daily operating time for these pump stations will be subjected to a trending analysis and compared to the threshold NAPOT. For those stations where the actual NAPOT exceeds the threshold (i.e., 10), a more detailed analysis of pump station performance will be conducted to determine if a problem exists.

The assumed peaking factor of 2.4 may be adjusted in the future if analyses of measured flows determine that this is appropriate.

NAPOT is not a suitable analysis technique for pump stations with different size pumps or pump stations with variable speed drives. The adequacy of these stations will be determined using the hydraulic model and pump operating times.

2.1.7.3 Root Cause Failure Analysis (RCFA)

RCFA is a step-by-step process that leads to the determination of a failure's underlying or root cause. Most failures involve a progression of events and consequences that lead to an ultimate failure mode.

RCFA will involve staff from KUB engineering, operations, and maintenance groups. The process involves development of a fault tree or cause-effect diagram that leads to the identification of the root cause. In many cases, it is not necessary to prevent the root cause from occurring; it is only necessary to prevent the chain of events from proceeding to the failure. For example, if a pump station experiences chronic pump failures due to blockages by rags, it is not necessary to prevent rags from entering the sewer. Instead, redesign of the system to include a screen or grinder may be more appropriate, unless a single source of rags can be identified.

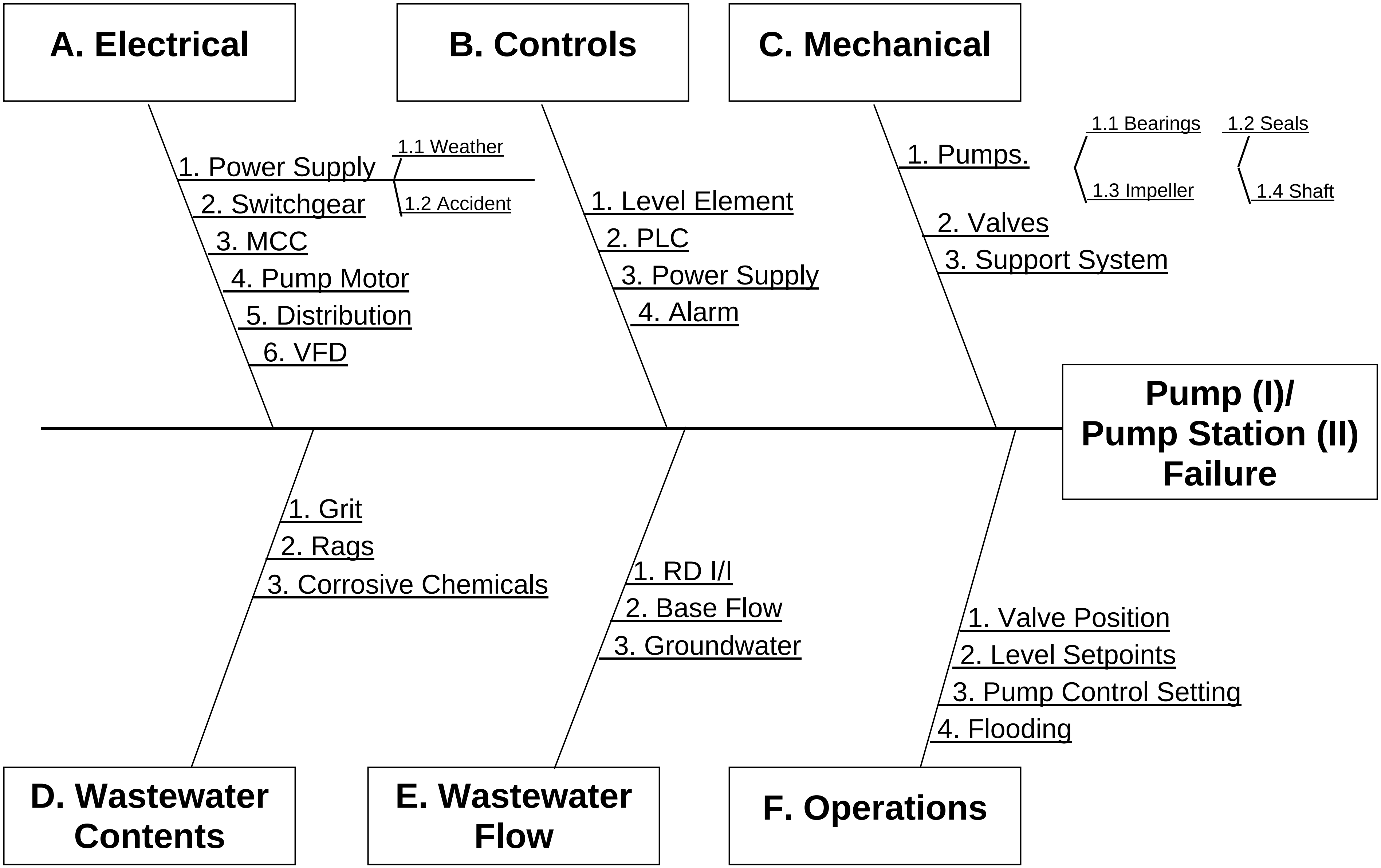
KUB's approach to employing RCFA will be to develop a failure tree similar to that illustrated in **Figure 2-7** for use in determining the root causes of pump or pump station performance failures. Additional failure codes will be added to the tree as they are experienced. The failure codes will provide a means for assessing root causes of failures for KUB's entire WCTS. For example, Classification II-A.1.1 indicates a pump station failed due to weather related failure of electrical power as detailed in Figure II-7. Chronic failures of a single pump or pump station (two or more failures due to the same root cause in a 24 month period) will trigger an engineering or operations study to identify modifications or improvements required to prevent future failures related to the same root cause.

2.1.7.4 Implementation Plan

The initial pump station adequacy evaluation will be completed as part of CAP development, which will be completed in early 2006. The database will be updated as projects are implemented. Pump operating times, including NAPOT, will be evaluated annually.

The RCFA will be developed and maintained as part of KUB's asset management system. Investigations will be conducted as needed based on frequency of failures due to recurrence of the same root cause.

Figure 2-7: RCFA Failure Tree



2.1.8 Private Lateral Inspection Analysis

The private lateral inspection is a combination of various assessment tools to determine the structural condition and operational performance of private laterals. Laterals are evaluated through smoke testing, CCTV inspection, and visual inspection.

The Private Lateral Condition Assessment will be scheduled according to the sub-basin prioritization matrix that is based on the findings of various factors to include the sub-basin prioritization matrix described in Section 1.3.1 Sub-Basin Priority Decision Tool, and from historical maintenance records.

Once a sub-basin has been targeted for lateral inspection, smoke testing work is initiated in that particular basin. If a defect that allows infiltration to enter the lateral is identified during a smoke test inspection, then a CCTV inspection will be performed to more exactly define the defect in the lateral. Lateral defects will be categorized using PACP standards. The information from the CCTV inspection will be used to determine if the lateral should be replaced or repaired under IRP. During mainline rehabilitation projects, it is KUB's current practice to replace the lateral from the sewer main to the property or easement line with a two way cleanout installed; although such lateral segment is legally the responsibility of the private property owner.

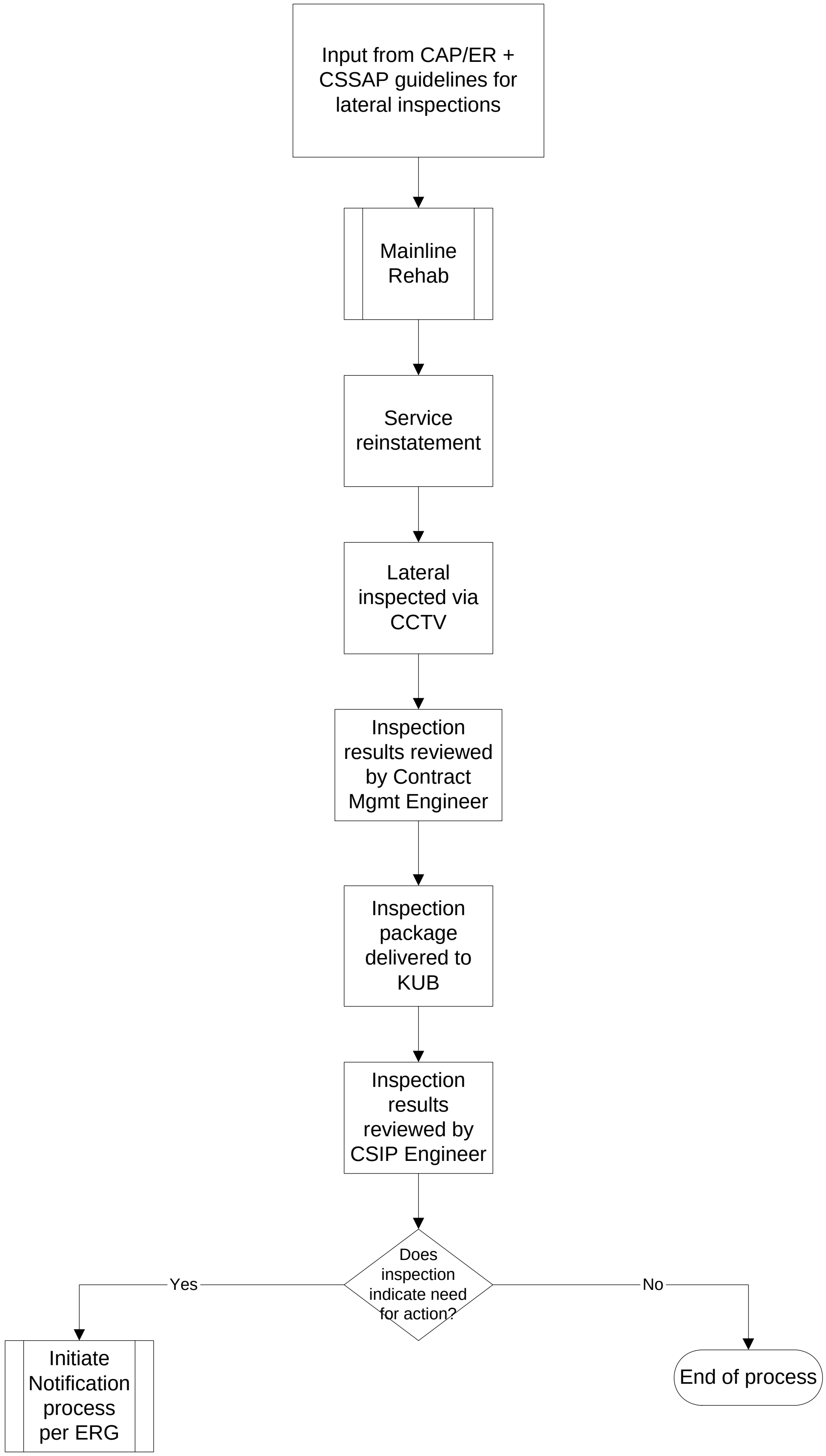
A Private Lateral Inspection Checklist is completed by the technician/engineer detailing recommended actions. After receiving the completed the checklist, the Private Lateral Program Coordinator will ensure that the defect is addressed appropriately. The following avenues can accomplish the repair, rehabilitation, or replacement of the lateral:

- Inclusion in CAP/ER, CIP, or IRP
- Property owner
- In-house repair by KUB crews (lower lateral or portion in public right-of-way)

The Private Lateral Inspection Workflow shown in **Figure 2-8** provides the sequence of events for inspecting and determining the most appropriate repair, if any.

In 2007, KUB began using a lateral launch camera to inspect laterals presumed to be in need of repair or replacement. When a wastewater trouble call is confirmed as a problem on property, the lateral launch camera is dispatched to identify defects in the private lateral. The inspection is reviewed by CSIP to determine if repair or replacement is required under the Private Lateral Program.

Figure 2-8: Private Lateral Inspection Workflow



SECTION 3: INFORMATION MANAGEMENT SYSTEMS (IMS)

To implement, track, and measure the success of the CSSAP program goals, IMSs are necessary. In the previous sections, references have been made to several applications to address this need. In this section, the key IMS programs are highlighted to illustrate their support to the CSSAP. They include

- The SWMM Model used for modeling the sewer system
- The CSM Program used to record field information
- The CCTV software for recording findings of CCTV inspections
- The Geographic Information System (GIS) used as a centralized database for collected information.

3.1 SWMM Model

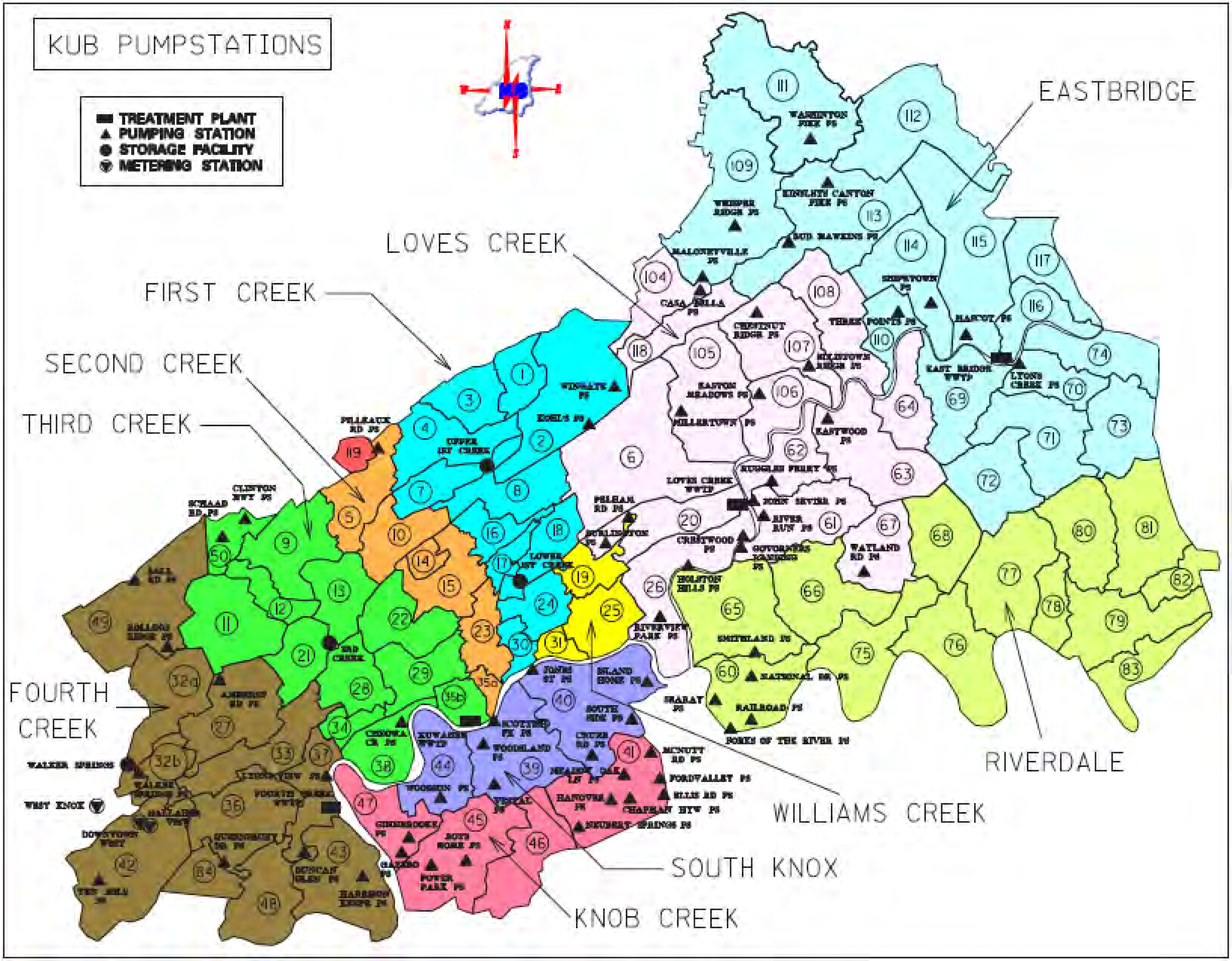
KUB, through a contract with CDM, has developed and continues to refine a hydraulic model of the WCTS to support development of the CAP/ER and the CAP. The model has been developed using physical attributes of the WCTS (sewer size, slope, roughness, elevations relative to grade, pump station capacities) along with dry and wet weather flow conditions developed through analysis of flow monitoring information. The model is continuing to be refined as new flow monitoring data becomes available.

The objectives of this hydraulic model development effort are to

- Develop a system-wide hydraulic model
- Diagnose dry and wet weather capacity problems
- Develop basin-wide improvement alternatives for the First Creek, Second Creek, Third Creek, Fourth Creek, South Knoxville/Knob Creek, Williams Creek, Loves Creek, Cheowa, and Northeast Knox drainage basins shown in Figure 3-1.

The recommended improvements are aimed at providing sufficient sewer capacity to handle increased flows from planning period future growth and to eliminate trunk sewer overflows from wet-weather flows caused by RD I/I. Improvements are developed to carry base wastewater flows and RD I/I flows from the two-year planning storm event with only minor system surcharging and no overflows.

Figure 3-1 KUB Sewer Watersheds (Including Pump Stations and WWTPs)



3.1.1 Hydraulic Model Development

CDM developed hydraulic models of the trunk sewer in each basin using the EXTRAN block of EPA's Stormwater Management Model (SWMM). Data furnished by KUB staff, review of available GIS information, and record drawings were used to create each model. The models include all major trunk sewers greater than 10-inches in diameter and approximately 61 major pumping stations within the WCTS. Smaller pump stations, typically around the periphery of the WCTS, are used as load points for entering hydrographs to the model. After the physical attributes of the system were entered into the models (pipe inverts, diameters, manhole rim elevations, and other system characteristics), the models were used to route predicted sewer flows through the system to determine downstream flows and water surface elevations for a range of different flow conditions in the system. Different flow conditions are estimated based on future growth projections in the study area as well as estimated quantities of RD I/I entering the system during wet-weather conditions, as determined from flow monitoring data.

3.1.2 Estimating Sanitary Sewer Flows

CDM calculated existing and future wastewater flows to analyze the performance of the KUB WCTS. Since only limited current flow monitoring data was initially available from a 1991-1992 CSSAP, the program employed systemwide temporary flow monitoring (2003-2005), population and employment projections, land use, and known industrial and commercial discharge patterns to predict wastewater flows under current and future dry-weather conditions. Dry-weather flows were developed for the years 2002 (existing), and in 10-year future increments to 20 to 40 years in the future. Future wet-weather conditions were based on predicted RD I/I into the system for a representative two-year 24-hour return period storm. The RD I/I hydrographs were simulated using a unit hydrograph technique. One of the key hydrograph parameters is the R-value, or the fraction of rainfall from a storm event that enters the sewer system as RD I/I. Unit hydrograph parameters for each sub-basin were calibrated to an actual storm event recorded during the flow monitoring program. The calibrated parameters were then applied to a simulated two-year 24-hour return period storm. Resulting RD I/I hydrographs were added to the 2002 (existing) and future dry-weather flows. The predicted flows are then used to evaluate future capacity needs in the system and to develop alternative sewer system improvements that address those needs.

3.1.3 Hydraulic Model Calibration

Dry-weather hydraulic analysis is performed by routing the diurnal base flow hydrographs through the trunk sewer system using the EXTRAN hydraulic model. To calibrate the models to dry weather conditions, the output flows produced by the simulation were matched against the flows measured by the monitors. Where necessary, adjustments were made to the model to calibrate to observed conditions. Wet-weather calibration is performed in the same manner as the dry weather calibration. Wet-weather flows are calibrated to a real storm event observed during the flow monitoring programs.

3.1.4 Hydraulic Model Use

KUB will continue to maintain the hydraulic model by

- Updating the sewer attribute database as projects are completed
- Periodic recalibration using permanent flow monitoring data
- Periodic revisions to wet weather RD I/I input hydrographs using temporary flow monitoring studies to determine the effectiveness of system rehabilitation
- Periodic updating of projected future dry weather flows using updated population and employment data.

KUB will continue to rely on the hydraulic model to support CAP/ER and other capital improvements including the IRP and to support the CAP.

3.2 Collection System Maintenance (CSM) Program

The CSM Program is the electronic record-keeping tool used by internal and external field crews. This multi-faceted program collects information for the proactive cleaning and assessment and also records the activities of the reactive crews, such as the Hot Crew and First Responders.

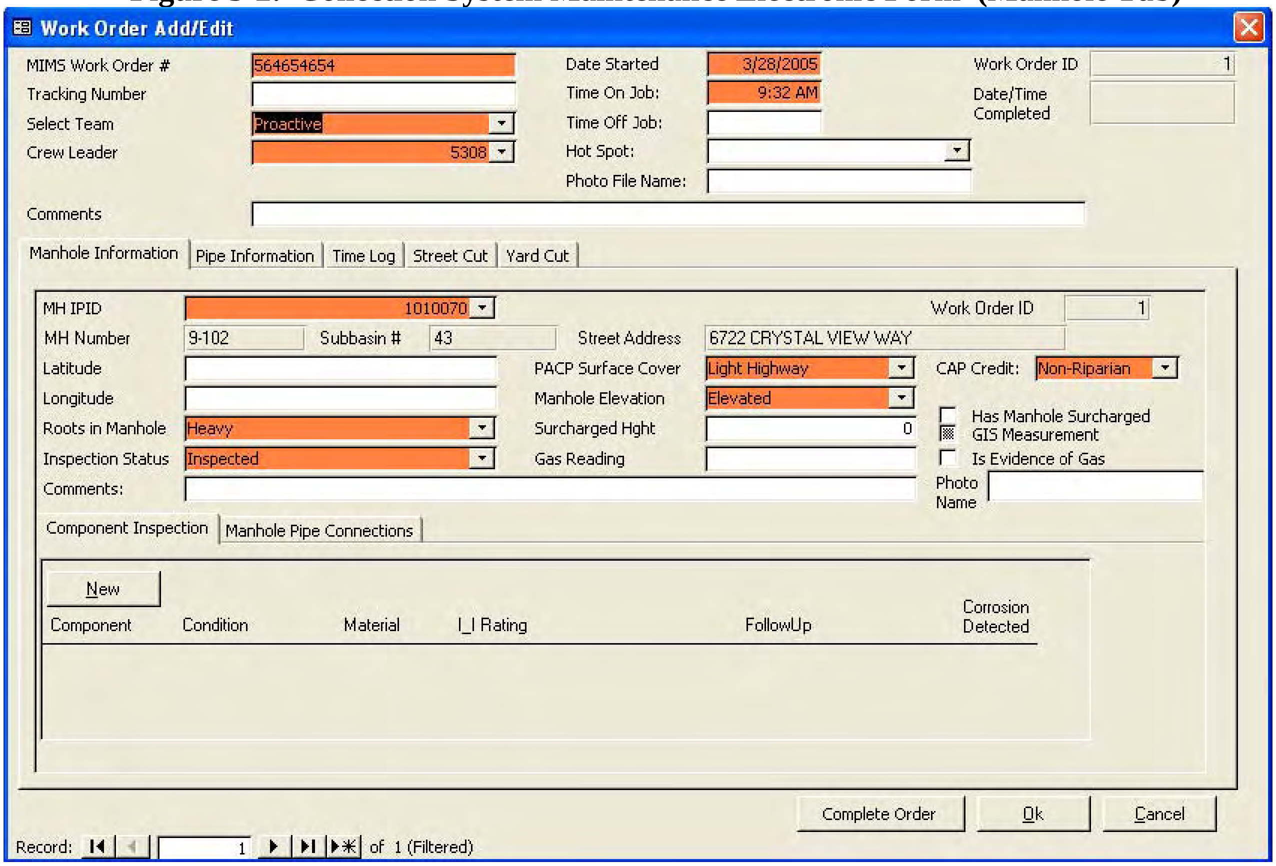
As illustrated in **Figure 3-2**, the typical information collected in this program includes

- Tracking numbers
- Team performing work (i.e. Proactive, Reactive, Standby, etc)
- Date and time
- Manhole information
- Pipe information
- Production numbers
- Follow-up street or landscaping repairs.

<u>Manhole Inspection Data</u>

The manhole information section of this program records the assessment during manhole inspections. **Figure 3-2** illustrates the electronic format for recording manhole information.

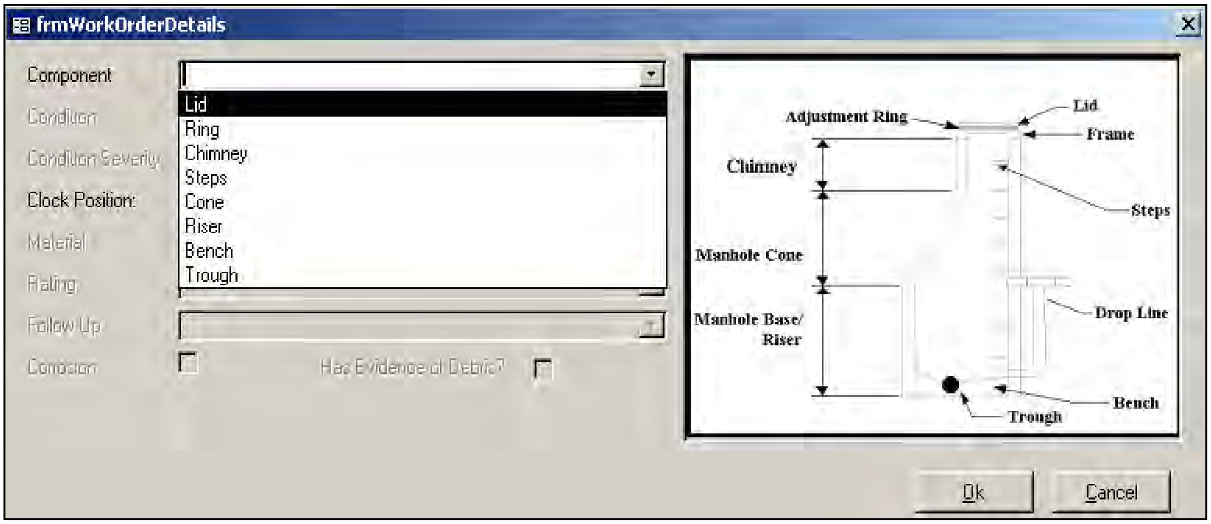
Figure 3-2: Collection System Maintenance Electronic Form (Manhole Tab)



The information collected for each manhole during the routine manhole inspection process includes the following general information:

- Manhole IPID (KUB's internal numbering system for manholes)
- PACP surface cover
- Manhole elevation (flush, above, or below the surrounding area)
- CAP credit (located in riparian, non-riparian, or paved area)
- Roots in manhole (severity of roots in manhole, if present)
- Inspection status (inspection completed, unable to locate manhole, etc.)
- Evidence that manhole has surcharge, and if so, to what height in manhole
- Evidence of gas in the manhole, and if so, what is the gas reading.

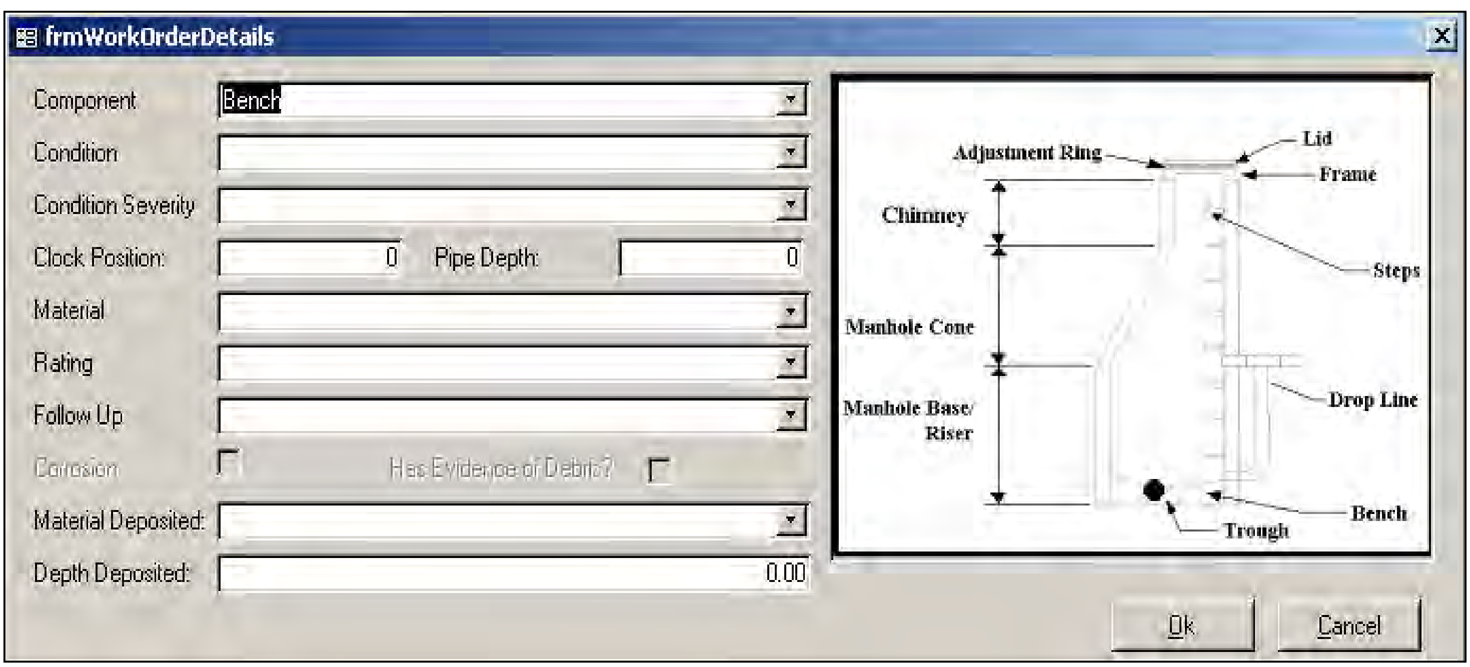
Figure 3-3: CSM Manhole Component Assessment



Specific information will be documented for each component of the manhole as illustrated in **Figure 3-3**. The manhole components to be inspected include

- Lid
- Ring
- Chimney
- Steps
- Cone
- Riser
- Bench
- Trough.

Figure 3-4



As shown in Figure 3-4, each component will be analyzed with the following criteria. The following conditions will not be applicable for all components. When they are not applicable, the data cannot be added.

- Condition (cracked, debris, etc.)
- Condition severity (what is the severity of the defect, such as severe, moderate, or light)
- Clock position (location of defect with respect to discharge pipe)
- Depth (vertical location of defect from invert)
- Material (concrete, brick, etc)
- Rating (CAP rating or severity of I/I, if present)
- Material deposited (type of material deposited, if present)
- Depth deposited (if material is deposited, what is the depth of the deposit)

<u>Pipe Maintenance and Assessment Data</u>

The CSM Program collects general information pertaining to the sewer line as shown in Figure 2-2 in Section 2.1.3. The general information collected for sewer lines include

- Pipe IPID
- PACP surface cover
- Confirmed pipe size (diameter of pipe)
- CAP credit (infiltration sources and severity, if present)
- Pipe material
- Pipe follow-up (Other maintenance or inspection activities recommended)
- Confirmed pipe length
- System disruption (broken pipe, debris, roots, grease, etc.)
- Evidence of gas in the manhole, and if so, what the gas reading is.

The specific activities pertaining to cleaning and inspecting the sewer mains are also recorded in this program.

- Job Code (records the specific work done to the asset)
- Work Code (records the asset receiving the work)
- Unit of measure (unit of work, such as linear feet or cubic yard)
- Amount of feet/cubic yards
- Truck number
- Amount of water used
- Number of passes (number of times that the line was either flushed or televised).

<u>Other Data</u>

The CSM collects other information relating to maintenance and assessment including the following:

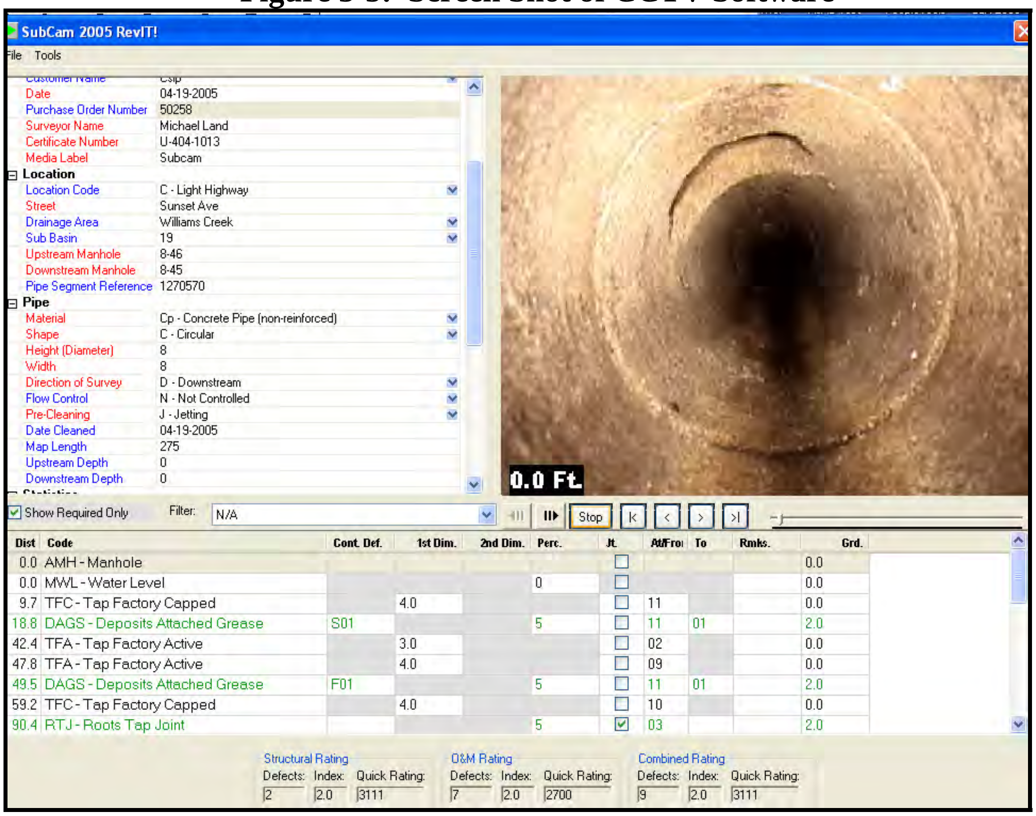
- Team leader (name of lead person)
- Crew members (names of KUB personnel performing work)
- Equipment number
- Number of employee and equipment hours (regular and overtime)
- Street and yard cut information (street repair required due to activities)

3.3 CCTV Software

KUB has incorporated information management software to record condition assessment of the WCTS. The CCTV software provides structured data input while ensuring a uniform standard to facilitate office review. Each individual CCTV inspection shall consist of tabular inspection data, linked still photos, and digital videos. The PACP-certified software shall fully support and conform to PACP Standard Data Format export and/or import guidelines.

A screen shot of the software used for CCTV inspections is illustrated in **Figure 3-5**.

Figure 3-5: Screen Shot of CCTV Software



Line segment inspections are facilitated through use of a computer screen displaying observations from CCTV camera and footage readings from properly calibrated footage counter. Footage readings are automatically displayed on the screen and the Survey Log includes footage readings that directly correspond to location of each coded defect tabulated therein. The same footage readings are consistently displayed in graphic and tabular reports subsequently generated.

In addition to video and footage readings, windows of the display screen shall display a blank inspection log, an assortment of data entry tools consisting of user-defined single-stroke hot-keys, drop-down code-selection menus, and other on-screen tools to record additional data required by PACP. After completion of each coded entry, the "entered" data is displayed in PACP tabular log format with additional column(s) displaying PACP

Condition Grades associated with individual coded entries. A special key is available to designate and automatically number "S" entries for continuous defects and means provided to automatically close those entries ("F" entries) when termination points are noted, and to prevent inspection termination until all continuous defects are "closed." In addition, built-in audit capability limits the array of data entry fields to only those associated with the PACP codes selected.

After exit from data entry mode, completed inspections shall be automatically stored on hard drives in a truck-mounted computer-data logger. Inspections are stored during the inspection and the reports are stored automatically after the inspection. The television software on each of the camera trucks will be downloaded onto the CSI server using portable hard drives.

Office technicians shall have the option to conduct an Intermediate Review of Field Inspections directly from "transport" media or to copy the data to a selected office computer hard drive or server.

1. **Intermediate Review:**
   The office system shall recognize transport media based on path data stored in the set-up file and generate an index from which to select individual inspections for review. Data from the selected inspection is displayed in an edit screen consisting of windows to display the tabular observation log, listing of associated header information, and a window in which to display still photos (jpegs) associated with each coded observation. Using forward/reverse tabs or selecting individual coded entries allows a quick review of coded entries and associated still photos.

   Additional menu options permit a shift from "quick review" mode to the original data entry screen format that includes the associated video.

   At either review level, edit capability enables reviewers to make corrections to tabular data and delete entries. When viewing full screen with video, additional defects are added to the inspection log.

2. **Review from Office Computer Hard Drive or Server:**
   Procedures for review and edit from the office hard drive or server is identical to those available for Intermediate Review.

   The CSI Team will review the results of the inspections. When the data has been verified, the information will be available to other KUB users and can be shared with KUB consultants to program system improvements.

   Office and Field Reports are generated in the same manner through selection from menus. Report generation is initiated by selecting individual inspections from the Inspection Index or Find Inspection screens and may be printed individually or in batch mode. Standard reports are available in the following formats:

1. Header Report - (PACP Header information and custom fields).
2. Defect Listing – PACP log format.
3. Defect Listing – Plot format – Horizontal or vertical plot, displaying all recorded observations in relation to footage locations and color-coded to reflect Condition Grade.
4. Defect Listing – Plot with Small photos – Same as (3) but including thumbnail photos of each coded observation.
5. Defect Listing – Small Image - Report sheets displaying Header information and 4 photos (with tabular data) per page.
6. Defect Listing – Large Image – Same as (5) but only 1 image per page.
7. Condition Grades – Tabular listing of PACP Condition Grades listed separately by "Structural", "O&M", and "Combined" categories - with a separate listing of each Continuous Defect and its length; and calculations displayed (by category) for PACP Pipe Rating, Structural Index, and Quick Rating.

A default selection of reports and output/export format may be made for each customer when the Customer File is established but selection may be changed at any time. Report Output Types are selected from PDF, Excel, HTML, Text, or TIFF formats and options are provided to "save" reports after edit changes, view the report on-screen, or to print it. Through an "Auto-Save" feature, reports may be automatically saved after completion of each field inspection and the saved report stored with tabular, jpeg, and video data for each inspection.

New CCTV equipment including software was implemented in June 2005. KUB currently uses two different software manufacturers; one for the LAMPS truck and one for all other CCTV inspection trucks.

3.4 GIS Integration

The Knoxville, Knox County, Knoxville Utilities Board Geographic Information System (KGIS) was established in 1985 by a charter agreement between the City of Knoxville, Knox County, and the Knoxville Utilities Board. KGIS is unique in that it was the nation's first major multi-participant municipal GIS.

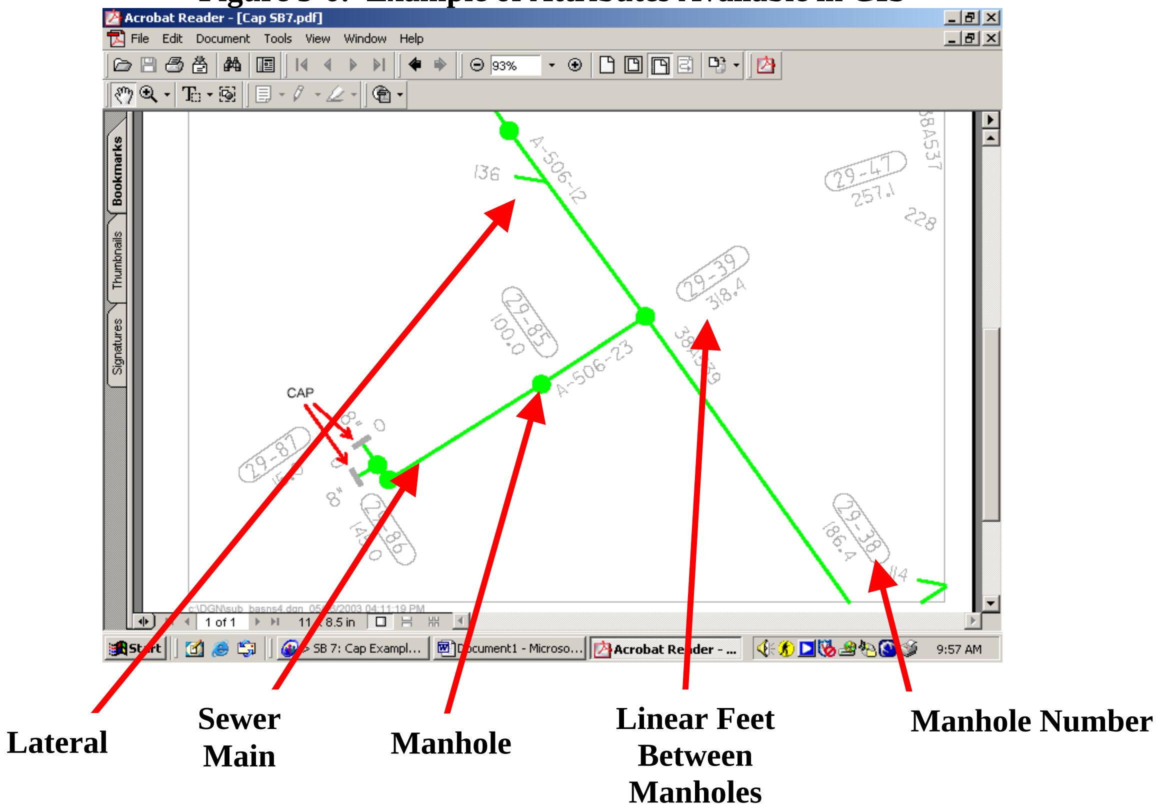
The KGIS Office administers the common portions of KGIS and its computer system. It also provides GIS and computer technical support and serves as a clearinghouse of GIS information and products.

The KGIS Office is also responsible for updating a common set of computer-based maps (for all Knox County) that are used by all of its users. This base map data includes planimetric maps, topographic maps, digital terrain models, and digital ortho aerial photography. KGIS is also responsible for selling hardcopy map products and for all licensing of digital map products to the general public or to groups providing services to one of the KGIS users.

The roughly 526 square miles of Knox County have been mapped at scales of one inch = 100 feet (1:1200) for highly urbanized areas or at one inch = 200 feet (1:2400) for lesserdeveloped areas. In addition to mapping the photo-identifiable features, the various agencies in KGIS have mapped other related information, including property and jurisdictional boundaries, road and address locations, utilities, and facilities.

From a technical standpoint, the GIS displays the graphic (map) data as layers of information; that is, streets on one layer, parcels on another, houses on another, etc. That allows an almost unlimited flexibility for viewing only the desired features and area. Non-graphic information is also associated with many map features and is stored in databases for immediate retrieval (**Figure 3-6**).

Figure 3-6: Example of Attributes Available in GIS



The information gathered from the CSSAP is stored in GIS tables to provide easily assessable information to Basin Owners, UGC field crews, consultants, etc. The viewing capability offered by GIS provides a visual representation of the data collected in the field. For example, manholes that have been recently inspected in an area can be isolated for system improvement planning. GIS will allow the information collected from CSSAP activities to be viewed graphically while providing a centralized database assessable for review by KUB and contractors.

Supervisory Control and Data Acquisition System (SCADA)
The automated SCADA system may also initiate a field order through System Operations. SCADA notifies System Operations if there is a system failure in any of KUB's 61 pump stations. That prompts System Operations to contact Station Management Services (SMS),

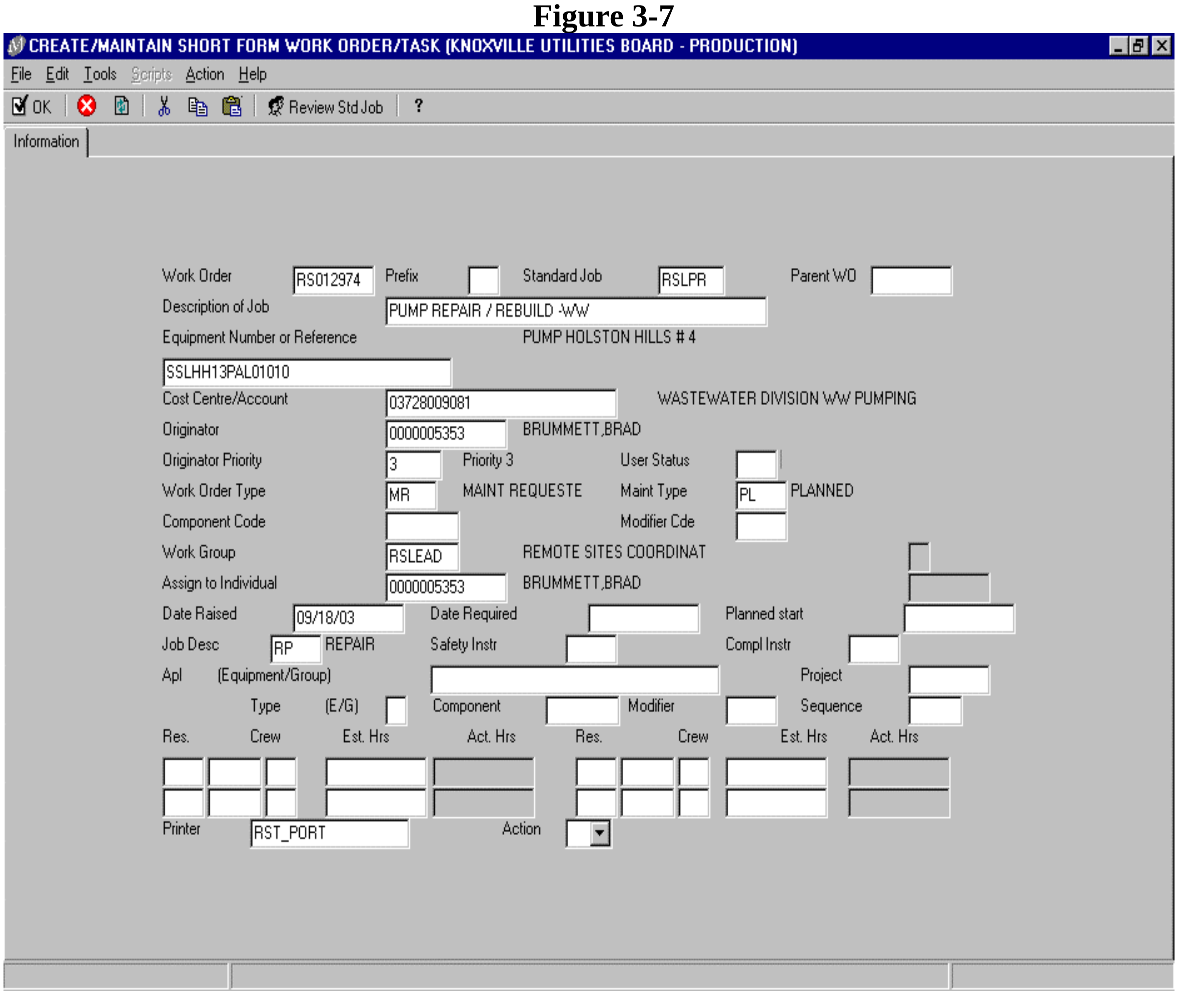
which investigates the event and remediate the problem. The possible overflow has then either been prevented or is cleaned up. SCADA gives valuable information on the duration and volume of the overflow as well as allows the pump operating time to be tracked. SCADA is also used to identify system improvements and the operability of the station and to identify potential SSO events so that measures can be taken to prevent a discharge.

Asset Management System

KUB's asset management system was implemented in June 1999. The goal for implementing this asset management system was to capture and report business information, supporting well-defined corporate metrics and strategy for doing business during the budget cycle, and support the use of established best practice methods for doing work.

The Operations Center uses the asset management system for equipment tracking, work orders, standard jobs, and generating work orders (**Figure 3-7**). Damage claims can be tracked for costing purposes. Engineering work orders, as well as overhead construction, can be tracked for time purposes.

Figure 3-7



The SMS group uses the asset management system extensively for maintenance equipment tracking. Larger equipment groups (large breakers, relays, pumps, etc.) are tracked for time purposes and job packaging. Entering a maintenance code and searching for the identified asset can query repair data. Job Packaging is used to create the hierarchy of a project area.