



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

JUL 30 2015

JUL 28 2015

CERTIFIED MAIL 7014 2870 0000 3318 2831
RETURN RECEIPT REQUESTED

Mr. Michael Patrick, P.E.
Director, Waste Resources Division
City of Chattanooga
455 Moccasin Bend Road
Chattanooga, Tennessee 37405

Re: Approval of the Sanitary Sewer Evaluation Study Work Plan
U.S. District Court Civil Action 1:12-cv-00245

Dear Mr. Patrick:

The U.S. Environmental Protection Agency Region 4 and the Tennessee Department of Environment and Conservation have reviewed and hereby approve the revised Sanitary Sewer Evaluation Study (SSES) Work Plan for the City of Chattanooga (the City) dated July 9, 2015, pursuant to Section VI.21 of the subject Consent Decree above. The City shall implement the SSES Work Plan in accordance with the submittal. In addition, the City shall certify the status of the implementation of the SSES Work Plan, including its completion, in the Semi-Annual or Annual Work Progress Report pursuant to Section IX of the subject Consent Decree.

Please contact Ms. Sara Janovitz at (404) 562-9870 or via email at janovitz.sara@epa.gov if you have any questions.

Sincerely,

A handwritten signature in blue ink, appearing to read "Maurice L. Horsey, IV".

Maurice L. Horsey, IV, Chief
Municipal & Industrial Enforcement Section
NPDES Permitting and Enforcement Branch

cc: See Attached List



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MAR 17 2015

MAR 12 2015

CERTIFIED MAIL 7010 1060 0002 1703 9300
RETURN RECEIPT REQUESTED

Mr. Michael Patrick, P.E.
Director, Waste Resources Division
City of Chattanooga
455 Moccasin Bend Road
Chattanooga, Tennessee 37405

Re: Review of the Sanitary Sewer Evaluation Study Work Plan
U.S. District Court Civil Action 1:12-cv-00245

Dear Mr. Patrick:

The U.S. Environmental Protection Agency Region 4 and the Tennessee Department of Environment and Conservation (TDEC) have reviewed the Sanitary Sewer Evaluation Study (SSES) Work Plan for the City of Chattanooga (the City) pursuant to Section VI.21 of the subject Consent Decree above. The EPA and TDEC have identified the following questions and issues needing additional clarification.

SSES Work Plan Questions and Comments:

1. Section VI.21.c of the Consent Decree requires performance goals and procedures for analysis of the effectiveness of completed rehabilitation for all of the components of the SSES Work Plan. See Comment Number 11 for Section 6.0 below for additional information.
2. Section VI.21.c.i of the Consent Decree requires a Corrosion Defect Identification component in the SSES Work Plan. This component has been included in the Force Main Condition Assessment and Rehabilitation component and the Pump Station Performance and Rehabilitation component. Will all infrastructure susceptible to corrosion, including gravity sewer lines, be inspected for corrosion defects? For example, a force main that flows into a pump station which then flows into a gravity sewer line needs to be inspected for corrosion. Is there a corrosion identification-specific form?
3. Section 3.5: Section VI.21.c.iii of the Consent Decree requires the SSES Work Plan include procedures for sewer cleaning associated with flow monitoring.
4. Section 4.3: When will the City's remaining 24 of 29 sub-basins be scored to determine the priority list for performing SSES investigation and rehabilitation work?

5. Section 5.2: Section IV.21.c.ii of the Consent Decree requires the Manhole Condition Assessment and Rehabilitation component of the SSES Work Plan establish an ongoing inventory of manhole rehabilitation. Is there a manhole inspection form? The Consent Decree requires a process for setting manhole rehabilitation priorities and expeditious schedules.
6. Section 5.3: Section IV.21.c.iv of the Consent Decree requires a process for the retention and retrieval of closed circuit television inspection data (CCTV).
7. Section 5.4: Section IV.21.c.v of the Consent Decree requires procedures for investigating private laterals to identify sources of infiltration and inflow (I/I) to the wastewater collection and transmission system. How will the City develop expeditious schedules for gravity sewer line rehabilitation? The Consent Decree also requires the City establish an ongoing inventory of gravity sewer line rehabilitation.
8. Section 5.5: What will be done if a force main cannot be taken out of service to perform CCTV or Sonar inspections? Section IV.21.c.vi of the Consent Decree requires standard procedures for the condition assessment of force mains. Please include more detailed procedures for condition assessments. How will force main rehabilitation work be prioritized? The Consent Decree also requires the City establish an ongoing inventory of force main rehabilitation.
9. Section 5.6: What can the City legally do if there is I/I in a private lateral, and the property owner does not want to repair the line?
10. Section 5.7: Section IV.21.c.viii.d of the Consent Decree requires the pump stations be evaluated based upon operating and mechanical failure history during at least the past five (5) years. Section IV.21.c.viii.e of the Consent Decree requires the pump station design and equipment, including the redundancy of pumps and electrical power supply, be evaluated.
11. Section 6.0: The Consent Decree requires the SSES Work Plan include an analysis of the effectiveness of the completed rehabilitation. In addition to analyzing the rainfall-derived infiltration/inflow and sanitary sewer overflows pre-rehabilitation and post-rehabilitation, the EPA also recommends evaluating the individual rehabilitation techniques used throughout the SSES to determine which techniques were effective and should continue to be used, and which ones should not be used in the future.
12. The EPA recommends including a signature page to catalog when the SSES Work Plan was reviewed, if any revisions were made, and what the revisions were.

Please contact Ms. Sara Janovitz at (404) 562-9870 or via email at janovitz.sara@epa.gov, within five days of receipt of this letter to schedule your attendance at a meeting either in person or via telephone conference.

Sincerely,



Maurice L. Horsey, IV, Chief
Municipal & Industrial Enforcement Section
NPDES Permitting and Enforcement Branch

cc: Mr. Karl Fingerhood
U.S. Department of Justice, Washington, D.C.

Mr. Phillip Hilliard
Office of the Attorney General

Ms. Jessica Murphy
Tennessee Department of Environment and Conservation

Mr. Donald L. Norris
City of Chattanooga

Mr. Wade Hinton
City of Chattanooga

Mr. Adam Sowatzka
King & Spalding LLP

Ms. Stephanie Matheny
Tennessee Clean Water Network



City of Chattanooga

Mayor Andy Berke

July 9, 2015

VIA CERTIFIED MAIL

Ms. Sara Schiff-Janovitz
Environmental Engineer
Clean Water Enforcement Branch
US EPA - Region 4
61 Forsyth Street, SW
Atlanta, GA 30303

**RE: *United States of America et. al. v. City of Chattanooga, No. 1:12-cv-00245*
Sanitary Sewer Evaluation Study (SSES) Work Plan – Resubmittal**

Dear Ms. Janovitz:

On behalf of the City of Chattanooga, Tennessee (“City”), and in accordance with the Consent Decree entered by the United States District Court for the Eastern District of Tennessee (Southern Division), on April 24, 2013, in the case styled the *United States of America et. al. v. City of Chattanooga, No. 1:12-cv-00245* (“Consent Decree”), we are resubmitting to both the Environmental Protection Agency (“EPA”) and the Tennessee Department of Environment and Conservation (“TDEC”) the Sanitary Sewer Evaluation Study (“SSES”) Work Plan (“SSES Work Plan”) in response to comments from the EPA dated March 12, 2015.

The comments received from the EPA and the responses and corrections made to the SSES Work Plan are as follows:

1. EPA Comment: *Section VI.21.c of the Consent Decree requires performance goals and procedures for analysis of the effectiveness of completed rehabilitation for all of the components of the SSES Work Plan. See Comment Number 11 for Section 6.0 below for additional information.*

City of Chattanooga Response: See City of Chattanooga Response to Comment Number 11.

2. EPA Comment: *Section VI.21.c.i of the Consent Decree requires a Corrosion Defect Identification component in the SSES Work Plan. This component has*

been included in the Force Main Condition Assessment and Rehabilitation component and the Pump Station Performance and Rehabilitation component. Will all infrastructure susceptible to corrosion, including gravity sewer lines, be inspected for corrosion defects? For example, a force main that flows into a pump station which then flows into a gravity sewer line needs to be inspected for corrosion. Is there a corrosion identification-specific form?

City of Chattanooga Response: Yes, as indicated in Appendix K, Pump Station and Force Main Inspection Forms, both the Pump Station/Structure Condition and Inspection Form and Force Main/Gravity Sewer Condition and Inspection Form indicate corrosion inspection will be performed on pipes, structures, and supports related to pump station facilities, force mains, and gravity lines.

3. EPA Comment Section 3.5: *Section VI.21.c.iii of the Consent Decree requires the SSES Work Plan include procedures for sewer cleaning associated with flow monitoring.*

City of Chattanooga Response: Section 3.3.3, Site Selection has been updated to include: "Cleaning shall be completed as necessary to ensure suitable flow monitoring conditions. Cleaning will be performed in accordance with methods outlined in section 33 01 30.14 Preconditioning and Cleaning of Underground Sewer Pipes in Appendix I, SSES Specifications." Specification section 33 01 30.14, Preconditioning and Cleaning of Underground Sewer Pipes has been added to Appendix I, SSES Specifications.

4. EPA Comment Section 4.3: *When will the City's remaining 24 of 29 sub-basins be scored to determine the priority list for performing SSES investigation and rehabilitation work?*

City of Chattanooga Response: The remaining sub-basins will be scored when necessary to complete SSES investigation and rehabilitation within the required time frame. Phase II prioritization may be completed more than once if necessary.

5. EPA Comment Section 5.2: *Section IV.21.c.ii of the Consent Decree requires the Manhole Condition Assessment and Rehabilitation component of the SSES Work Plan establish an ongoing inventory of manhole rehabilitation. Is there a manhole inspection form? The Consent Decree requires a process for setting manhole rehabilitation priorities and expeditious schedules.*

City of Chattanooga Response: No, a manhole inspection form is not included in the SSES Work Plan. All manhole rehabilitation requirements are covered in specification 33 01 30.29, which dictates all manhole inspections must be completed under NASSCO MACP standards.

6. EPA Comment Section 5.3: *Section IV.21.c.iv of the Consent Decree requires a process for the retention and retrieval of closed circuit television inspection data (CCTV).*

City of Chattanooga Response: As indicated in Section 5.1.1, SSES, Gravity Sewer, and Manhole Data, CCTV data is stored on a network share drive maintained and archived by the City. Section 33 01 30.16, Closed Circuit TV Inspection of Existing Underground Sewer Pipelines, has been added, which details CCTV inspection procedures.

7. EPA Comment Section 5.4: *Section IV.21.c.v of the Consent Decree requires procedures for investigating private laterals to identify sources of infiltration and inflow (I/I) to the wastewater collection and transmission system. How will the city develop expeditious schedules for gravity sewer line rehabilitation? The Consent Decree also requires the City establish an ongoing inventory of gravity sewer line rehabilitation.*

City of Chattanooga Response: According to Section 5.6.1, Private Lateral Investigations, the City will investigate I/I in private laterals through main line CCTV or smoke testing inspections via the Sewer Lateral Assessment Program (SLAP). The procedures for smoke testing investigations closed circuit TV inspections of private laterals are outlined in Appendix I, SSES Specifications, 33 01 30.24 Smoke Testing of Underground Sewer Pipelines, and 33 01 30.16 Closed Circuit TV Inspection of Existing Underground Sewer Pipelines.

Section 4.0, Developing SSES Project Priorities, outlines the steps the City is taking to assess and prioritize gravity sewer line rehabilitation. The SSES project prioritization has been split up into two phases. Phase I SSES projects are to be completed within five years of EPA's approval of the SSES Work Plan, and Phase II includes SSES projects to be completed within 15 years of EPA's approval of the SSES Work Plan.

The inventory of future gravity sewer line rehabilitation will be collected and maintained on a list in the City's database server, as indicated in Section 5.1.1, SSES, Gravity Sewer, and Manhole Data.

8. EPA Comment Section 5.5: *What will be done if a force main cannot be taken out of service to perform CCTV or Sonar inspections? Section IV.21.c.vi of the Consent Decree requires standard procedures for the condition assessment of force mains. Please include more detailed procedures for condition assessment. How will force main rehabilitation work be prioritized? The Consent Decree also requires the City establish an ongoing inventory of force main rehabilitation.*

City of Chattanooga Response: Section 5.1.3, Pump Station and Force Main Data, indicates that force main rehabilitation data is contained in the City's Asset

Management System. Further details regarding procedures for condition assessment are outlined in the Pump Station Preventive Maintenance Program.

As indicated in Section 5.5.1.2, Corrosion Defect Identification Inspections, if a pipe cannot be taken out of service, the City may perform external pipe, non-pipe, and internal to the pipe investigations. These tasks will be performed in accordance to the National Association of Corrosion Engineers' *Pipeline External Corrosion Direct Assessment Methodology* listed in Appendix N, Reference Standards.

9. EPA Comment Section 5.6: *What can the City legally do if there is I/I in a private lateral, and the property owner does not want to repair the line?*

City of Chattanooga Response: According to City Code Section 31-15(a): "All users shall be required to maintain their private sewer lines so as to prevent infiltration of ground or stormwater as a condition of use of the system and shall immediately repair or replace any leaking or damaged lines." The City has the ability to compel the resident via fine or termination of water service to make required repairs.

10. EPA Comment Section 5.7: *Section IV.21.c.vii.d of the Consent Decree requires the pump stations be evaluated based upon operating and mechanical failure history during at least the past five (5) years. Section IV.21.c.vii.e of the Consent Decree requires the pump station design and equipment, including the redundancy of pumps and electrical power supply, be evaluated.*

City of Chattanooga Response: Pump station condition assessment processes are provided in more detail in the Pump Station Operations Program and Pump Station Preventive Maintenance Program. These assessments are based on structural inspections, equipment inspections, and O&M history. The inspection form is located in Appendix K, Pump Station and Force Main Inspection Forms.

11. EPA Comment Section 6.0: *The Consent Decree requires the SSES Work Plan include an analysis of the effectiveness of the completed rehabilitation. In addition to analyzing the rainfall-derived infiltration/inflow and sanitary sewer overflows pre-rehabilitation and post-rehabilitation, the EPA also recommends evaluating the individual rehabilitation techniques used throughout the SSES to determine which techniques were effective and should continue to be used, and which ones should not be used in the future.*

City of Chattanooga Response: Section 6.0, Analysis of Completed Rehabilitation Effectiveness, has been updated with the following language: In particular, the City will review completed work and further evaluate successful projects based on RDII and SSO reductions."

Ms. Sara Schiff-Janovitz
July 9, 2015
Page Five

12. EPA Comment: *The EPA recommends including a signature page to catalog when the SSES Work Plan was reviewed, if any revisions were made, and what the revisions were.*

City of Chattanooga Response: A Review Approval Signature Page has been added to the front of the document.

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering such information, the information submitted is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

We look forward to receiving EPA's and TDEC's approval of the SSES Work Plan. In the meantime, please let me know if you have any questions regarding our submittal.

Sincerely,



Michael C. Patrick, P.E.
Director, Waste Resources Division

Enclosure

cc: Karl Fingerhood, Esq., US DOJ
Chief, Environmental Enforcement Section, US DOJ
Chief, Clean Water Enforcement Branch, US EPA Region 4
Bill Bush, Esq., US EPA
Phillip Hilliard, Office of the Attorney General
Enforcement Coordinator, Water Pollution Control, TDEC
Stephanie Durman, Esq., TCWN
Mike Marino, PE, Jacobs
Adam Sowatzka, Esq., King & Spalding



**City of Chattanooga
Waste Resources Division
Consent Decree Program**

Document Review Approval

Document: SSES Work Plan

Revision Number:

This document has been reviewed and is approved for release.

Reviewer: _____

Signature: _____

Date: _____

Reviewer: _____

Signature: _____

Date: _____

Reviewer: _____

Signature: _____

Date: _____

Reviewer: _____

Signature: _____

Date: _____

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Sanitary Sewer Evaluation Study (SSES) Work Plan

Prepared for

**United States Environmental Protection Agency
and Tennessee Department of Environment and
Conservation**

City of Chattanooga
Waste Resources Division
Consent Decree Program
Case No. 1:12-cv-00245

Prepared by

City of Chattanooga
Waste Resources Division

Submitted by

JACOBS®

Jacobs Engineering Group Inc.
Consent Decree Program Manager

Chattanooga, Tennessee

November 18, 2014
Revised July 7, 2015

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Acronyms and Abbreviations

CD	Consent Decree
CCTV	Closed Circuit Television
CFD	Chattanooga Fire Department
CFR	Code of Federal Regulations
CIPP	Cured-In-Place Pipe
CMMS	Computerized Maintenance and Management System
CMOM	Capacity, Management, Operations, and Maintenance
CSO	Combined Sewer Overflow
CSOTF	Combined Sewer Overflow Treatment Facility
CSS	Combined Sewer System
DPW	Department of Public Works
EMRIP	Equipment Maintenance and Reliability Improvement Program
EPA	United States Environmental Protection Agency
FM	Force Main
GIS	Geographic Information System
GLPMP	Gravity Line Preventative Maintenance Program
gpm	Gallons Per Minute
I&I	Infiltration and Inflow
MBWWTP	Moccasin Bend Wastewater Treatment Plant
MOM	Management, Operations, and Maintenance
MOR	Monthly Operating Report
NPDES	National Pollution Discharge Elimination System
PS	Pump Station
RDII	Rainfall-Derived Inflow and Infiltration
SCADA	Supervisory Control and Data Acquisition System
SORP	Sewer Overflow Response Protocol
SSO	Sanitary Sewer Overflow
SSS	Sanitary Sewer System

TCWN	Tennessee Clean Water Network
TDEC	Tennessee Department of Environment and Conservation
TWRA	Tennessee Wildlife Resources Agency
WCTS	Wastewater Collection and Transmission System
WRD	Waste Resources Division
WWTF	Wastewater Treatment Facility
WWTP	Wastewater Treatment Plant

1.0 Introduction

1.1 Purpose

On April 24, 2013, the City of Chattanooga (City) entered into a consent decree with the United States and the State of Tennessee, in the case styled United States of America et. al. v. City of Chattanooga, No. 1:12-cv-00245 (“CD”). The City’s Waste Resources Division (WRD) has prepared a Sanitary Sewer Evaluation Survey (SSES) Work Plan for review and approval by the United States Environmental Protection Agency (EPA) and the Tennessee Department of Environment and Conservation (TDEC), pursuant to paragraph 21 of the CD.

The purpose of this SSES Work Plan is to establish the procedures for setting priorities and expeditious schedules for undertaking the Wastewater Collection and Transmission System (WCTS) assessment and rehabilitation throughout the duration of the Consent Decree.

This document will determine how the City will assess, analyze, and rehabilitate the WCTS infrastructure to among other things, address Inflow and Infiltration (I&I), structural defects, and other conditions causing, or that are likely to cause, sanitary sewer overflows (SSOs).

1.2 Authority

The City’s legal authority for the development and implementation of this SSES Work Plan is

- The U.S. Clean Water Act;
- National Pollutant Discharge Elimination System (NPDES) Permit Number TN0024210;
- Tennessee Water Quality Control Act; and
- The CD.

1.3 Related City of Chattanooga Documents

The City has several CD documents that are critical to and referenced throughout this SSES Work Plan. The documents and the status of the documents are shown in Table 1-1 below.

Table 1-1
CD Related Documents

Document	Location
Gravity Line Preventative Maintenance Program (GLPMP)	CD Public Document Repository
Pump Station Preventive Maintenance Program	CD Public Document Repository
Pump Station Operations Program	CD Public Document Repository
Sewer Overflow Response Program (SORP)	CD Public Document Repository

2.0 Overview

2.1 Description of Wastewater Collection and Transmission System

As a regional wastewater utility, the City of Chattanooga, a Municipal Corporation, owns, operates, maintains, and manages a network of pipes, manholes, pump stations (PSs), force mains, CSOTFs, and associated appurtenances that transport wastewater from homes, businesses, and industries to the Moccasin Bend Wastewater Treatment Plant (WWTP). All of this infrastructure is part of the Wastewater Collection and Transmission System (WCTS), as defined in the CD and herein, and managed by the WRD. The City has historically classified the WRD, WWTP and the WCTS as part of the Interceptor Sewer System (ISS). With the advent of the CD and recent reorganizations within the City, the term ISS is not recognized by all stakeholders and therefore the City will refer to WCTS and WWTP as the infrastructure and WRD as the organization to manage this infrastructure going forward. Property owners own the private service laterals from the served residential, commercial, and industrial structures to the public main line in the street or right-of-way, including the connection.

The City's WCTS currently serves approximately 170,000 people with approximately 61,000 customers within the City including 80 permitted industries. It also provides treatment for eight (8) regional or satellite users comprised of approximately 25,000 customers. The WCTS is composed of:

- 1,263 miles of gravity sewers (approximate), including 70 miles of combined sewers;
- 30,000 manholes (approximate);
- 70 pump stations;
- 53 miles of force main;
- Eight (8) CSOTFs;
- One (1) Combined Sewer Storage Facility;
- 192 (approximate) residential/grinder pumps; and
- One (1) Moccasin Bend WWTP.

An organizational chart of Waste Resources Division is provided in Appendix A.

2.2 Sewer Basins

The WCTS is divided into 12 major sewer basins which are further divided into 105 individual sewer sub-basins for SSES analysis. Table 2-1 below lists the sub-basins and the major basins in which they are contained. Figure 2-1 in Appendix B is a map depicting the basins. The detailed delineation of the sewer basins is outlined in Section 3.4 of this document.

Table 2-1
Sewer Basins

Chattanooga Creek					
Chattanooga Creek 1	Chattanooga Creek 2	Chattanooga Creek 3	Chattanooga Creek 4	Chattanooga Creek 5	Chattanooga Creek 6
Citico Creek					
Citico Creek 1	Citico Creek 2	Citico Creek 3	Citico Creek 4	Citico Creek 5	
CSO					
CSO 1	CSO 2	CSO 3	CSO 4	CSO 5	CSO 6
CSO 7	CSO 8				
Dobbs Branch					
Dobbs Branch 1	Dobbs Branch 2	Dobbs Branch 3	Dobbs Branch 4	Dobbs Branch 5	Dobbs Branch 6
Friars Branch					
Friars Branch 1	Friars Branch 2	Friars Branch 3	Friars Branch 4	Friars Branch 5	Friars Branch 6
Friars Branch 7	Friars Branch 8	Friars Branch 9	Friars Branch 10	Friars Branch 11	Friars Branch 12
Friars Branch 13	Friars Branch 14	Friars Branch 15	Friars Branch 16	Friars Branch 17	
Lookout Creek					
Lookout Creek 1	Lookout Creek 2	Lookout Creek 3	Lookout Creek 4	Lookout Creek 5	
Mackey Branch					
Mackey Branch 1	Mackey Branch 2	Mackey Branch 3	Mackey Branch 4	Mackey Branch 5	Mackey Branch 6
Mackey Branch 7					
Mountain Creek					
Mountain Creek 1	Mountain Creek 2				
North Chickamauga Creek					
North Chick Creek 1	North Chick Creek 2	North Chick Creek 3	North Chick Creek 4	North Chick Creek 5	North Chick Creek 6
North Chick Creek 7	North Chick Creek 8	North Chick Creek 9			
Poe Branch					
Poe Branch					
South Chickamauga Creek					
South Chick Creek 1	South Chick Creek 2	South Chick Creek 3	South Chick Creek 4	South Chick Creek 5	South Chick Creek 6
South Chick Creek 7	South Chick Creek 8	South Chick Creek 9	South Chick Creek 10	South Chick Creek 11	South Chick Creek 12
South Chick Creek 13	South Chick Creek 14	South Chick Creek 15	South Chick Creek 16	South Chick Creek 17	South Chick Creek 18
South Chick Creek 19					

Table 2-1
Sewer Basins

Tennessee River					
Tennessee River 1	Tennessee River 2	Tennessee River 3	Tennessee River 4	Tennessee River 5	Tennessee River 6
Tennessee River 7	Tennessee River 8	Tennessee River 9	Tennessee River 10	Tennessee River 11	Tennessee River 12
Tennessee River 13	Tennessee River 14	Tennessee River 15	Tennessee River 16	Tennessee River 17	Tennessee River 17b
Tennessee River 18	Tennessee River 19				

2.3 Pump Stations and Force Mains

A full detailed list of the wastewater pump stations and CSOTFs can be found in Section 1 of the Pump Station Preventive Maintenance Program document. Figure 2-2 in Appendix C is a map showing the locations of the City's Pump Stations and force mains.

2.4 Key Elements of the SSES Work Plan

The key elements of the SSES Work Plan are addressed individually as follows:

- Section 3.0 Rainfall and Flow Monitoring Program
- Section 4.0 Developing SSES Project Priorities
- Section 5.0 WCTS Condition Assessment and Rehabilitation
- Section 6.0 Analysis of Completed Rehabilitation

2.5 Definitions

City: The City of Chattanooga, Tennessee and its Department of Public Works, the Waste Resources Division (WRD), and the Interceptor Sewer System.

Director: The Director of the WRD is responsible for the oversight and management of the WRD of the Department of Public Works of the City.

Publicly Owned Treatment Works (POTW): A publicly owned treatment works is a wastewater treatment facility (WWTF) and its entire infrastructure that is owned by a state or municipality.

Rainfall-Derived Inflow and Infiltration (RDII): RDII is the portion of I&I that is directly influenced by the intensity and duration of a storm event.

User: Any person that contributes, causes, or permits the contribution or introduction of wastewater or pollutants into the WCTS, whether intentional or unintentional, and whether direct or indirect.

Wastewater Collection and Transmission System (WCTS): The WCTS is the wastewater collection, retention, and transmission systems, including all gravity sewer lines, force mains, pump stations, manholes, and other related appurtenances designed to collect and convey domestic, commercial, industrial wastewaters and combined sewer to the WWTP or CSOTFs.

WRD: Waste Resources Division is responsible for the planning, management, operation, and maintenance of the WCTS and WWTP for the City.

Wastewater Treatment Plant or WWTP: WWTP shall mean devices or systems used in the storage, treatment, recycling, and reclamation of municipal wastewater at the Moccasin Bend WWTP located at 455 Moccasin Bend Road, Chattanooga, TN 37405-4403.

3.0 Rainfall and Flow Monitoring Program

The SSES work plan is based on an initial analysis of the entire WCTS utilizing flow data for the sub-basins illustrated in Figure 3-1 in Appendix D. The City's flow monitoring program is divided into two phases. The Phase I flow monitoring program was an initial flow monitoring period to support the development of a hydraulic model and project prioritization. The Phase II flow monitoring program is an ongoing effort to support model validation, evaluation of pre- and post-conditions of rehabilitation projects, and continued analysis of the system.

3.1 Flow Monitoring Program

3.1.1 Phase I Flow Monitoring Program

The City implemented the Phase I flow monitoring program to support the development of a dynamic computer model of the sanitary and combined sewer system in November 2009. As part of this phase, the City hired a contractor, ADS Environmental Services (ADS), to install and maintain 104 flow monitors and 12 rain gauges. During this phase, ADS also became responsible for maintaining 12 billing monitors used to monitor flow from 8 regional customers as well. The Phase I flow monitoring period occurred from November 23, 2009 to April 23, 2010. The Phase I flow period is the primary flow data used to develop and calibrate the hydraulic model. By the end of April 2010, about half of the monitors were removed and additional monitors installed to meet additional operational needs and to allow further development of the hydraulic model. The data from the Phase I period was used to determine the initial SSES basin priorities based on observed Net Normalized Rainfall Dependent (RD) Inflow & Infiltration (II) as further discussed in Section 4.

The Phase II flow monitoring program will continue to assess changing flow conditions and provide continued insight to the system response to a larger number of storms. The ongoing efforts associated with Phase II represent a long-term flow monitoring program, provides the data necessary for subsequent model validation and evaluation of the pre- and post-conditions of the rehabilitation projects.

3.2 Rainfall Data

The flow monitoring data is supplemented by 12 rain gauges, which are distributed throughout the service area to record the spatial variation in rainfall events and correlate rainfall volume to rainfall-derived inflow and infiltration (RDII). Multiple gauges are required to obtain adequate coverage given the unpredictability associated with the rainfall distribution over such a large service area. The rainfall data is recorded in 5-minute time intervals, which provided the resolution necessary to capture the effects of inflow (short-term response) and first infiltration (intermediate-term response).

The rain gauges are ADS Rain Alert II Model 6000 units or similar units. Gauges are to be installed, operated, and maintained by contracted personnel and per manufacturer's specifications. Each gauge was mounted on a level, flat surface and located away from

obstructions (e.g., trees, buildings) in a clear area to capture the natural rainfall distribution. Additional rain gauges may be added as necessary.

3.3 Flow Monitoring

Flow monitoring, as it relates to this SSES work plan, includes performing routine flow monitoring during dry and wet weather to support engineering analysis related to sewer system capacity and peak flow rates. The following sections describe the need, and general methodology to be used by the City when implementing a flow monitoring program for SSES.

3.3.1 Need for Analysis

Flow monitoring, for the purposes of SSES, is used to:

- Determine volume and variation of flow for specific areas in the sewer system;
- Understand collection system responses during wet-weather events; and
- Isolate areas of high RDII contributions during wet-weather events to determine their magnitude and plan subsequent remedial measures.

Flow monitoring analyses are dependent upon flow and rainfall data collected by flow monitors and rainfall gauges within the system. Flow data is classified as dry weather and wet weather. This flow classification is determined through analysis of rainfall data into periods of significant rainfall and without significant rainfall.

3.3.2 Flow Monitoring Locations

The City maintains permanent monitors at the treatment facilities and pump stations, as well as billing monitors. While these monitors were not selected for use in SSES prioritization, they can be used to supplement the monitors deployed specifically for SSES.

3.3.3 Site Selection

Site selection for the City's flow monitoring program was performed with a high resolution monitoring program. Ideally basins should be equitable in size and of common performance due to material, construction methods, and age. Studies have shown the recommended optimal basin sizes per flow meter range from 10,000 – 15,000 LF of sewer per flow monitor based on per linear foot unit cost comparisons of flow monitoring, SSES, and remedial measures. As such, it is financially advantageous to maximize the number of flow monitors for similar size areas during these studies.

Flow monitors for the SSES should isolate individual sewer sub-basins and be placed along the primary trunk sewers and interceptors. Additional site selection considerations include:

- SSO locations;
- Pump stations;
- CSOs;
- Treatment facilities;
- Large Industrial Discharges that don't have typical diurnals; and

- Net flows/Subtraction of Monitors.

Ideally, monitors should be located upstream of SSO locations, at critical points along trunk sewers, influent lines to CSO and treatment facilities, away from pump station discharge points, and have the ability to isolate large Industrial customers.

Another important consideration in site selection is the potential additive computation errors that can occur when subtracting an upstream monitor from a downstream monitor to isolate net flow contributions. The lower the net flow contribution of the basin is to the total flow the higher the percent error is for the flow calculation. Subtraction of rates from flow monitors to generate small net basin contributions should be minimized to allow for higher accuracy flow calculations.

Final site selection should consist of thorough site investigations to ensure field conditions are suitable for installation and calibration of the monitor. Site specific conditions include evaluation of velocity, turbulence, uneven flows, accelerating flows, silt, and depth to reduce the monitoring errors.

Cleaning shall be completed as necessary to ensure suitable flow monitoring conditions. Cleaning will be performed in accordance with methods outlined in Section 33 01 30.14 Preconditioning and Cleaning of Underground Sewer Pipes in Appendix I, SSES Specifications.

Rain gages should be installed to provide adequate coverage of the sewer basins being studied. Typically, gages should be installed every 5-10 square miles within the study area. Each rain gage should allow for accuracy to 0.01 inch, and have the ability to record rainfall in 5 minute increments. Each rain gage should be assigned to a designated area and linked to flow monitors within that area for analysis. Additional rain gauges should be included for known areas of climatological anomalies.

3.3.4 Flow Monitoring Periods

3.3.4.1 Duration

Ideally, the monitoring period should continue until there are three (3) or more storms ranging in size from a minimum 0.5 to 2.5 inches over a 24 hour period. Furthermore, a period without significant rainfall should be measured during the monitoring period to allow the system to return to dry weather flow status to allow for determination of base flows. The dry-weather period should be dependent upon the location of the system and sensitivity to rainfall.

Based on historical rainfall for Chattanooga, we expect that a flow monitoring program will generally last for 6 months. Also, where possible, gathering more flow data allows for higher resolution and more detailed regression analysis of RDII to total rainfall.

3.3.4.2 Seasonality

Flow monitoring should be conducted as part of an SSES program generally during December to May. Historically, this has been the time period with highest RDII contributions due to increase groundwater I/I.

Seasonal SSES flow monitoring programs may not characterize true base flow rates due to seasonally higher groundwater table; however, the monitoring program will consider this and

review periods of distinct separation in time from wet-weather events to determine base flows used in estimating RDII volumes.

3.3.5 Monitoring Equipment

The objective of the monitoring equipment is to obtain quality data from the selected sites. The equipment selected should have a history of proven performance. Several equipment technologies are available, and each site should be evaluated on a site by site basis with a flow monitoring equipment/technology company to obtain the best site specific solution.

3.3.6 Flow Monitoring Resources

Proper maintenance procedures are required to improve meter performance for the duration of the flow monitoring portion of the SSES. Site visits are typically performed on a weekly basis for SSES studies, or twice a week, if the site is determined to be problematic due to sedimentation deposition or other hydraulic issues are noted and if deemed necessary. Remote data acquisition can be used in lieu of site visits to collect data, and provide operational checks. If remote data acquisition is used site visits should still be performed as necessary.

3.4 Basin Delineation

3.4.1 Basins

The City's WCTS is comprised of 12 basins. Since most of the collection system flows by gravity, each basin boundary roughly coincides with the sub-regional watershed boundary. As a result, each basin is described by the sub-regional watershed designation. In addition, each basin represents wastewater flows that are conveyed to a common discharge point.

3.4.2 Sub-Basins

The basins were divided into sub-basins to implement a comprehensive flow monitoring program that provides an accurate assessment of the system-wide conditions and SSES. The sub-basin boundaries were developed to maintain a comparable length of piping and a similar number of linear foot of pipe in each sub-basin. The geographic information system (GIS) database for the sewer system included system connectivity, pipe sizes, and flow direction, which were evaluated to identify potential flow monitoring sites.

3.5 Flow Analysis

Flow data analysis consists of classifying and quantifying wastewater as dry weather flow, or wet weather flow. Flow analysis requires engineering judgment and consideration of the antecedent conditions, regression of wet weather flows, as well as seasonal impacts associated with the WCTS.

3.5.1 Dry Weather Flow

Dry-weather flows directly reflect the water usage of the community and consequently fluctuate hourly, daily, and seasonally. This wastewater flow component includes domestic, commercial, institutional, and industrial sewage and specifically excludes I&I.

3.5.2 Wet Weather Flow

Wet-weather events were analyzed based on the system response and the hydrologic characteristics associated with excess precipitation and the resulting runoff. In general, there are three response types associated with RDII, which are characterized as slow, intermediate, and fast. The slow response represents runoff that percolates through the soil before entering the collection system (i.e., infiltration). The fast response is characterized as runoff that enters the collection system immediately following a rainfall event via direct inflow through illegal connections, or below grade manholes. RDII volume and peak factors are determined through comparison of flows measured during periods with precipitation and dry weather flows.

4.0 Developing SSES Project Priorities

The first phase of SSES work involves flow monitoring the WCTS to determine which areas of the WCTS have excessive RDII, in order to determine which areas of the WCTS need further assessment and SSES work. The SSES project prioritization is split up into two phases which are described throughout this section. Phase I SSES projects are to be completed within 5 years of EPA’s approval of the SSES Work Plan, and Phase II includes SSES projects to be completed within 15 years of EPA’s approval of the SSES Work Plan.

4.1 Initial RDII Analysis

4.1.1 Normalized Net RDII

RDII is defined as the portion of I&I that is directly influenced by the intensity and duration of a storm event. The response generated by this component of I&I is an increase in the system flow during and after a rainfall event. This extraneous water enters the sewer system in direct response to rainfall through storm drains and other sources such as leaky manhole covers and defective sewers.

The Net RDII is defined as each sub-basins specific contribution to the cumulative RDII volume. The Net RDII is determined by calculating the volume of RDII measured at each flow monitor and removing the volume of RDII measured at upstream flow monitors. The Net RDII for each sub-basin is then normalized by dividing the net RDII by the total linear footage within each respective sub-basin. Normalization of the RDII allows for comparison of each basin against one another by providing a unit volume rather than an overall volume of RDII.

4.2 Phase I SSES Project Priorities

Utilizing the Phase I flow monitoring program, the sub-basins were ranked by Normalized Net RDII. The top five ranking Normalized Net RDII contributing basins were included in the Phase I SSES projects. These basins are shown geographically in Figure 4-1A of Appendix E.

The Phase I SSES projects include the following sub-basins:

Table 4-1
Phase I SSES Priority Sub-Basins

Phase I SSES Priority Sub-Basins
Chattanooga Creek 4
South Chickamauga Creek 1
South Chickamauga Creek 16
Dobbs Branch 3
South Chickamauga Creek 5

4.3 Phase II SSES Project Priority Criteria

The decision methodology for sub-basin schedule prioritization of the Phase II projects will be based on several prioritization parameters which include: RDII, SSOs, risk to impaired streams, relative age, environmental justice area concerns, and other factors as described below. The prioritization criteria will be incorporated into a scoring matrix. These scores will be normalized and weighted to ensure comparability and relative importance of each parameter in relation to the other parameters. The application of this methodology to the City's next 24 of the top 29 sub-basins will result in a priority list for performing SSES investigation and rehabilitation for the Phase II projects.

The Phase II SSES projects include the sub-basins shown in Table 4-2. These basins are shown geographically in Figure 4-1B of Appendix E.

Table 4-2

Phase II SSES Priority Sub-Basins

Phase II SSES Priority Sub-basins
Chattanooga Creek 3
Dobbs Branch 6
Chattanooga Creek 1
South Chick Creek 11
Citico Creek 3
Citico Creek 5
Chattanooga Creek 6
Tennessee River 6
Citico Creek 4
Dobbs Branch 1
Tennessee River 5
Citico Creek 2
Chattanooga Creek 2
Tennessee River 10
Mackey Branch 5
Friars Branch 13
Friars Branch 15
Dobbs Branch 2
Chattanooga Creek 5
South Chick Creek 9
South Chick Creek 15
Tennessee River 8

Table 4-2

Phase II SSES Priority Sub-Basins

Phase II SSES Priority Sub-basins
Lookout Creek 3
Mountain Creek 2

4.3.1 Phase II Priority Analysis

Phase II Analysis includes an analysis of Net Normalized RDII including data from the Phase I flow monitoring study as well as the City's annual flow monitoring program.

4.3.2 SSOs

The City maintains a database of SSOs throughout the WCTS that is tracked and reviewed in a SQL database. The SSO detailed information recorded includes location, date, duration, cause, discharge location, estimated volume, and other supplemental information. The quantity of wet weather SSOs for both major and minor events will be totaled for each sub-basin and then weighted for comparison in the prioritization matrix.

4.3.3 Impaired Streams TDEC CWA Section 303(d)

Impaired streams in the Chattanooga area are identified from the EPA's "303(d)" list. The proximity to sub-basins will be determined by comparing the length of impaired stream contained within the sub-basin with the length of sewer in the basin. This comparison will present values that will then be weighted for comparison in the prioritization matrix. Figure 4-2 is a map of the impaired streams in relation to the sub-basins and can be found in Appendix F.

4.3.4 Environmental Justice Areas

As a part of an updated Chattanooga Master Plan, the environmental justice areas will be compared with the sub-basins. The percentages based on low-income and minority population densities will be averaged to obtain a combined "severity level" of environmental justice concerns for each sub-basin. The sub-basins will then be ranked in order of severity with the most severe ranking receiving a ranking of one. Figure 4-2 is a map of the environmental justice concerns delineated by sub-basin and can be found in Appendix G.

4.3.5 Preliminary Sewer Assessments

Preliminary sewer assessments including existing sewer capacities from the hydraulic model, areas in need of repeat maintenance due to excess silt or debris, or other studies resulting from other city based assessments will be represented in the analysis.

4.3.6 Customer Complaints, Nature and Extent

Customer complaints are recorded through the City of Chattanooga's 311 system program and the data received from complaints are handled on a regular basis through the City's annual cleaning and rehabilitation program. Any complaints resulting from SSOs will be included in this analysis represented in the SSO criteria.

4.3.7 Underway Remedial Measures

The City currently has an annual SSES and rehabilitation program which focuses on customer complaints, emergency repairs, field work orders, and other known concerns throughout the system. The priority determination will be used as a basis for scheduling future measures when determining priority and measures already in process will be removed from the rankings.

4.3.8 Flow Isolation Studies

Flow isolation studies may be performed as necessary to specifically target significant sources of I&I. This data may be utilized to prioritize specific study areas where the entire sub-basin may not have been determined to be a priority but when other factors show signs of significant I&I.

See standard specification 33 01 30.22 Flow Isolation Inspection of Underground Sewer Pipelines located in Appendix I for flow isolation study procedures.

4.3.9 Other Factors in Priority Determination

The age of the gravity sewer components of the WCTS will also be used as a parameter when developing the prioritization of the sub-basins. The City will utilize its GIS system, which includes the installation date of the system components, to give each sub-basin a priority ranking averaging the installation dates throughout the sub-basin.

4.4 Prioritization Analysis Matrix

The purpose of the matrix will be to utilize the priority criteria to categorize the different sub-basins into priority groups that will assist the City in determining the order of SSES investigation. Three priority groups will be chosen to provide the WRD with manageable rational milestones for completing the inspections. These priority groups are identified as: high priority which need immediate attention and is represented in the five Phase I projects, intermediate priority which can be deferred until after the high priority is complete and will consist of the next 24 sub-basins to be completed in Phase II, and low priority which can be completed as time and budget allow and through the Gravity Line Preventative Maintenance Program (GLPMP). The identification of these groups will be based on the summation of the score for each parameter in a given sub-basin, then comparing the total score to the scores for the other sub-basins to determine the order of priority in performing the SSES.

Initially, each parameter will be scored differently, e.g. using count of structural and service defects, value of peak to average ratio for RDII, and total length of water bodies.

So that scores are independent of basin size, all scores will be divided by the total linear footage of sewer in the respective sub-basins. Furthermore, the scores will also be normalized on a scale of 1 to 10 so that they can be compared equally across the different parameters. For each parameter, the sub-basin with the highest overall value will receive a score of 10.

All other sub-basins will then be rated relative to the sub-basin with the highest score, thus receiving scores between 0 and 10.

5.0 WCTS Condition Assessment and Rehabilitation

5.1 Information Management

5.1.1 SSES, Gravity Sewer, and Manhole Data

The City has developed standard specifications and requirements for the collection of SSES data. This includes conformity to NASSCO standards for Pipeline Assessment & Certification Program (PACP) and Manhole Assessment and Certification Program (MACP) inspections, delivery of a compliant NASSCO exchange database format, and specific media file (video, photo, PDF reports) naming conventions. The City requires that smoke test inspection records be submitted in a consistent standard data structure. Selected vendors are required to collect data as described throughout Section 5 of this document and the SSES specifications as found in Appendix I. See Attachment A- Field Data Delivery Format Requirements located in Appendix I for an overview of how SSES data is to be provided to the City.

Upon receipt of the SSES data deliverable, the City of Chattanooga conducts a systematic QA/QC audit on the data submittal to assess the level of compliance with specifications.

Approved data including databases, CCTV videos, inspection field reports, observation photographs, and other supplemental files related to the SSES are stored on a network share drive that is maintained and archived by the City.

All gravity sewer and manhole rehabilitation data will be collected and maintained on a list in the City's database server which will allow querying and reporting of the records and viewing in GIS maps.

5.1.2 GIS Data

The City's sewer asset inventory GIS data is stored in a GIS database, which is maintained and archived by the City.

SSES inspection records will be compared to the City's GIS asset inventory. This includes resolving any asset ID conflicts, and any pipe length, diameter, shape, and material discrepancies, and updating the GIS asset inventory to include structures identified during SSES that were previously unmapped.

All SSES inspection and observation records, when feasible, are integrated into the City's GIS asset inventory. This allows for direct access to all inspection records and related media files from the asset inventory as well as viewing the locations of SSES observations.

5.1.3 Pump Station and Force Main Data

Pump Station and Force Main Data consists mainly of checklists, work orders, and reports maintained as described in the Pump Station Preventive Maintenance Program. This data is contained in the City's Asset Management System and managed and populated by

maintenance staff through work orders. This process is described more thoroughly in the City's Pump Station Preventive Maintenance Program and workflow charts depicting this process are included in the Appendix A of the document.

Pump Station and force main rehabilitation will be tracked through the City's Asset Management System as outlined in the Pump Station Preventive Maintenance Program.

5.2 Manhole Condition Assessment and Rehabilitation

5.2.1 Standard Procedures for the Condition Assessment of Manholes

Manhole Inspections will be performed on accessible manholes in the sub-basins as determined by the project prioritization. See section 33 01 30.29 Inspection of Sanitary Sewer Manholes located in Appendix I for manhole condition assessment procedures.

5.2.2 Standard Procedures for Manhole Rehabilitation

Manholes located within the project priority sub-basins will be reviewed for defects. Manholes with defects will be reviewed more thoroughly to develop the required rehabilitation techniques necessary to remove I&I and repair any structural defects encountered. The assessment of which defects are to be corrected are discussed below in section 5.4. Manhole rehabilitation will be broken up into 2 categories: 1) subsurface manhole rehabilitation; or 2) surface manhole rehabilitation.

5.2.2.1 Subsurface Manhole Rehabilitation

Subsurface manhole rehabilitation includes non-destructive manhole rehabilitation utilizing either cementitious or polymer resin-based products.

Standard methods and procedures for subsurface manhole rehabilitation are found in specification Section 33 01 30.83 Subsurface Manhole Rehabilitation in Appendix J.

5.2.2.2 Surface Manhole Rehabilitation

Surface manhole rehabilitation includes the use of manhole inflow dish inserts or manhole frame chimney seals to reduce I&I from entering the manhole.

Standard methods and procedures for surface manhole rehabilitation are found in specification Section 33 01 30.84 Surface Manhole Rehabilitation in Appendix J.

5.3 Closed Circuit Television (CCTV) Inspection

CCTV Inspection will be performed on accessible piping in the sub-basins as determined by the project prioritization. Generally, pipes less than 24 inches in diameter will have Preconditioning and Cleaning and CCTV inspections performed and pipes with sizes 24 inches in diameter and greater will have a combination CCTV and sonar inspection performed.

5.3.1 Standard Procedures CCTV Cleaning, CCTV, and Sonar Inspection

See standard specifications 33 01 30.14 Preconditioning and Cleaning of Underground Sewer Pipelines and 33 01 30.16 Closed Circuit TV Inspection of Existing Underground Sewer Pipelines located in Appendix I for CCTV cleaning and CCTV inspection procedures.

See standard specification 33 01 30.27 Sonar Inspection of Existing Underground Sewer Pipelines located in Appendix I for combination sonar and CCTV inspection procedures.

5.4 Gravity Sewer Line Defect Analysis and Rehabilitation

5.4.1 Standard Procedures for Analysis of Gravity Sewer Line Defects

NASSCO-standard databases contain records for each CCTV inspection run and the condition observed by the operating crew. These conditions (observations) are electronically coded and include data that will be leveraged for analysis. Such data generally includes:

- Pipe reference and associated manhole references;
- Observation type (crack, infiltration, water level reading, general photograph, etc.);
- Distance from end of pipe;
- Clock position in pipe;
- Standardized severity codes; and
- Associated photographs.

Condition records will be checked for quality by using the database information to import them into GIS. Common errors will be highlighted by this process, such as typographical errors in reference fields (pipe, manhole, etc) or inspections being performed in a pipe other than the one labeled. Databases with such errors will be rejected until the errors can be corrected. Once corrections are made to such errors and the spatially referenced conditions exist as points in ArcMap, manual quality control of captured data is greatly facilitated. This quality control consists of scanning a planview of the SSES project area and accessing pictures and video through hyperlinks, enabling a user to quickly identify the worst-case structures and review these and nearby structures in greater detail. Once the quality of the data is deemed acceptable, tabular functions in ArcMap enable the creation of input tables for the logical rehabilitation assessment.

5.4.1.1 Defect identification procedures and guidelines

Most observation codes are identifiable as defects worthy of evaluation for rehabilitation. Some codes, however, are intended for structural features or general observations, and these will not be considered as defects for purposes of rehabilitation evaluation. Codes that are not considered defects include:

- Access points (manholes, cleanouts, etc.);
- Taps that are not defective or intruding;
- Point repairs that are not defective;
- Several miscellaneous codes, including:
 - General observations and photographs;
 - Changes in joint length, lining, pipe material, pipe size, or pipe shape;

- Water levels not caused by sags; and
 - Abandoned survey codes (which should always be paired with a corresponding defect code that is the cause of the abandoned survey).
- Lining failures for abandoned connections.

All remaining codes will be considered as defects and will be considered for rehabilitation, utilizing a logical assessment process.

5.4.1.2 Cataloging Defects

NASSCO provides a mechanism for scoring internal pipe defects based on their type and severity. Defects are assigned a grade of 1 through 5, with 1 being a minor defect and 5 being the most significant defect grade. These grades alone are insufficient to select rehabilitation measures, but are a critical input to the assessment logic. There are two types of defects that are considered: 1) structural and 2) operations & maintenance (O&M).

In general, structural defects represent damage or failure of the pipe which can only be addressed through rehabilitation measures. These measures may include point repairs, lining, or replacement through pipe bursting or open excavation. Some examples of structural defects are cracks, holes, or exposed concrete aggregate. Structural defects receive a “structural grade” indicating severity. On the other hand, O&M defects consist of foreign materials in the pipe that may reduce the system capacity, such as gravel or roots. These defects are commonly addressed through cleaning. O&M defects receive an “O&M Grade”. For rehabilitation assessment, only structural defects and their associated structural grades are considered.

The structural grade of each defect is calculated based on the standard mechanism called for in the NASSCO PACP standards. These grades are used to compose a structural pipe rating that offers a quick glimpse into the severity of any pipe.

5.4.2 Gravity Sewer Line Rehabilitation

5.4.2.1 Rehabilitation Prioritization

Utilizing the CCTV and sonar inspection data, the rehabilitation of the piping will be prioritized to reduce I&I and reduce the risk of future SSOs. NASSCO-approved databases containing inspection and defect information will be analyzed to produce rehabilitation recommendations on the associated pipes. The analysis will consist of integration of the SSES data with the GIS environment (as described in Section 5.1.2), followed by the application of a rehabilitation support tool built to apply rehabilitation selection logic to each pipe that was inspected.

5.4.2.2 Initial Rehabilitation Recommendations

Following the collection and quality control of defect coding, the pipe segments within each sub-basin determined necessary for rehabilitation will be processed through the initial rehabilitation recommendation process. This process is a standard method for analyzing the system uniformly to determine the piping necessary for rehabilitation. The rehab assessment tool will be automated utilizing the following five basic principles:

1. Focus on grade 4 and 5 defects in addition to infiltration defects.

2. Address significant sags in pipe.
3. Assess relative location of defects and facilitate full vs. partial segmental rehab.
4. Address mains, manholes, and laterals in relation to each other.
5. Eliminate insignificant defects.

The results from the initial rehab assessment will then be reviewed for constructability. This review includes a review for anomalies in the data and a spot check of “no rehab” sections as well as the recommended lateral and manhole rehab methodologies.

5.4.2.3 Final Rehabilitation Recommendations

Once all initial rehab assessment has been completed, the piping will then be analyzed for final design and construction. All initial assessments will be reviewed and verified to determine that the correct methods of rehabilitation have been chosen based on constructability, full vs. partial rehabilitation, environmental concerns, and cost.

5.4.2.4 Gravity Sewer Line Rehabilitation Procedures

The City will generally utilize the following rehabilitation techniques to perform the gravity sewer line rehabilitation:

- Cured-in-Place Pipe (CIPP);
- CIPP Lateral Rehabilitation;
- Pipe Bursting;
- Open Cut Replacement;
- External Point Repair; and
- Internal Point Repair.

Standard procedures for CIPP, CIPP lateral rehabilitation, and pipe bursting are included in the standard specifications found in Appendix J.

Additional techniques may be utilized if deemed necessary and the City will review and approve these rehabilitation techniques on a case-by-case basis.

5.5 Force Main Condition Assessment and Rehabilitation

Force mains will be determined for condition assessment or rehabilitation based on several factors including SSOs, age, work orders, master planning, and capacity. Once determined necessary for assessment or rehabilitation, the City will determine the necessary techniques to be utilized and may perform the assessment or rehabilitation through their maintenance program or by a contractor.

5.5.1 Force Main Inspection Procedures and Technologies

Prior to performing field inspections, a force main (FM) will be assessed through an initial review utilizing typical data gathering activities. An example of data to be analyzed can be found in Table 5.1 in Appendix L. Table 5.2 in Appendix L details typical field preparation activities that are used in FM analysis as well. Inspection of FMs will be in accordance with Water Environment Research Foundation’s (WERF) *Inspection Guidelines for Wastewater Force*

Mains and field inspections will utilize PACP forms or a FM Inspection Form similar to the form located in Appendix K.

5.5.1.1 Physical Inspection Methods

CCTV and Sonar will be utilized for FM inspections as necessary, assuming the piping can be taken out of service. CCTV and Sonar should meet the requirements as described in Section 5.3 of this document.

5.5.1.2 Corrosion Defect Identification Inspections

FMs may be investigated for evidence of corrosion and corrosion potential using non-destructive testing (NDT) external (non- pipe), external (pipe surface), and/or internal (to the pipe) means. Limited destructive testing may also be utilized.

5.5.1.2.1 External (non-pipe) Surveys

External surveys may consist of the following:

- Close Interval Potential (CIP) – pipe to soil surveys on cathodically protected or electrically continuous pipelines.
- Geotechnical information review – evaluation of geotechnical data from prior construction or other investigations looking for foundation issues, unsuitable soils and high or fluctuating ground water table in the pipe bedding zone.
- Soil and water chemistry – soil conductivity and resistivity sampling employing Wenner 4 Pin Method, 2 Pin Method and Soil Box Method for total soil acidity and soil pH; ground water sampling for chlorides, sulfates, and Langelier Index.
- Adjacent utilities review – identify utilities with cathodic protection (CP) systems that may create stray current corrosion potential affecting ferrous pipes.

5.5.1.2.2 External (pipe surface) Surveys

Surveys conducted on the pipe surface or on pipe appurtenances may consist of the following:

- Acoustic average wall thickness – ferrous, PCCP/RCP, PVC and asbestos cement (AC) materials.
- Acoustic emissions testing (AET) – detect wire breaks and wire/pipe related events in PCCP, BWP.
- Ultrasonic (UT) thickness – ferrous materials.
- Magnetic flux leakage (MFL) – external or internal measure of ferrous wall thickness and defect identification, 360-degrees axial direction along pipe.
- Broadband Electro-Magnetic (BEM) - external or internal measure of ferrous wall thickness and defect identification, 360-degrees axial direction along pipe.

5.5.1.2.3 Internal (to the pipe) Surveys

Internal (in the flow stream) surveys may consist of the following:

- Acoustic leak/air pocket detection – all pipe materials via fixed location, tethered or free-swimming platform.
- MFL – see description in 5.5.1.2.2
- BEM – see description in 5.5.1.2.2
- Remote field eddy current (RFEC) – detect wire breaks and wire/pipe related events in PCCP, BWP via crawler, tethered or free-swimming platform.

5.5.1.2.4 Destructive Testing

Destructive testing may consist of the following:

- Coupons - Removal of pipe wall samples for metallurgical and/or radiographic inspection. This can be done with operating assets, stock or removed pipe material and is typically ferrous or AC materials.
- Continuity testing – Removal of outer layer of concrete on PCCP and BWP to test wires/bars for electrical continuity and observe corrosion or other material distress that might result in loss of hoop stress in pipe.

5.5.2 Force Main Defect Grading and Analysis

Following inspection of the force main, identified defects will be reviewed according to severity using NASSCO's PACP defect grading scale along with other information collected depending on the inspection techniques utilized. This data will be used to determine further assessment and/or rehabilitation and also to schedule further maintenance and future work orders if necessary.

5.5.3 Force Main Rehabilitation Effectiveness

In addition to post-construction flow monitoring, rehabilitated FMs will be scheduled for periodic physical inspections – generally, a baseline after construction and “in service” of rehabilitated pipe followed by periodic monitoring based on an accepted duration criteria estimated from the mean expected remaining useful life of the refurbished FM. Inspection will consist of visual checks and spot wall thickness measurements.

5.5.4 Air Release Valve (ARV) Program

Identification and inspection of all of the ARVs will be performed by the City as a continuous improvement item in the Pump Station Preventive Maintenance Program. Most of the ARVs are located in manholes and inspections can be performed without interruption to pumping operations. Location coordinates will be logged using GPS and the information will be imported into GIS. An initial inspection will be conducted when the ARVs are located. The City will develop a plan for maintenance and replacement. Preventive maintenance work orders will be tracked in the City's asset management database. As feasible, the City will utilize specifications to standardize ARVs to simplify valve maintenance and so replacements can be made during inspections, where required.

5.6 Smoke Testing

Smoke testing will be performed when possible in sub-basins as determined by the project prioritization. The smoke testing will be performed as described in the standard specification and will be utilized to assess the system for significant sources of I&I.

See standard specification 33 01 30.24 Smoke Testing of Underground Sewer Pipelines located in Appendix I for smoke testing procedures.

5.6.1 Private Lateral Investigations

Private lateral investigations will be completed through main line CCTV or through smoke testing inspections in sub-basins as determined by the project prioritization. The City will analyze smoke testing anomalies that land on private property and split them into the following three categories:

- Lateral line anomalies;
- Cleanouts; and
- Other (new lines with unbuilt homes, public owned property, home gutters or home storm drainage connections, etc.).

Each property with an anomaly will be assigned a case number and the City will send certified notification letters and additional warning letters to follow up if necessary. The lateral line anomaly letters offer information about the City's Sewer Lateral Assessment Program (SLAP) grant program for possible financial assistance to fix the anomalies. The City also has an ongoing program to cap or replace cleanouts.

Depending on the anomaly, the case will be closed with either pictures, plumbing inspection tags, communication with plumbers, or other methods of communication.

The City will also request through notification letters that laterals no longer in service will be closed off.

5.7 Pump Station Performance and Rehabilitation

5.7.1 Capacity and Performance Evaluation

Pump capacity and performance may be evaluated utilizing various methods depending on the setup of the pump station. Pump run time meters will be used at the majority of the wastewater collection pump stations. Flow meters are read at the 6 major stations as well as 24 other smaller stations. During routine operational visits, PS operators will collect flow meter readings and pump runtime readings. Where necessary, flow meter readings are recorded on a form and entered into the Hach-WIMS (Water Information Management System) to assist with billing certain customers. Pump runtime readings are recorded in the station logbook for operator review. An example Flow Meter Reading form is located in the Appendix of the Pump Station Operations Program. Pump start counters are located at all of the wastewater collection pump stations. The PS pump status is collected twice per shift at the MBWWTP for a total of four times daily in accordance with SOP PS-0005. The Pump Status Checklist is used to document that a PS's pumps are operating as expected. The Pump Status Checklists are kept on file at

the MBWWTP. Any abnormal issues resulting from the checklists are documented in the plant Operations Room Logbook and are reported to the appropriate work center, often PS Operations. An example PS Status Checklist is located in the Appendix of the Pump Station Operations Program.

Pump station capacity will be evaluated using methods described in the Water Environment Federation's (WEF) Manual of Practice FD-4, *Design of Wastewater and Stormwater Pumping Stations*. Property information from GIS will be used to estimate number of connections, current land use, available land for development, and existing infrastructure. Utilizing these available tools with existing master planning documents, the current and future theoretical capacity of each pump station sub-basin can be estimated and compared against design capacity and actual field results. In instances where the flow values are not in alignment, those pump stations will be identified for upgrades. Pump stations will also be evaluated for conformance with the design guidelines established in "Ten States Standards". For example, the City's standard specifications as well as "Ten States Standards" require the pump station to be capable of handling the peak flow with the largest pump out of service. The actual peak pumping rates will be compared to the design rate and system curve. Differences in these values will be evaluated and can indicate possible issues.

The Nominal Average Pump Operating Time (NAPOT) will be computed by using runtime data over a 1 year assessment period for the stations with fixed speed pumps. The total run time in hours for a station will be summed over the assessment period. The sum will be divided by the number of days in the assessment period and the result in hours/day will be divided by the sum of the total pumps in the station minus one. This value will be considered the NAPOT. If the NAPOT is greater than 10 hrs/day, the station will be identified as needing additional investigation. The NAPOT for stations with variable frequency drives will be computed using records of power consumption over the assessment period.

A Root Cause Failure Analysis may be conducted for pump stations with a history of operational failures. This analysis will begin with a data collection investigation to determine the events that have led to pump station failures and their consequences. The assessment protocol will document the individual components of the pump station determine the failure modes, failure causes, and the failure consequences for each. Through this assessment, patterns of events will be recognized and recommendations for early detection and corrective actions can be made.

5.7.2 Pump Controls Evaluation

The pump stations have SCADA alarms and telemetry to communicate wet well level, pump on/off, and other related information. The City is in the process of a system-wide SCADA upgrade. Review of SCADA data such as start/stop times, accumulated run-times, and motor starts may be used in the calculation of the NAPOT.

The pump station capacity evaluation will use the hydraulic model and/or draw-down tests to confirm pumping performance and wet well capacity in all operating sequences. The evaluation may also involve temporary flow monitoring:

- Magnetic or Doppler flow monitors on force mains; and

- Open channel flow monitors on influent sewers (paddle or ultrasonic type).

5.7.3 Pump Station Condition Assessment

The City will assess the pump stations utilizing the processes set up in the Pump Station Operations Program and Pump Station Preventive Maintenance Programs along with the inspection form located in Appendix K.

The assessment will generally include the following components:

- Structural – Physical inspections will be used to assess structural condition of pump stations. Physical inspection sheets are located in the Appendix of the Pump Station Preventive Maintenance Program and inspection forms are located in Appendix K of this document.
- Equipment – Mechanical and electrical inspections will be used to assess condition of pump station equipment. Equipment in each station has its own schedule for PM and has been programmed into the City’s asset management system. Mechanical and electrical inspection sheets are located in the Appendix of the Pump Station Preventive Maintenance program.
- O&M history

5.7.3.1 Corrosion Defect Identification

Primarily visual inspection of structures and systems will be used to identify active or past corrosion as well as functional design and operation that might lead to corrosion exposure. This inspection will be performed as outlined in the Pump Station Preventive Maintenance Program and will generally include the items described throughout this section.

5.7.3.1.1 Structural Integrity

- Wet wells, influent structures, terminal manholes, splitter boxes (any structures exposed to raw wastewater flow) – concrete and metal components. Exposed reinforcing bars, spalling, rust.
- Above-grade facilities, dry wells, buildings (structures that might be exposed to H₂S or other corrosives that off-gas from raw wastewater as well as normal age-related deterioration) – concrete and metal components. Exposed rebars, spalling, rust, corroded fasteners, anchorages, crane rails and frames (other lifting apparatus).

5.7.3.1.2 Electrical and Mechanical Systems (components exposed to off-gas constituents as well as raw wastewater flow)

- Main switchboard, motor starters/VFDs, panelboards, transformers, lights, conduit. Presence of conduit seal-offs, coated conduit, NEMA 4/4X and 7 (explosion-proof) enclosures, conductor attachment, grounding wires, corroded windings. Standby power fixed generators and “plug-in” facilities.
- Instrumentation & control components. Similar to general electrical considerations for corrosion and functionality – especially note devices that immersed or otherwise exposed to raw wastewater (floats, venturi and other meters).

- Mechanical process equipment (handling raw wastewater). Pump supports, couplings, anchorages/bases, motors and associated electrical devices. Solids handling (macerators/grinders/comminutors, mechanical screens). Odor control and chemical feed equipment.
- Mechanical building equipment. HVAC components (fans, heaters, air conditioning, louvers), plumbing and fire protection sprinklers. Elevators, lifts, cranes (overhead, rail, jib). Standby power fueling and genset enclosures, fuel tanks and piping.

5.7.4 Inspection and Repair Prioritization

Inspection of FMs and pump stations will be documented using forms that may be completed by hand or electronically recorded in the field. As inspections are completed, items requiring urgent remediation will be identified. Urgent remediation will be defined as required when a failure has occurred or pending failure is evident that compromises facility operation such that an SSO could occur or that personnel safety is at risk. Repair of these urgent items will be prioritized as outlined in the Pump Station Preventive Maintenance Program. The pump station inspection forms to be utilized can be found in Appendix K.

5.7.5 Station Reliability Assessment

The Equipment Maintenance and Reliability Improvement Program (EMRIP) established a pump station criticality based on likelihood and consequence of failure. This documentation is used as a screening tool by the Pump Station Operations group to set priorities in routine and emergency operations including the operational visit. The Pump Station Operations Program lists the operational visit schedules. The City will utilize the information from pump station assessments to determine any deficiencies found with equipment and electrical components that affect the overall reliability of the station. These factors will be prioritized as described in the Pump Station Preventive Maintenance Program.

5.7.6 Station Operations and Maintenance Response Assessment

The City will evaluate critical response times by reviewing the time interval between high alarm wet well levels and when the first SSO in the system would begin under peak flow conditions. The critical response under peak wet weather conditions will be evaluated using the hydraulic model and existing system operation procedures, such as:

- Pump operation – sequence, lead-lag, any real time control data to “early start” or select pumps of different capacities based on expected or modeled flow;
- Wet well levels – activation (start/stop) of pumps and sequence for pumps of varying capacities, including pumps operated under variable speed (VS) conditions; and
- Estimated time to overflows – predicted time to overflow wet well and/or surcharge upstream manholes based on surveyed inverts or grades and hydraulic model geometry.

This evaluation will also include the estimation of the ability of maintenance personnel to take corrective action within the critical response time.

5.7.7 Pump Station Rehabilitation

The City currently has several Pump Station Upgrade Projects underway as determined by analysis from the Pump Station Preventive Maintenance Program and as outlined in the CD.

Pump Station rehabilitation techniques include:

- Pump and motor upgrades;
- Valve and piping improvements;
- Level and controls upgrades;
- SCADA improvements;
- Structural repairs and coating systems;
- Screening improvements; and
- Contingency plans (bypass connections, generators).

These projects have been determined to be of the highest priority and are listed in Table 5-1 below:

Table 5-1

Phase I Pump Station Projects

Phase I Pump Station Upgrade Projects
South Chickamauga Creek Pump Station
Pineville Pump Station
Altamont Pump Station
East Brainerd Pump Station
Orchard Knob Pump Station
Friars Branch Pump Station
DuPont Pump Station
Collegedale Pump Station

Additional rehabilitation projects will be prioritized and performed as outlined in the Pump Station Preventive Maintenance Program. The effectiveness of rehabilitation will be determined based on performance measures. These measures will be unique to each pump station rehabilitation project but will include measurable indicators such as flow rate, run times, pump starts, work orders, SSOs, etc. This data will be compiled and available through the SCADA system and the City's asset management system. Thus, if there is overlap between the Pump Station Preventive Maintenance Program and the SSES Work Plan for pump stations, the Pump Station Preventive Maintenance Program will control.

6.0 Analysis of Completed Rehabilitation Effectiveness

The effectiveness of completed rehabilitation will be assessed with data collected prior to and following rehabilitation efforts. In particular, the City will review completed work and further evaluate successful projects based on RDII removal and SSO reductions. The effectiveness of rehabilitation will be analyzed both on a project by project basis and on an overall CD program basis as described throughout this section.

6.1 Pre and Post Rehab Flow Monitoring

The City will continue their program to monitor flows within project priority sub-basins to establish flows prior to performing SSES and for a comparison following rehabilitation efforts. The City will install flow monitors for a minimum duration of 6 months, when feasible, prior to SSES and rehabilitation efforts. The flow monitors should be removed at the start of construction as data is not valid during bypassing scenarios and due to the possibility of being damaged while working. Following construction, flow monitors will be replaced when feasible and will record data over a comparable period.

The flow monitoring for pre- and post-rehab monitoring should follow the following plan:

Where: (Overall Basins)

- A monitor at the exit of the sewershed;
- A monitor at any entrance points to the sewershed; and
- Pre rehab monitors will be placed as soon as sewersheds are identified for project sewersheds.

Project Rehab Specific:

- Downstream of rehab and as close to the rehab as possible to eliminate as much of the un-rehabbed sewer as possible;
- Upstream of rehab and as close to the rehab as possible; and
- Pre rehab monitors will be placed as soon as rehab areas are identified (likely 30%).

Utilizing the pre- and post-flow monitoring data, the City will perform an RDII analysis as described in Sections 3 and 4 of this document.

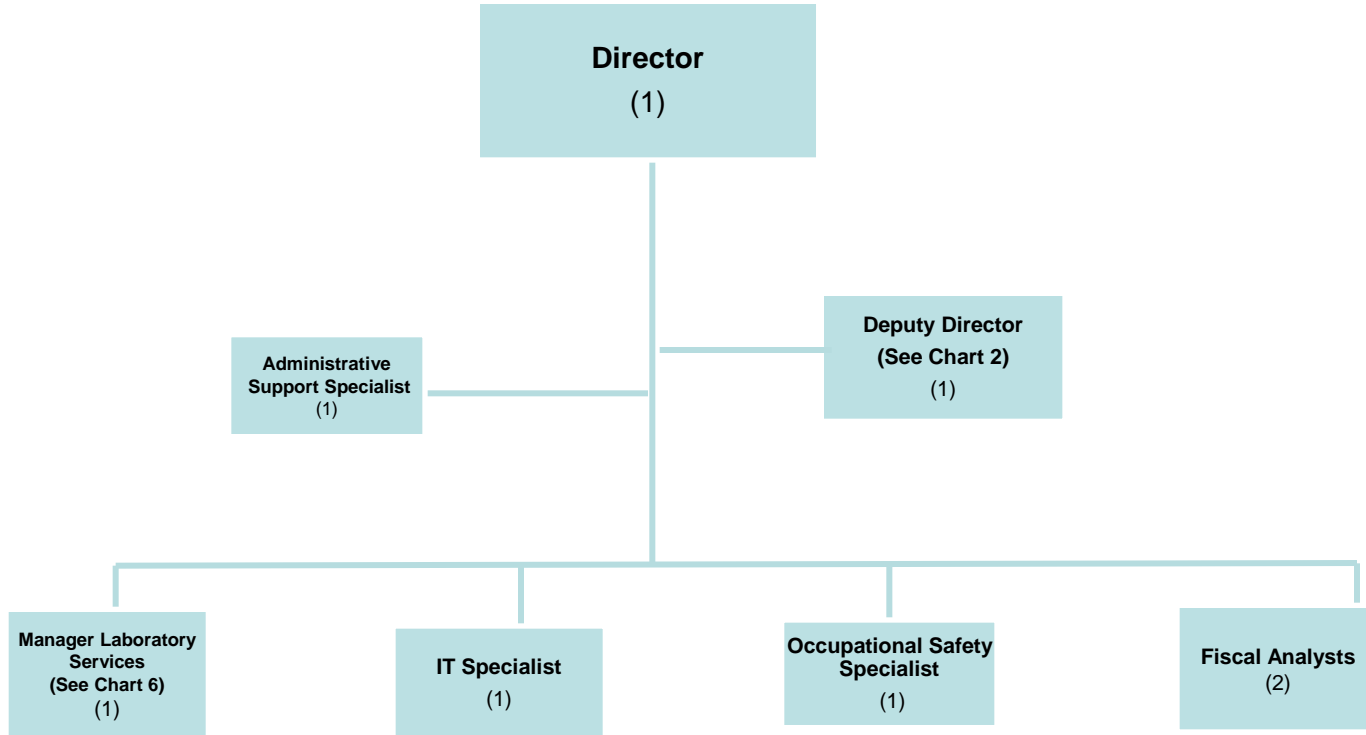
Comparing post-rehabilitation base flows and RDII volumes with pre-rehabilitation, along with actual RDII, will assist the City in determining the overall and project performance of the rehabilitation efforts.

6.2 SSO Trending

As discussed in Section 4.3.2, a complete database is collected and maintained regarding reported SSOs in the system. Wet weather SSOs will be trended on a regular basis to review project results. This trending will be performed utilizing charts and GIS maps to represent SSO quantity and volume and rainfall data trending over time. The City will review the SSOs reported occurring during pre-SSES and rehabilitation periods to like rainfall events during post-SSES and rehabilitation periods and make representative comparisons as a factor in evaluating the performance of the constructed rehabilitation. The City will also review sewer backup and customer complaint data that may be available in the same manner.

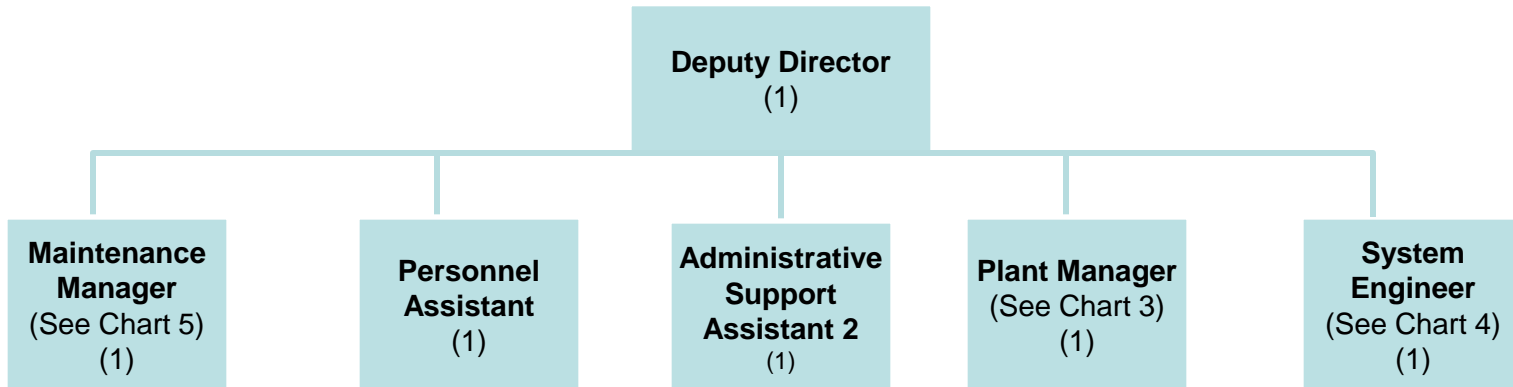
Appendix A
Waste Resources Division Organizational Chart

WASTE RESOURCES DIVISION
ORGANIZATIONAL CHART
(September, 2014)



WASTE RESOURCES DIVISION
ORGANIZATIONAL CHART

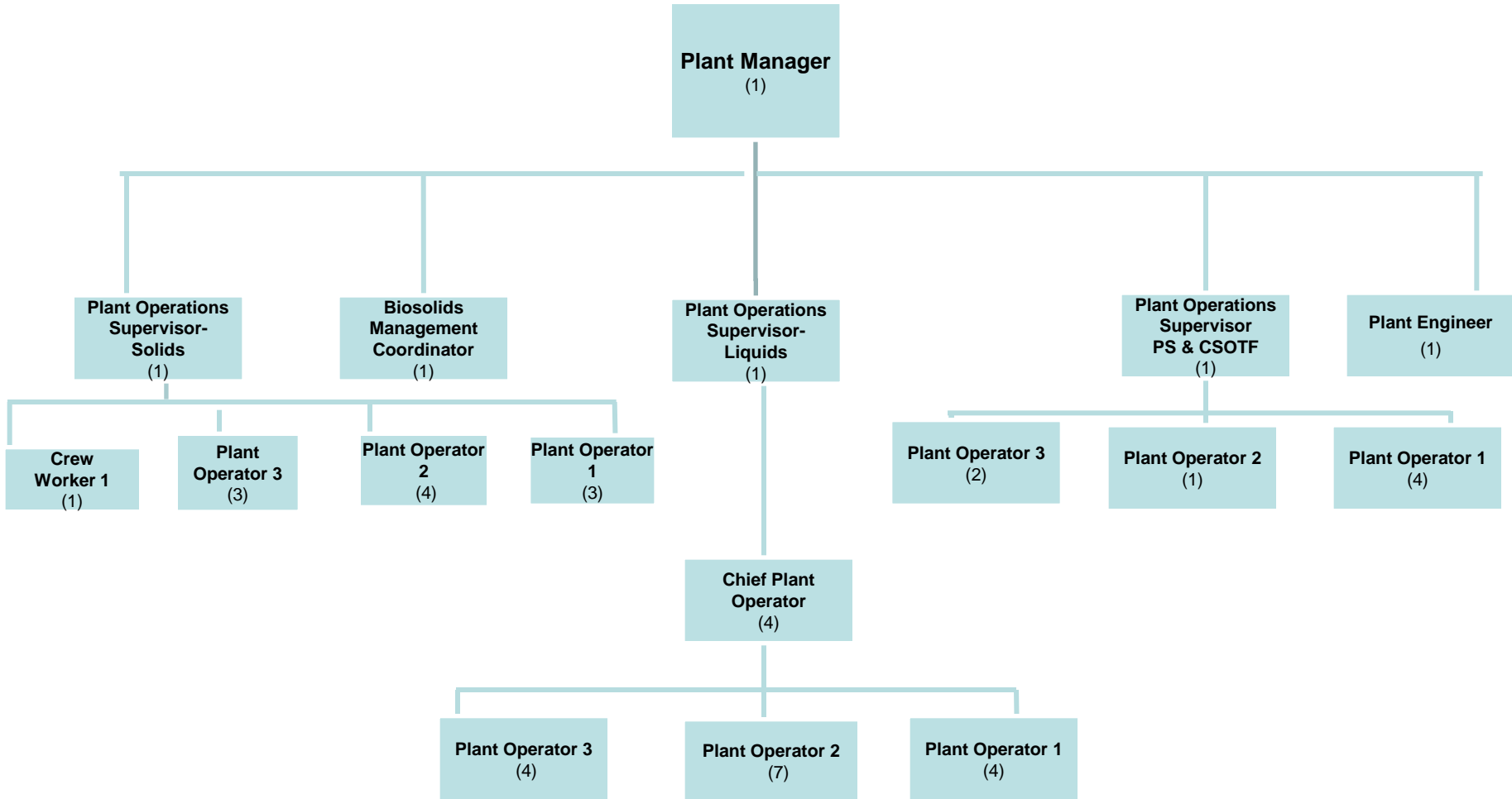
Chart 2
(September, 2014)



WASTE RESOURCES DIVISION ORGANIZATIONAL CHART

Chart 3

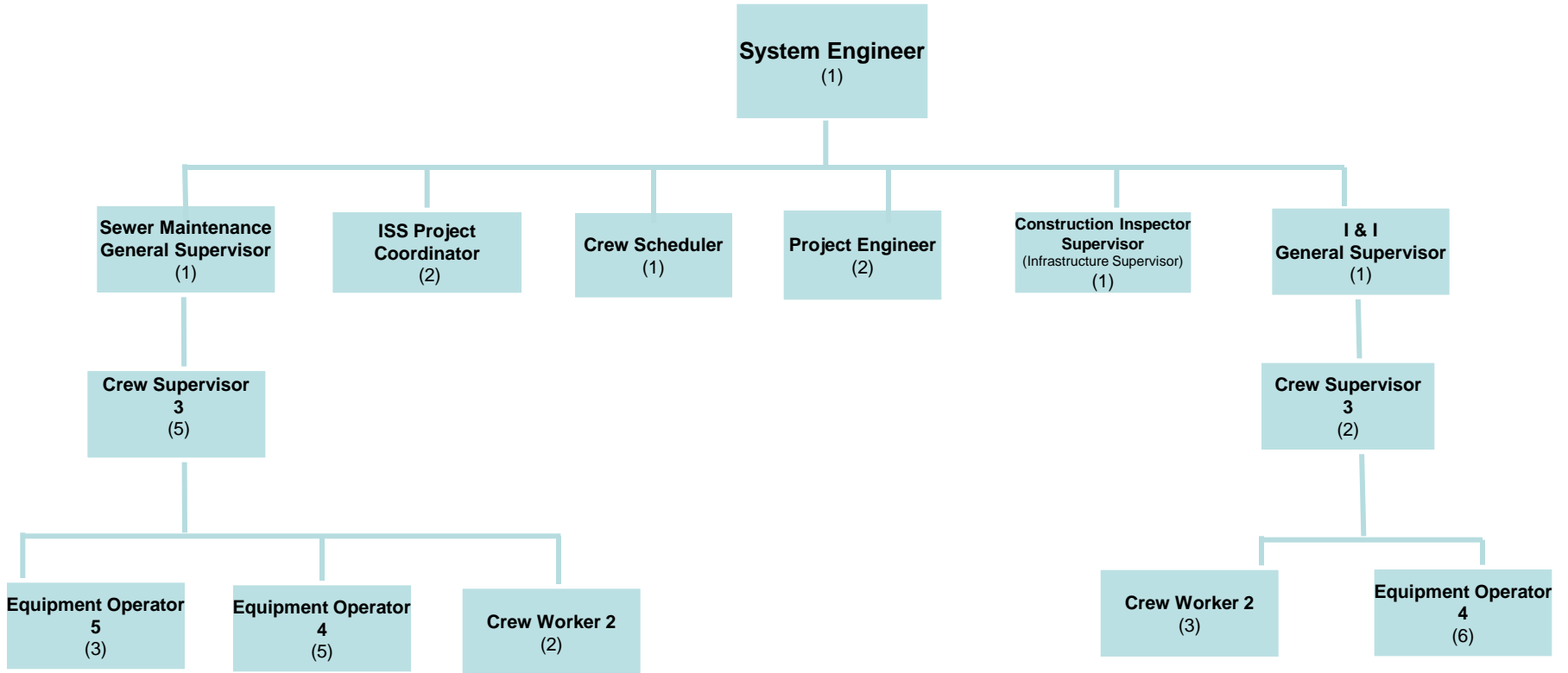
(September, 2014)



WASTE RESOURCES DIVISION ORGANIZATIONAL CHART

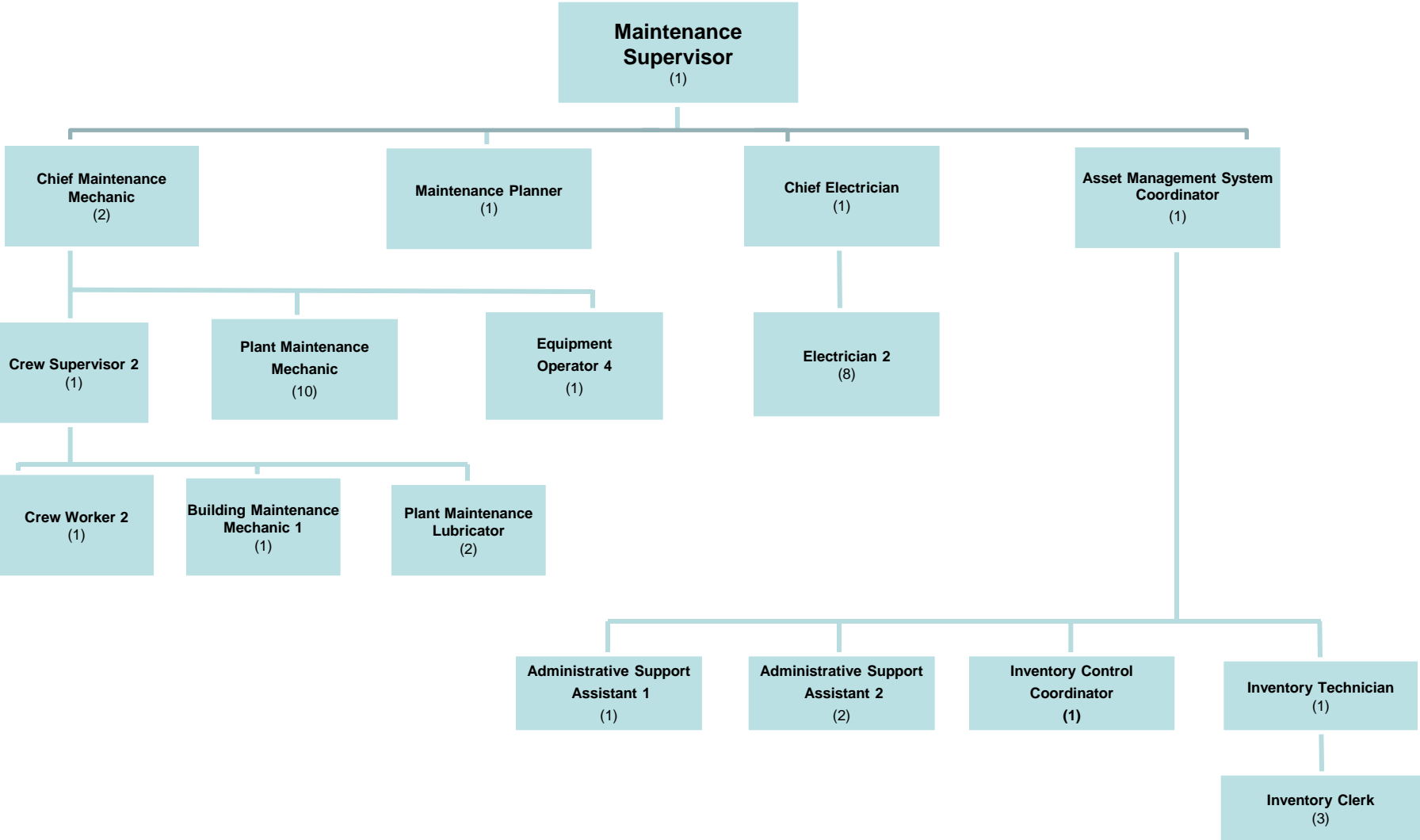
Chart 4

(September, 2014)



WASTE RESOURCES DIVISION ORGANIZATIONAL CHART

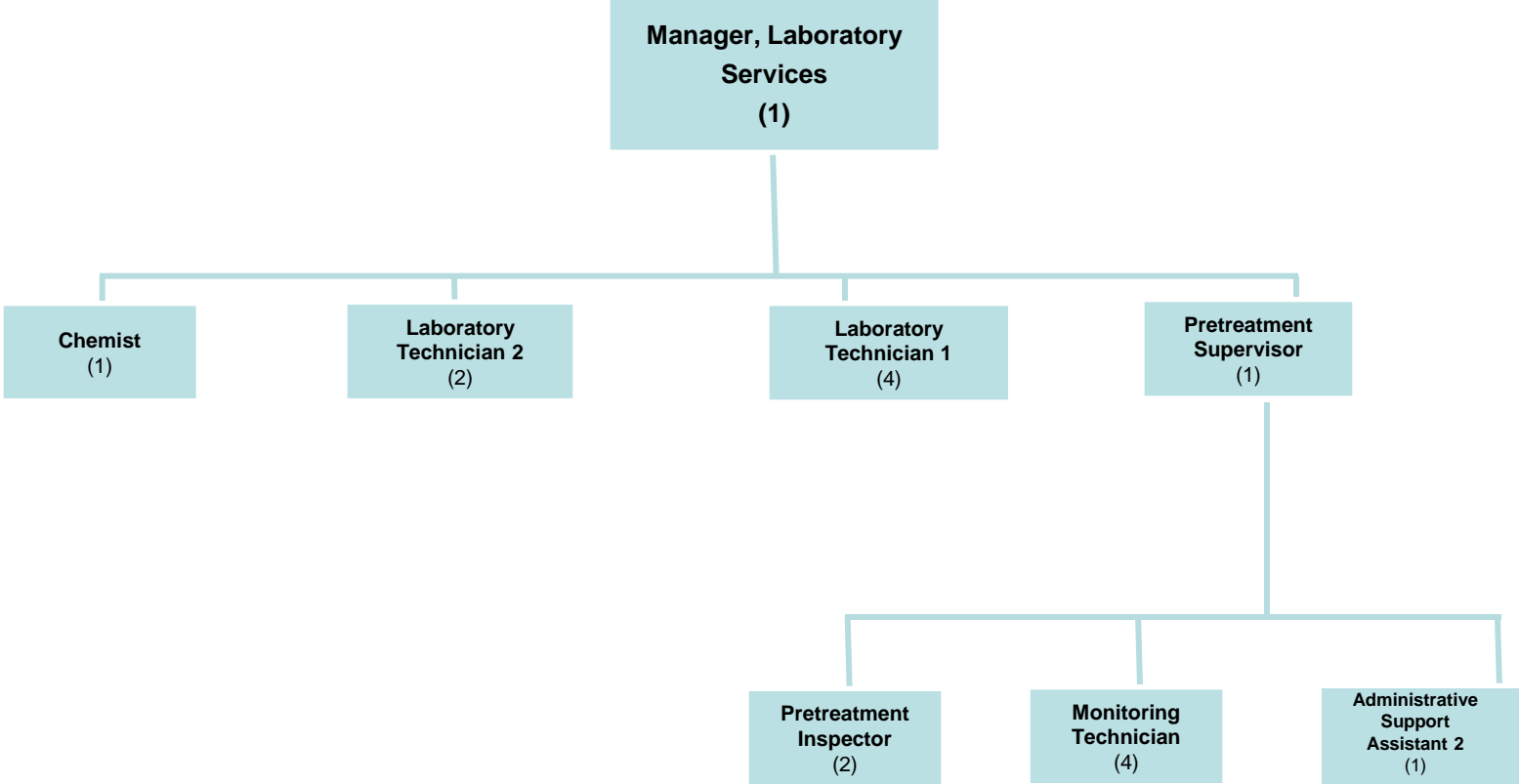
Chart 5
(September, 2014)



WASTE RESOURCES DIVISION ORGANIZATIONAL CHART

Chart 6

(September, 2014)



Appendix B
Sewer Basin Map Figure 2-1

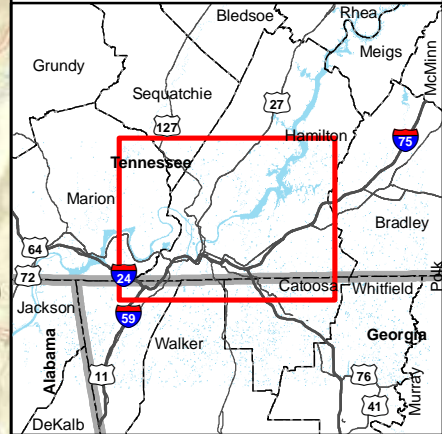
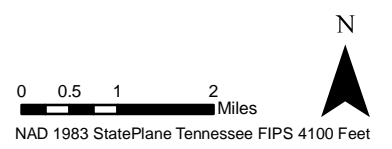
SSES Work Plan

Figure 2-1

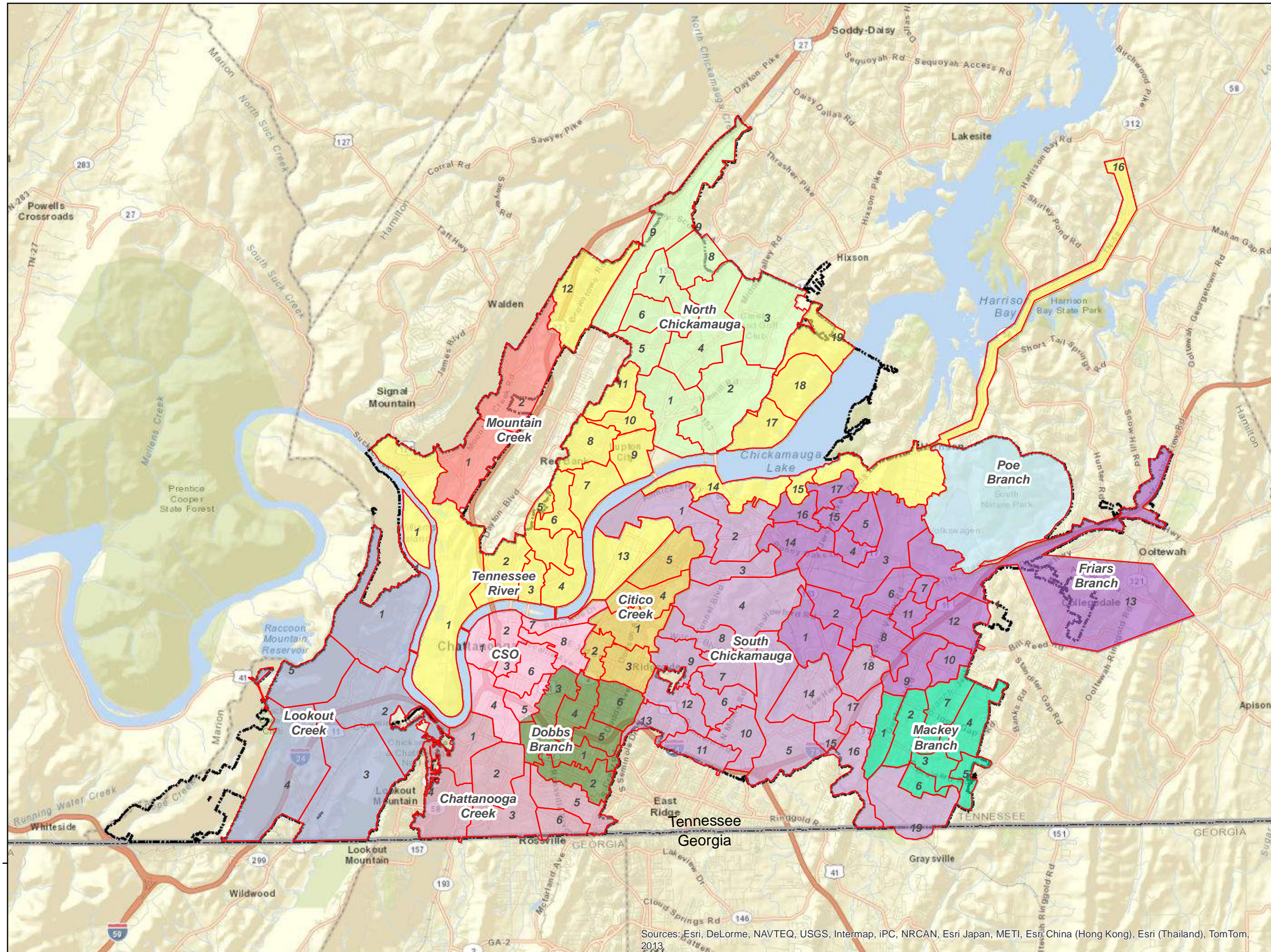
Sewer Basins and Sub-basins

Legend

- Sewer Sub-basins
- CSO
- Chattanooga Creek
- Citico Creek
- Dobbs Branch
- Friars Branch
- Lookout Creek
- Mackey Branch
- Mountain Creek
- North Chickamauga
- Poe Branch
- South Chickamauga
- Tennessee River
- Chattanooga City Limits
- US State Boundaries



Map Created: 9/10/2014 5:13:58 PM
 Project #: C6A02300
 Author: Rogers, Jonathan



Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, IPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013

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Appendix C
Pump Station and Force Main Map Figure 2-2

SSES Work Plan

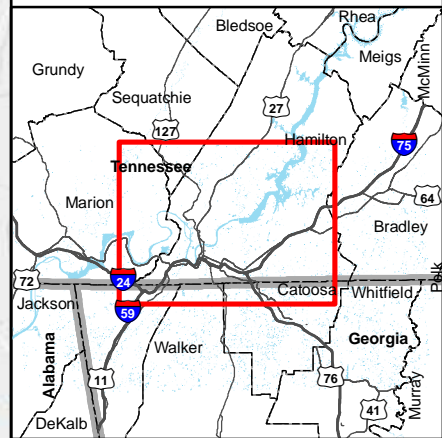
Figure 2-2

Chattanooga Sewer Pump Stations

Legend

- Sewer Pressurized Mains
- Highways and Interstates
- Sewer Pump Stations
- Sewer Sub-basins
- CSO
- Chattanooga Creek
- Citico Creek
- Dobbs Branch
- Friars Branch
- Lookout Creek
- Mackey Branch
- Mountain Creek
- North Chickamauga
- Poe Branch
- South Chickamauga
- Tennessee River
- Chattanooga City Limits
- US State Boundaries

0 0.5 1 2 Miles
NAD 1983 StatePlane Tennessee FIPS 4100 Feet

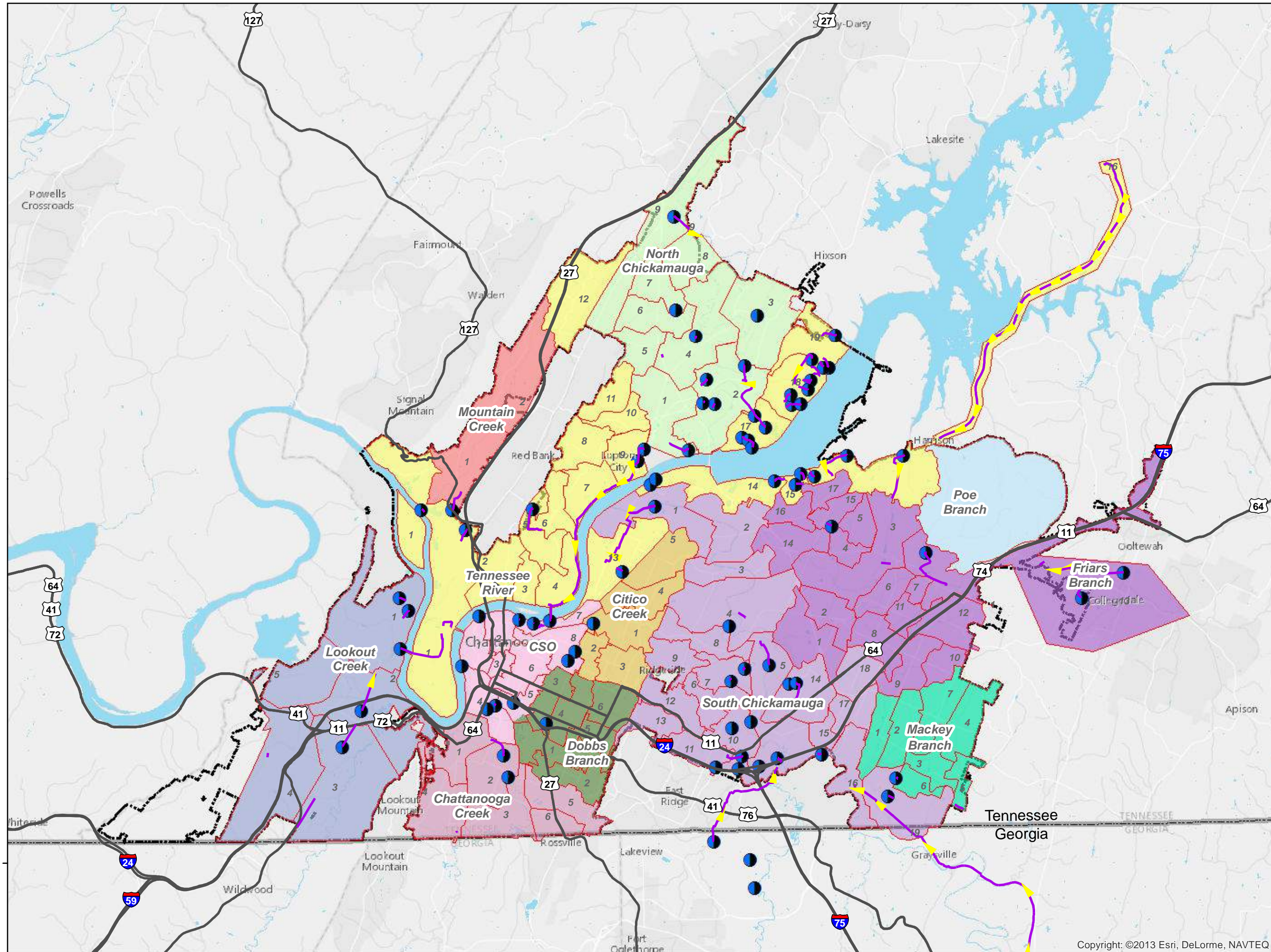


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Author: Rogers, Jonathan



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Appendix D
Rain Gauge Location Map Figure 3-1

SSES Work Plan

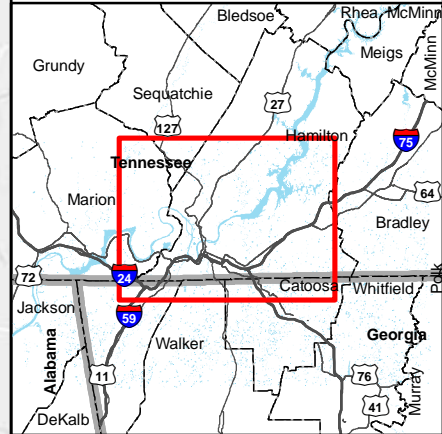
Figure 3-1

Chattanooga Rain Gauge Locations

Legend

- Rain Gauges
- Highways and Interstates
- Sewer Sub-basins
- CSO
- Chattanooga Creek
- Citico Creek
- Dobbs Branch
- Friars Branch
- Lookout Creek
- Mackey Branch
- Mountain Creek
- North Chickamauga
- Poe Branch
- South Chickamauga
- Tennessee River
- Chattanooga City Limits
- US State Boundaries

0 0.5 1 2 Miles
NAD 1983 StatePlane Tennessee FIPS 4100 Feet

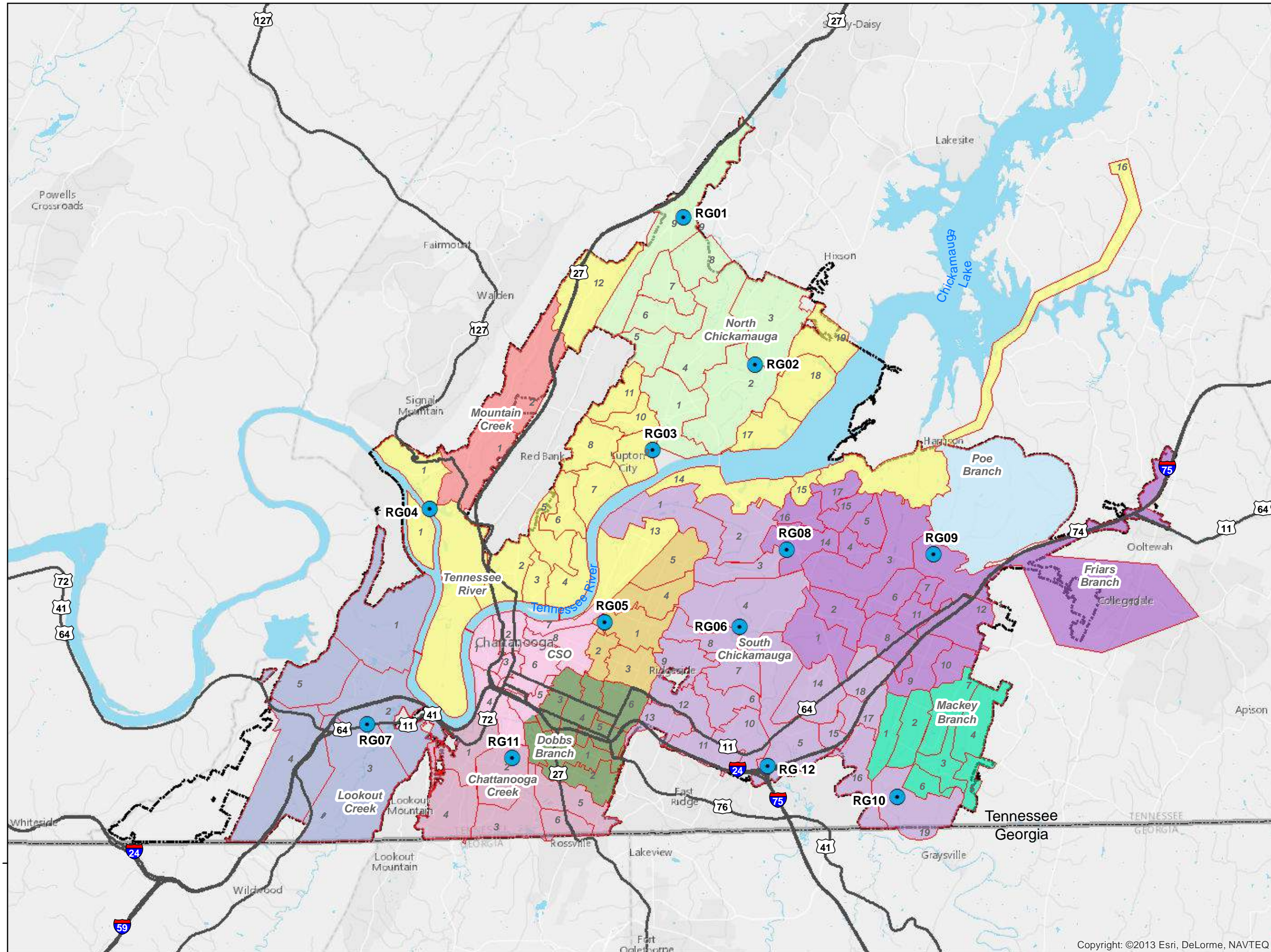


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 Author: Rogers, Jonathan



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Appendix E
Phase I and II Priority SSES Sub-basins

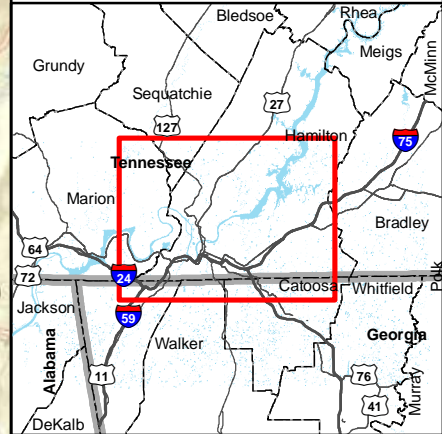
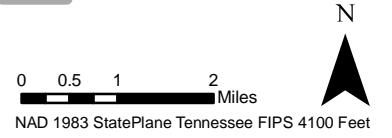
SSES Work Plan

Figure 4-1A

Phase I SSES Project
Priority Sub-basins

Legend

- Sewer Sub-basins
- Top 5 Sewer Sub-basins
- CSO
- Chattanooga Creek
- Citico Creek
- Dobbs Branch
- Friars Branch
- Lookout Creek
- Mackey Branch
- Mountain Creek
- North Chickamauga
- Poe Branch
- South Chickamauga
- Tennessee River
- Chattanooga City Limits
- US State Boundaries

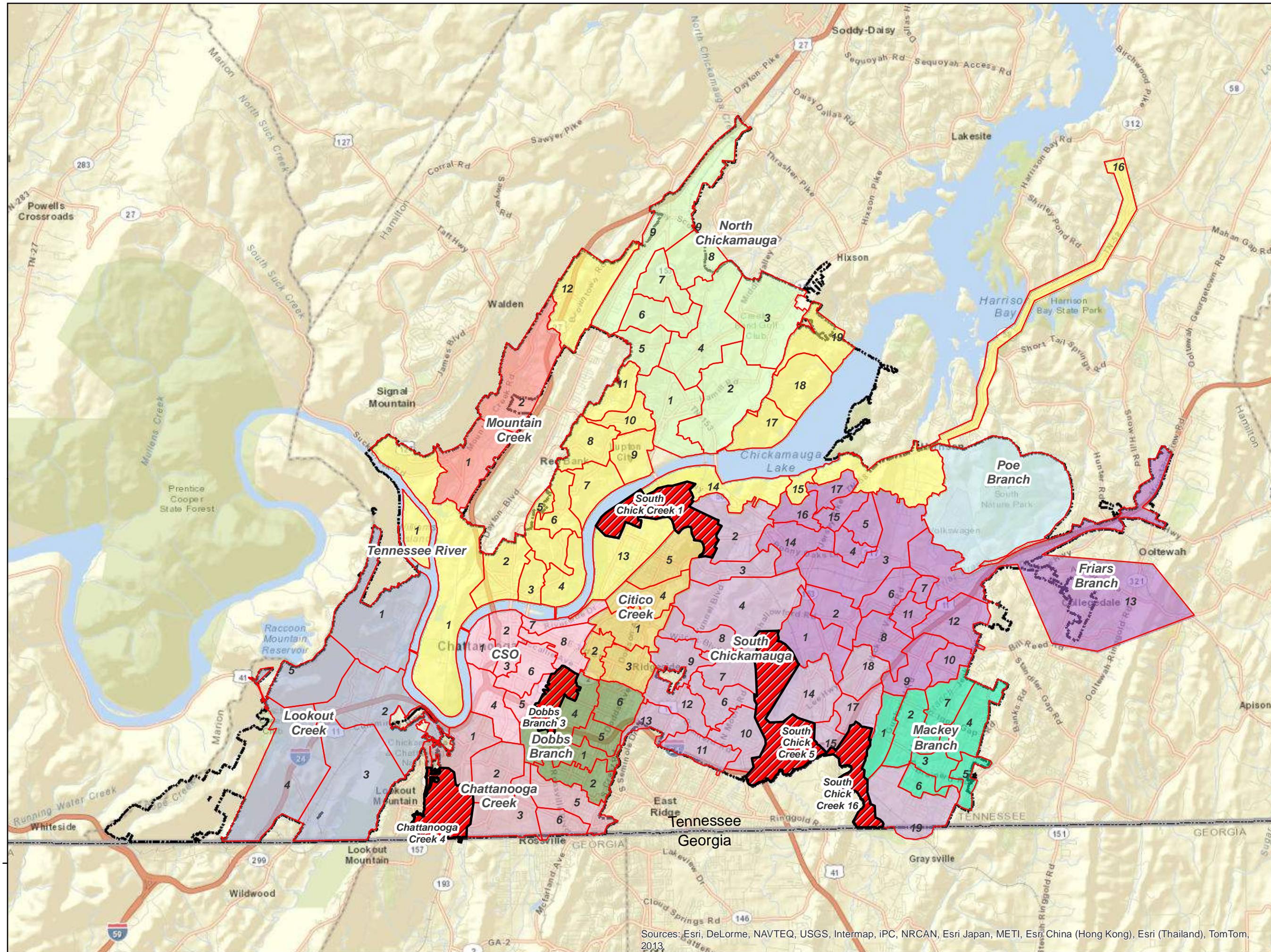


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Author: Rogers, Jonathan



Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, IPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013

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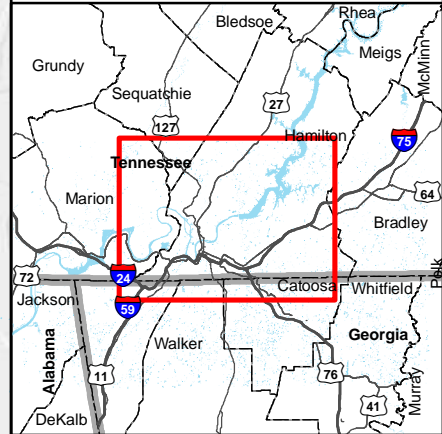
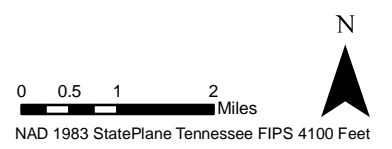
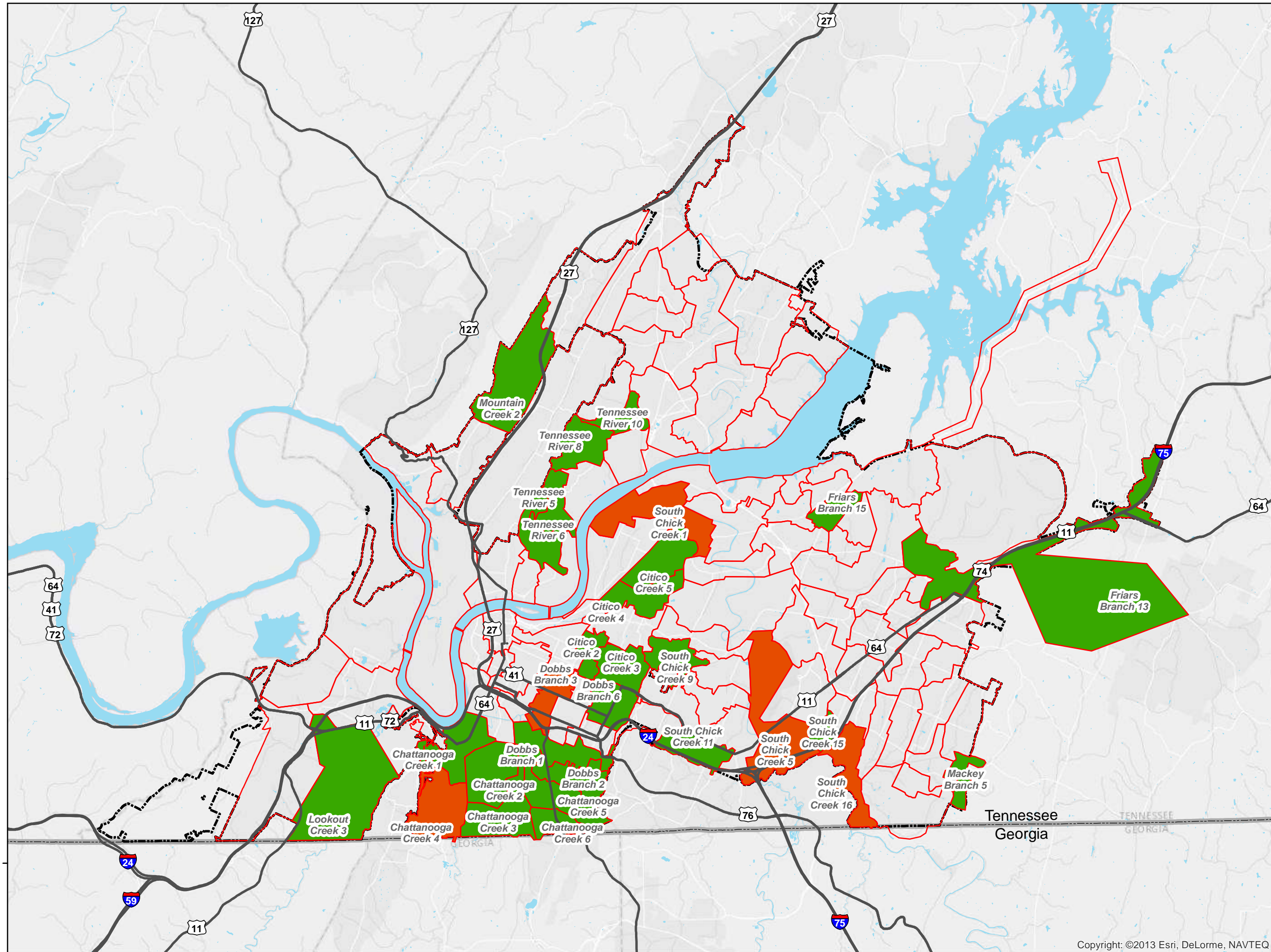
SSES Work Plan

Figure 4-1B

Phase 1 and 2 Priority SSES Sub-basins

Legend

- Highways and Interstates
- Sewer Sub-basins
- SSES Phase**
 - 1
 - 2
- Chattanooga City Limits
- US State Boundaries



Map Created: 10/9/2014 2:34:05 PM
Project #: C6A02300
Author: Rogers, Jonathan



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Appendix F
Impaired Stream Map Figure 4-2

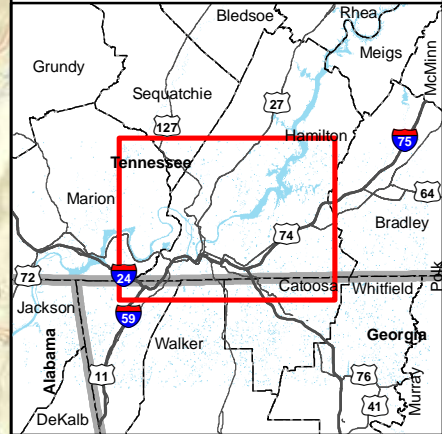
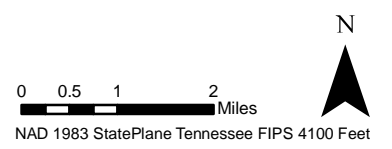
SSES Work Plan

Figure 4-2

Chattanooga Impaired Streams

Legend

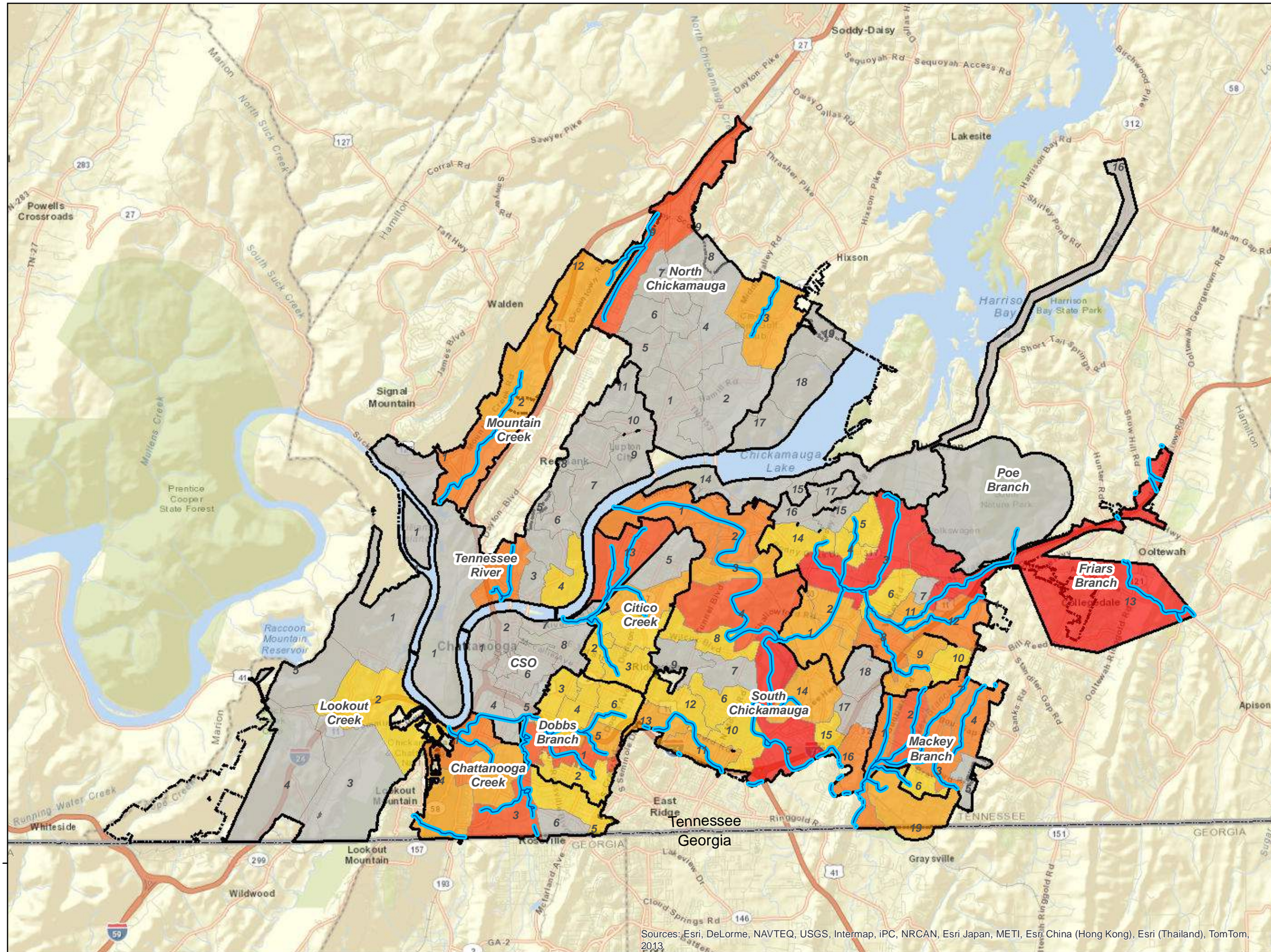
- Impaired Streams
- Sewer Basins
- Stream Length per Basin (feet)
 - Streams not found/considered
 - 0 - 4,146
 - 4,146 - 8,210
 - 8,210 - 13,069
 - 13,069 - 18,587
 - 18,587 - 34,290
- Chattanooga City Limits
- US State Boundaries



Map Created: 9/10/2014 5:28:17 PM
Project #: C6A02300
Author: Rogers, Jonathan



Path: J:\C6A02300\GIS\IMXD\SSES Work Plan\SSES_WorkPlan_Figure 4-2_ImpairedStreams.mxd



Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, IPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013

Appendix G
Environmental Justice Map Figure 4-3

SSES Work Plan

Figure 4-3

Chattanooga Environmental Justice Areas

Legend

— Highways and Interstates

▭ Sewer Basins

Environmental Justice Ranking

▭ Non-EJ/Not Ranked

▭ 0 - 0.2

▭ 0.2 - 0.3

▭ 0.3 - 0.5

▭ 0.5 - 0.8

▭ 0.8 - 1.3

▭ 1.3 - 2.0

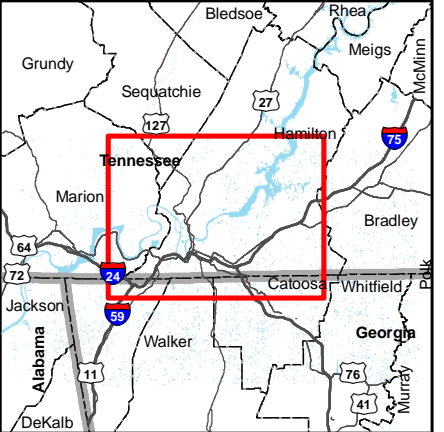
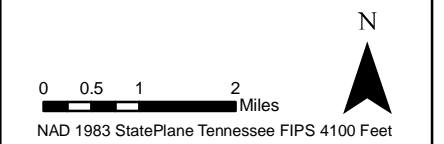
▭ 2.0 - 3.3

▭ 3.3 - 5.0

▭ 5.0 - 10.0

▭ Chattanooga City Limits

▭ US State Boundaries



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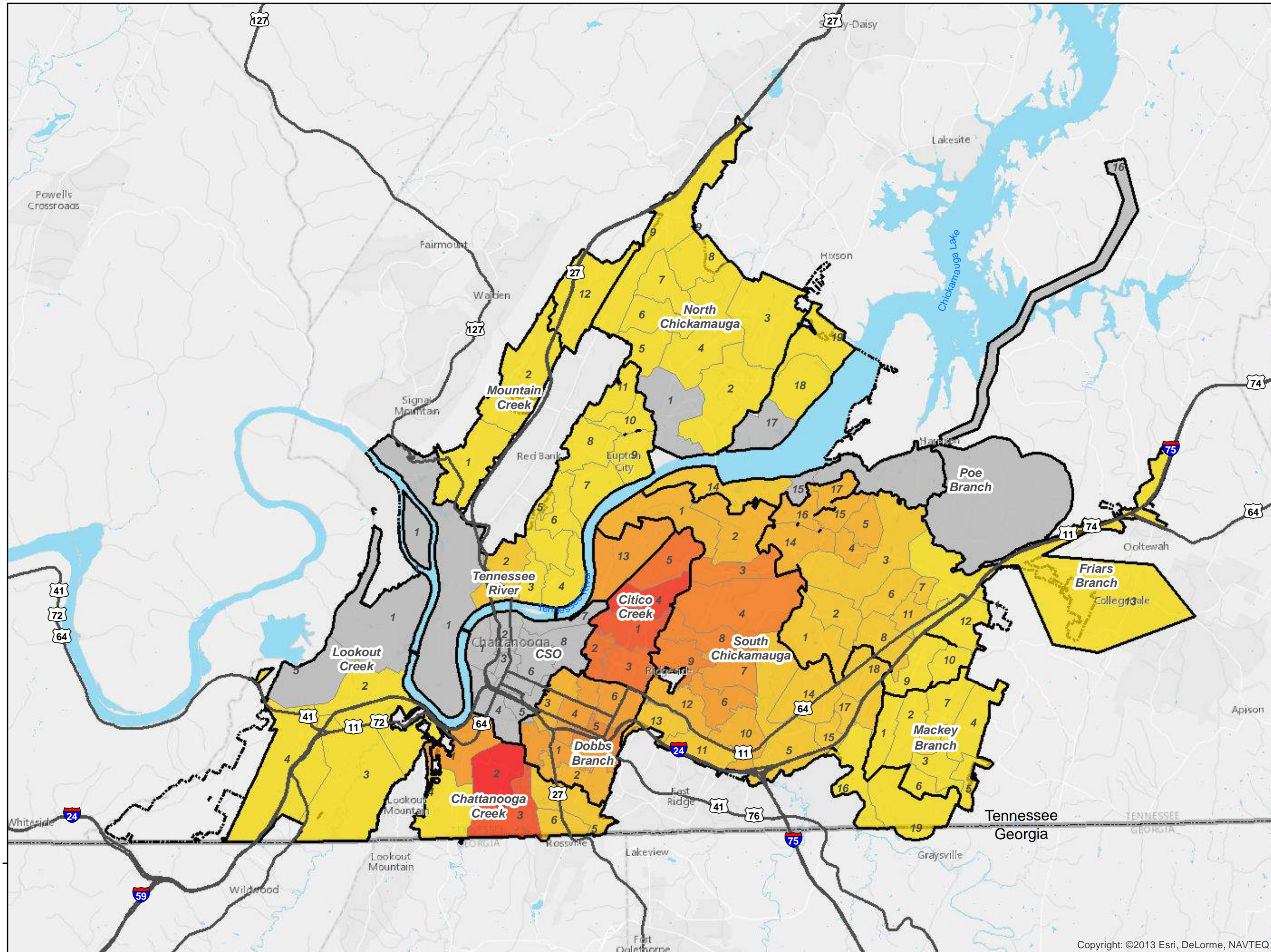
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Author: Rogers, Jonathan



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











Appendix H
Approximate Sewer Age Map Figure 4-4

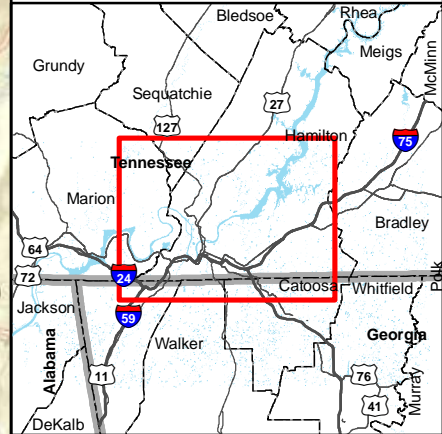
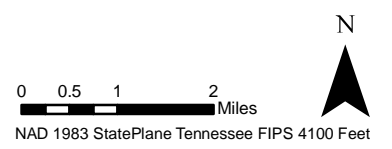
SSES Work Plan

Figure 4-4

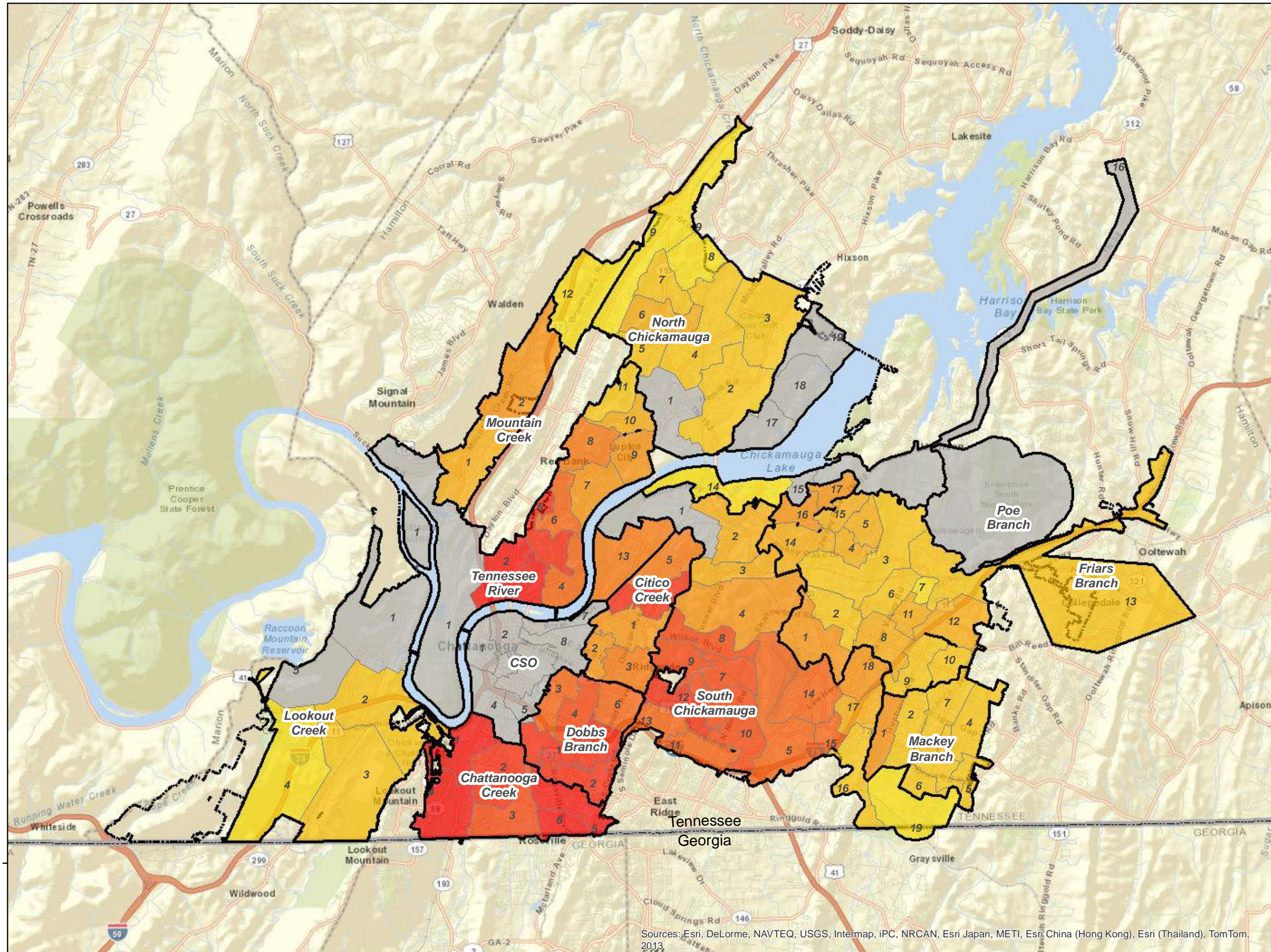
Relative Sewer Age

Legend

-  Sewer Basins
-  Sewer Sub-basins
- Relative Sewer Age (Years)**
-  Sewer Age Not Available
-  18 - 22
-  24 - 28
-  29 - 33
-  34 - 38
-  40 - 42
-  43 - 47
-  49 - 55
-  57 - 66
-  72 - 78
-  Chattanooga City Limits
-  US State Boundaries



Map Created: 9/10/2014 5:31:34 PM
 Project #: C6A02300
 Author: Rogers, Jonathan



Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013

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Appendix I

SSES Specifications

SPECIFICATIONS

Section Title

Division 33 – Utilities

33 01 30.14	Preconditioning and Cleaning of Underground Sewer Pipelines
33 01 30.16	Closed Circuit TV Inspection of Existing Underground Sewer Pipelines
33 01 30.22	Flow Isolation Inspection of Underground Sewer Pipelines
33 01 30.24	Smoke Testing of Underground Sewer Pipelines
33 01 30.26	Dye-Water Testing of Underground Sewer Pipelines
33 01 30.27	Sonar Inspection of Existing Underground Sewer Pipelines
33 01 30.28	Laser Profile Inspection of Existing Underground Sewer Pipelines
33 01 30.29	Inspection of Sanitary Sewer Manholes

Attachment A- Field Data Delivery Format Requirements

Preconditioning and Cleaning of Underground Sewer Pipelines

Part 1 General

1.01 Scope

The work covered by this Section includes furnishing all labor, material, equipment and services required for cleaning all sewer pipelines, prior to inspection of the sewers, by closed circuit television, authorized by the Engineer, as shown on the Drawings and/or specified herein. The objective of preconditioning and cleaning is to maximize sewer and manhole service efficiency and effectiveness. Preconditioning and cleaning involves removal of silt, which is defined as any and all solid or semi-solid materials, including fine and granular material, such as sand, grit, gravel, and rock as well as debris, grease, oil, sludge, slime, or any other loose material or encrustation lodged in the manhole or sewer. Preconditioning and cleaning also involves removal of invading roots, corroded concrete, intruding laterals and any other extraneous debris.

1.02 Definition

The term "clean" as used in this Section, shall mean removing all sand, dirt, roots, grease and all other solid or semi-solid materials from the sewer pipelines, so that a closed circuit television camera can be used in the internal pipeline inspection for the purpose of discerning structural defects, misalignment and infiltration/inflow sources.

"Heavy Cleaning" shall be defined as the pipe being more than 25% full of debris or requiring the use of apparatus other than normal high-pressure jetting equipment (i.e. buckets, "pigs", power-rod machines, grinders, or dragging devices). The Contractor shall be paid for "Heavy Cleaning" on the basis of the distance loosened debris is moved to the nearest point of extrication from the sewer. Payment shall be calculated on a lineal foot basis and be paid in addition to the normal cleaning rate shown on the bid form. "Heavy Cleaning" must be pre-approved by the Engineer.

Part 2 Products

2.01 General

- A. The Contractor shall certify that sufficient cleaning units can be provided, including standby units in the event of breakdown, in order to complete the work within the Contract period. Further, the Contractor shall certify that standby or back-up equipment can be delivered to the site within 24 hours in the event of equipment breakdown.
- B. Prior to the commencement of work, the Contractor shall coordinate access to water with the local water utility. Water will not be furnished by the Owner.
- C. All details of the point of water connection, backflow protection, conveyance methods, draw-off rates, times and all local conditions regarding the use of water shall be approved by the Engineer and the utility providing the water prior to

commencement of work. All equipment, labor, and material required for obtaining water for the work shall be provided by the Contractor. The Contractor must ensure that a 6 inch minimum air gap is maintained at the water supply point on desilting/cleaning/jetting equipment or any other receiving apparatus used to obtain water from the utility's hydrants.

Part 3 Execution

3.01 Cleaning

- A. Cleaning will be accomplished by utilizing a high pressure, hydraulic sewer pipeline cleaner. Pressure jetting equipment used shall be sufficient for the purposes of attaining the degree of cleanliness in sewers as specified.
- B. The cleaning unit(s) shall be capable of operating routinely, up to a minimum of 500 feet from the point of access to the sewer; minimal hose diameter shall be 1 inch.
- C. The Contractor's rates specified in the Proposal Forms shall be for jetting in sewers both upstream and downstream.
- D. Successive passes using constantly moving pressure jetting techniques shall be applied to sewers until they are cleaned to the level specified. Nozzle hold-time (stationary time), for any particular location, shall not be more than 60 seconds in order to forestall damage to the pipe being cleaned. Ideally nozzles shall have jet angles of between 30° to 45°. "High efficiency nozzles" (discharging "pencil jets") with jet angles higher than this figure shall not be allowed to be stationary at any time.
- E. Cleaning shall be done immediately prior to the internal inspection to preclude the build-up of debris from infiltration/inflow sources and upstream manhole sections. Should television inspection reveal that a sewer pipeline is not clean; the cleaning operations shall be repeated until the sewer pipeline is clean. This additional cleaning shall be done at the expense of the Contractor, at no additional cost to the Owner.
- F. During preconditioning and cleaning work and all other associated Contract operations, sewer services shall be maintained at all times. This requirement may be relaxed only with the written approval of the Engineer.
- G. The manholes and sewers to be preconditioned and cleaned convey sanitary sewage or combined sewage. In many instances such sewers are subject to high flows, either continuously or in a periodically varying cycle, due to rainfall, infiltration, and/or pumping operations. The Contractor shall include in his proposal provisions for dealing with such variations, and where necessary, schedule his Work to accommodate such variation in flows.
- H. Cleaning shall include the trapping and removal of all sediments and residual wastes from successive manholes as the cleaning progresses. When hydraulic cleaning equipment is used, a suitable weir or dam shall be constructed in the downstream manhole, in such a manner, that the solids and water are trapped. Under no circumstances shall sewage or solids removed there from, be dumped onto streets, in

catch basins or in storm drains. Material which could cause pipeline stoppages, accumulations of sand in wet wells, or damage to pumps, shall not be permitted to pass from manhole section to manhole section. The cost of trapping, removing, hauling and disposing of the residual wastes shall be included in the cost of cleaning. Disposal of residual wastes shall be in accordance with, and at a location approved by the Engineer and the Owner.

- I. The Contractor shall provide for the pumping down of any surcharged manhole section and provide all bypass pumping, if required, during the cleaning operation. All bypass pumping shall be approved by the Engineer.
- J. The Contractor shall submit a comprehensive equipment list to the Engineer before commencement of the Work. The complete list, which shall include all backup and standby equipment, shall be broken down into the following categories (at a minimum):
 - 1. Safety equipment
 - 2. Manhole preconditioning and cleaning equipment
 - 3. Sewer preconditioning and cleaning equipment
 - 4. Flow diversion and flow control equipment
 - 5. Traffic control equipment
 - 6. All other equipment necessary for the completion of the work.
- K. Blockages in the system shall be reported to the Engineer immediately.
- L. A responsible representative of the Contractor shall be present on the site of the work, or other location approved by the Engineer, to provide supervision of the work. At all times, and especially when a change of work location is underway, the Contractor's representative shall keep the Engineer continuously aware of the location, progress, planned execution of the work, and problems encountered.

3.02 Precautions

- A. The Contractor shall take all necessary precautions to ensure that water used does not flood property or buildings served by the sewer pipeline being cleaned.
- B. No fire hydrant shall be obstructed, in case of a fire in the area served by the hydrant.
- C. The Contractor shall take all necessary precautions to protect the sewer pipelines from damage that might be inflicted by improper use of cleaning equipment and shall repair, at no cost to the Owner, any damage caused by the cleaning operation.
- D. The Contractor shall furnish, to the Owner, certification of the accuracy of the automatic counter before any work shall begin on this Project. If, at any time, the

Engineer has reason to believe that the counter is inaccurate, the calibration of the counter will be checked before any more work progresses.

- E. The Contractor shall provide, operate, maintain and subsequently remove on completion, adequate ventilation apparatus in the form of blowers and/or fans. The ventilation apparatus shall introduce a fresh air supply to support a safe environment for Work in sewers, manholes and all other confined spaces, which shall be kept free from dangerous, toxic and/or explosive gases, whether generated from sewage, soil strata or other source.
- F. The Contractor shall employ the “best practicable means” to minimize and mitigate noise as well as vibration resulting from operations. Mitigation measures shall include the utilization of sound suppression devices on all equipment and machinery particularly in residential areas and in the near vicinity of hospitals and schools, especially at night.
- G. The Contractor shall inform the Engineer before the commencement of any portion of the work of any significant change in the methods of noise attenuation from those previously approved.
- H. All pumps, generators, combination cleaners or other noise emitting equipment shall be suitably screened to minimize nuisance and noise pollution. This requirement shall not be taken as preventing or prohibiting the execution of work necessary for the saving of life, protection of property, or safety of the personnel and/or facilities. The Contractor shall notify the Engineer of such use of plant or equipment in an emergency situation as soon as practicable.

3.03 Data Collection

- A. The Contractor shall complete a cleaning report for each sewer segment cleaned. A hard copy of this report shall be furnished on a weekly basis to the Engineer. The information required on the cleaning report shall be as follows:
 - 1. Location, size and condition of sewer line. Location will be indicated by road name, intersection(s) and GPS coordinates. Size will be indicated by nominal internal diameter. Condition will be indicated by narrative describing visual observation and the items below, augmented by photos where needed.
 - 2. Degree and nature of deposits prior to cleaning.
 - 3. Length of sewer cleaned.
 - 4. Estimated amount and types of debris and sediment removed. Indicate approximate location
 - 5. Grease build-ups. Indicate approximate location.
 - 6. Structural failures. Indicate approximate location.

Preconditioning and Cleaning of Underground Sewer Pipelines

7. Blockages. Indicate percent blockage or free area.
8. Method and man hours actually expended for cleaning.

END OF SECTION

Closed Circuit TV Inspection of Existing Underground Sewer Pipelines

Part 1 General

1.01 Scope

The work covered by this Section includes furnishing all labor, materials, equipment and services required to perform the closed circuit television (CCTV) inspection of the specific sewer pipelines authorized by the Engineer.

1.02 Definition

"Internal inspection" shall consist of using a closed circuit television within a designated sewer pipeline segment to detect point sources of infiltration/inflow or exfiltration and to determine the physical condition of the sewer pipeline.

1.03 CCTV Camera Operator Certification Requirements

- A. The Contractor will provide current certification that operators conducting CCTV inspections have undergone National Association of Sewer Service Companies (NASSCO) Pipeline Assessment and Certification Program (PACP[®]) training prior to commencement of inspection activities. Defect coding, as well as material, shape, and lining coding used throughout the Project will conform to NASSCO PACP standards version 6.0.2.
- B. Each operator must have at least 5 years experience in the coding of CCTV inspections and must have reported upon more than 250,000 feet of CCTV. The Contractor must use NASSCO certified data collection software (PACP version 6.0.2), with final approval by the Engineer prior to the start of the Contract.

Part 2 Products

2.01 Television Equipment

- A. The camera unit shall be a color pan and tilt unit. The television camera shall have a resolution of 700 lines minimum and shall have a source of illumination attached to it. With the monitor adjusted for correct saturation, the six colors plus black and white shall be clearly resolved with the primary and complementary colors in order of decreasing luminance. The gray scale shall appear in contrasting shades of gray with no tint. To ensure the camera shall provide similar results when used with its own illumination source, the lighting shall be fixed in intensity prior to commencing the inspection. In order to ensure color constancy, no variation in illumination shall take place during the inspection. The televised image shall be displayed on a monitor, located in an enclosed space in the television inspection vehicle.
- B. CCTV Focus/Iris/Illumination: The adjustment of focus and iris shall allow optimum picture quality to be achieved and shall be remotely operated. The adjustment of focus and iris shall provide a minimum focal range from 6 inches in front of the camera's lens to infinity. The distance along the sewer in focus from the initial point of observation

shall be a minimum of twice the vertical height of the sewer. The illumination must allow an even distribution of the light around the sewer perimeter without the loss of contrast picture, flare out or shadowing.

- C. The camera shall be self-propelled or mounted on skids and drawn through the sewer by winches for pipelines with an equivalent diameter from 6 to 36 inches. The inspecting equipment shall be capable of inspecting a length of sewer up to at least 1,000 ft. when entry into the sewer may be obtained at each end and up to 750 feet where a self-propelled unit is used, where entry is possible at one end only. The Contractor shall maintain this equipment in full working order and shall satisfy the Engineer at the commencement of each working shift that all items of equipment have been provided and are in full working order.
- D. Each inspection unit shall contain a means of transporting the CCTV camera equipment in a stable condition through the sewer under inspection. Such equipment shall ensure the maintained location of the CCTV camera on or near to the central axis of a circular shaped sewer when required in the prime position.
- E. Where the CCTV camera head is towed by winch and bond through the sewer, all winches shall be stable with either lockable or ratcheted drums. All bonds shall be steel or of an equally non-elastic material to ensure the smooth and steady progress of the CCTV camera and/or Sonar equipment. All winches shall be inherently stable under loaded conditions.
- F. Each unit shall carry sufficient numbers of guides and rollers such that, when inspecting, all bonds are supported away from pipe and manhole structures and all CCTV cables and/or lines used to measure the CCTV camera's head location within the sewer are maintained in a taut manner and set at right angles where possible, to run through or over the measuring equipment.
- G. The Contractor shall use a suitable metering device, which enables the cable length to be accurately measured; this shall be accurate to within +/- 2 inches. When requested by the Engineer in writing at any time during a survey or inspection, the Contractor shall demonstrate compliance with the above tolerance. The device used by the Contractor to measure the footage along the sewer will be compared with a standard tape measure. The results will be noted. If the Contractor fails to meet the required standard of accuracy, the designated Engineer shall instruct the Contractor to provide a new device to measure the footage.
- H. The in-sewer photographic/video camera system and suitable illumination shall be capable of providing an accurate, uniform and clear record of the sewer's internal condition. In-sewer lighting standards shall meet the requirements of the designated Engineer and applicable codes regarding safety and power.
- I. A reserve television camera shall be available to replace the regular television camera in the event of a breakdown. Should the reserve equipment malfunction, another camera shall be provided within 24 hours.
- J. Suitable flow control devices shall be plugs designed and manufactured for use in sanitary sewers. Sand bags or other types of devices shall not be used within sanitary sewer pipelines or manholes.

2.02 Television Equipment Operation

Operation of the television inspection equipment shall be controlled from above ground, with a skilled technician at the control panel in the television inspection van controlling the movement of the television camera. The technician shall have the capability to: adjust the brilliance of the built-in lighting system; change the focus of the television camera by remote control; control the pan and tilt feature of the camera; control the forward and reverse motion of the camera; and determine the camera's position, at any time. Operators of the television inspection equipment shall meet the requirements stated in Section 1.03 of this Specification.

Part 3 Execution

3.01 Procedure

The television inspection shall be performed in one section of the sewer pipeline at a time, between adjacent manholes. The inspection shall be performed by pulling or propelling the television camera through the section of the sewer along the axis of the pipeline. A position tolerance of $\pm 10\%$ of the vertical sewer dimension will be allowed. The inspection shall be performed in a forward and/or backward direction, as dictated by the pipeline conditions at the time of the inspection. During the inspection of the sewer pipeline, every possible means shall be taken to ensure total viewing of the inside periphery of the pipeline. The inspection shall be conducted in such a manner as to determine that the line is clean and to locate all leaking joints, breaks, defects and faults in the pipeline. Television camera movement shall be temporarily halted at each defect in order to pan or tilt the camera head and observe the full extent of the defect in detail, and to allow for a clear photograph of the defect. Camera movement will not resume with visible point sources of infiltration/inflow until the leakage rate from the source is quantified. The camera shall also be stopped at service connections where flow is discharging. If the discharge persists, the property involved shall be checked, at the ground surface level, to determine whether or not the discharge is wastewater. If checking determines that the discharge is not wastewater, it shall be considered infiltration/inflow. The leakage rate of each infiltration/ inflow source shall be estimated in gallons per day (gpd).

3.02 Provisions

- A. The Contractor shall maintain on site at all times a competent field supervisor in charge of the inspection. The field supervisor shall be responsible for the safety of all site workers and site conditions as well as ensuring that all work is conducted in conformance with these Specifications and to the level of quality specified.
- B. The Contractor shall provide bypass pumping, where necessary, to prevent flooding or sanitary sewer overflows.
- C. The Contractor shall provide for the pumping down of any surcharged manhole section, if required, before television inspection commences. Bypass pumping must be approved by the Engineer prior to set up.

- D. The Contractor shall furnish, to the Owner, certification of the accuracy of the automatic counter before any work shall begin on the Project. If, at any time, the Engineer has reason to believe that the counter is inaccurate, the calibration of the counter will be checked before any more work progresses.
- E. CCTV Camera Head Speed: The speed of the CCTV camera in the sewer shall be limited to 30 feet per minute for inspections to enable all details to be extracted from the final video recording.
- F. At the start of each sewer length being surveyed or inspected and each reverse set-up, the length of pipeline from zero footage (the entrance to the pipe) up to the cable calibration point shall be recorded and reported in order to obtain a full record of the sewer length. Only one inspection shall be indicated in the final report. All reverse set-ups, blind manholes, and buried manholes shall be logged on a separate log. Each log shall make reference to a start (ST) and finish (FH) manhole unless abandonment took place because of blockage.
- G. Should the Contractor encounter a buried manhole during the course of inspection that cannot be readily accessed, the Contractor shall notify the Engineer, and shall make note of such in the appropriate field on the inspection header.
- H. If during the course of CCTV Inspection, a protruding tap is discovered in the pipeline that will not allow the passage of a CCTV inspection camera and a reverse setup cannot be completed, then the Contractor will be required to remove the protruding tap via a remotely controlled robotic cutting device. Prior to removing the protruding tap, the Contractor must receive approval from the Engineer.
- I. If for any reason the camera becomes disabled inside the sewer and cannot further proceed, the Contractor shall be responsible for retrieving the camera at no additional cost to the Owner.
- J. All digital video shall be continuous with no evidence of missed footages or "blink-outs." That the entire pipeline segment was traversed and inspected shall be obvious on the final video recording.
- K. Prior to inspection, each length of sewer shall be cleaned pursuant to Specification 33 01 30.14. All inspected pipe should be free of debris to allow for a complete, unobstructed view of the pipe. If upon viewing a final inspection, the Engineer deems that the view is obstructed, the pipe will be cleaned and re-televised at no cost to the Owner.

3.03 Data Collection

- A. The Contractor shall furnish all equipment and software required for taking photographs and videos of the view which appears on the monitor. Digital Video will be used to record all point sources and defects, severe leaks, holes, collapses, misalignments, etc. Still pictures shall be taken of all coded observations. Data logging and defect coding conforming to the NASSCO PACP will be required as part of all pipeline inspections.

- B. All inspection information shall be captured utilizing NASSCO certified data collection software and following all NASSCO PACP (version 6.0.2 or greater) standard data fields, formats, and conventions provided by the Engineer.
- C. All inspection media file naming formats and folder organizational structures must remain consistent throughout all internal inspections. See naming conventions in Section 3.04, Part E.
- D. A digital encoded inspection video shall be continuously captured for the entire length of each inspection. All digital encoded inspection video files shall be in MPEG-1 file format. For all digital encoded inspection videos, the file naming format shall be generated using a concatenation of standard PACP database fields in the format "Upstream_MH"_"Downstream_MH"_"Direction"_"Date"_"Time". CCTV inspections in which the camera lens is or becomes obstructed, dirty, greasy, etc. during the inspection, and remains so for up to two feet, will not be accepted.
- E. A digital still image shall be captured for each coded observation. All digital still images shall be in JPEG file format. For all digital still images, the file naming format shall be generated using a concatenation of standard PACP database fields in the format "InspectionID"_"ConditionID"_"Distance"_"PACP_Code".
- F. Each digital encoded inspection video shall begin with the camera facing towards the bottom of the manhole and oriented so that the outgoing sewer connection is at the 6 o'clock position. This position shall be held during video recording for a minimum of five seconds prior to lowering the camera to the bottom of the manhole. Once the camera has been lowered into the manhole and oriented in its direction of travel, the camera shall be directed towards the top of the manhole, with this position held during video recording for a minimum of five seconds prior to advancement into the sewer.
- G. A comprehensive summary inspection report shall be generated for each inspection, and shall be in Portable Document Format (PDF). The report shall include the findings on major defects, including but not limited to fractures, displaced joints, deformation, corrosion, lateral intrusions, and dominant surface features including encrustation and silt depths. All pdf report files shall be in a dedicated folder called "PACP_Reports"
- H. Each sewer length (the length of the sewer between two consecutive manholes) will be entered into the PACP database field "Total_Length". If field maps are provided for the project area and include a total length, then this value will be entered into the field "Total_Length".
- I. When a length of sewer between two consecutive manholes cannot be inspected for practical reasons, the reason for abandonment shall be described in the PACP database field "Additional_Info". At unmapped manholes, a new inspection will be started and the footage re-set to zero (0.0).
- J. When the Contractor elects to "pull through" a manhole during a CCTV and/or Sonar Inspection, a new inspection will be started at the manhole "pulled through", and the footage re-set to zero (0.0) at the manhole wall where the pipe exits/enters the manhole.

- K. When a reverse or second inspection is required to complete the inspection of a sewer, the PACP database field "Reverse_Setup" shall be populated with corresponding inspection number. The "Reverse_Setup" field shall be null for all inspections that are not reverse or follow-up inspections.
- L. When an unmapped manhole is discovered during an inspection, the Contractor shall assign a temporary field-assigned ID to the manhole. This temporary field ID shall be entered into the appropriate PACP database field (either "Upstream_MH" or "Downstream_MH"), and the comment "Unmapped MH" shall be entered in the PACP database field "Additional_Info". The inspection shall be terminated and a new inspection shall begin, so that the unexpected manhole effectively divides the pipe into two segments. The "Total_Length" field for the terminated inspection shall be populated with the distance in feet at which the unexpected manhole was discovered during inspection. The pipe segment receiving the next inspection shall be assigned a temporary field ID, and the newly-discovered manhole ID shall be entered into the corresponding "Upstream_MH" or "Downstream_MH" field. The proposed naming scheme for unmapped manholes and pipes shall be approved by the Engineer prior to start of inspections. The Contractor shall ensure that each newly-discovered manhole and pipe is given an ID that is not already assigned to another manhole or pipe. The contractor shall also ensure that the field-assigned ID of each newly-discovered manhole is consistent between PACP and MACP submittals.
- M. At the start of each sewer length, a data generator shall electronically generate and clearly display on the viewing monitor and subsequently on the final recording a record of data in alpha-numeric form containing the following minimum information:
1. Automatic update of the camera's footage position in the sewer line from adjusted zero.
 2. Sewer dimensions in inches
 3. Manhole numbers (must conform to Owner's identification number)
 4. Date of survey
 5. Road name (nearest)/location
 6. Direction of survey, i.e., downstream or upstream
 7. Time of start of survey
 8. Material of construction of the pipe
 9. Contractor
 10. Engineer
- N. The size and position of the data display shall be such as not to interfere with the main subject of the picture.

- O. Once the survey of the pipeline is under way, the following minimum information shall be continually displayed:
 - 1. Automatic update of the camera's footage position in the sewer line from adjusted zero.
 - 2. Sewer dimensions in inches
 - 3. Manhole numbers (must conform to Owner's identification number)
 - 4. Direction of survey, i.e., downstream or upstream
- P. At each defect of any kind, the camera movement shall be halted, and the camera shall be tilted and panned as necessary to observe the full extent of the defect before it is electronically coded.
- Q. At each coded observation, the following minimum information shall be displayed:
 - 1. The PACP code and/or PACP code description.
 - 2. The footage position of the defect.
 - 3. The "Additional_Info" field in any cases where it is utilized.
- R. The actual field work will be monitored by the Engineer. A Project representative will be available during internal television inspection, and no work shall be performed without the Engineer's Project representative present, unless authorized by the Engineer.
- S. The Contractor shall take caution to ensure that the pipe IDs and manhole IDs entered into the PACP database are correct, free from typos, and consistent with the data supplied by the Engineer. Databases with substantial rates of error in these fields will not be accepted.
- T. The Contractor must have an internal quality assurance/quality control system (QA/QC) in place, and all inspection data shall be subjected to the procedures prior to submittal to the Engineer. The Engineer will perform QA/QC audits on submitted data. Any data or files not meeting these specifications or NASSCO standards will be returned to the Contractor for correction. Contractor shall present their proposed QA/QC system to the Engineer prior to the start of the Contract.

3.04 CCTV Inspection Deliverables

- A. All the supplied data and information will become the property of the Owner.
- B. Sample Submittal: An example of a typical CCTV Inspection final deliverable will be submitted for approval by the Engineer prior to the start of work. The example deliverable will contain the following:

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1. A sample NASSCO PACP Standard Exchange Database, version 6.0.2 or greater, in Microsoft Access file format (.mdb), as exported from the Contractor's data collection software.
 2. A proprietary database as generated by the Contractor's data collection software.
 3. Example media files, including observation photos, CCTV videos, and reports; with all files consistently utilizing the required file naming conventions and folder structures.
 4. The proposed viewing software to be used with the proprietary inspections database and related media.
 5. NASSCO PACP validation report in PDF format, demonstrating the sample is fully conforming to NASSCO PACP standards and conventions. Validation reports can be obtained by submitting a sample database to:

http://www.nassco.org/training_edu/te_database_upload.aspx.
 6. Inspections database(s) shall be fully cross-referenced to the videos, images, and reports.
 7. Example reports will be presented in both hard copy and in PDF format, and all other sample data will be presented in digital format on an external hard drive.
- C. Intermediate Submittals: No later than every 14 days following the completion of a pipeline inspection, the Contractor will submit the following:
1. Two hard copies of full details report for each inspection, showing the position and full text of each defect encountered and their grades.
 2. An overall summary report detailing major defects and inspections that require attention.
 3. A list of unmapped manholes and/or pipe segments that were identified during inspections but were not shown on field maps. This list shall include the field-assigned ID and a geographic reference or description (street address, intersection, etc.)
 4. A statistical report showing lengths of sewers inspected and a breakdown of sizes and lengths inspected.
 5. At regular agreed intervals, an external hard drive will be submitted to the Engineer containing a single NASSCO PACP Standard Exchange Database (version 6.0.2 or greater) containing all inspections to date, encoded videos, observation photos, inspection reports in PDF format, and support files. The supplied data and information will become the property of the Owner.
- D. Final Submittal: At the completion of all inspection work, the Contractor will supply the following to the Engineer on an external hard drive:

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1. A single, consolidated NASSCO PACP Standard Exchange Database (version 6.0.2 or greater) in Microsoft Access file format (.mdb) containing all inspections.
2. NASSCO PACP validation report for the consolidated database (see Section 3.04.B.5.)
3. All encoded inspection videos, observation photos, and inspection reports using required file naming formats.
4. A single, consolidated proprietary database containing all inspections for the Contract, as generated by the Contractor's data collection software.
5. Free-issue software to be used for the viewing of the proprietary inspections database and related media from within the database.
6. Four hours training in the use of any supplied free-issue software will be included in the rates.

E File Formatting and Naming Conventions: All submittals shall have the following file formatting and naming conventions, unless otherwise approved by the Engineer.

SUBMITTAL DESCRIPTION	FILE NAMING CONVENTION	FILE FORMAT
Digital encoded videos	"Upstream_MH" "Downstream_MH" "Direction" "Date" "Time"	.mpg
Digital still images of all observations	"InspectionID"_"ConditionID"_"Distance"_"PACP_Code" (multiple digital still images may have "-01", "-02", "-03" at end of file name)	.jpg or .jpeg
Color, Hi-res Laser profiling image of pipe 50' cross-sections	"InspectionID"_"ConditionID"_"Distance"_"PACP_Code"	.jpg or .jpeg
Pipe Segment Cleaning Report	CR-"Pipe_Segment_Reference"	.pdf
Pipe Segment Inspection Report	"Upstream_MH"_"Downstream_MH"_"Direction"_"Date"_"Time"	.pdf
NASSCO PACP Validation Report	"yyyymmdd(date of submittal)"_"Project Name"_"Validation Report"	.pdf
NASSCO PACP Exchange Database	"yyyymmdd(date of submittal)"_"Project Name"_"StandardPACPExchange"	.mdb

- F. External Hard Drive Requirements: External hard drives shall be a minimum of 500 Gigabytes (GB) in capacity, shall have a USB 2.0 compliant connection, and shall be powered either through the host USB connection or have an external power adapter provided. External hard drives will be returned within 5 business days to the Contractor for use on outstanding inspections after download by the Engineer. At the conclusion of the project, the final submittal external hard drive will become the property of the Owner for use in archival of data. The Contractor shall keep a copy of final submitted external hard drives for up to 3 years.
- G. NASSCO PACP Compliance: The submitted database(s) should consist of, at a minimum, the NASSCO PACP standard data fields, formats, and conventions as set forth in this specification and Attachment A – Field Data Delivery Format Requirements.

END OF SECTION

Flow Isolation Inspection of Underground Sewer Pipelines

Part 1 General

1.01 Scope

The work covered by this Section includes furnishing all labor, material, equipment and services required for performing flow isolation inspection services, authorized by the Engineer, as shown on the Drawings and/or specified herein. The objective of flow isolation inspection is to determine the amount of extraneous water entering the sewer. It is used to determine the specific reaches of sewer that have excessive infiltration so that further action, i.e. internal inspection, may then be performed.

1.02 Definition

The term "flow isolation" as used in this Section, shall mean isolating a section of sewer through the use of flow control or plugging devices to reduce the flow in the sewer to that originating from sources other than domestic or commercial wastewater.

Part 2 Products

2.01 General

The equipment needed for the flow isolation testing is limited to that required to sufficiently block or divert the flows in the sewers and suitable measurement devices, such as portable V-notch weirs.

Part 3 Execution

3.01 Flow Isolation Inspection

- A. The method to be used during flow isolation inspection shall be the plugging method. This method will consist of physically isolating the sewer length from the rest of the system by means of plugs inserted into the sewer pipes. After a section of sewer is isolated by plugging, sufficient time will be allowed for the pipe to drain down before any measurements are attempted. This time will increase with the length of sewer isolated and the average slope of the sewer. The drain down time will be estimated by assuming a flow velocity of approximately 0.5 ft/sec from the plug to the point of downstream measurement. Before any measurements are taken, an equilibrium flow situation will be verified at the point of measurement by the method of successive readings.
- B. Two measurement techniques will be allowed under this work: Use of a portable V-notch weir and the velocity-area method:
 - 1. V-Notch Weir - For a usable measurement, care must be taken to ensure that:
 - a. The weir is installed level.

- b. The weir is properly seated and watertight at its perimeter.
 - c. The nappe is aerated.
 - d. The velocity of approach is small;
 - e. The flow over the weir has reached an equilibrium condition; and
 - f. The weir is properly read.
2. Velocity-Area Method – Under this measurement technique the flow, “Q” is determined by multiplying the mean velocity, “V” by the cross sectional area, “A” of the flow. The mean velocity may be determined by the use of magnetic or propeller current meters. The cross sectional area of the flow will be determined by first measuring the depth of flow at the point where the velocity reading is obtained. The depth of flow will be measured by pipe caliper. If sediment is present, the depth of debris will be estimated by seating a ruler on the pipe invert and marking the apparent top of the debris on the ruler by feel and withdrawing it from the flow to obtain the reading. The cross sectional area of flow “A” may be computed by reference to prepared tables or by geometry. The sediment area should be subtracted from the total wetted area to obtain the actual area of flow.
- C. The Contractor shall provide for the pumping down of any surcharged manhole section and provide all bypass pumping, if required, during the inspection. No separate payment shall be made for bypass pumping.
- D. The Contractor shall submit a comprehensive equipment list to the Engineer before commencement of the Work. The complete list, which shall include all backup and standby equipment, shall be broken down into the following categories (at a minimum):
1. Safety equipment
 2. Flow measurement devices and techniques to be used
 3. Flow diversion and flow control equipment
 4. Traffic control equipment
 5. All other equipment necessary for the completion of the Work
- E. Blockages in the system shall be reported to the Engineer immediately.
- F. A responsible representative of the Contractor shall be present on the site of the work, or other location approved by the Engineer, to provide supervision of the work. At all times, and especially when a change of work location is underway, the Contractor’s representative shall keep the Engineer continuously aware of the location, progress, planned execution of the work, and problems encountered.

3.02 Precautions

- A. The Contractor shall take all necessary precautions to ensure that water used does not flood property or buildings served by the sewer pipeline being inspected.
- B. A valved air line will be attached to a bag or plug so that it may be deflated from the surface.
- C. The water level within structures will be observed and the minimum level that will cause flow to back up into buildings and cause property damage will be determined prior to initiating operations so that flooding of buildings and property will not occur.
- D. Remove all plugs when a setup is complete. Failure to do this may result in backup and property damage.
- E. The Contractor shall provide, operate, maintain and subsequently remove on completion, adequate ventilation apparatus in the form of blowers and/or fans. The ventilation apparatus shall introduce a fresh air supply to support a safe environment for Work in sewers, manholes and all other confined spaces, which shall be kept free from dangerous, toxic and/or explosive gases, whether generated from sewage, soil strata or other source.
- F. The Contractor shall employ the “best practicable means” to minimize and mitigate noise as well as vibration resulting from operations. Mitigation measures shall include the utilization of sound suppression devices on all equipment and machinery particularly in residential areas and in the near vicinity of hospitals and schools, especially at night.
- G. The Contractor shall inform the Engineer before the commencement of any portion of the work of any significant change in the methods of noise attenuation from those previously approved.
- H. All pumps, generators, combination cleaners or other noise emitting equipment shall be suitably screened to minimize nuisance and noise pollution. This requirement shall not be taken as preventing or prohibiting the execution of work necessary for the saving of life, protection of property, or safety of the personnel and/or facilities. The Contractor shall notify the Engineer of such use of plant or equipment in an emergency situation as soon as practicable.

3.03 Data Collection

- A. The Contractor shall document minimum required information for each sewer segment inspected, either in a digital format or a hand-written field log sheet. If the Contractor elects to document flow isolation information digitally, the Contractor may choose to utilize a Microsoft Access database or Microsoft Excel spreadsheet provided by the Engineer to collect the flow isolation information on a field computer or laptop. The Contractor may also elect to utilize or develop their own format for digitally capturing the required flow isolation information, with final format approval by

The Engineer prior to the start of work. Alternatively, the Contractor can elect to document all required flow isolation information onto hand-written field logs, with final format approval by the Engineer prior to the start of work. All hand-written field logs shall be scanned and converted to Portable Document Format (PDF) files, with each PDF file using a consistent naming convention of "FlowIsolation-[sequential number]" (such as "FlowIsolation-1.PDF"). Inspection report files shall be furnished on a weekly basis to the Engineer. A new digital record or hand-written field log sheet shall be completed for each flow isolation test. The following is the minimum required information to be collected for each flow isolation test:

1. Unique numeric ID assigned to each inspection.
 2. Date of inspection
 3. Time of inspection.
 4. Field crew performing inspection.
 5. Weather conditions at time of inspection.
 6. Location, size and condition of sewer line inspected.
 7. Type of setup.
 8. Sketch of setup to include locations of plugs installed.
 9. Primary ID of each sewer manhole inspected.
 10. Primary ID of each sewer pipe segment inspected.
 11. Digital photograph file name(s) of flow isolation setup (refer to 3.03.D)
 12. Flow readings after equalization.
 13. Estimate of infiltration into the sewer reach.
 14. Additional comments, such as access details, unusual conditions encountered, or difficulties incurred in performing the test.
- B. A field sketch shall be drawn for each flow isolation test setup. The field sketch should be very clear. It should indicate exactly what was isolated with respect to the sanitary sewer system.
- C. Digital photographs shall be captured for each flow isolation test setup using a digital camera capable of a minimum of five megapixel resolution. The photograph shall be taken from an angle or observation point so that any reference features (such as house, driveway, or street intersection) are visible. All photographs shall be in Joint Photographic Experts Group (JPG or JPEG) file format and shall utilize a consistent file naming convention which shall be approved by the Engineer.

- D. The Contractor must have an internal quality assurance/quality control system (QA/QC) in place, and all inspection data shall be subjected to the procedures prior to submittal to the Engineer. The Engineer will perform QA/QC audits on submitted data. Any data or files not meeting these specifications or NASSCO standards will be returned to the Contractor for correction. Contractor shall present their proposed QA/QC system to the Engineer prior to the start of the Contract.

3.04 Flow Isolation Inspection Deliverables

- A. At the completion of work, the Contractor shall provide all data collected during flow isolation inspections either as a Microsoft Excel spreadsheet (.xls or .xlsx), or as a Microsoft Access 2003 database. If the Contractor so chooses, The Engineer can provide a formatted Microsoft Access database or Microsoft Excel spreadsheet for the Contractor to populate and return to the Engineer. The spreadsheet or database shall include a minimum of one record to correspond to each flow isolation. The spreadsheet or database shall include for each record, at a minimum, all items listed under 3.03.A. The spreadsheet or database shall be structured so that appropriate relationships are established between inspection records and their related information, such as inspected manholes and inspected pipe segments, in order to provide referential integrity between worksheets or tables. The format used by the Contractor shall be reviewed and approved by the Engineer prior to the start of work.
- B. All hand-written field logs and/or sketches delivered electronically in PDF format, utilizing the file naming convention described in 3.03.A.
- C. All digital photographs of flow isolation setups delivered electronically in JPG or JPEG format, in an approved naming convention as described in 3.03.C.
- D. All deliverables shall be submitted on an external hard drive with a minimum of 500 gigabytes (GB) capacity, shall have a minimum USB 2.0 compliant connection, and shall be powered either through the host USB connection or have an external power adapter provided. External hard drives will be returned within 5 business days to the Contractor for use on any outstanding inspections or data deliverables after download by the Engineer. At the conclusion of the project, the final submittal external hard drive will become the property of the Owner for use in archival of data. The Contractor shall maintain a copy of the final deliverables for up to 3 years.

END OF SECTION

Part 1 General

1.01 Scope

The work covered by this Section includes furnishing all labor, material, equipment and services required for performing smoke testing inspection services, authorized by the Engineer, as shown on the Drawings and/or specified herein. The objective of smoke testing is to detect sources of inflow such as storm sewer cross connections and point source inflow leaks in drainage paths or ponding areas, roof leaders, cellar, yard and area drains, fountain drains, abandoned building sewers, and faulty service connections. Smoke testing will also detect overflow points in the sewer systems if groundwater is below the sewer. It also will be used to determine the specific reaches of sewer that have excessive infiltration so that further action, i.e. internal inspection, may then be performed.

1.02 Communication and Supervision of Work

- A. A responsible representative of the Contractor shall be present on the site of the work to provide supervision at all times. The Contractor shall provide to the Engineer the name and phone number of the on-site superintendent(s) who can be reached at any time that work is being performed. At all times, and especially when a change of work location is underway, the Contractor's representative shall keep the Engineer continuously aware of the location, progress, planned execution of the work, and problems encountered. The field supervisor shall be responsible for the safety of all site workers and site conditions as well as ensuring that all work is conducted in conformance with these Specifications and to the level of quality specified.
- B. The Engineer shall be given advanced notice of, and the opportunity to witness, all field work performed.
- C. Blockages in the system shall be reported to the Engineer immediately.
- D. Should the Contractor encounter a buried manhole that cannot be readily accessed, the Engineer shall be immediately notified. Detailed directions to the location of the buried manhole shall be provided by the Contractor to the Engineer.

1.03 Traffic Control Plans

It is the Contractor's responsibility to prepare, submit and obtain approval for any required traffic control plan. The City of Chattanooga, Tennessee is the agency which determines when traffic control plans are required, reviews and provides approval of traffic control plans. The Engineer will provide to the Contractor the contact information for the appropriate traffic control plan representative(s).

1.04 Submittals

The Contractor shall submit a comprehensive equipment list to the Engineer before commencement of the Work. The complete list, which shall include all backup and standby equipment, shall be broken down into the following categories (at a minimum):

- A. Safety equipment
- B. Smoke producing equipment devices and techniques to be used
- C. Flow diversion and flow control equipment
- D. Traffic control equipment
- E. All other equipment necessary for the completion of the Work

Part 2 Products

2.01 General

- A. Smoke bombs and/or canisters capable of generating nontoxic, odorless, and non-staining smoke.
- B. An air blower used to force the smoke into the sewer pipes; the air blower should have a minimum capacity of 53 cubic feet per second (cfs).
- C. Digital camera and/or camcorder used to document smoke coming out of the ground, catch basins, pipes, and other sources during the test. Camera and/or camcorder shall be capable of at least 5 mega pixel resolution.
- D. Flyers and/or door hangers for notifying residents and businesses of testing.
- E. GPS unit capable of sub-meter accuracy (horizontal +/- 3 feet) for documenting location of defects.

Part 3 Execution

3.01 Smoke Testing

- A. Smoke Testing Procedure:
 - 1. The Contractor shall attend a stakeholder coordination meeting scheduled by the Engineer which will occur at least two weeks prior to conducting smoke testing operations. The Contractor shall be represented at this meeting with both the Contractor's project manager and on-site superintendent who will be present during any smoke testing operations. The purpose of this meeting is to familiarize stakeholders with the smoke testing operations and discuss locations that smoke testing will occur and the anticipated schedule for such operations. During this meeting the Contractor will be provided directions for lines of

communication and be provided points of contact information. The Contractor shall submit a plan for approval by the Engineer regarding notification and coordination of smoke testing.

2. Seventy-two hours prior to conducting smoke testing operations, the Contractor shall notify the Engineer of the location of the segments to be tested. The Engineer will coordinate with the Owner to ensure that the local media is contacted and notified to inform residents and proper authorities have been contacted to obtain approval for the activity. The Contractor shall assist the Engineer and Owner as necessary in their coordination with the local media and the authorities.
3. Twenty-four hours prior to conducting smoke testing operations, the Contractor shall place door hangers at all residential homes and/or businesses in the area that could be affected by smoke testing operations informing residents that smoke testing will be conducted in their area within the next 24 hours. The Contractor shall submit a plan for approval by the Engineer regarding notification and coordination of smoke testing.
4. The day of smoke testing, Contractor shall contact the local fire and police departments and inform them of the times and locations of smoke testing operations.
5. Prior to initiating smoke testing, the Contractor shall isolate the line sections to be tested. Up to three reaches or approximately 1,000 linear feet of pipeline may be tested at one time. In the case of surcharged lines, the Contractor shall provide "flow-thru" plugs or removable weirs or dams to attenuate the flow so that smoke may move through the isolated reaches.
6. The Contractor shall prepare a basic smoke sketch, showing the location, crew and date/time of the smoke testing operation. Hard copy maps from the Owner's Geographic Information System (GIS) may be used provided that the scale is no larger than 1-inch to 200 feet and sufficient detail is provided in the map to accurately reference and describe the location of defects.
7. The Contractor shall provide blowers necessary to ensure the isolated line sections are adequately pressurized to force smoke into service laterals and potential defect locations.
8. Smoke will be generated continuously throughout the visual inspection and cataloguing period.
9. The Contractor shall conduct a visual inspection of the area isolated to include front and back yards, around buildings and house foundations. If the visual inspection requires the Contractor to leave public right-of-way or the Owner's easement, permission to access those areas shall first be granted by the property owner.
10. The Contractor shall capture the exact location of each positive smoke observation using one of the following methods:

- a. Global Positioning System (GPS) receiver capturing coordinates (Northing and Easting coordinate in NAD83 HARN, Feet, State Plane Coordinate System format approved by the Engineer) with sub-meter accuracy (+/- 3 feet). The unique identifier of the recorded GPS locations (“waypoints”) for each smoke observation shall also be included in the field sketch as described under paragraph 6 above.
 - b. Document all smoke observations by referencing the distance from the upstream manhole to a point on the main sewer line that is parallel with the smoke observation, the offset direction (left or right, if smoke observation is not on main sewer line), and the offset distance from the main sewer line to the smoke observation (“distance/offset” method).
11. A photograph shall be taken of each positive smoke observation. All photographs shall be captured with a digital camera capable of at least five megapixel resolution. The photo shall be taken from a perspective that shows the maximum amount of smoke from the leak. It shall be taken close enough to show the exact location of the leak, but far enough back to include the general location of the smoke relative to adjacent structures and other landmarks. In some situations, it may be necessary to capture multiple photographs of the smoke observation so that both a close-up view and a panoramic view of the smoke observation can be provided. A numbering system shall be used to catalog photos, described further in 3.03.C. This number shall be properly annotated on the sketch described in paragraph 6 above.
 12. Once all defects have been properly documented, the Contractor shall extinguish and properly dispose of any used smoke bombs or canisters and remove all flow control devices from the isolated reach. Removal of plugs and dams will be accomplished in a controlled manner to avoid any downstream surcharging or flooding.
- B. The Contractor shall provide for the pumping down of any surcharged manhole section and provide all bypass pumping, if required, during the inspection. All bypass pumping shall be approved by the Engineer.

3.02 Precautions

- A. The Contractor shall take all necessary precautions to ensure that water used does not flood property or buildings served by the sewer pipeline being inspected.
- B. A valved air line will be attached to a bag or plug so that it may be deflated from the surface.
- C. The water level within structures shall be observed and the minimum level that will cause flow to back up into buildings and cause property damage shall be determined prior to initiating operations so that flooding of buildings and property will not occur.

- D. Remove all plugs when a setup is complete. Failure to do this may result in backup and property damage.
- E. The Contractor shall provide, operate, maintain and subsequently remove on completion, adequate ventilation apparatus in the form of blowers and/or fans. The ventilation apparatus shall introduce a fresh air supply to support a safe environment for Work in sewers, manholes and all other confined spaces, which shall be kept free from dangerous, toxic and/or explosive gases, whether generated from sewage, soil strata or other source.
- F. The Contractor shall employ the “best practicable means” to minimize and mitigate noise as well as vibration resulting from operations. Mitigation measures shall include the utilization of sound suppression devices on all equipment and machinery particularly in residential areas and in the near vicinity of hospitals and schools, especially at night.
- G. The Contractor shall inform the Engineer before the commencement of any portion of the work of any significant change in the methods of noise attenuation from those previously approved.
- H. All pumps, generators, combination cleaners or other noise emitting equipment be shall be suitably screened to minimize nuisance and noise pollution. This requirement shall not be taken as preventing or prohibiting the execution of work necessary for the saving of life, protection of property, or safety of the personnel and/or facilities. The Contractor shall notify the Engineer of such use of plant or equipment in an emergency situation as soon as practicable.

3.03 Data Collection

- A. The Contractor shall document minimum required information for each smoke test, either in a digital format or a hand-written field log sheet. If the Contractor elects to document smoke test information digitally, the Contractor may choose to utilize a Microsoft Access database or Microsoft Excel spreadsheet provided by the Engineer to collect all smoke test information on a field computer or laptop. The Contractor may also elect to utilize or develop their own format for digitally capturing the required smoke test information, with final format approval by the Engineer prior to the start of work. Alternatively, the Contractor can elect to document all required smoke test information onto hand-written field logs, with final format approval by the Engineer prior to the start of work. All hand-written field logs shall be scanned and converted to Portable Document Format (PDF) files, with each PDF file using a consistent naming convention of “SmokeTest-[sequential number]” (such as “SmokeTest-1.PDF”). Inspection report files shall be furnished on a weekly basis to the Engineer. A new digital record or hand-written field log sheet shall be completed for each smoke test. The following is the minimum required information to be collected for each smoke test inspection:
 - 1. Unique numeric ID assigned to each inspection.

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2. Date of inspection.
 3. Time of inspection.
 4. Field crew performing inspection.
 5. Weather conditions at time of inspection.
 6. Location description (street intersection, business name, etc.)
 7. Total footage of sewer pipe tested.
 8. Setup method.
 9. Primary ID of each pipe segment inspected.
 10. Setup method.
 11. Sketch of setup, including locations of plugs installed and blower locations, and approximate locations of any positive smoke observations.
 12. Primary ID of each sanitary sewer manhole inspected
 13. Digital Photograph file names of smoke test setup and positive smoke observations (refer to 3.03.C).
 14. Geographic locations of positive smoke observations, using one of the methods described in 3.01, section 10.
 15. Unique numeric ID assigned to each positive smoke observation.
 16. Smoke severity ranking of positive smoke observations (light, moderate, heavy).
 17. Leak source description of positive smoke observation (i.e. broken main line, broken service lateral, broken clean-out, missing clean-out cap, roof drain, storm drain, etc.)
 18. Ground condition at positive smoke observation (dry, damp, wet).
 19. Nearest street address of positive smoke observation.
 20. Map page/sheet reference (if field maps are provided by the Engineer).
 21. Additional comments, such as access details, unusual conditions encountered, or difficulties incurred in performing the test.
- B. A field sketch shall be drawn for each smoke test setup. The field sketch should be very clear. It should indicate exactly what was isolated with respect to the sanitary sewer system.

- C. Digital photographs shall be captured for each smoke test setup and all positive smoke test observations, using a digital camera capable of a minimum of five megapixel resolution. The photograph shall be taken from an angle or observation point so that any reference features (such as house, driveway, or street intersection) are visible. All photographs shall be in Joint Photographic Experts Group (JPG or JPEG) file format and shall utilize a consistent file naming convention which shall be approved by the Engineer. Provide video footage (MPG or MPEG) only where such record clarifies or enhances still photographs.
- D. The Contractor must have an internal quality assurance/quality control system (QA/QC) in place, and all inspection data shall be subjected to the procedures prior to submittal to the Engineer. The Engineer will perform QA/QC audits on submitted data. Any data or files not meeting these specifications or NASSCO MACP standards will be returned to the Contractor for correction. Contractor shall present their proposed QA/QC system to the Engineer prior to the start of the Contract.

3.04 Smoke Testing Deliverables

- A. At the completion of work, the Contractor shall provide all data collected during smoke testing either as a Microsoft Excel spreadsheet (.xls or .xlsx), or as a Microsoft Access database (.mdb). If the Contractor so chooses, the Engineer can provide a formatted Microsoft Access database or Microsoft Excel spreadsheet for the Contractor to populate and return to the Engineer. The spreadsheet or database shall include a minimum of one record to correspond to each smoke test. The spreadsheet or database shall include for each record, at a minimum, all items listed under 3.03.A. The spreadsheet or database shall be structured so that appropriate relationships are established between inspection records and their related information, such as positive smoke observations, inspected manholes, and inspected sewer pipe segments, in order to provide referential integrity between worksheets or tables. The format used by the Contractor shall be reviewed and approved by the Engineer prior to the start of Work.
- B. Positive smoke testing results recorded by GPS equipment shall also be provided to the Engineer in a .txt file in a PNEZD (Point Reference, Northing, Easting, Elevation, Description) comma delineated format
- C. All hand-written field logs and/or sketches delivered electronically in PDF format, using the file naming convention described in 3.03.A.
- D. All digital photographs of each smoke test setup and all positive smoke observations delivered electronically in JPG or JPEG format, in an approved naming convention as described in 3.03.C.

- E. All deliverables shall be submitted on an external hard drive with a minimum of 500 gigabytes (GB) capacity, shall have a minimum USB 2.0 compliant connection, and shall be powered either through the host USB connection or have an external power adapter provided. External hard drives will be returned within 5 business days to the Contractor for use on any outstanding inspections or data deliverables after download by the Engineer. At the conclusion of the Project, the final submittal external hard drive will become the property of the Owner for use in archival of data. The Contractor shall maintain a copy of the final deliverables for up to 3 years.

END OF SECTION

Dye-Water Testing of Underground Sewer Pipelines

Part 1 General

1.01 Scope

The work covered by this Section includes furnishing all labor, material, equipment and services required for performing dye water testing services, authorized by the Engineer, as shown on the Drawings and/or specified herein. The objective of dye-water testing is to pinpoint specific points of entry of inflow into the sanitary sewer system, such as direct and indirect connections of storm drains, yard drain inlets and pipes, sinkholes, leaking manholes in unpaved areas and leaking manhole covers and rings. Dye-water testing shall also be used to trace line segments during sewer map updating, and co-relationship of individual properties to sewer lines.

1.02 Definition

The term "testing" as used in this Section, shall mean flooding or other techniques used to simulate rainfall to identify specific defects that can contribute to infiltration and/or inflow (I/I) during a rainfall event.

Part 2 Products

2.01 General

- A. The equipment needed for the dye-water testing is limited to that required to carry the water to the testing site and to sufficiently block the sewers or the study areas before the testing and fluorescent dyes.
- B. Dyes shall be of a distinct color that is readily detectable by eye. A suitable dye should be safe to handle, visible in low concentrations, miscible in water, inert to the soils and debris in the sewers, biodegradable, and non-toxic.
- C. Prior to the commencement of work, the Contractor shall coordinate access to water with the local water utility. Water will not be furnished by the Owner.
- D. All details of the point of water connection, backflow protection, conveyance methods, draw-off rates, times and all local conditions regarding the use of water shall be approved by the Engineer and the utility providing the water prior to commencement of work. All equipment, labor, and material required for obtaining water for the work shall be provided by the Contractor. The Contractor must ensure that a 6-inch minimum air gap is maintained at the water supply point on water tankers or any other receiving apparatus used to obtain water from the utility's hydrants.

Part 3 Execution

3.01 Dye Water Testing

- A. The following are situations where dye-water flooding may be utilized:
1. Storm drains that parallel or cross sanitary sewer sections (including services) and have crown elevations higher than the invert elevations of the sanitary sewers.
 2. Stream sections, drainage ditches, and ponding areas located near or above sanitary sewer lines (including services).
 3. Yard, area, and foundation drains, roof drains, abandoned building sewers, and faulty and/or illegal connections.
 4. Verification and/or quantification of actual or suspected problems identified from other tests such as smoke testing or physical survey.
- B. Depending on the infiltration and inflow (I/I) sources to be identified, and the configuration of the runoff situation that is being simulated (that is, storm drain, drainage ditch, spot flood), the procedures for dye-water flooding differ. Five examples are provided below:
1. Determination of I/I conditions caused by storm sewer sections. Storm drains that parallel or cross sanitary sewer sections and have crown elevations greater than the invert elevations of the sanitary sewers can be sources of rainfall induced infiltration or inflow. They are inflow sources if there are cross-connections between the storm drain sections and sanitary sewers. They are infiltration sources if the storm water can exfiltrate from them, percolate through the soil, and enter the sanitary sewers through pipe defects, broken pipes, or leaking joints. The general procedures for dye-water testing in storm drain sections are as follows:
 - a. Plug both ends of the storm drain section to be tested with sand bags or other materials. Block all the overflow and by-pass points in the sewer section. Provide bypassing of flow, if necessary.
 - b. Fill the storm drain section with water from fire hydrants or other nearby water sources. Add dye to the water.
 - c. Monitor the downstream manhole of the sanitary sewer system for evidence of dyed water.
 - d. Measure the flows in the manhole before and during the dye-water testing. As an alternative, the flows can be simultaneously measured at both the upstream and downstream manholes during the test.

- e. Record the location of storm drains and sanitary sewer lines being tested, the time and duration of tests, the manholes where the flows are monitored and the flow rates, the observed presence, concentrations and travel time of the dyed water into the flow monitoring manholes, and the soil characteristics.
2. Determination of I/I conditions caused by stream section. To determine whether the stream sections, ditch sections, and ponding areas located near or above sanitary sewer sections are causing I/I conditions in the sanitary sewers, a procedure similar to that described above shall be used. In these cases, the stream sections, ditch sections, and pond areas to be tested will be plugged or dammed (if necessary) and filled with dyed water to the desired levels. The presence, concentration, and travel time of the dyed water into the sanitary sewers are then monitored in the downstream manholes. Weir measurements or depth and velocity measurements should be made where quantification of I/I is desired.
 3. Identification of roof leader, cellar, yard and area drains, abandoned building sewers, faulty connections, and illegal connections. Most of these inflow sources are located on private properties. The property owners should be notified before the tests to identify the aforementioned in-flow sources. To identify the above mentioned inflow sources, dyed water is poured into the corresponding fixtures and their presence is checked in the closest downstream manhole in the sanitary sewer system. The date of the test, the address where the inflow sources are identified and the type of inflow sources should all be recorded. Again, weir or depth and velocity measurements can be made at the down-stream manhole to quantify the source.
 4. Identification of structurally damaged manholes. The dye-water test can also be used to identify the structurally damaged manholes that impose potential I/I problems. This is accomplished by flooding the area close to the suspected man-holes with dyed water and observing the presence of the dyed water at the manhole walls.
 5. Verification and/or quantification of actual or suspected I/I sources found in other field investigation phases. The dye-water test can be used in verifying suspected sources of I/I identified in the physical inspection of manholes or during smoke testing. Quantification of the defects will be done at the same time. The log sheet from the field study is used to identify and locate the source if the area of the suspected source is flooded. In some cases it may be necessary to restrict the runoff with sand bags to allow the area to become saturated. The downstream manhole is monitored for presence of the dyed water. If a positive result occurs, a weir or depth and velocity measurement will be taken to quantify the source.
- C. The Contractor shall provide for the pumping down of any surcharged manhole section and provide all bypass pumping, if required, during the dye-water testing operation. No separate payment shall be made for bypass pumping.

- D. The Contractor shall submit a comprehensive equipment list to the Engineer before commencement of the Work. The complete list, which shall include all backup and standby equipment, shall be broken down into the following categories (at a minimum):
 - 1. Safety equipment
 - 2. Flow measurement devices and techniques
 - 3. Flow diversion and flow control equipment
 - 4. Traffic control equipment
 - 5. All other equipment necessary for the completion of the work
- E. Blockages in the system shall be reported to the Engineer immediately.
- F. A responsible representative of the Contractor shall be present on the site of the work, or other location approved by the Engineer, to provide supervision of the work. At all times, and especially when a change of work location is underway, the Contractor's representative shall keep the Engineer continuously aware of the location, progress, planned execution of the work, and problems encountered.

3.02 Precautions

- A. The Contractor shall take all necessary precautions to ensure that water used does not flood property or buildings served by the sewer pipeline being inspected.
- B. No fire hydrant shall be obstructed, in case of a fire in the area served by the hydrant.
- C. A gate valve will be used to control the flow of water from a hydrant. Hydrants shall always be opened and closed slowly and completely. Hydrants shall not be used to throttle the flow. A pressure gauge will be used when inflating plugs or bags.
- D. A valved air line will be attached to a bag or plug so that it may be deflated from the surface.
- E. The water level within structures will be observed and the minimum level that will cause flow to back up into buildings and cause property damage will be determined prior to initiating operations so that flooding of buildings and property will not occur.
- F. Traffic control will be provided where hoses cross streets to prevent damage to both the water system and cars as a result from hitting the hoses at high speeds.
- G. The discharge end of the hoses will be secured.

- H. Remove all plugs when a setup is complete. Failure to do this may result in backup and property damage.
- I. The Contractor shall provide, operate, maintain and subsequently remove on completion, adequate ventilation apparatus in the form of blowers and/or fans. The ventilation apparatus shall introduce a fresh air supply to support a safe environment for Work in sewers, manholes and all other confined spaces, which shall be kept free from dangerous, toxic and/or explosive gases, whether generated from sewage, soil strata or other source.
- J. The Contractor shall employ the "best practicable means" to minimize and mitigate noise as well as vibration resulting from operations. Mitigation measures shall include the utilization of sound suppression devices on all equipment and machinery particularly in residential areas and in the near vicinity of hospitals and schools, especially at night.
- K. The Contractor shall inform the Engineer before the commencement of any portion of the work of any significant change in the methods of noise attenuation from those previously approved.
- L. All pumps, generators, combination cleaners or other noise emitting equipment shall be suitably screened to minimize nuisance and noise pollution. This requirement shall not be taken as preventing or prohibiting the execution of work necessary for the saving of life, protection of property, or safety of the personnel and/or facilities. The Contractor shall notify the Engineer of such use of plant or equipment in an emergency situation as soon as practicable.

3.03 Data Collection

- A. The Contractor shall document the following minimum required information for each sewer segment inspected, either in a digital format or a hand-written field log sheet. If the Contractor elects to document dye-water test information digitally, the Contractor may choose to utilize a Microsoft Access database or Microsoft Excel spreadsheet provided by the Engineer to collect the dye-water test information on a field computer or laptop. The Contractor may also elect to utilize or develop their own format for digitally capturing the required dye-water test information, with final format approval by the Engineer prior to the start of work. Alternatively, the Contractor can elect to document all required dye-water test information onto hand-written field logs, with final format approval by the Engineer prior to the start of work. All hand-written field logs shall be scanned and converted to Portable Document Format (PDF) files, with each PDF file using a consistent naming convention of "DyeTest-[sequential number]" (such as "DyeTest-1.PDF"). A new digital record or hand-written field log sheet shall be completed for each dye-water test whether or not a positive transference is observed. The following is the minimum required information to be collected for each dye-water test:
 - 1. Unique numeric ID assigned to each test.

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2. Date of test
 3. Time of test
 4. Field crew performing test.
 5. Weather conditions at time of test.
 6. Location, size and condition of sewer line test.
 7. Type of setup.
 8. Sketch of setup.
 9. Primary ID of each sewer manhole tested.
 10. Primary ID of each sewer pipe segment tested.
 11. Dye transference information.
 12. Flow readings before transference and during transference.
 3. Flooding time.
 14. Pipe size and storm footage involved.
 15. Additional comments, such as access details, unusual conditions encountered, or difficulties incurred in performing the test.
- B. A field sketch shall be drawn for each dye-water test setup. The field sketch should be very clear. It should indicate exactly what was flooded with respect to the sanitary sewer system.
- C. Digital photographs shall be captured for each dye-test setup, using a digital camera capable of a minimum of five megapixel resolution. The photograph shall be taken from an angle or observation point so that any reference features (such as house, driveway, or street intersection) are visible. All photographs shall be in Joint Photographic Experts Group (JPG or JPEG) file format and shall utilize a consistent file naming convention which shall be approved by the Engineer.
- D. The Contractor must have an internal quality assurance/quality control system (QA/QC) in place, and all inspection data shall be subjected to the procedures prior to submittal to the Engineer. The Engineer will perform QA/QC audits on submitted data. Any data or files not meeting these specifications or NASSCO standards will be returned to the Contractor for correction. Contractor shall present their proposed QA/QC system to the Engineer prior to the start of the Contract.

3.04 Dye Water Test Deliverables

- A. At the completion of work, the Contractor shall provide all data collected during dye-water testing either as a Microsoft Excel spreadsheet (.xls or .xlsx), or as a Microsoft Access database. If the Contractor so chooses, the Engineer can provide a formatted Microsoft Access database or Microsoft Excel spreadsheet for the Contractor to populate and return to the Engineer. The spreadsheet or database shall include a minimum of one record to correspond to each dye test. The spreadsheet or database shall include for each record, at a minimum, all items listed under 3.03.A. The spreadsheet or database shall be structured so that appropriate relationships are established between inspection records and their related information, such as inspected manholes and inspected pipe segments, in order to provide referential integrity between worksheets or tables. The format used by the Contractor shall be reviewed and approved by the Engineer prior to the start of work.
- B. All hand-written field logs and/or sketches delivered electronically in PDF format, utilizing the file naming convention described in 3.03.A.
- C. All digital photographs of dye-water test setups delivered electronically in JPG or JPEG format, in an approved naming convention as described in 3.03.C.
- D. All deliverables shall be submitted on an external hard drive with a minimum of 500 gigabytes (GB) capacity, shall have a minimum USB 2.0 compliant connection, and shall be powered either through the host USB connection or have an external power adapter provided. External hard drives will be returned within 5 business days to the Contractor for use on any outstanding inspections or data deliverables after download by the Engineer. At the conclusion of the project, the final submittal external hard drive will become the property of the Owner for use in archival of data. The Contractor shall maintain a copy of the final deliverables for up to 3 years.

END OF SECTION

Sonar Inspection of Existing Underground Sewer Pipelines

Part 1 General

1.01 Scope

The work covered by this Section includes furnishing all labor, materials, equipment and services required to perform the sonar inspection of the specific sewer pipelines authorized by the Engineer.

1.02 Definition

"Internal inspection" shall consist of using sonar within a designated sewer pipeline segment to detect point sources of infiltration/inflow or exfiltration and to determine the physical condition of the sewer pipeline including internal diameter, ovality, meander, degree of sedimentation, and type and location of defects.

1.03 Application

- A. Sonar shall be used independently or in conjunction with closed circuit television (CCTV) to inspect and provide data on the condition of sewer pipes below the water line. Unless directed otherwise by the Engineer, both sonar and CCTV inspections shall be conducted simultaneously employing a single platform carrying both types of sensors utilizing "Totally Integrated Sonar and CCTV Inspection Technique" (TISCIT). Where laser profiling is also used, the platform shall also transport that sensor. See Specification Section 33 01 30.16 for CCTV requirements. See Specification Section 33 01 30.28 for Laser Profiling requirements.
- B. Generally CCTV combined with sonar is used for internal condition assessment where depth of flow of sewage varies from 25% to 75% of overall sewer diameter for sewers greater than 24-inches in diameter. Where the sewer is less than 24-inches in diameter and depth of flow of sewage exceeds 25% and is less than 75% of overall sewer diameter the operator on site shall make the decision to continue the inspection or utilize one inspection method.

1.04 Sonar Operator Certification Requirements

- A. The Contractor shall provide current certification that operators conducting sonar inspections have undergone National Association of Sewer Service Companies (NASSCO) Pipeline Assessment and Certification Program (PACP®) training prior to commencement of inspection activities. Defect coding, as well as material, shape, and lining coding used throughout the Project shall conform to NASSCO PACP standards version 6.0.2.
- B. Each operator must have at least 5 years experience in the coding of sonar inspections and must have reported upon more than 250,000 feet of sonar. The Contractor must use NASSCO certified data collection software (PACP version 6.0.2), with final approval by the Engineer prior to the start of the Contract.

Part 2 Products

2.01 Sonar Equipment

- A. Sonar head and controller shall be contained in a waterproof, submersible enclosure mounted either on a tractor-driven, floating or submersible platform designed to traverse the interior of sewer pipe with a minimum equivalent internal diameter of 8-inches in a fully submerged flow or 21-inches in a semi-surcharged flow where flow depth is at least 25%, for up to 5,000 feet from the access point on a single deployment. Sensor, transducer, and data acquisition cable shall all be engineered for submerged sewage environments.
- B. The sonar sensor head shall be capable of 360° profile below the water line of the pipe interior, scanning continuously in a single pass at least once per second. High definition digital images shall be returned from scanning at least once per every 4 inches of forward travel. Acoustic signal frequency shall be 2 MHz. The acoustic signal shall be amplified and logarithmically compressed prior to being digitized. The acoustic beam width shall be a maximum of 1.1° from the center of the transducer and pitch and roll sensors inside the scanner shall record the attitude of the sonar to a resolution of 0.1°. At 10 feet range, the range resolution shall be a maximum of 0.5-inches.
- C. Digital imagery shall generate graphics display using 256 colors to represent a single amplitude. Imagery shall be returned in real time to a remote video viewing screen or computer monitor. Imagery shall be transmitted in MPEG 1 format and recordable to DVD or CD-ROM media.
- D. As the scanner is moved through the pipe an indication of the distance traveled shall be shown on the viewing screen allowing for accurate determination of the location of defects in the pipe. Internal sensors shall monitor and display pitch and roll indicators in analog and digital form on the screen to show the orientation of the transducer unit.
- E. Where used with CCTV, the sonar data stream shall be synchronized to provide subsurface information of the same pipe segment as the CCTV sensor in "real time". Display can be provided as split screen or picture-in-picture (PIP) mode.
- F. Where pipe is semi-surcharged, sonar equipment may be affixed to and floated on a raft, tethered skid or a self-propelled tractor.

2.02 Sonar Equipment Operation

- A. Operation of the sonar inspection equipment shall be controlled from above ground, with a skilled technician at the control panel in the sonar inspection van controlling the movement of the sonar platform. The technician shall have the capability to control the forward and reverse motion of the sonar platform and determine the sensor head's position, at any time. Operators of the television inspection equipment shall meet the requirements stated in Section 1.04 of this Specification.

- B. The following guidelines concerning the use of CCTV and sonar shall be followed, subject to the review and approval of the Owner:
1. Generally, CCTV alone shall be used for internal condition assessment where the depth of flow of sewage is less than 20% of overall sewer diameter at the start of the Inspection. The Contractor shall make an informed decision to continue should the depth of flow increase beyond the 20% level but no greater than 40% of overall sewer diameter at any time throughout the length.
 2. Generally, CCTV combined with sonar shall be used for internal condition assessment where the depth of flow of sewage varies from 20% to 75% of overall sewer diameter for sewers greater than 21-inches in diameter.
 3. The CCTV camera/sonar head shall be positioned to reduce the risk of picture distortion. In circular sewers the CCTV camera lens and/or sonar head shall be positioned, where possible, centrally within the "dry" area for the CCTV and the "wet" area for the sonar. In non-circular sewers, picture orientation shall be taken at mid-height, unless otherwise agreed, and centered horizontally. In all instances the camera lens shall be positioned looking along axis of the sewer. A positioning tolerance of + 10% of the vertical sewer dimension shall be allowed.
 4. When the scanning sonar is deployed, either stand alone or combined with CCTV, the speed shall be limited to 4 inches per second.
 5. A general condition 360° CCTV rotational scan must be implemented at every 50 feet interval (minimum) along sewers and at manholes and any salient, specified, defect features. More frequent scans must be made should the condition of the pipe differ from the previous scan. The tilt must not be less than 225°.
 6. The picture update speed shall not result in unsatisfactory picture resolution from either sensor head.

Part 3 Execution

3.01 Procedure

The sonar inspection shall be performed in one section of the sewer pipeline at a time, between adjacent manholes. The inspection shall be performed by pulling or propelling the sonar platform through the section of the sewer along the axis of the pipeline. A position tolerance of $\pm 10\%$ of the vertical sewer dimension will be allowed. The inspection shall be performed in a forward and/or backward direction, as dictated by the pipeline conditions at the time of the inspection. During the inspection of the sewer pipeline, every possible means shall be taken to ensure total viewing of the inside periphery of the pipeline. The inspection shall be conducted in such a manner as to determine that the line is clean and to locate all leaking joints, breaks, defects and faults in the pipeline. Sonar movement shall be temporarily halted at each defect in order to pan or tilt the sonar head and observe the full extent of the defect in detail, and to allow for a clear photograph of the defect. Sonar movement will not resume with

visible point sources of infiltration/inflow until the leakage rate from the source is quantified. The sonar shall also be stopped at service connections where flow is discharging. If the discharge persists, the property involved shall be checked, at the ground surface level, to determine whether or not the discharge is wastewater. If checking determines that the discharge is not wastewater, it shall be considered infiltration/inflow. The leakage rate of each infiltration/ inflow source shall be estimated in gallons per day (gpd).

3.02 Provisions

- A. The Contractor shall maintain on site at all times a competent field supervisor in charge of the inspection. The field supervisor shall be responsible for the safety of all site workers and site conditions as well as ensuring that all work is conducted in conformance with these Specifications and to the level of quality specified.
- B. The Contractor shall provide bypass pumping, where necessary, to prevent flooding or sanitary sewer overflows. Bypass pumping shall comply with provisions of Section 01 51 43 Temporary Bypass Pumping.
- C. The Contractor shall provide for the pumping down of any surcharged manhole section, if required, before television inspection commences. Bypass pumping must be approved by the Engineer prior to set up.
- D. The Contractor shall furnish, to the Owner, certification of the accuracy of the automatic counter before any work shall begin on the Project. If, at any time, the Engineer has reason to believe that the counter is inaccurate, the calibration of the counter will be checked before any more work progresses.
- E. Sonar Sensor Head Speed: The speed of the sonar sensor in the sewer shall be limited to 30 feet per minute for inspections to enable all details to be extracted from the final data imagery recording.
- F. At the start of each sewer length being surveyed or inspected and each reverse set-up, the length of pipeline from zero footage (the entrance to the pipe) up to the cable calibration point shall be recorded and reported in order to obtain a full record of the sewer length. Only one inspection shall be indicated in the final report. All reverse set-ups, blind manholes, and buried manholes shall be logged on a separate log. Each log shall make reference to a start (ST) and finish (FH) manhole unless abandonment took place because of blockage.
- G. Should the Contractor encounter a buried manhole during the course of inspection that cannot be readily accessed, the Contractor shall notify the Engineer, and shall make note of such in the appropriate field on the inspection header.
- H. If during the course of sonar inspection, a protruding tap is discovered in the pipeline that will not allow the passage of a sonar inspection platform and a reverse setup cannot be completed, then the Contractor will be required to remove the protruding tap via a remotely controlled robotic cutting device. Prior to removing the protruding tap, the Contractor must receive approval from the Engineer.

- I. If for any reason the camera becomes disabled inside the sewer and cannot further proceed, the Contractor shall be responsible for retrieving the camera at no additional cost to the Owner.
- J. All digital imagery shall be continuous with no evidence of missed footages or “blink-outs.” That the entire pipeline segment was traversed and inspected shall be obvious on the final data recording.
- K. Prior to inspection, each length of sewer shall be cleaned pursuant to Specification 33 01 30.14 Preconditioning and Cleaning of Underground Sewer Pipelines. All inspected pipe should be free of debris to allow for a complete, unobstructed view of the pipe. If upon viewing a final inspection, the Engineer deems that the view is obstructed, the pipe will be cleaned and re-televised at no cost to the Owner.

3.03 Data Collection

- A. The Contractor shall furnish all equipment and software required for taking still photograph captures and videos of the view which appears on the monitor. Digital imagery will be used to record all point sources and defects, severe leaks, holes, collapses, misalignments, etc. Still pictures shall be taken of all coded observations. Data logging and defect coding conforming to the NASSCO PACP will be required as part of all pipeline inspections.
- B. All inspection information shall be captured utilizing NASSCO certified data collection software and following all NASSCO PACP (version 6.0.2 or greater) standard data fields, formats, and conventions provided by the Engineer.
- C. All inspection media file naming formats and folder organizational structures must remain consistent throughout all internal inspections. See naming conventions in Section 3.04, Part E.
- D. A digital encoded inspection video shall be continuously captured for the entire length of each inspection. All digital encoded inspection video files shall be in MPEG 1 file format. For all digital encoded inspection videos, the file naming format shall be generated using a concatenation of standard PACP database fields in the format "Upstream_MH"_"Downstream_MH"_"Direction"_"Date"_"Time". Sonar inspections in which the sensor head is or becomes obstructed, dirty, greasy, etc. during the inspection, and remains so for up to two feet, will not be accepted.
- E. A digital still image shall be captured for each coded observation. All digital still images shall be in JPEG file format. For all digital still images, the file naming format shall be generated using a concatenation of standard PACP database fields in the format "InspectionID"_"ConditionID"_"Distance"_"PACP_Code".
- F. Each digital encoded inspection video shall begin with the sonar head facing down the length of pipe after being lowered into the manhole. This position shall be held during recording for a minimum of five seconds prior to proceeding down the pipe. For CCTV/sonar inspection, once the camera has been lowered into the manhole and oriented in its direction of travel, the camera shall be directed towards the top of the

manhole, with this position held during video recording for a minimum of five seconds prior to advancement into the sewer.

- G. A comprehensive summary inspection report shall be generated for each inspection, and shall be in Portable Document Format (PDF). The report shall include the findings on major defects, including but not limited to fractures, displaced joints, deformation, corrosion, lateral intrusions, and dominant surface features including encrustation and silt depths. All pdf report files shall be in a dedicated folder called "PACP_Reports".
- H. Each sewer length (the length of the sewer between two (2) consecutive manholes) will be entered into the PACP database field "Total_Length". If field maps are provided for the project area and include a total length, then this value will be entered into the field "Total_Length".
- I. When a length of sewer between two consecutive manholes cannot be inspected for practical reasons, the reason for abandonment shall be described in the PACP database field "Additional_Info". At unmapped manholes, a new inspection will be started and the footage re-set to zero (0.0).
- J. When the Contractor elects to "pull through" a manhole during a sonar and/or CCTV/sonar inspection, a new inspection will be started at the manhole "pulled through", and the footage re-set to zero (0.0) at the manhole wall where the pipe exits/enters the manhole.
- K. When a reverse or second inspection is required to complete the inspection of a sewer, the PACP database field "Reverse_Setup" shall be populated with corresponding inspection number. The "Reverse_Setup" field shall be null for all inspections that are not reverse or follow-up inspections.
- L. When an unmapped manhole is discovered during an inspection, the Contractor shall assign a temporary field-assigned ID to the manhole. This temporary field ID shall be entered into the appropriate PACP database field (either "Upstream_MH" or "Downstream_MH"), and the comment "Unmapped MH" shall be entered in the PACP database field "Additional_Info". The inspection shall be terminated and a new inspection shall begin, so that the unexpected manhole effectively divides the pipe into two segments. The "Total_Length" field for the terminated inspection shall be populated with the distance in feet at which the unexpected manhole was discovered during inspection. The pipe segment receiving the next inspection shall be assigned a temporary field ID, and the newly-discovered manhole ID shall be entered into the corresponding "Upstream_MH" or "Downstream_MH" field. The proposed naming scheme for unmapped manholes and pipes shall be approved by the Engineer prior to start of inspections. The Contractor shall ensure that each newly-discovered manhole and pipe is given an ID that is not already assigned to another manhole or pipe. The contractor shall also ensure that the field-assigned ID of each newly-discovered manhole is consistent between PACP and MACP submittals.
- M. At the start of each sewer length, a data generator shall electronically generate and clearly display on the viewing monitor and subsequently on the final recording a record of data in alpha-numeric form containing the following minimum information:

1. Automatic update of the sonar platform's footage position in the sewer line from adjusted zero.
 2. Sewer dimensions in inches
 3. Manhole numbers (must conform to Owner's identification number)
 4. Date of survey
 5. Road name (nearest)/location
 6. Direction of survey, i.e., downstream or upstream
 7. Time of start of survey
 8. Material of construction of the pipe
 9. Contractor
 10. Engineer
- N. The size and position of the data display shall be such as not to interfere with the main subject of the picture.
- O. Once the survey of the pipeline is under way, the following minimum information shall be continually displayed:
1. Automatic update of the camera's footage position in the sewer line from adjusted zero.
 2. Sewer dimensions in inches
 3. Manhole numbers (must conform to Owner's identification number)
 4. Direction of survey, i.e., downstream or upstream
- P. At each defect of any kind, the sonar movement shall be halted, and the sonar head shall be tilted and panned as necessary to observe the full extent of the defect before it is electronically coded.
- Q. At each coded observation, the following minimum information shall be displayed:
1. The PACP code and/or PACP code description.
 2. The footage position of the defect.
 3. The "Additional_Info" field in any cases where it is utilized.
- R. The actual field work will be monitored by the Engineer. The Engineer will have a Project Representative available during sonar inspection, and no work shall be

performed without the Engineer's Project Representative present, unless authorized by the Engineer.

- S. The contractor shall take caution to ensure that the pipe IDs and manhole IDs entered into the PACP database are correct, free from typos, and consistent with the data supplied by the Engineer. Databases with substantial rates of error in these fields will not be accepted.
- T. The Contractor must have an internal quality assurance/quality control system (QA/QC) in place, and all inspection data shall be subjected to the procedures prior to submittal to the Engineer. The Engineer will perform QA/QC audits on submitted data. Any data or files not meeting these Specifications or NASSCO standards will be returned to the Contractor for correction. Contractor shall present their proposed QA/QC system to the Engineer prior to the start of the Contract.

3.04 Sonar Inspection Deliverables

- A. All the supplied data and information will become the property of the Owner.
- B. Sample Submittal: An example of a typical sonar inspection final deliverable will be submitted for approval by the Engineer prior to the start of work. The example deliverable will contain the following:
 - 1. A sample NASSCO PACP Standard Exchange Database, version 6.0.2 or greater, in Microsoft Access file format (.mdb), as exported from the Contractor's data collection software.
 - 2. A proprietary database as generated by the Contractor's data collection software.
 - 3. Example media files, including observation photos, sonar videos, and reports; with all files consistently utilizing the required file naming conventions and folder structures.
 - 4. The proposed viewing software to be used with the proprietary inspections database and related media.
 - 5. NASSCO PACP validation report in PDF format, demonstrating the sample is fully conforming to NASSCO PACP standards and conventions. Validation reports can be obtained by submitting a sample database to:

http://www.nassco.org/training_edu/te_database_upload.aspx.
 - 6. Inspections database(s) shall be fully cross-referenced to the videos, images, and reports.
 - 7. Example reports will be presented in both hard copy and in PDF format, and all other sample data will be presented in digital format on an external hard drive.

- C. Intermediate Submittals: No later than every 14 days following the completion of a pipeline inspection, the Contractor will submit the following:
1. Two hard copies of full details report for each inspection, showing the position and full text of each defect encountered and their grades.
 2. An overall summary report detailing major defects and inspections that require attention.
 3. A list of unmapped manholes and/or pipe segments that were identified during inspections but were not shown on field maps. This list shall include the field-assigned ID and a geographic reference or description (street address, intersection, etc.)
 4. A statistical report showing lengths of sewers inspected and a breakdown of sizes and lengths inspected.
 5. At regular agreed intervals, an external hard drive will be submitted to the Engineer containing a single NASSCO PACP Standard Exchange Database (version 6.0.2 or greater) containing all inspections to date, encoded videos, observation photos, inspection reports in PDF format, and support files. The supplied data and information will become the property of the Owner.
- D. Final Submittal: At the completion of all inspection work, the Contractor will supply the following to the Engineer on an external hard drive:
1. A single, consolidated NASSCO PACP Standard Exchange Database (version 6.0.2 or greater) in Microsoft Access file format (.mdb) containing all inspections.
 2. NASSCO PACP validation report for the consolidated database (see Section 3.04.B.5.).
 3. All encoded inspection videos, observation photos, and inspection reports using required file naming formats.
 4. A single, consolidated proprietary database containing all inspections for the Contract, as generated by the Contractor's data collection software.
 5. Free-issue software to be used for the viewing of the proprietary inspections database and related media from within the database.
 6. Four hours training in the use of any supplied free-issue software will be included in the rates.
- E. File Formatting and Naming Conventions: All submittals shall have the following file formatting and naming conventions, unless otherwise approved by the Engineer:

SUBMITTAL DESCRIPTION	FILE NAMING CONVENTION	FILE FORMAT
Digital encoded videos	"Upstream_MH"_"Downstream_MH"_"Direction"_"Date"_"Time"	.mpg

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SUBMITTAL DESCRIPTION	FILE NAMING CONVENTION	FILE FORMAT
Digital still images of all observations	"InspectionID"_"ConditionID"_"Distance"_"PACP_Code" (multiple digital still images may have "-01", "-02", "-03" at end of file name)	.jpg or .jpeg
Color, Hi-res Laser profiling image of pipe 50' cross-sections	"InspectionID"_"ConditionID"_"Distance"_"PACP_Code"	.jpg or .jpeg
Pipe Segment Cleaning Report	CR-"Pipe_Segment_Reference"	.pdf
Pipe Segment Inspection Report	"Upstream_MH"_"Downstream_MH"_"Direction"_"Date"_"Time"	.pdf
NASSCO PACP Validation Report	"yyyymmdd(date of submittal)"_"Project Name"_"Validation Report"	.pdf
NASSCO PACP Exchange Database	"yyyymmdd(date of submittal)"_"Project Name"_"StandardPACPExchange"	.mdb

- F. External Hard Drive Requirements: External hard drives shall be a minimum of 500 Gigabytes (GB) in capacity and shall have a USB 2.0 compliant connection and shall be powered either through the host computers USB hub or shall have an external power adapter provided. External hard drives will be returned within 5 business days to the Contractor for use on outstanding inspections after download by the Engineer. At the conclusion of the Project, the final submittal external hard drive will become the property of the Owner for use in archival of data. The Contractor shall keep a copy of final submitted external hard drives for up to three years.
- G. NASSCO PACP Compliance: The submitted database(s) should consist of, at a minimum, the NASSCO PACP standard data fields, formats, and conventions as set forth in this specification and Attachment A – Field Data Delivery Format Requirements.

END OF SECTION

Laser Profile Inspection of Existing Underground Sewer Pipelines

Part 1 General

1.01 Scope

The work covered by this Section includes furnishing all labor, materials, equipment and services required to perform the sonar inspection of the specific sewer pipelines authorized by the Engineer.

1.02 Definition

"Internal inspection" shall consist of using laser profiling within a designated sewer pipeline segment to detect point sources of infiltration/inflow or exfiltration and to determine the physical condition of the sewer pipeline including internal diameter, lateral diameter, ovality, meander, holes, corrosion, depth of sedimentation, off-set joints, water levels, and type and location of defects.

1.03 Application

- A. Laser profiling shall be used in conjunction with closed circuit television (CCTV) to inspect and provide data on the condition of sewer pipes above the water line. Both laser profiling and CCTV inspections shall be conducted simultaneously employing a single platform carrying both types of sensors. Where sonar is also used, the platform shall also transport that sensor. See Specification Section 33 01 30.16 for CCTV requirements. See Specification Section 33 01 30.27 for Sonar requirements.
- B. In combination with CCTV and sonar information, laser profiling as "structured light" profile and light detection and ranging (LIDAR) creating a "point cloud" may be used to construct a three dimensional (3D) surface model of the pipe interior.

1.04 Laser Profiling Operator Certification Requirements

- A. The Contractor shall provide current certification that operators conducting laser profiling inspections have undergone National Association of Sewer Service Companies (NASSCO) Pipeline Assessment and Certification Program (PACP®) training prior to commencement of inspection activities. Defect coding, as well as material, shape, and lining coding used throughout the project shall conform to NASSCO PACP standards version 6.0.2.
- B. Each operator must have at least 5 years experience in the coding of laser profiling inspections and must have reported upon more than 125,000 feet of laser profiling. The Contractor must use NASSCO certified data collection software (PACP version 6.0.2), with final approval by the Engineer prior to the start of the Contract.

Part 2 Products

2.01 Laser Profiling Equipment

- A. Laser profiling head for “structured light” profiling and controller shall be contained in a waterproof, submersible enclosure mounted either on a tractor-driven or floating platform designed to traverse the interior of sewer pipe with a minimum equivalent internal diameter of 6-inches in a fully dewatered pipe or 18-inches in a semi-surcharged flow where flow depth is less than 50%, for up to 5,000 feet from the access point on a single deployment. LIDAR sensors shall be configured similarly for application in pipes with a minimum equivalent internal diameter of 30-inches. Sensor, transducer, and data acquisition cable shall all be engineered for submerged sewage environments.
- B. The laser profiling sensor head shall be capable of 360° profile above the water line of the pipe interior, scanning continuously in a single pass at least 30 times per second. LIDAR sensor heads shall be used to measure pipe geometries where bends are present. The laser assembly shall include an internal inclinometer to ascertain the laser image is projected perpendicular to the pipe axis. The laser assembly shall include a laser micrometer to measure the dimensions and depths of pipe defects and pipe joints. Accuracy will be within 0.04-inches (1 mm) when measuring diameters, deformation and ovality.
- C. Digital imagery shall generate graphics display using 256 colors to represent 3D profile of pipe surface. Imagery shall be returned in real time to a remote video viewing screen or computer monitor. Imagery shall be transmitted in MPEG 1 format and recordable to DVD or CD-ROM media.
- D. As the laser profiler is moved through the pipe an indication of the distance traveled shall be shown on the viewing screen allowing for accurate determination of the location of defects in the pipe. Internal sensors shall monitor and display pitch and roll indicators in analog and digital form on the screen to show the orientation of the transducer unit.
- E. The laser profiling data stream shall be synchronized to provide above water surface information of the same pipe segment as the CCTV sensor once the CCTV lighting source is turned off. The laser image (“ring of light”) will be in the field of view of the camera while the camera moves through the pipe. Display can be provided as split screen or picture-in-picture (PIP) mode.
- F. Where pipe is semi-surcharged, laser profiling equipment may be affixed to and floated on a raft, tethered skid or a self-propelled tractor that keeps the sensor head above the water surface.

2.02 Laser Profiling Equipment Operation

- A. Operation of the laser profiling inspection equipment shall be controlled from above ground, with a skilled technician at the control panel in the laser profiling inspection van

controlling the movement of the laser profiling platform. The technician shall have the capability to control the forward and reverse motion of the laser profiling platform and determine the sensor head's position, at any time. Operators of the television inspection equipment shall meet the requirements stated in Section 1.04 of this Specification.

- B. The following guidelines concerning the use of CCTV and laser profiling shall be followed, subject to the review and approval of the Owner:
1. Generally, CCTV alone shall be used for internal condition assessment where the depth of flow of sewage is less than 20% of overall sewer diameter at the start of the Inspection. The Contractor shall make an informed decision to continue should the depth of flow increase beyond the 20% level but no greater than 40% of overall sewer diameter at any time throughout the length.
 2. The CCTV camera/laser profiling head shall be positioned to reduce the risk of picture distortion. In circular sewers the CCTV camera lens and/or laser profiling head shall be positioned, where possible, centrally within the "dry" area for both the CCTV and the laser profiling. In non-circular sewers, picture orientation shall be taken at mid-height, unless otherwise agreed, and centered horizontally. In all instances the camera lens shall be positioned looking along axis of the sewer above the water surface. A positioning tolerance of + 10% of the vertical sewer dimension shall be allowed.
 3. When laser profiling is deployed the speed shall be limited to four inches per second.
 4. A general condition 360° CCTV rotational scan must be implemented at every 50 feet interval (minimum) along sewers and at manholes and any salient, specified, defect features. More frequent scans must be made should the condition of the pipe differ from the previous scan. The tilt must not be less than 225°.
 5. The picture update speed shall not result in unsatisfactory picture resolution from either sensor head.

Part 3 Execution

3.01 Procedure

The laser profiling inspection shall be performed in one section of the sewer pipeline at a time, between adjacent manholes. The inspection shall be performed by pulling or propelling the laser profiling platform through the section of the sewer along the axis of the pipeline. A position tolerance of $\pm 10\%$ of the vertical sewer dimension will be allowed. The inspection shall be performed in a forward and/or backward direction, as dictated by the pipeline conditions at the time of the inspection. During the inspection of the sewer pipeline, every possible means shall be taken to ensure total viewing of the inside periphery of the pipeline. The inspection shall be conducted in such a

manner as to determine that the line is clean and to locate all leaking joints, breaks, defects and faults in the pipeline. Laser profiling movement shall be temporarily halted at each defect in order to pan or tilt the laser profiling sensor head and observe the full extent of the defect in detail, and to allow for a clear photograph of the defect. Laser profiling movement will not resume with visible point sources of infiltration/inflow until the leakage rate from the source is quantified. The laser profiling shall also be stopped at service connections where flow is discharging. If the discharge persists, the property involved shall be checked, at the ground surface level, to determine whether or not the discharge is wastewater. If checking determines that the discharge is not wastewater, it shall be considered infiltration/inflow. The leakage rate of each infiltration/ inflow source shall be estimated in gallons per day (gpd).

3.02 Provisions

- A. The Contractor shall maintain on site at all times a competent field supervisor in charge of the inspection. The field supervisor shall be responsible for the safety of all site workers and site conditions as well as ensuring that all work is conducted in conformance with these Specifications and to the level of quality specified.
- B. The Contractor shall provide bypass pumping, where necessary, to prevent flooding or sanitary sewer overflows. Bypass pumping shall comply with provisions of Section 01 51 43 Temporary Bypass Pumping.
- C. The Contractor shall provide for the pumping down of any surcharged manhole section, if required, before CCTV/laser profiling inspection commences. Bypass pumping must be approved by the Engineer prior to set up.
- D. The Contractor shall furnish, to the Owner, certification of the accuracy of the automatic counter before any work shall begin on the Project. If, at any time, the Engineer has reason to believe that the counter is inaccurate, the calibration of the counter will be checked before any more work progresses.
- E. Laser Profiling Sensor Head Speed: The speed of the laser profiling sensor in the sewer shall be limited to 20 feet per minute for inspections to enable all details to be extracted from the final data imagery recording.
- F. At the start of each sewer length being surveyed or inspected and each reverse set-up, the length of pipeline from zero footage (the entrance to the pipe) up to the cable calibration point shall be recorded and reported in order to obtain a full record of the sewer length. Only one inspection shall be indicated in the final report. All reverse set-ups, blind manholes, and buried manholes shall be logged on a separate log. Each log shall make reference to a start (ST) and finish (FH) manhole unless abandonment took place because of blockage.
- G. Should the Contractor encounter a buried manhole during the course of inspection that cannot be readily accessed, the Contractor shall notify the Engineer, and shall make note of such in the appropriate field on the inspection header.
- H. If during the course of laser profiling inspection, a protruding tap is discovered in the pipeline that will not allow the passage of a laser profiling inspection platform and a

reverse setup cannot be completed, then the Contractor will be required to remove the protruding tap via a remotely controlled robotic cutting device. Prior to removing the protruding tap, the Contractor must receive approval from the Engineer.

- I. If for any reason the laser becomes disabled inside the sewer and cannot further proceed, the Contractor shall be responsible for retrieving the laser at no additional cost to the Owner.
- J. All digital imagery shall be continuous with no evidence of missed footages or “blink-outs.” That the entire pipeline segment was traversed and inspected shall be obvious on the final data recording.
- K. Prior to inspection, each length of sewer shall be cleaned pursuant to Specification 33 01 30.14. All inspected pipe should be free of debris to allow for a complete, unobstructed view of the pipe. If upon viewing a final inspection, the Engineer deems that the view is obstructed, the pipe will be cleaned and re-televised at no cost to the Owner.

3.03 Data Collection

- A. The Contractor shall furnish all equipment and software required for taking still photograph captures and videos of the view which appears on the monitor. Digital imagery will be used to record all point sources and defects, severe leaks, holes, collapses, misalignments, etc. Still pictures shall be taken of all coded observations. Data logging and defect coding conforming to the NASSCO PACP will be required as part of all pipeline inspections.
- B. All inspection information shall be captured utilizing NASSCO certified data collection software and following all NASSCO PACP (version 6.0.2 or greater) standard data fields, formats, and conventions provided by the Engineer.
- C. All inspection media file naming formats and folder organizational structures must remain consistent throughout all internal inspections. See naming conventions in Section 3.04, Part E.
- D. A digital encoded inspection video shall be continuously captured for the entire length of each inspection. All digital encoded inspection video files shall be in MPEG 1 file format. For all digital encoded inspection videos, the file naming format shall be generated using a concatenation of standard PACP database fields in the format "Upstream_MH"_"Downstream_MH"_"Direction"_"Date"_"Time". Laser profiling inspections in which the sensor head is or becomes obstructed, dirty, greasy, etc. during the inspection, and remains so for up to two feet, will not be accepted.
- E. A digital still image shall be captured for each coded observation. All digital still images shall be in JPEG file format. For all digital still images, the file naming format shall be generated using a concatenation of standard PACP database fields in the format "InspectionID"_"ConditionID"_"Distance"_"PACP_Code".

- F. Each digital encoded inspection video shall begin with the laser profiling head facing towards the bottom of the manhole and oriented so that the outgoing sewer connection is at the 6 o'clock position. This position shall be held during recording for a minimum of five seconds prior to lowering the platform to the bottom of the manhole. For CCTV/laser profiling inspection, once the camera has been lowered into the manhole and oriented in its direction of travel, the camera shall be directed towards the top of the manhole, with this position held during video recording for a minimum of five seconds prior to advancement into the sewer.
- G. A comprehensive summary inspection report shall be generated for each inspection, and shall be in Portable Document Format (PDF). The report shall include the findings on major defects, including but not limited to fractures, displaced joints, deformation, corrosion, lateral intrusions, and dominant surface features including encrustation and silt depths. All pdf report files shall be in a dedicated folder called "PACP_Reports".
- H. Each sewer length (the length of the sewer between two consecutive manholes) will be entered into the PACP database field "Total_Length". If field maps are provided for the project area and include a total length, then this value will be entered into the field "Total_Length".
- I. When a length of sewer between two consecutive manholes cannot be inspected for practical reasons, the reason for abandonment shall be described in the PACP database field "Additional_Info". At unmapped manholes, a new inspection will be started and the footage re-set to zero (0.0).
- J. When the Contractor elects to "pull through" a manhole during a laser profiling and/or CCTV/laser profiling inspection, a new inspection will be started at the manhole "pulled through", and the footage re-set to zero (0.0) at the manhole wall where the pipe exits/enters the manhole.
- K. When a reverse or second inspection is required to complete the inspection of a sewer, the PACP database field "Reverse_Setup" shall be populated with corresponding inspection number. The "Reverse_Setup" field shall be null for all inspections that are not reverse or follow-up inspections.
- L. When an unmapped manhole is discovered during an inspection, the Contractor shall assign a temporary field-assigned ID to the manhole. This temporary field ID shall be entered into the appropriate PACP database field (either "Upstream_MH" or "Downstream_MH"), and the comment "Unmapped MH" shall be entered in the PACP database field "Additional_Info". The inspection shall be terminated and a new inspection shall begin, so that the unexpected manhole effectively divides the pipe into two segments. The "Total_Length" field for the terminated inspection shall be populated with the distance in feet at which the unexpected manhole was discovered during inspection. The pipe segment receiving the next inspection shall be assigned a temporary field ID, and the newly-discovered manhole ID shall be entered into the corresponding "Upstream_MH" or "Downstream_MH" field. The proposed naming scheme for unmapped manholes and pipes shall be approved by the Engineer prior to start of inspections. The Contractor shall ensure that each newly-discovered manhole and pipe is given an ID that is not already assigned to another manhole or pipe. The

Contractor shall also ensure that the field-assigned ID of each newly-discovered manhole is consistent between PACP and MACP submittals.

- M. At the start of each sewer length, a data generator shall electronically generate and clearly display on the viewing monitor and subsequently on the final recording a record of data in alpha-numeric form containing the following minimum information:
1. Automatic update of the laser profiling platform's footage position in the sewer line from adjusted zero.
 2. Sewer dimensions in inches
 3. Manhole numbers (must conform to Owner's identification number)
 4. Date of survey
 5. Road name (nearest)/location
 6. Direction of survey, i.e., downstream or upstream
 7. Time of start of survey
 8. Material of construction of the pipe
 9. Contractor
 10. Engineer
- N. The size and position of the data display shall be such as not to interfere with the main subject of the picture.
- O. Once the survey of the pipeline is under way, the following minimum information shall be continually displayed:
1. Automatic update of the laser's footage position in the sewer line from adjusted zero.
 2. Sewer dimensions in inches
 3. Manhole numbers (must conform to Owner's identification number)
 4. Direction of survey, i.e., downstream or upstream
- P. At each defect of any kind, the laser profiling movement shall be halted, and the laser profiling sensor head shall be tilted and panned as necessary to observe the full extent of the defect before it is electronically coded.
- Q. At each coded observation, the following minimum information shall be displayed:
1. The PACP code and/or PACP code description.

2. The footage position of the defect.
 3. The "Additional_Info" field in any cases where it is utilized.
- R. The actual field work will be monitored by the Engineer. The Engineer will have a Project Representative available during laser profiling inspection, and no work shall be performed without the Engineer's Project Representative present, unless authorized by the Engineer.
- S. The Contractor shall take caution to ensure that the pipe IDs and manhole IDs entered into the PACP database are correct, free from typos, and consistent with the data supplied by the Engineer. Databases with substantial rates of error in these fields will not be accepted.
- T. The Contractor must have an internal quality assurance/quality control system (QA/QC) in place, and all inspection data shall be subjected to the procedures prior to submittal to the Engineer. The Engineer will perform QA/QC audits on submitted data. Any data or files not meeting these specifications or NASSCO standards will be returned to the Contractor for correction. Contractor shall present their proposed QA/QC system to the Engineer prior to the start of the Contract.

3.04 Laser Profiling Inspection Deliverables

- A. All the supplied data and information will become the property of the Owner.
- B. Sample Submittal: An example of a typical laser profiling inspection final deliverable will be submitted for approval by the Engineer prior to the start of work. The example deliverable will contain the following:
1. A sample NASSCO PACP Standard Exchange Database, version 6.0.2 or greater, in Microsoft Access file format (.mdb), as exported from the Contractor's data collection software.
 2. A proprietary database as generated by the Contractor's data collection software.
 3. Example media files, including observation photos, laser profiling videos, and reports; with all files consistently utilizing the required file naming conventions and folder structures.
 4. The proposed viewing software to be used with the proprietary inspections database and related media.
 5. NASSCO PACP validation report in PDF format, demonstrating the sample is fully conforming to NASSCO PACP standards and conventions. Validation reports can be obtained by submitting a sample database to:

http://www.nassco.org/training_edu/te_database_upload.aspx.

6. Inspections database(s) shall be fully cross-referenced to the videos, images, and reports.
 7. Example reports will be presented in both hard copy and in PDF format, and all other sample data will be presented in digital format on an external hard drive.
- C. Intermediate Submittals: No later than every 14 days following the completion of a pipeline inspection, the Contractor will submit the following:
1. Two hard copies of full details report for each inspection, showing the position and full text of each defect encountered and their grades.
 2. An overall summary report detailing major defects and inspections that require attention.
 3. A list of unmapped manholes and/or pipe segments that were identified during inspections but were not shown on field maps. This list shall include the field-assigned ID and a geographic reference or description (street address, intersection, etc.)
 4. A statistical report showing lengths of sewers inspected and a breakdown of sizes and lengths inspected.
 5. At regular agreed intervals, an external hard drive will be submitted to the Engineer containing a single NASSCO PACP Standard Exchange Database (version 6.0.2 or greater) containing all inspections to date, encoded videos, observation photos, inspection reports in PDF format, and support files. The supplied data and information will become the property of the Owner.
- D. Final Submittal: At the completion of all inspection work, the Contractor will supply the following to the Engineer on an external hard drive:
1. A single, consolidated NASSCO PACP Standard Exchange Database (version 6.0.2 or greater) in Microsoft Access file format (.mdb) containing all inspections.
 2. NASSCO PACP validation report for the consolidated database (see Section 3.04.B.5.).
 3. All encoded inspection videos, observation photos, and inspection reports using required file naming formats.
 4. A single, consolidated proprietary database containing all inspections for the Contract, as generated by the Contractor's data collection software.
 5. Free-issue software to be used for the viewing of the proprietary inspections database and related media from within the database.
 6. Four hours training in the use of any supplied free-issue software will be included in the rates.

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- E File Formatting and Naming Conventions: All submittals shall have the following file formatting and naming conventions, unless otherwise approved by the Engineer

SUBMITTAL DESCRIPTION	FILE NAMING CONVENTION	FILE FORMAT
Digital encoded videos	"Upstream_MH"_"Downstream_MH"_"Direction"_"Date"_"Time"	.mpg
Digital still images of all observations	"InspectionID"_"ConditionID"_"Distance"_"PACP_Code" (multiple digital still images may have "-01", "-02", "-03" at end of file name)	.jpg or .jpeg
Color, Hi-res Laser profiling image of pipe 50' cross-sections	"InspectionID"_"ConditionID"_"Distance"_"PACP_Code"	.jpg or .jpeg
Pipe Segment Cleaning Report	CR-"Pipe_Segment_Reference"	.pdf
Pipe Segment Inspection Report	"Upstream_MH"_"Downstream_MH"_"Direction"_"Date"_"Time"	.pdf
NASSCO PACP Validation Report	"yyyymmdd(date of submittal)"_"Project Name"_"Validation Report"	.pdf
NASSCO PACP Exchange Database	"yyyymmdd(date of submittal)"_"Project Name"_"StandardPACPExchange"	.mdb

- F. 3D Profile Maps: When specified as a deliverable, 3D profile maps of the interior pipe surface shall be flat, unfolded maps of the surface. For the surface inspected, the map shall depict:
1. Data on a grid of not less than 0.5-inch square gridlines
 2. Pipe joints
 3. Pipe laterals
 4. Pipe defects – length, width, depth
 5. Wall loss based on internal corrosion
 6. Debris and debris depth
 7. Quantity calculator for debris
- G. External Hard Drive Requirements: External hard drives shall be a minimum of 500 Gigabytes (GB) in capacity and shall have a USB 2.0 compliant connection and shall be powered either through the host computers USB hub or shall have an external power adapter provided. External hard drives will be returned within 5 business days to the Contractor for use on outstanding inspections after download by the Engineer. At the conclusion of the Project, the final submittal external hard drive will become the property of the Owner for use in archival of data. The Contractor shall keep a copy of final submitted external hard drives for up to three years.

- H. NASSCO PACP Compliance: The submitted database(s) should consist of, at a minimum, the NASSCO PACP standard data fields, formats, and conventions as set forth in this Specification and Attachment A – Field Data Delivery Format Requirements.

END OF SECTION

Part 1 General

1.01 Scope

The work covered by this Section includes furnishing all labor, material, equipment and services required for performing sanitary sewer manhole inspection services, authorized by the Engineer, as shown on the Drawings and/or specified herein. The objective of manhole inspection is to detect sources of inflow and infiltration, as well as determine the structural condition of the manholes.

1.02 General Provisions

- A. The Contractor will provide all equipment and tools necessary to safely access and inspect the manholes.
- B. The Contractor shall perform inspections of the project manholes and record any defect discovered. The inspection shall include, at a minimum, surface, manhole cover and frame, chimney, walls, invert and all appurtenances. Unless specified otherwise, all manhole inspections shall be fully-conforming to National Association of Sewer Service Companies (NASSCO) MACP standards.
- C. The Contractor shall use a digital camera to capture all images of manhole components, defects, inflow and infiltration and observations. The Contractor may use a combination of CCTV camera equipment and field data collection software for the manhole inspections with approval by the Engineer. If a standard digital camera is used, the camera must be equipped with a strobe flash and be capable of producing high resolution digital images with minimum of 5 mega pixel resolution.
- D. The Contractor will provide current certification that operators have undergone NASSCO MACP training prior to undertaking manhole condition assessment work for Owner. Unless specified otherwise, all defect coding used throughout the Project will conform to NASSCO MACP standards version 6.0.1.
- E. A diligent effort shall be made to locate all structures. Metal detectors shall be used to locate buried manholes. Once a buried manhole has been located, it shall be marked with paint and/or flagging, if necessary. All pertinent information available shall be recorded including area photo, address, etc. Contractor shall notify the Engineer weekly with a list of those manholes that could not be fully inspected due to being buried, surcharged, could not open, or otherwise unable to locate.
- F. The Contractor's personnel conducting inspections must have at least 5 years experience in the coding of the manhole condition assessments and must have reported upon more than 1,000 individual manhole inspections. Proof of such experience will be submitted prior to start of work. The Contractor must use NASSCO certified data collection software (MACP version 6.0.1), with final approval by the Engineer prior to the start of the Contract.

- G. A GPS unit capable of sub-meter accuracy (horizontal +/- 3 feet) shall be used for documenting location of manholes not shown on the Owner's system maps.

Part 2 Execution

2.01 Manhole Inspection

- A. All sanitary sewer manholes in the Project Area will be visually inspected to determine sources of inflow and infiltration and structural defects. The Contractor shall conduct a Level 1 surface inspection for every manhole and a Level 2 internal inspection shall be completed for select manholes at the direction of the Engineer. Inspections shall be done by completing MACP inspection forms as outlined in Part 3, Section 3.03 of this Specification.
- B. Level 2 inspections shall be conducted for every manhole showing visible signs of infiltration or defects. If a manhole cannot be determined to be free of defects or infiltration, then a Level 2 inspection shall be performed.
- C. The Contractor shall provide for the pumping down of any surcharged manhole section and provide all bypass pumping, if required, during the inspection. The Contractor shall receive Engineer's approval prior to bypass pumping.
- D. The Contractor shall submit a comprehensive equipment list to the Engineer before commencement of the Work. The complete list, which shall include all backup and standby equipment, shall be broken down into the following categories (at a minimum):
 - 1. Safety equipment
 - 2. Flow diversion and flow control equipment
 - 3. Traffic control equipment
 - 4. All other equipment necessary for the completion of the Work
- E. Blockages in the system shall be reported to the Engineer immediately.
- F. A responsible representative of the Contractor shall be present on the site of the work, or other location approved by the Engineer, to provide supervision of the work. At all times, and especially when a change of work location is underway, the Contractor's representative shall keep the Engineer continuously aware of the location, progress, planned execution of the work, and problems encountered.
- G. Should the Contractor encounter a buried manhole during the course of inspection that cannot be readily accessed, the Contractor shall notify the Engineer.

2.02 Precautions

- A. The Contractor shall take all necessary precautions to ensure that water used does not flood property or buildings served by the sewer pipeline being inspected.
- B. A valved air line will be attached to bags or plugs used to control flow so that they may be deflated from the surface.
- C. The water level within structures will be observed and the minimum level that will cause flow to back up into buildings and cause property damage will be determined prior to initiating operations so that flooding of buildings and property will not occur.
- D. Remove all plugs when a setup is complete. Failure to do this may result in backup and property damage.
- E. The Contractor shall provide, operate, maintain and subsequently remove on completion, adequate ventilation apparatus in the form of blowers and/or fans. The ventilation apparatus shall introduce a fresh air supply to support a safe environment for Work in sewers, manholes and all other confined spaces, which shall be kept free from dangerous, toxic and/or explosive gases, whether generated from sewage, soil strata or other source.
- F. The Contractor shall employ the “best practicable means” to minimize and mitigate noise as well as vibration resulting from operations. Mitigation measures shall include the utilization of sound suppression devices on all equipment and machinery particularly in residential areas and in the near vicinity of hospitals and schools, especially at night.
- G. The Contractor shall inform the Engineer before the commencement of any portion of the work of any significant change in the methods of noise attenuation from those previously approved.
- H. All pumps, generators, combination cleaners or other noise emitting equipment be shall be suitably screened to minimize nuisance and noise pollution. This requirement shall not be taken as preventing or prohibiting the execution of work necessary for the saving of life, protection of property, or safety of the personnel and/or facilities. The Contractor shall notify the Engineer of such use of plant or equipment in an emergency situation as soon as practicable.

3.03 Data Collection

- A. The Contractor shall complete a separate Manhole Inspection Header Form, Manhole Component Observation Form, and Manhole Pipe Connection Form for each manhole inspected, both Level 1 and Level 2 inspections.
 - 1. Level 1 inspections record observations of the manhole’s condition as seen from the ground surface outside of the manhole.

2. In addition to the surface observations of Level 1 inspection, Level 2 inspections will identify defects of the manhole through a confined space entry of the manhole.
 3. Manhole Inspection Header Forms, Manhole Component Observation Forms, and Manhole Pipe Connection Forms shall be filled out containing, at a minimum, the mandatory information required for Level 1 and/or Level 2 inspections per MACP (version 6.0.1).
- B For all Level 2 inspections, the Contractor must complete a Level 2 – Manhole Component Defect Form for each manhole inspected as directed by MACP (version 6.0.1).
1. This form shall be used to record all defects for the chimney, cone, wall, bench and channel only. All other manhole component defects shall be recorded in the Manhole Component Observation Form.
 2. When inspecting manholes all applicable PACP coding shall be utilized, except for tap codes, camera underwater code, and line direction codes.
- C. All inspections shall be recorded on standard manhole forms provided by or approved by the Engineer.
- D. Unless an alternative system is approved by the Engineer, all inspections data shall be entered, by the Contractor, into a NASSCO Manhole Assessment Certification Program (MACP) compliant database (version 6.0.1 minimum).
- E. If inspection forms are filled out manually, all forms shall be scanned to Portable Document Format (PDF), with the file name being the MH identification number (example: AB123.pdf).
- F. Inspections database shall be fully cross-referenced to all videos, images and reports. All media file names and relative path locations shall be present in the NASSCO MACP database.
- G. Digital photographs shall be captured of the exterior and the invert of each inspected manhole. All digital photographs captured from the exterior of the manhole shall be oriented so that the outgoing pipe connection is at the 6 o'clock position with respect to the camera view orientation.
- H. A digital still image shall be captured for each defect. All digital still images shall be in JPEG file format. If inspections are recorded in the field electronically into a NASSCO MACP database, all digital still images of defects shall be generated using a concatenation of standard MACP database fields in the format "Manhole ID_Condition ID_MACP Code". If inspections are recorded manually in the field, file names of defect digital still images shall follow the convention "Manhole ID_[sequential number]_MACP Code".

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- I. Contractor shall maintain a copy of all report material. The Contractor shall provide comments as necessary to fully describe the existing condition of the manhole on the inspection forms.
 - J. Contractor shall be responsible for modifications to equipment and/or inspection procedures to achieve reporting requirements identified in these Specifications.
 - K. No work shall commence prior to approval of the submitted material by the Engineer. Once accepted, the report material shall serve as a standard for the remaining work.
 - L. When an unmapped manhole is discovered during an inspection, the Contractor shall assign a temporary field-assigned ID to the manhole. This temporary field ID shall be entered into the appropriate PACP database field (either "Upstream_MH" or "Downstream_MH"), and the comment "Unmapped MH" shall be entered in the PACP database field "Additional_Info". The inspection shall be terminated and a new inspection shall begin, so that the unexpected manhole effectively divides the pipe into two segments. The "Total_Length" field for the terminated inspection shall be populated with the distance in feet at which the unexpected manhole was discovered during inspection. The pipe segment receiving the next inspection shall be assigned a temporary field ID, and the newly-discovered manhole ID shall be entered into the corresponding "Upstream_MH" or "Downstream_MH" field. The proposed naming scheme for unmapped manholes and pipes shall be approved by the Engineer prior to start of inspections. The Contractor shall ensure that each newly-discovered manhole and pipe is given an ID that is not already assigned to another manhole or pipe. The contractor shall also ensure that the field-assigned ID of each newly-discovered manhole is consistent between PACP and MACP submittals.
 - M. If the Contractor uses a Global Positioning System device (GPS), then coordinates of all uncharted manholes shall be collected with device using a coordinate system and file format approved by the Engineer prior to the start of the Contract. For recording of all uncharted manholes, coordinates and coordinate system shall be required on the Manhole Inspection Header Form at the time of inspection.
 - N. The inspection photographs, report documents, and inspections database shall be in accordance with NASSCO MACP.
 - O. The comments area on the Header Form can be used to record observations and information such as:
 1. Previous and existing weather conditions.
 2. Soil conditions.
 3. Access for future maintenance or rehabilitation.
 4. Unusual conditions in the sanitary system and difficulties incurred in performing the inspection
 5. Catalog of photographs and videos of manhole

6. Any other remarks/comments not covered under any form headings
- P. The Contractor must have an internal quality assurance/quality control system (QA/QC) in place, and all inspection data shall be subjected to the procedures prior to submittal to the Engineer. The Engineer will perform QA/QC audits on submitted data. Any data or files not meeting these specifications or NASSCO MACP standards will be returned to the Contractor for correction. Contractor shall present their proposed QA/QC system to the Engineer prior to the start of the Contract.

3.04 Manhole Inspection Deliverables

- A. All the supplied data and information will become the property of the Owner.
- B. Sample Submittal: An example of a typical Manhole Inspection final deliverable will be submitted for approval by the Engineer prior to the start of the Contract. The example deliverable will contain the following:
1. A sample NASSCO MACP Standard Exchange Database (version 6.0.1) in Microsoft Access file format (.mdb), as exported from the Contractor's data collection software (if inspections are to be recorded electronically).
 2. A proprietary database as generated by the Contractor's data collection software (if inspections were recorded electronically).
 3. Example GPS data files of all uncharted manholes (if GPS will be used for geographic reference).
 4. Example media files, including observation photos, videos, and reports; with all files consistently utilizing the required file naming conventions.
 5. The proposed viewing software to be used with the proprietary inspections database and related media.
 6. NASSCO MACP validation report in PDF format, demonstrating the sample is fully conforming to NASSCO MACP standards and conventions (if inspections are to be recorded electronically). Validation reports can be obtained by submitting a sample database to:

http://www.nassco.org/training_edu/te_database_upload.aspx
 7. Inspections database(s) shall be fully cross-referenced to the videos, images, and reports.
 8. Example reports will be presented in both hard copy and in PDF format, and all other sample data will be presented in digital format on an external hard drive.
- C. Intermediate Submittals: No later than 14 days following the completion of a manhole inspection, the Contractor will submit the following:

1. Two hard copies of full details report for each inspection.
 2. An overall summary report detailing major defects, uncharted manholes including field-assigned ID and geographic reference, and inspections that require attention.
 3. GPS data files of all uncharted manholes and/or pipe segments that were identified during inspections but were not shown on field maps. This list shall include the field-assigned ID and a geographic reference or description (street address, intersection, etc.).
 4. At regular agreed intervals, an external hard drive will be submitted to the Engineer containing a single NASSCO MACP Standard Exchange Database (version 6.0.1) containing all inspections to date, encoded videos, observation photos, inspection reports in PDF format, and support files. The supplied data and information will become the property of the Owner.
- D. Final Submittal: At the completion of all inspections, the Contractor will supply the following to the Engineer on an external hard drive:
1. A single, consolidated NASSCO MACP Standard Exchange Database (version 6.0.1) in Microsoft Access file format (.mdb) containing all inspections for the Contract.
 2. NASSCO MACP validation report for the consolidated database (see Section 3.04.B.6.).
 3. All encoded inspection videos, observation photos, and inspection reports using required file naming formats.
 4. A single, consolidated proprietary database containing all inspections for the Contract, as generated by the Contractor's data collection software.
 5. Free-issue software to be used for the viewing of the proprietary inspections database and related media from within the database.
 6. Four hours training in the use of any supplied free-issue software.
- E. NASSCO MACP Compliance: The submitted database(s) should consist of, at a minimum, the NASSCO MACP standard data fields, formats, and conventions as set forth in this specification and Attachment A – Field Data Delivery Format Requirements.

END OF SECTION

Attachment A - Field Data Delivery Format Requirements

PACP "Inspections" Table - Fields, Formats, and Descriptions

All field names, data types, and descriptions are from PACP Standard Exchange v6.0.2 unless otherwise noted.

Field Name	Data Type	Description of Field (bold text denotes special requirements by the City of Chattanooga)
InspectionID	AutoNumber	This field is automatically populated when any inspection information is entered. The number generated must be entered in the InspectionID field of the Conditions table for all conditions recorded during the inspection
Surveyed_By	Text	Name of individual conducting survey
Certificate_Number	Text	NASSCO PACP # of Surveyor
Owner	Text	Owner of collection system surveyed
Customer	Text	Entity commissioning the survey
Drainage_Area	Text	Common name of drainage area - this field shall be populated with the drainage basin or area name/ID, which will be provided by The Engineer
PO_Number	Text	Customer's Purchase Order Number
Pipe_Segment_Reference	Text	Client provided segment number - If pipe segment number is not provided, use the convention "Upstream Manhole ID_Downstream Manhole ID"
Date	Date/Time	Inspection Date
Time	Date/Time	Time of inspection
Street	Text	Street Number and Name
City	Text	City name where sewer located
Location_Details	Text	Descriptive explanation of sewer location
Upstream_MH	Text	Client provided designation for upstream manhole
Up_Rim_to_Invert	Number	Distance (ft and tenths of ft) or (meters to 2 decimal places max) from rim to invert of upstream manhole
Up_Grade_to_Invert	Number	Distance (ft and tenths of ft) or (meters to 2 decimal places max) from average grade to invert of upstream manhole
Up_Rim_to_Grade	Number	Distance (ft and tenths of ft) or (meters to 2 decimal places max) from rim to average grade of upstream manhole
Downstream_MH	Text	Client provided designation for downstream manhole
Down_Rim_to_Invert	Number	Distance (ft and tenths of ft) or (meters to 2 decimal places max) from rim to invert of downstream manhole
Down_Grade_to_Invert	Number	Distance (ft and tenths of ft) or (meters to 2 decimal places max) from average grade to invert of downstream manhole
Down_Rim_to_Grade	Number	Distance (ft and tenths of ft) or (meters to 2 decimal places max) from rim to average grade of downstream manhole
Sewer_Use	Text	Purpose of sewer
Direction	Text	Direction of survey, Upstream or Downstream
Flow_Control	Text	Type restriction of flow used
Height	Number	Diameter of sewer (or height if non-circular) to nearest inch(999) or nearest mm(99999)
Width	Number	Width of non-circular sewer to nearest inch(999) or nearest mm(99999)
Shape	Text	Sewer shape
Material	Text	Type of pipe material
Lining_Method	Text	Type of process used to line the host pipe
Pipe_Joint_Length	Number	Length of pipe joint sections measured to one decimal place whether in feet or meters
Total_Length	Number	Distance between the exit of the start manhole and the entrance of the finish measured to one decimal place whether it is feet or meters
Length_Surveyed	Number	If the survey is abandoned, enter the actual length surveyed to one decimal place whether it is feet or meters
Year_Laid	Number	Year sewer surveyed was constructed
Year_Renewed	Number	Year sewer surveyed was renewed
Media_Label	Text	Unique identifier for tape/media
Purpose	Text	Reason for conducting survey
Sewer_Category	Text	Importance of sewer, to be provided by client
Pre-Cleaning	Text	Type of preparatory cleaning conducted prior to survey
Date_Cleaned	Date/Time	Date when sewer was cleaned prior to survey
Weather	Text	Weather conditions when survey conducted

Location_Code	Text	General description of ground cover of surveyed segment
Additional_Info	Text	Supplemental info regarding survey or segment
Reverse_Setup	Number	Specifys that a second survey has been done on the pipe segment--use inspection ID from matching survey
Sheet_Number	Number	Number used to identify individual surveys done within a group - If field maps are provided, this field shall be populated with the map sheet number or ID
IsImperial	Yes/No	Used to identify whether units are metric or imperial. Defaults to imperial.
PressureValue	Number	Grouting pressure value
WorkOrder	Text	Work order or Project reference for Asset Management
Project	Text	Project Title or reference for Asset Management
Report_Name (custom field)	Text	The Pipe Segment Inspection Report PDF file name for the inspection
Report_Location (custom field)	Text	relative path to the PDF report file

Appendix J

Rehabilitation Specifications

NTS: Cured-in-Place Pipe projects are very specialized. Many factors must be considered prior to writing the specification. If it is believed air inversion/steam curing is necessary and with written approval by the City, additional provisions will need to be included.

Part 1 General

1.01 Scope

- A. Furnish all labor, material and equipment to provide for the reconstruction of existing sewer pipes using an approved Cured-In-Place Pipe (CIPP) method by forming a new pipe within an existing pipe. See Section 33 01 30.74 for Lateral Rehabilitation by CIPP.
- B. The sewer reconstruction shall be accomplished by the installation of a thermosetting resin-impregnated flexible felt-fiber tube coated on one side with an impermeable plastic which is installed into the existing sewer utilizing hydrostatic head. Curing is accomplished by circulating hot water throughout the length of the inverted tube to cure the resin into a hard, impermeable pipe with the plastic coating on the interior surface of the newly formed pipe. The CIPP shall extend the full length of the original pipe segment and shall provide a structurally sound, joint-less, close fitting and corrosion resistant cured-in-place pipe.
- C. The work performed under this Section of the Specifications is deemed to be Specialty Contractor Work and is subject to the provisions of [Section 00 72 00 General Conditions, Article 10, Paragraph (b)].
- D. The deterioration of sewers is an on-going process. In the event pre-construction inspections reveal the sewers to be in substantially different conditions than those in the design requirements specified herein, the Contractor shall submit a changed site condition notice and request such changes in liner thickness, supporting such requests with the appropriate design data satisfactory to the Engineer.

1.02 Reference Standards

Supply all products and perform all work in accordance with applicable American Society for Testing and Material (ASTM), American Water Works Association (AWWA), American National Standards Institute (ANSI), or other recognized standards. The latest revisions of all standards in effect on the date of advertisement are applicable. Where differences exist, or any latitude is either inferred or interpreted between this Specification and referenced product/process standards, this Specification shall govern.

1.03 Quality Assurance

- A. In order to establish minimum product quality and Installer capability, the following minimum requirements shall be met. The purpose for these submittals is to allow the Owner/Engineer the opportunity to conduct a complete, thorough and objective

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evaluation of proposed CIPP products and the Installing Contractor and to determine if the submitted products and Installer meet all experience, quality and utility standards required by the Specifications.

- B. CIPP System Manufacturer: The CIPP system must have a minimum proven performance record of 1,000,000 linear feet installed of the exact name-brand product bid in the United States, with a minimum of 20,000 linear feet in diameters 24-inch or larger over the last five years. In addition, a minimum of 10,000 linear feet of 36-inch diameter or larger, of the exact name brand product must have been installed in the United States. Documentation shall be submitted with the Bid in accordance with the Instructions to Bidders.
- C. Contractor/Installer Experience: The Installing Contractor for the cured-in-place reconstruction of sewers must have a minimum of five years of experience using the exact named product proposed and, have installed at least 300,000 linear feet of the exact named proposed product including at least 20,000 feet of 24-inch diameter or larger cured-in-place product. Documentation along with contact names and telephone numbers from the last ten projects shall be submitted with the Bid in accordance with the Instructions to Bidders.
- D. On Site Field Superintendent: The Qualifying Superintendent must have a minimum of five years of experience with cured-in-place pipe products. In addition, the Qualifying Superintendent must have supervised jobs in which at least 20,000 feet of pipe has been reconstructed using the exact named product proposed including a minimum of 5,000 feet of 24-inch diameter or larger cured-in-place product. The Contractor shall submit information to document this with the Bid in accordance with the Instructions to Bidders. The superintendent for the Project shall be on-site during all phases of the work involving any pre and post-installation video inspection, sewer cleaning or insertion and processing of the CIPP.
- E. Resin Class
 - 1. The Contractor shall designate a wet-out facility and shall provide wet-out liner tubes from this designated facility only. Multiple facilities to supply wet-out liner tubes for the duration of this Contract may not be used without prior approval of the Engineer.
 - 2. The Contractor shall place a sampling valve in-line at a point in the resin/catalyst mixing stage so that a sample of non-catalyzed resin may be taken. A second sampling valve shall be placed in-line at a point after the resin/catalyst mixing stage, but prior to catalyzed resin injection into the liner so that a resin sample may be taken. Both sampling valves shall be left in place for the duration of the Contract.
 - 3. The Engineer shall have the right to inspect the designated wet-out facility and draw samples from one or both sampling valves without prior notice to the Contractor for the duration of the Contract.
 - 4. Infrared Analysis
 - a. The Engineer reserves the right to subject resin samples to an infrared

analysis (IR) Scan. This standard analytical test involves shining a beam of light in the infrared frequency region through a thin sample of subject resin. The frequency of light is then varied across the infrared spectrum. Chemical functional groups present in the resin being analyzed will absorb infrared light at specific frequencies and with characteristic absorption intensities.

- b. A spectrum created from the measurement of light transmitted through the sample across the range of infrared frequencies shall be used to determine the resin's chemical fingerprint. For Standard Polyester, an overlaid IR spectrum of Reichhold PolyLite® 33420 shall be used as a baseline comparison for the purpose of a test under this contract. For Enhanced Polyester resin, an overlaid IR spectrum of Reichhold PolyLite® 33420-E shall be used as a baseline comparison for the purpose of a test under this contract.
- c. The Engineer may perform random Infrared Scans (IR Scans) and/or Composite Burn-offs to ensure resin quality and consistency throughout the duration of the Contract and shall be responsible for the cost of IR testing.

1.04 Submittals

- A. Submit shop drawings in accordance with the requirements of Section 01 33 23 of these Specifications. Specific submittal information shall include the following:
 1. The Contractor shall furnish submittal data establishing the structural capabilities, chemical composition, and other mechanical properties of the liner system proposed.
 2. The Contractor shall furnish the proposed liner thickness for each pipe size and depth categories, along with a certification, signed and sealed by an engineer registered in the state that the Project is located, to the effect that the proposed liner thicknesses were calculated based on the parameters specified in Article 2.04 of this section of the Specifications and the site specific external loads. In no case will the proposed liner thicknesses be less than those specified in Article 2.04 of this section of the Specifications. The Standard Dimension Ratio (SDR) is the ratio of the outside diameter (OD) of the pipe to its minimum wall thickness. All CIPP wall thicknesses, SDRs by diameters, and depth ranges corresponding to the requirements of the Contract Documents, must be submitted to the Engineer for approval prior to installation.
 3. The Contractor shall furnish copies of the manufacturer's brochures giving a complete description of the product proposed, its physical and chemical composition, the same for the thermosetting resin or epoxy hardener.
 4. Pre- and post-installation videos and logs per Article 3.03 shall be submitted during the course of work.
 5. Catalyst system and resin/catalyst ratio.

6. The proposed curing schedules and process shall be approved by the resin manufacturer in writing. Cure schedules shall include specific information on curing procedures, “post exothermic cooking times” duration and “cool down” procedures – all to be approved by the resin manufacturer in writing.
 7. The Contractor shall submit a Certificate of Authenticity from the resin manufacturer for each shipment to the wet-out facility to include the date of manufacture and Heat Distortion Temperature. This information shall be submitted before the manufacture or installation of any CIPP.
- B. The manufacturer shall submit written certification that the lining system complies with all applicable requirements of these Specifications.
- C. The Contractor shall submit its proposed plan for ensuring that the finished and installed CIPP meets the minimum thickness requirements. The plan shall include detailed inversion procedures to reduce stretching and resin loss and to minimize shrinkage.

1.05 Warranty

The Contractor shall warrant all work and materials installed under this Contract for five years from the date of final acceptance. All CIPP liners shall have a minimum design and service life of 50 years. The date of final acceptance shall be the date final payment is made to the Contractor.

Part 2 Products

2.01 Resins

- A. The resin for CIPP installed under this Contract shall be a Standard Polyester Resin or Enhanced Polyester Resin unless otherwise directed by the Engineer due to site-specific field conditions and/or design requirements.
- B. Standard Polyester Resins
1. The resin used shall be a corrosion resistant isophthalic polyester specifically designed for the CIPP being installed. Only premium, virgin, non-recycled resin shall be used. The resin shall be manufactured under ISO 9002 certified procedures.
 2. The resin shall have been tested according to ASTM D2990, D5813, and F1216 by accredited, third-party testing facilities. Results of these tests shall be made available to Engineer upon request.
 3. The resin vendor must be able to reference the corrosion scale with the resin itself having a heat deflection temperature greater than 212 degrees Fahrenheit.
- C. Enhanced Polyester Resins

1. The resin used shall be a corrosion resistant enhanced thixotropic, medium reactivity, high viscosity, and rigid, chemical resistant isophthalic resin. These resins contain a mineral filler to enhance mechanical properties and are specifically formulated for use in the cured-in-place pipe (CIPP) industry.
 2. The resin shall have physical and chemical properties equal to those of Reichhold PolyLite® 33420-E and shall have been tested according to ASTM D 2990, D 5813 and F 1216 by accredited third party testing facilities. Results of these tests shall be made available to the Engineer upon request.
 3. The resin must be manufactured under ISO 9002 certified procedures. The resin vendor must be able to reference the corrosion scale with the resin itself having a heat deflection temperature greater than 224 degrees Fahrenheit. Only premium, non-recycled resins will be accepted.
- D. Resins shall be shipped directly from the resin manufacturer's facility to the CIPP wet-out facility. Resins shall not be sent to any intermediate mixing facility. Copies of the shipping documents from the resin manufacturer shall be submitted to the Engineer indicating dates of shipment, originating and receiving locations.

NTS: Pay special attention to selection of resins for the project. The use of alternative resins shall be for special circumstances only and must be approved by the owner.

~~E. Urethane-Modified Vinyl Ester Resins~~

- ~~1. The resin used shall be a premium vinyl ester combining corrosion resistance and high temperature performance with excellent laminating characteristics. Only premium, virgin, non-recycled resins will be accepted. The resin must be manufactured under ISO 9002 certified procedures.~~
- ~~2. The resin vendor must be able to reference the heat corrosion scale with the resin itself having a heat deflection temperature greater than 244 degrees Fahrenheit.~~
- ~~3. The resin shall be equal to Reichhold Dion® 9800.~~

~~F. Low VOC Resins~~

2.02 Catalyst Systems

- A. The catalyst system shall be made up of a primary catalyst and a secondary catalyst. The primary catalyst shall be added at a maximum of 1% of the resin volume by weight unless otherwise approved by the Engineer. The secondary catalyst shall be added at a maximum of 0.05% of the resin volume by weight unless otherwise approved by the Engineer.
- B. Resins, catalysts and resin/catalyst mix ratios shall not be changed or altered during this Contract unless specifically approved by the Engineer in writing.

2.03 Liner Tube

- A. The tube shall consist of one or more layers of absorbent non-woven felt fabric and meet the requirements of ASTM F1216.
- B. The acceptable liner tube shall be constructed under ISO 9002 certified procedures. Proper certification shall be provided prior to the manufacture or installation of any CIPP.
- C. The tube shall be constructed to withstand installation pressures, have sufficient strength to bridge missing pipe, and stretch to fit irregular shaped pipe sections.
- D. The wet-out tube shall have a uniform thickness that when compressed at installation pressures shall meet or exceed design thickness.
- E. The tube shall be manufactured to a size that when installed shall tightly fit the internal circumference and length of the original pipe. In the event that under-sized pipe is present, liner tube shall be manufactured so that overlap folds or wrinkles do not occur. Allowances shall be made for circumferential stretching during inversion.
- F. The outside layer of the tube, before installation, shall have an impermeable polyurethane or polyethylene plastic coating. This coating shall be an impermeable, flexible membrane that shall contain the resin and facilitate monitoring of resin saturation during resin impregnation. This coating shall form the inner layer of the finished pipe and is required for enhancement of corrosion resistance, flow and abrasion properties.
- G. The tube shall be homogeneous across the entire wall thickness containing no intermediate or encapsulated layers. No material may be included in the tube that may cause de-lamination in the cured liner, and no dry or unsaturated areas or layer shall be evident.
- H. The wall color of the interior liner surface after installation shall be such that a clear, detailed inspection with closed-circuit television equipment may be conducted.
- I. The outside of the tube shall be marked for distance at regular intervals not to exceed 10 feet. The tube shall be stamped with the manufacturer's name or identifying symbol in regular intervals not to exceed 20 feet.
- J. The minimum length shall be that deemed necessary by the Contractor to effectively span the distance between manhole sections of the segment to be lined unless otherwise specified. The line lengths shall be verified in the field before impregnation of the tube with resin.

2.04 CIPP Design

NTS: It is very important that the Engineer understand that these values change from project to project and that the CIPP design be based on actual project conditions.

A. Liner Thickness

1. The CIPP thickness shall be designed in accordance with the applicable provisions of ASTM F 1216 and D 2412 for “fully deteriorated gravity pipe conditions” and the following design conditions:
 - a. AASHTO HS20-44 Live Load, whether under streets or not. The live load will vary based on depth of pipe.
 - b. A dead load based on the depth of pipe shown on the Drawings and a soil modulus of elasticity of [1,000] [700] psi, soil weight of [120] pounds per cubic foot and a coefficient of friction of $Ku'=0.130r$.
 - c. Short-term flexural modulus and long-term modulus when tested in accordance with ASTM D790.
 - i. Standard Polyester: 250,000 psi and 125,000 psi, respectively
 - ii. Enhanced Polyester: 400,000 psi and 200,000 psi, respectively
 - d. Minimum Flexural Stress of 4,500 psi, when tested in accordance with ASTM D790.
 - e. Safety factor of 2.0.
 - f. Groundwater height at the ground surface.
 - g. Maximum pipe ovality of [5%] [2%].
 - h. Poisson ratio of 0.3.
 - i. Enhancement factor (K) of 7.
 - j. Service temperature range shall be 40 to 140 degrees F.
 - k. Maximum long-term deflection shall be 5%.
 - l. Any and all other site specific external loads. It is the Contractor's responsibility to determine the site specific external loads.
2. Minimum Acceptable Pipe Thickness

Pipe Diameter (Inches)	Depth to Invert (Feet)	Minimum Thickness (mm)
8	0-17	6.0
10	0-9	6.0
10	9.1-16	7.5
12	0-11	7.5
12	11.1-13	7.5
15	0-8	7.5

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Pipe Diameter (Inches)	Depth to Invert (Feet)	Minimum Thickness (mm)
15	8.1-11	9.0
18	0-13.5	10.5
18	13.6-17	12.0
24	0-9.5	12.0
24	9.6-12.5	13.5
24	12.6-15.8	15.0
24	15.9-19.5	16.5
27	0-9.5	13.5
27	9.6-12	15.0
27	12.1-15	16.5
36	0-9.5	18.0
36	9.6-11.7	19.5
36	11.8-14	21.0
36	14.1-16	22.5
36	16.1-18	24.0
36	18.1-21	25.5
36	21.1-22.5	27.0

3. The liner thickness shall be the greater of the calculated thickness to meet the design requirements of Paragraph 1 above or the minimum acceptable pipe thickness from Paragraph 2 above. If calculations require a thicker wall, round to the next higher multiple of 1.5 mm currently in manufacture.
 4. All references to liner thickness shall be defined as total thickness after installation and after curing is complete.
- B. The finished CIPP shall provide a uniform smooth interior wall surface with a Manning “n” coefficient of 0.011.

Part 3 Execution

3.01 General

- A. All reconstruction of existing gravity sewers using an approved CIPP product and installer shall be performed in strict accordance with this Specification and ASTM F1216.

NTS: Pull-in installations shall only be utilized when approved by the City

- B. Pull-in and inflate methods of CIPP installations (reference ASTM F1743) will not be acceptable without written approval by the Engineer.
- C. The Contractor shall carry out his operations in strict accordance with all applicable OSHA standards. Particular attention is drawn to those safety requirements involving

work on an elevated platform and entry into a confined space and the operation of high-pressure air/steam equipment.

- D. The Contractor shall be responsible for obtaining water necessary for cleaning, inversion and other work items requiring water. The Contractor shall be responsible for obtaining a hydrant use permit from [Tennessee American Water] [Eastside Utilities] [Hixson Utility District].
- E. The Contractor shall be responsible for locating and access to all manholes.
- F. All surfaces, which have been damaged by the Contractor's operations, shall be restored to a condition at least equal to that in which they were found immediately prior to the beginning of the Contractor's operations. Suitable materials and methods, acceptable to the Engineer, shall be used for such restoration. The restoration of existing property or structures shall be performed as promptly as practicable and shall not be left until the end of the construction period. The cost for correcting damages resulting from the Contractor's actions shall be the responsibility of the Contractor.
- G. The tube shall be fabricated to a size that, when installed, will neatly fit the internal circumference of the conduit(s) designated for CIPP. Allowance shall be made for the circumferential stretching during insertion of the tube.
- H. The Contractor shall be responsible for determining the minimum length to effectively span the distance from the manhole to manhole and shall verify the length of the fabric tube in the field before the tube is either cut to length or wet-out with resin. The tube may run through one or more manholes with the approval of the Engineer.
- I. Protruding Service Connections: When service connections protrude into the existing pipe, the Contractor shall remove the protruding portion of the service connection to be flush with the inside pipe wall or to the satisfaction of the Engineer. Removal of the protruding portion of the service connection shall be accomplished using a television camera and internal cutting device, which shall not damage the collection line or the portion of the service line to remain in place. This work shall be accomplished prior to the installation of the CIPP.
- J. Traffic Control: The Contractor shall be responsible for traffic control during the course of each phase of the Work. Prior to beginning Work, Contractor shall submit a traffic control plan for each section of Work for the review and approval. It is the intent that this Work is to be accomplished with as little disturbance to traffic, private property, and the public as is reasonably possible, consistent with timely completion thereof. The traffic control plan shall reflect such requirements where applicable. Signs, signals, and detours shall conform to the local and state requirements for streets and highways. The Contractor shall have and maintain on site a sufficient supply of traffic cones and other traffic signaling devices, including trained and properly equipped flagmen, to safely control all traffic through the work zone(s). Road closures and / or detours will require advance scheduling and prior approval by the Engineer.

3.02 Daily Work Schedule

Insofar as is possible, Work shall be so scheduled that the lining of the pipe, curing of the tube, and the reinstatement of service connections can be accomplished in a single working day or shift. Prior approval must be obtained from the Engineer if work is to be performed at night or on weekends to minimize traffic disturbance. At the end of each working day, temporary tie connections shall be made between the relined section of pipe and the existing system and the plug in the upstream manhole removed, but not before the section being lined has been properly cured in accordance with the manufacturer's instructions and all service connections are reinstated. In some instances, it may be necessary to bypass effluent from service connections.

3.03 By-Pass Pumping

NTS: Verify and coordinate with any temporary bypass specifications included, reference section if necessary.

- A. The installation methodology contemplated requires the temporary blocking and back-ups of sewers and sewage. Contractor shall be responsible to limit the extent and duration of such blockages and back-ups so that overflows and spillage onto public or private property and into storm sewers, waterways, and streets does not occur. In the event that such spillage or overflows do occur during the course of or as a result of the Work, the Contractor performing the Work shall immediately eliminate the spillage or overflow and, as necessary, remove the blockage and eliminate the back-up. On elimination of the spillage or overflow, the Contractor is to clean up and disinfect the area. Work to stop or contain such events is to be deemed emergency in nature and sufficient justification for total mobilization of resources, the use of overtime or double time, and any other reasonable measures to assure correction of the problem without delay. Damages arising from blockages, back-ups, spillage, or overflows of sewage during the course of the Work or because of the Work shall be the sole responsibility of the Contractor.
- B. Sewage flow shall be pumped around segments during the installation and testing of cured-in-place pipe, the televising of sewers and lateral service reinstatement.
- [] C. Pumping equipment shall have the capacity to convey 100% of peak flows around the construction area. The flow shall be intercepted at the upstream end of the construction area and shall be pumped through temporary piping of adequate size. The flow shall be discharged into a manhole on the downstream side of the construction area, thus by-passing the sewer segment(s) under construction. The Contractor shall be required to contact all residential and commercial customers whose service lines connect to the sewer main being bypassed and inform them that they will be temporarily out of service. The Contractor shall also advise those customers against water usage until the mainline is back in service. After completing the necessary work on the main line to allow its reuse, the Contractor shall advise those customers that the sewer main is back in service. The Contractor shall maintain a high degree of professionalism, both in workmanship and appearance, at all times. Should a condition arise that the Contractor cannot restore service within [12] hours of service interruption; the Contractor shall make provisions for pumping all flows within the service interruption area at no cost to the Owner.
- D. Open channels or trenches shall not be used to convey flow.

- E. A standby pump of the same capacity shall be required on site.
- F. The Contractor is responsible for paying all fines imposed for overflows or spills during construction.

3.04 Preliminary Installation Requirements

- A. Contractor shall notify the Engineer prior to beginning cleaning activities and pre-construction closed-circuit televising (CCTV) inspection. Contractor shall plan cleaning and pre-construction CCTV inspection activities far enough in advance of CIPP lining activities to allow Engineer time to review any critical damage reports that may develop from the CCTV inspection results.
- B. Prior to CIPP installation, the pipe shall be cleaned to the satisfaction of the Engineer in accordance with Section 33 01 30.14 of these Specifications.
- [] C. Debris Disposal: All debris cleaned from the pipe shall be removed and disposed of at [the Owner's Wastewater Treatment Plant] [a location determined by the Contractor and approved by the Engineer]. Debris shall not be allowed to wash into any other pipe segment either upstream or downstream from the pipe segment being cleaned. [All waste disposal at the Owner's Wastewater Treatment Plant shall meet the requirements set forth by the Owner including dewatering of waste prior to disposal.]
- D. Pre-Installation CCTV Video Inspection: The section of sewer designated for CIPP shall to be televised its full length using a remote television camera in accordance with Section 33 01 30.16 of these Specifications and shall be submitted to the Engineer for review.

3.05 Resin Impregnation of the CIPP Tube (Wet-Out)

The Contractor shall designate a location where the tube shall be impregnated or "wet out" with resin, using distribution rollers and a vacuum impregnation system to thoroughly saturate the tube's felt fiber prior to installation in the field. The impregnated tube shall be free of pinholes, resin voids and other defects. If the cured-in-place pipe is impregnated at the manufacturing plant, it shall be delivered to the job site in a refrigerated truck, and remain refrigerated (below 45⁰ Fahrenheit or as specified by the resin manufacturer) prior to installation to prevent premature curing. The flexible tube shall be vacuum impregnated with resin under controlled conditions or by such other means provided such means can assure thorough resin impregnation to the full satisfaction of the Engineer. The volume of resin used shall be sufficient to fill all voids in the tube material at normal or required thickness and diameter. The volume of resin shall be adjusted by adding seven to ten percent excess resin for the change in resin volume due to polymerization and allow for any migration of resin into the cracks and joints in the original pipe.

3.06 Inversion of CIPP

- A. The preferred method of installation and cure for CIPP shall be inversion using

hydrostatic head (water column) pressure and curing with heated, circulated water. The use of pressurized air inversion/steam cure will be considered on a case-by-case basis only. The Contractor shall submit a written request for the use of pressurized air/steam in sewer segments where the Contractor feels that the utilization of pressurized air/steam will be beneficial to the Owner. The Contractor shall not assume in any case that the use of pressurized air/steam is acceptable to the Owner without prior written authorization from the Owner. The impregnated tube shall be inverted through an existing manhole or other approved access point utilizing a hydrostatic water column until it has fully traversed the designated line length and the inversion face breaches the destination manhole or termination point. Contractor must have written approval from the Engineer prior to using pressurized air for inversion. The fluid column shall have been adjusted and maintained to be sufficient to cause the impregnated tube to hold tight against the existing pipe wall, produce dimples at side connections, and flared ends at the manholes. Lubricant during inversion shall be used as necessary in accordance with the CIPP manufacturer's recommendations. The lubricant used should be a nontoxic, oil-based product that has no detrimental effects on the tube, heating source and pump system, will not support the growth of bacteria, and will not adversely affect the fluid to be transported. Lubricant shall be used in processes with permeable coatings. Thermocouples shall be placed at the top and bottom interface of termination manhole which is furthest from the heat source for monitoring temperature during the cure cycle. Care should be taken during tube installation not to over-stress the fabric fiber and to minimize longitudinal stretch, resin loss and thinning of the liner wall.

- B. Before the inversion begins, the tube manufacturer shall submit to the Contractor, and the Contractor to the Engineer, the minimum pressure required to hold the tube tight against the host pipe and the maximum allowable pressure so as not to damage the tube.
- C. When using pressurized air, particular attention should be given to the maintenance of the minimum required "finished and installed" thickness of the CIPP.
- D. Once the inversion has started, pressure shall be maintained between the minimum and maximum pressures until the inversion has been accomplished.

3.07 Curing

- A. Using Circulated Water
 - 1. A suitable source of heat and water recirculation equipment is required to circulate heated water throughout the pipe. The equipment shall be capable of delivering hot water throughout the inverted tube to uniformly raise the temperature required to affect a cure of the resin.
 - 2. Initial cure will occur during temperature heat-up and is completed when exposed portions of the new pipe appear to be hard and sound and the thermocouples indicate that the temperature is of a magnitude to realize an exotherm or cure in the resin. After initial cure is reached, the temperature should be raised to the post-cure temperature recommended by the resin

manufacturer. Post-cure temperature should be held for a period as recommended by the resin manufacturer, during which time the recirculation of the water and cycling of the heat source to maintain the temperature continues.

3. Prior to any inversion, the Contractor shall provide a Post-Cure Hold Time and Temperature Table. This table shall indicate the minimum time and temperature the inverted tube will be held at in order to achieve desired physical properties. The resin manufacturer shall certify both the time and temperatures presented in the table.
4. Curing must take into account the existing pipe material, the resin system, and the ground conditions (temperature, moisture level, and thermal conductivity of the soil).

NTS: The use of steam curing shall not be used unless specific project scenarios require it. Steam curing shall not be included without written approval by the City.

3.09 Cool-Down

Cool-down of the cured pipe liner shall be in accordance with the manufacturer's recommendations. Care should be taken during the cool-down process so as to minimize shrinkage of the CIPP.

3.10 Termination and Sealing at Manhole Outlets

- A. Termination of the cured-in-place pipe at the manhole shall be completed by trimming the inverted pipe end back in accordance with the CIPP manufacturer's recommendations and to the satisfaction of the Engineer
- B. No annular space shall be visible between the CIPP and manhole wall. If, in the judgment of the Engineer the CIPP does not fit tightly against the sewer main at its termination point(s), the void between the host pipe and the CIPP shall be sealed by filling it with a resin/epoxy mixture compatible with the CIPP approved by the Engineer or by utilizing manhole end seals or hydro-tite gaskets, all at no additional cost to the Owner.

3.11 Testing of CIPP

- [] A. [The Contractor shall prepare CIPP Acceptance Tests for each CIPP line segment during the duration of this Contract.] [The Engineer may, at its discretion, direct the Contractor to collect samples of the cured CIPP.] The samples shall be for laboratory determination of flexural strength, flexural modulus and wall thickness for each test sample. These three individual analyses shall comprise one completed test. All samples shall be collected per the sampling protocols set forth in ASTM F1216.
- [] B. [For each line segment,]From the point most distant from the heat source, the Contractor shall remove one restrained sample of the installed liner at least 12

inches in length for testing. [For sewers 15 inches and larger, plate samples may be taken and cured in the same water as the installed CIPP.] For each sample taken, the Contractor shall cut and deliver a 12 inch in length representative sample (taken at least 2 inches from the end of the specimen) to the Engineer. The sample delivered to the Engineer shall be clearly labeled with the date of installation and sewer segment and removed from any restraining mold. The samples shall be taken in the presence of the Engineer. The Engineer may return such samples to the Contractor for disposal.

- C. The tests shall be used to verify that the installed CIPP meets these Specifications. CIPP thickness shall be measured in accordance with ASTM D5813. Flexural properties shall be determined per ASTM D790. The Contractor shall label and date all samples and deliver the samples directly to the Engineer. All testing shall be performed by an independent, ASTM-certified testing laboratory of Engineer's designation. Payment to the Contractor shall be withheld pending the Engineer's acceptance of the CIPP test results. [The Laboratory costs will be paid in accordance with the terms and conditions of Cash Allowances specified elsewhere.]
- D. Any liner that does not meet the specified strength and/or thickness requirements, regardless of the amount below the specified requirements, shall be corrected by the Contractor in a manner approved by the Engineer at no additional cost to the Owner. The Engineer's decision on how to correct deficient CIPP installations shall be final. Options for correcting deficient liners that may be considered by the Engineer include removing the liner and re-lining the sewer, [or] excavating and replacing the sewer from manhole to manhole, [or providing the Owner with a credit]. The primary option that will be considered will be to re-line the sewer. [Credits will only be authorized for CIPP that does not meet required thickness. If a credit is acceptable to the Owner, the credit shall be calculated by multiplying the bid price by the percent that the liner thickness is below the required installed thickness as follows:

$$\text{Credit} = (1 - \text{Installed CIPP thickness}/\text{required CIPP thickness}) \times \text{bid price}$$
- E. The Contractor shall not assume a credit will be acceptable to the Owner in any case.]

3.12 Lateral Service Reconnection - Internal

- A. After the CIPP has been cured, the existing service connections and laterals shall be reinstated. In general, reinstatement of service connections and laterals shall be accomplished internally, without surface excavation, using a remote control cutting device equipped with a television monitor. Reopened services shall be wire brushed to the satisfaction of the Engineer. In some cases, remote reinstatement may not be possible. In these instances, reconnection by excavation as specified below is acceptable. All connections must be reinstated by at least 95-percent of the original opening. Holes cut outside the lateral opening or oversized cutting (more than 100%) must be repaired at the Contractor's expense. Particular attention shall be given to the lower quadrant of the opening to ensure that no accumulation of solids or debris will occur at the service tie-in.

- B. All capped or factory plugged service connections shall not be opened unless otherwise directed by the Engineer.

3.13 Lateral Service Reconnection By Excavation

- A. General: Sewer lateral house connections accomplished by excavation shall be connected to the pipe by dual-strapped saddles. The Contractor shall connect existing sewer house lateral service pipe to the saddle using a flexible coupling. After connection to the saddle, the sewer house connection pipe shall have a slope toward the newly lined sewer equal to the pre-existing on the lateral pipe or a minimum of two percent.
- B. Execution
 1. The Contractor shall excavate the area of the lateral connection so that the host pipe and existing connection is exposed. The host pipe shall be broken back or removed in such a manner that the new CIPP liner is exposed without causing damage to the liner.
 2. An appropriately sized hole acceptable to the Engineer shall be cut into the CIPP using a circular hole cutter. Hanging or loose cuttings shall be removed so that the newly opened hole is smoothed around its edges.
 3. A sealant compatible with CIPP and acceptable to the Engineer shall be liberally applied around the newly cut hole to form a watertight seal between the CIPP liner and PVC pipe saddle used to make the connection.
 4. A dual-strap PVC pipe saddle acceptable to the Engineer shall be secured to the CIPP in accordance with the manufacturer's recommendations.
 5. Before the service lateral pipe is connected to the saddle, the Contractor shall hand wipe a hydrogen sulfide resistant composite epoxy resin mixture inside the saddle where the saddle and CIPP surfaces meet to ensure a watertight seal.
 6. The Contractor shall connect the lateral service pipe to the saddle according to the manufacturer's recommendations and in a manner acceptable to the Engineer.

3.14 Final Acceptance

- A. Post-installation videos shall be conducted and submitted to the Engineer in accordance with Section 33 01 30.16 of these Specifications. The finished CIPP shall be continuous over the length of pipe between two manholes and shall be an impermeable, joint-less conduit, free from visual defects such as foreign inclusions, dry spots, pin holes, lifts, or delamination.
- B. Wrinkles in the CIPP (other than minor, longitudinal pressure wrinkles) will not be acceptable. The Engineer shall determine as to the acceptability of pressure wrinkling with that decision being final.

Cured-In-Place Pipe (CIPP)

- C. After curing of the resin is completed, the hardened CIPP shall extend from manhole to manhole of the section designated providing a structurally sound, corrosion-resistant, watertight conduit that excludes exfiltration and infiltration, is tight-fitting within the existing pipe, and is free of voids or annular spaces between the CIPP and the existing pipe walls. K-Factor for tightness shall equal 7.0 or greater. All terminations into manhole walls shall be watertight at the time of final inspection. No annular space shall be visible between the CIPP and manhole wall.
- D. The finished pipe must be such that when the thermosetting resin cures, the total wall thickness will be a homogeneous, monolithic felt and resin composite matrix that will be chemically resistant to withstand internal exposure to domestic sewage. When cured, the CIPP must form a mechanical bond with the host pipe.

3.15 Customer Notifications

- A. The Contractor shall contact all residential and commercial customers whose service is to be interrupted by rehabilitation work or who may be affected by upstream or downstream rehabilitations. The customer shall be informed that they will be temporarily out of service. This notification shall be made a minimum of 24 hours prior to beginning rehabilitation work. **See the Drawings and Section 01 35 00 Unique Requirements regarding any additional notification requirements.**
- B. For all residences the Contractor shall leave a door hanger detailing the service outage and providing contact information. Door hanger samples shall be submitted to the Engineer for review and approval. The Contractor shall also advise those customers against water usage until the mainline and lateral are back in service. After completing the necessary work on the main line and lateral to allow their reuse, the Contractor shall advise those customers that the sewer is back in service. Should a condition arise that the Contractor cannot restore service within 12 hours of service interruption; the Contractor shall make provisions for pumping all flows within the service interruption area at no cost to the Owner.
- C. All customer notification documentation and procedures shall meet the requirements of the Owner.

END OF SECTION

Sanitary Sewer Service Lateral Rehabilitation by Cured-In-Place Pipe Method

NTS: Cured-in-Place Pipe projects are very specialized. Many factors must be considered prior to writing the specification.

Part 1 General

1.01 Scope

- A. Provide all labor, material and equipment to provide for the reconstruction of existing sanitary sewer service laterals using an approved Cured-In-Place Pipe (CIPP) method by forming a new pipe within an existing pipe, which has generally maintained its original shape. See Section 33 01 30.73 for CIPP as that Section covers the general requirements for this Section's referenced Specifications, standards, CIPP manufacturer and installer qualifications, submittal and warranty guidelines, materials, pre-installation and installation procedures, and testing.
- B. The work performed under this Section of the Specifications is deemed to be Specialty Contractor Work and is subject to the provisions of [Section 00 72 00 General Conditions, Article 10, Paragraph (b)].
- C. The deterioration of sewers is an on-going process. Should pre-construction inspections reveal the sewers to be in substantially different conditions than those in the design considerations, the Contractor shall request such changes in reconstruction liner thickness, supporting such requests with design data. The deviation, if approved, shall be incorporated into a change order.

1.02 Reference Standards

Supply all products and perform all work in accordance with applicable American Society for Testing and Material (ASTM), American Water Works Association (AWWA), American National Standards Institute (ANSI), or other recognized standards. The latest revisions of all standards in effect on date of advertisement are applicable. Where differences exist, or any latitude is either inferred or interpreted between this Specification and referenced product/process standards, this Specification shall govern.

1.03 Quality Assurance

- A. The CIPP used shall be the exact name-brand product proposed with the Contractor having been actively involved in its installation for at least five years. In addition, Contractor shall have successfully installed CIPP liner product in at least 2,000 laterals in wastewater collection system applications.
- B. On Site Field Superintendent: The Qualifying Superintendent must have a minimum of five years of experience with CIPP products. In addition, the Qualifying Superintendent must have supervised jobs in which at least 20,000 feet of pipe has been reconstructed using the exact named product proposed. The Contractor shall submit information to document this with the Bid in accordance with the Instructions to Bidders. The

superintendent for the Project shall be on-site during all phases of the work involving any pre and post-installation video inspection, sewer cleaning or insertion and processing of the CIPP.

C. Resin Class

1. The Contractor shall designate a wet-out facility and shall provide wet-out liner tubes from the designated facility only. Multiple facilities may not be used for the duration of this Contract to supply wet-out liner tubes without prior approval of the Engineer. The impregnated tube shall be free of pinholes, resin voids and other defects. If the cured-in-place pipe is impregnated at the manufacturing plant, it shall be delivered to the job site packed in ice in a refrigerated truck, and remain refrigerated prior to installation to prevent premature curing.
2. The Contractor shall place a sampling valve in-line at a point in the resin/catalyst mixing stage so that a sample of non-catalyzed resin may be taken. A second sampling valve shall be placed in-line at a point after the resin/catalyst mixing stage, but prior to catalyzed resin injection into the liner so that a resin sample may be taken. Both sampling valves shall be left in place for the duration of the Contract.
3. The Engineer shall have the right to inspect the designated wet-out facility and draw samples from one or both sampling valves without prior notice to the Contractor for the duration of the Contract.
4. Infrared Analysis
 - a. The Engineer reserves the right to subject resin samples to an infrared analysis (IR) Scan. This standard analytical test involves shining a beam of light in the infrared frequency region through a thin sample of subject resin. The frequency of light is then varied across the infrared spectrum. Chemical functional groups present in the resin being analyzed will absorb infrared light at specific frequencies and with characteristic absorption intensities.
 - b. A spectrum created from the measurement of light transmitted through the sample across the range of infrared frequencies shall be used to determine the resin's chemical fingerprint. For Standard Polyester, an overlaid IR spectrum of Reichhold Polylite® 33420 shall be used as a baseline comparison for the purpose of a test under this contract. For Enhanced Polyester resin, an overlaid IR spectrum of Reichhold Polylite® 33420-E shall be used as a baseline comparison for the purpose of a test under this contract.
 - c. The Engineer may perform random Infrared Scans (IR Scans) and/or Composite Burn-offs to ensure resin quality and consistency throughout the duration of the Contract and shall be responsible for the cost of IR testing.

1.04 Submittals

- A. Submit shop drawings in accordance with the requirements of Section [01 33 23] of these Specifications. Specific submittal information shall include the following:
1. The Contractor shall furnish data establishing the structural capabilities, chemical composition, and other mechanical properties of the liner system proposed.
 2. The Contractor shall furnish the proposed liner thickness for each pipe size and depth categories, along with a certification, signed and sealed by an engineer registered in the state that the Project is located, to the effect that the proposed liner thicknesses were calculated based on the parameters specified in Article 2.05 of this section of the Specifications and the site specific external loads. In no case will the proposed liner thicknesses be less than those specified in Article 2.05 of this section of the Specifications.
 3. The Contractor shall furnish copies of the manufacturer's brochures giving a complete description of the product proposed, its physical and chemical composition, the same for the thermosetting resin or epoxy hardener.
 4. Pre- and post-installation videos and logs shall be submitted during the course of work.
 5. Catalyst system and resin/catalyst ratio.
 6. The proposed curing schedules and process shall be approved by the resin manufacturer in writing. Cure schedules shall include specific information on "step curing" procedures, "post exothermic cooking times" duration and "cool down" procedures – all to be approved by the resin manufacturer in writing.
 7. The Contractor shall submit a Certificate of Authenticity from the resin manufacturer for each shipment to the wet-out facility to include the date of manufacture and Heat Distortion Temperature. This information shall be submitted before the manufacture or installation of any CIPP.
 8. Detailed installation procedures and specific procedures for rehabilitation of sanitary service laterals.
- B. The manufacturer shall submit written certification that the lining system complies with all applicable requirements of these Specifications.
- C. The Contractor shall submit his proposed plan for ensuring that the installed CIPP meets the minimum thickness requirements. The plan shall include the proposed CIPP thickness to be installed (pre-installation thickness) and detailed inversion procedures to reduce stretching and resin loss.

1.05 Warranty

The Contractor shall warrant all work and materials installed under this Contract for five years from the date of final acceptance. All CIPP liners and components in lateral rehabilitation shall have a minimum design and service life of 50 years. The date of final acceptance shall be the date final payment is made to the Contractor.

Part 2 Products

2.01 Acceptable Manufacturer

The CIPP lateral rehabilitation system shall be "T-Liner" as manufactured by LMK Enterprises, Inc., or "Top-Hat/Top-Hat Plus" as manufactured by BLD Services, LLC.

2.02 Resins

- A. The resin for CIPP installed under this Contract shall be a Standard Polyester Resin or Enhanced Polyester Resin unless otherwise directed by the Engineer due to site-specific field conditions and/or design requirements.
- B. Standard Polyester Resins
 - 1. The resin used shall be a corrosion resistant isophthalic polyester specifically designed for the CIPP being installed. Only premium, virgin, non-recycled resin shall be used. The resin shall be manufactured under ISO 9002 certified procedures.
 - 2. The resin shall have been tested according to ASTM D2990, D5813, and F1216 by accredited, third-party testing facilities. Results of these tests shall be made available to Engineer upon request.
 - 3. The resin vendor must be able to reference the corrosion scale with the resin itself having a heat deflection temperature greater than 212 degrees Fahrenheit.
- C. Resins shall be shipped directly from the resin manufacturer's facility to the CIPP wet-out facility. Resins shall not be sent to any intermediate mixing facility. Copies of the shipping documents from the resin manufacturer shall be submitted to the Engineer indicating dates of shipment, originating and receiving locations.

2.03 Catalyst Systems

- A. The catalyst system shall be made up of a primary catalyst and a secondary catalyst. The primary catalyst shall be added at a maximum of 1% of the resin volume by weight unless otherwise approved by the Engineer. The secondary catalyst shall be added at a maximum of 0.05% of the resin volume by weight unless otherwise approved by the Engineer.
- B. Resins, catalysts and resin/catalyst mix ratios shall not be changed or altered during this Contract unless specifically approved by the Engineer in writing.

2.04 Liner Tube

- A. The tube shall be continuous in length and consist of one or more layers of absorbent non-woven felt fabric and meet the requirements of ASTM F1216 and ASTM D5812 Sections 6 and 8, to produce a Type III class of CIPP. In the event of a discrepancy between the referenced ASTM requirement and this Specification, this Specification will govern.
- B. The acceptable liner tube shall be constructed under ISO 9002 certified procedures. Proper certification shall be provided prior to the manufacture or installation of any CIPP.
- C. The tube shall be constructed to withstand installation pressures, have sufficient strength to bridge missing pipe, and stretch to fit irregular shaped pipe sections.
- D. The wet-out tube shall have a uniform thickness that when compressed at installation pressures shall meet or exceed design thickness.
- E. The tube shall be manufactured to a size that when installed shall tightly fit the internal circumference and length of the original pipe. In the event that under-sized pipe is present, liner tube shall be manufactured so that overlap folds or wrinkles do not occur. Allowances shall be made for circumferential stretching during inversion.
- F. The outside layer of the tube, before installation, shall have an impermeable polyurethane or polyethylene plastic coating. This coating shall be an impermeable, flexible membrane that shall contain the resin and facilitate monitoring of resin saturation during the resin impregnation (wet-out) procedure. This coating shall form the inner layer of the finished pipe and is required for enhancement of corrosion resistance, flow and abrasion properties.
- G. The mainsheet and lateral tube shall be a one-piece assembly formed in the shape of a "T" or WYE. No intermediate or encapsulated elastomeric layers shall be in the textile that may cause de-lamination in the cured-in-place pipe. The tube shall be homogeneous across the entire wall thickness containing no intermediate or encapsulated layers. No material may be included in the tube that may cause de-lamination in the cured liner, and no dry or unsaturated areas or layer shall be evident. The lateral tube will be capable of conforming to offset joints, bells and disfigured pipe sections.
- H. The wall color of the interior liner surface after installation shall be such that a clear, detailed inspection with closed-circuit television equipment may be conducted.
- I. The outside of the tube shall be marked for distance at regular intervals not to exceed 10 feet. Such markings shall include the manufacturers name or identifying symbol that must appear in at least one location per setup.
- J. The minimum length shall be that deemed necessary by the Contractor to effectively span the distance between the connection with the main sewer pipeline and a clean out installed at the edge of the utility right-of-way or easement. The line lengths shall

be verified in the field before impregnation of the tube with resin.

- K. The liner tube utilized for sanitary sewer service laterals shall be continuous between the main sanitary sewer pipeline and the clean-out installed at the utility right-of-way. No sectionalized or overlapping liner segments will be allowed.

2.05 CIPP Design

NTS: It is very important that the Engineer understand that these values change from project to project and that the CIPP design be based on actual project conditions.

A. Liner Thickness

1. The CIPP thickness shall be designed in accordance with the applicable provisions of F 1216 and D 2412 for "fully deteriorated gravity pipe conditions" and shall meet the following design conditions:
 - a. AASHTO HS20-44 Live Load whether under streets or not. The live load will vary based on depth of pipe.
 - b. A dead load based on the depth of pipe shown on the drawings and a soil modulus of elasticity of [1,000][700] psi, soil weight of 120 pounds per cubic foot and a coefficient of friction of $Ku'=0.130r$.
 - c. Minimum short-term flexural modulus of 250,000 psi and minimum long-term modulus of 125,000 psi when tested in accordance with ASTM D790
 - d. Minimum Flexural stress of 4,500 psi when tested in accordance with ASTM D790.
 - e. Safety factor of 2.0 .
 - f. Groundwater height at ground surface.
 - g. Maximum pipe ovality of [5%][2%].
 - h. Poisson ratio of 0.3.
 - i. Enhancement factor (K) of 7.
 - j. Service temperature range shall be 40 to 140 degrees F.
 - k. Maximum long-term deflection shall be 5%.
 - l. Any and all other site specific external loads. It is the Contractor's responsibility to determine the site specific external loads.

- m. The installed, cured thickness shall be the largest thickness as calculated for deflection, bending, buckling and minimum stiffness.

2. Minimum Acceptable Pipe Thickness

Diameter (Inches)	Depth to Invert (Feet)	Minimum Thickness (mm)
4	0 – 15	3.0
4	> 15	4.5
6	0 – 17	4.5
6	> 17	6.0
8	0 – 17	6.0
8	> 17	7.5

3. The liner thickness shall be the greater of the calculated thickness to meet the design requirements of Paragraph 1 above or the minimum acceptable pipe thickness from Paragraph 2 above. If calculations require thicker wall, round to the next higher multiple of 0.15 mm.
4. All references to cured liner thickness shall be defined as total thickness after installation and after curing is complete.

- B. The finished CIPP shall provide a uniform smooth interior wall surface with a Manning “n” coefficient of 0.011.

Part 3 Execution

3.01 General

- A. The lateral reconstruction is accomplished using a non-woven textile tube of particular length and a thermo-set resin with physical and chemical properties appropriate for the application. The lateral tube located within a bladder is impregnated with the synthetic resin and is then placed inside of a protective carrying device. The mainline portion of the liner is physically attached to the lateral portion and is affixed around a rigid launching device. The protective launching device is winched into the existing sewer. When the launching device is properly positioned at the lateral connection, the mainline bladder is inflated by pressurized air that presses the main liner against the host pipe. The lateral portion is then, inverted up through the lateral service line by the action of the inversion bladder. Once the resin-saturated liner is cured, the inversion bladder and launching/carrying devices are removed. All reconstruction of existing gravity sewer service laterals using a pre-approved CIPP Product and Installer shall be performed in accordance with ASTM F 1216.
- B. The Contractor shall carry out his operations in strict accordance with all applicable OSHA standards. Particular attention is drawn to those safety requirements involving work on an elevated platform and entry into a confined space.
- C. The Contractor shall be responsible for obtaining water necessary for cleaning, inversion and other work items requiring water. [The Contractor shall be responsible

for obtaining a hydrant use permit from [Tennessee American Water] or [Eastside Utilities].

- D. The Contractor shall be responsible for locating and access to all manholes.
- E. Prior to installation, the service lateral shall be cleaned and closed circuit television (CCTV) inspected per Sections 33 01 30.14 and 33 01 30.16, respectively, of these Specifications.
- F. The Contractor shall install a cleanout meeting the requirements of the detail shown on the Drawing at the edge of the right-of-way or utility easement, should one not exist.
- G. The upstream side of the cleanout shall be plugged during insertion and curing of the liner assembly ensuring no flows enter the pipe and no air, steam or odors will enter the building. Main sewer line flows will be by-passed per methods outlined in Section 33 01 30.73 of these Specifications.
- H. The existing service lateral shall be clear of obstructions that prevent the proper insertion and expansion of the lining system. Changes in pipe size shall be accommodated, if the lateral tube is sized according to the pipe diameter and condition. Obstructions may include dropped or offset joints of no more than 20% of the inside pipe diameter.
- I. The CIPP shall be free of dry spots, lifts, and delaminated portions. The CIPP shall taper at each end so as to accept video equipment and maintain a proper flow. After the work is completed, the installer shall provide the Engineer with video footage documenting the repair and the visual markings identifying the sewer lateral address as completed work per Section 33 01 30.16 of these Specifications. The finished product shall provide an airtight/watertight verifiable nonleaking connection between the main sewer and sewer service lateral.
- J. All surfaces, which have been damaged by the Contractor's operations, shall be restored to a condition at least equal to that in which they were found immediately prior to the beginning of the Contractor's operations. Suitable materials and methods shall be used for such restoration. The restoration of existing property or structures shall be done as promptly as practicable and shall not be left until the end of the construction period. Compensation for this work will be included in the rehabilitation item to which it pertains.
- K. Traffic Control: The Contractor shall be responsible for traffic control during the course of each phase of the Work. Prior to beginning Work, Contractor shall submit a traffic control plan for each section of Work for the review and approval. It is the intent that this Work is to be accomplished with as little disturbance to traffic, private property, and the public as is reasonably possible, consistent with timely completion thereof. The traffic control plan shall reflect such requirements where applicable. Signs, signals, and detours shall conform to the local and state requirements for streets and highways. The Contractor shall have and maintain on site a sufficient supply of traffic cones and other traffic signaling devices, including trained and properly equipped flagmen, to safely control all traffic through the work zone(s).

Road closures and / or detours will require advance scheduling and prior approval by the Engineer.

- L. Daily Work Schedule: Insofar as is possible, Work shall be so scheduled that the lining of the pipe, curing of the tube, and the reinstatement of service connections can be accomplished in a single working day or shift. Prior approval must be obtained from the Engineer if work is to be performed at night or on weekends to minimize traffic disturbance. At the end of each working day, temporary tie connections shall be made between the relined section of pipe and the existing system and the plug in the upstream manhole removed, but not before the section being lined has been properly cured in accordance with the manufacturer's instructions and all service connections are reinstated. In some instances, it may be necessary to bypass effluent from service connections.

3.02 "T-Liner" Installation (LMK Enterprises, Inc.)

- A. The lateral tube and mainline sheet shall be encapsulated within the translucent bladder (liner/bladder assembly) and shall be vacuum impregnated with resin (wet-out) under controlled conditions. The volume of resin used shall be sufficient to fill all voids in the textile lining material at nominal thickness and diameter. The volume shall be adjusted by adding 5% to 10% excess resin for the change in resin volume due to polymerization and to allow for any migration of resin into the cracks and joints in the original pipe. No dry or unsaturated area in the mainline sheet or lateral tube shall be acceptable upon visual inspection.
- B. The lateral tube and inversion bladder shall be inserted into the carrying device. The mainline liner and bladder shall be wrapped around the "T" launching device and held firmly by four hydrophilic O-rings. A two-part 100% solid epoxy shall be applied to the main/lateral interface. The epoxy shall be applied to the main liner, adjacent to the lateral opening and shall consist of a two-inch wide bands, 300 ml in volume. Both the launching and carrying device shall be pulled into the pipe using a cable winch. The pull will be complete when the open port of the "T" launching device is aligned with the interface of the service connection and mainline pipe. The lateral tube shall be completely protected during the pull. The mainline liner shall be supported on a rigid "T" launcher that is elevated above the pipe invert through the use of a rotating skid system. The liner assembly shall not be contaminated or diluted by exposure to dirt, debris, or water during the pull.
- C. The main sheet in a tubular shape shall be unfolded and the hydrophilic O-rings shall be expanded coming in contact with the main pipe by action of the main inflation bladder. The lateral tube shall be inverted by the action of the lateral bladder through the center of the wrapped main sheet up into an existing lateral pipe fully extending to the designated termination point. The main and lateral bladders shall extend past all ends of the liner forcing the ends to remain open so no cutting for reinstatement is required.
- D. After liner placement is complete, pressure shall be maintained to press the liner firmly against the inner pipe wall. The liner shall be chemically cured at ambient temperatures or by a suitable heat source. The heating equipment shall be capable of

delivering a mixture of steam and air throughout the liner bladder assembly to uniformly raise the temperature above the temperature required to cure the resin. The curing of the CIPP shall take into account the existing pipe material, the resin system, and ground conditions (temperature, moisture level, and thermal conductivity of the soil). The heat source temperatures shall be monitored and logged during the cure and cool down cycles. The manufacturer's recommended cure schedule shall be submitted.

- E. Curing shall be performed with air or a mixture of air and steam without pressure interruption for the proper duration of time per the resin manufacturer's recommendations. The cure cycle and cool down shall take into account actual field conditions and shall be according to the manufacturer's recommendations. The curing temperatures shall be monitored via thermocouples placed in the upstream and extreme downstream end of the liner to ensure that sufficient heat is being supplied to the system to affect proper cure. Once the pipe has been cured, cool water shall be slowly introduced into the rehabilitated pipe. The water temperature shall be cooled inside of the pipe at a rate of 20 to 30 degrees per hour until the water temperature is within 20 degrees of the ambient temperature. The cool down process shall take into account actual field conditions and may be modified in cases of severe conditions or below normal ground temperatures.
- F. The finished CIPP shall be continuous over the entire length of the rehabilitated sewer service lateral and 16-inches of the main pipe (5-inch on either side of a 6-inch lateral or 6-inch on either side of a 4-inch lateral connection).

3.03 "Top-Hat/Top-Hat Plus" Installation (BLD Services, LLC)

- A. The lateral tube shall be encapsulated within the bladder (liner/bladder assembly) and shall be vacuum impregnated with resin (wet-out) under controlled conditions. The volume of resin used shall be sufficient to fill all voids in the textile lining material at nominal thickness and diameter. The volume shall be adjusted by adding 5% to 10% excess resin for the change in resin volume due to polymerization and to allow for any migration of resin into the cracks and joints in the original pipe. No dry or unsaturated area in the lateral tube shall be acceptable upon visual inspection.
- B. The lateral tube and inversion bladder shall be inserted into the carrying device. Both the launching and carrying device shall be pulled into the pipe using a cable winch. The pull will be complete when the open port of the launching device is aligned with the interface of the service connection and mainline pipe. The lateral tube shall completely protected during the pull. The mainline liner shall be supported on a rigid launcher that is elevated above the pipe invert through the use of a rotating skid system. The liner assembly shall not be contaminated or diluted by exposure to dirt, debris, or water during the pull.
- C. The lateral bladder shall extend past all ends of the liner forcing the ends to remain open so no cutting for reinstatement is required.
- D. After liner placement is complete, pressure shall be maintained to press the liner firmly against the inner pipe wall. The liner shall chemically cured at ambient temperatures or by a suitable heat source. The heating equipment shall be capable of delivering a

mixture of steam and air throughout the liner bladder assembly to uniformly raise the temperature above the temperature required to cure the resin. The curing of the CIPP must take into account the existing pipe material, the resin system, and ground conditions (temperature, moisture level, and thermal conductivity of the soil). The manufacturer's recommended cure schedule shall be submitted.

- E. Curing shall be performed with air or a mixture of air and steam without pressure interruption for the proper duration of time per the resin manufacturer's recommendations. When the heat source is removed, the CIPP shall be cooled until the temperature on both ends of the CIPP reaches 100 degrees Fahrenheit. The cure cycle and cool down shall take into account actual field conditions and shall be according to the manufacturer's recommendations.
- F. The finished CIPP shall be continuous over the entire length of the rehabilitated sewer service lateral.
- G. The Contractor shall install the top hat into the service lateral connection within five days of the main line CIPP liner installation.

3.04 Laterals Terminating Inside Manholes (Either Process)

Where lateral services terminate inside a manhole, the CIPP liner/insertion bladder shall fully breach the full cross-sectional area of the lateral opening. Once proper cure has been accomplished, the CIPP shall be cut flush with the lateral opening. There shall be no annular space evident between the CIPP and the host pipe. If water is observed around the cured liner between the host pipe or, if an annular space exists, the void shall be filled with an epoxy sealant, Hydro-Tite gasket or other method compatible with the CIPP and approved by the Engineer.

3.05 Point Repairs

It is recognized that the deterioration of sewers is an on-going process and in the event that a point repair is deemed necessary by the Engineer, the repair shall be accomplished by the Contractor in a timely manner.

3.06 Sample Preparation and Testing of Cured CIPP

- A. The Engineer shall, at his discretion, perform up to three acceptance tests during the course of the Project. The Contractor shall be instructed to prepare a sample for testing.
- B. In the presence of the Engineer, the Contractor shall remove one sample of the installed liner at least 12-inches in length for testing of installed CIPP flexural properties and thickness. The CIPP testing shall include determining flexural strength, flexural modulus and thickness of each sample. These three individual tests shall comprise one completed CIPP Acceptance Test. The Contractor shall furnish all equipment and personnel necessary to conduct all required sample preparations.

3.07 Leakage Testing of CIPP Service Laterals

- A. Leakage testing of all finished CIPP-lined service laterals shall be conducted in the presence of the Engineer in accordance with the exfiltration test method for gravity pipes. The Contractor shall furnish all equipment and personnel necessary to conduct all of the leakage tests.
- B. Gravity Pipe Leakage Testing: For CIPP, low-pressure air test as specified in Section **33 08 00.13** shall be required after liner has been installed in existing pipe.

3.08 Final Inspection and Acceptance

- A. At the completion of the rehabilitation of the sewer, a digitally formatted video inspection, conforming to Section 33 01 30.16 of these Specifications shall be submitted to the Engineer for review. If, in the judgment of the Engineer, any unsatisfactory conditions are present, the Contractor shall correct conditions in these areas at no cost to the Owner.
- B. The finished pipe must be such that when the thermosetting resin cures, the total wall thickness will be a homogeneous, monolithic felt and resin composite matrix that will be chemically resistant to withstand internal exposure to domestic sewage. When cured, the CIPP must form a mechanical bond with the host pipe.

3.09 Customer Notifications

- A. The Contractor shall contact all residential and commercial customers whose service lines are to be rehabilitated or who may be affected by upstream or downstream rehabilitations and inform them that they will be temporarily out of service. This notification shall be made a minimum of 24 hours prior to beginning rehabilitation work. **See the Drawings and Section 01 35 00 Unique Requirements regarding any additional notification requirements.**
- B. For all residences the Contractor shall leave a door hanger detailing the service outage and providing contact information. Door hanger samples shall be submitted to the Engineer for review and approval. The Contractor shall also advise those customers against water usage until the mainline and lateral are back in service. After completing the necessary work on the main line and lateral to allow their reuse, the Contractor shall advise those customers that the sewer is back in service. Should a condition arise that the Contractor cannot restore service within 12 hours of service interruption, the Contractor shall make provisions for pumping all flows within the service interruption area at no cost to the Owner.

END OF SECTION

Part 1 General

1.01 Scope

- A. The work covered by this section shall consist of replacing existing sanitary sewer pipes by a pipe bursting method of trenchless pipeline replacement utilizing a pneumatic burster unit to split the existing host pipe while simultaneously installing a new approved material pipe of the same size or larger diameter where the previous pipe existed. Existing pipe is broken with a “moling” device (hydraulic, pneumatic, or boring “knife”) and moved into the surrounding soil. The replacement pipe is either pulled or pushed by means of hydraulic force into place. The size hammer to be used shall be the minimum diameter necessary to facilitate the process. Oversized hammers shall not be allowed.
- B. No pipe bursting restoration will be accepted that has created a sag in the restored line by oversized hammers or other procedures. The Contractor shall be responsible for correcting existing sags (as defined in this Section, 3.01) and any sags that are created by the new construction.
- C. The work performed under this Section of the Specifications is deemed to be Specialty Contractor Work and is subject to the provisions of [Section 00 72 00 General Conditions, Article 10, Paragraph (b)].
- D. The deterioration of sewers is an on-going process. In the event pre-construction inspections reveal the sewers to be in substantially different conditions than those in the design requirements specified herein, the Contractor shall submit a changed site condition notice and request such changes in liner thickness, supporting such requests with the appropriate design data satisfactory to the Engineer.

1.02 Reference Standards

Supply all products and perform all work in accordance with applicable American Society for Testing and Material (ASTM), American Water Works Association (AWWA), American National Standards Institute (ANSI), or other recognized standards. The latest revisions of all standards in effect on date of advertisement are applicable. Where differences exist, or any latitude is either inferred or interpreted between this Specification and referenced product/process standards, this Specification shall govern. Reference is also made to Section 33 30 00 Sewers and Accessories for complete technical requirements of approved pipe materials.

1.03 Quality Assurance

- A. If requested by the Engineer, submit evidence that the superintendent for the pipe bursting work has been in responsible charge of at least two successfully completed pipe bursting projects within the past two years.
- B. Personnel directly involved with installing the new pipe shall have received training from a qualified representative of the pipe manufacturer in the proper methods for handling and installing the pipe and connections associated with pipe bursting.

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- C. Only personnel certified as fusion technicians by a manufacturer of HDPE pipe shall perform HDPE pipe jointing. They shall be trained, certified, and experienced in the operation of butt-fusing equipment and the installation of electro-fusion fittings by a manufacturer of HDPE pipe.
- D. The Contractor shall certify in writing that he is a fully trained licensee of an approved pipe bursting system.
- E. Product manufacturers shall provide the Engineer with written certification that all products furnished comply with all applicable provisions of these Specifications.
- F. If ordered by the Engineer, each pipe manufacturer shall furnish the services of a competent factory representative to supervise and/or inspect the installation of pipe. This service will be furnished for a minimum of five days during initial pipe installation.

1.04 Submittals

- A. Complete product data and engineering data shall be submitted to the Engineer in accordance with the requirements of Section 01 33 23 of these Specifications.
- B. The Contractor shall submit a work plan to the Engineer for review and acceptance. The work plan shall address the following minimum preparation/steps, unless directed otherwise by the Engineer:
 - 1. Safety
 - 2. Pre-installation CCTV Inspection
 - 3. Bypass Pumping
 - 4. Line Obstructions
 - 5. Sags In Line
 - 6. Description of bursting method
 - 7. Type of bursting tool and pulling unit
 - 8. Equipment operating procedures
 - 9. Type of lubricant and MSDS
 - 10. Traffic Control Plan
 - 11. Copies of all the training certifications for the personnel fusing HDPE pipe and fittings working on the Project must be submitted to the Engineer prior to commencing work, including copies of any required technology licenses.

- C. Submit the location and dimensions of the pits to be excavated. Submit proposed modifications to existing manholes, if any, if manholes are to be used as machine pits or pipe insertion pits.

1.05 Transportation and Handling

- A. Unloading: Furnish equipment and facilities for unloading, handling, distributing and storing pipe, fittings and accessories. Make equipment available at all times for use in unloading. Do not drop or dump materials. Any materials dropped or dumped will be subject to rejection without additional justification.
- B. Handling: Handle pipe, fittings, and accessories carefully to prevent shock or damage. Handle pipe by rolling on skids, forklift, or front loader. Do not use material damaged in handling.

1.06 Storage and Protection

- A. Store all pipe which cannot be distributed along the route. Make arrangements for the use of suitable storage areas.
- B. Stored materials shall be kept safe from damage. The interior of all pipe, fittings and other appurtenances shall be kept free from dirt or foreign matter at all times.
- C. Pipe shall not be stacked higher than the limits recommended by the manufacturer. The bottom tier shall be kept off the ground on timbers, rails or concrete. At least two rows of timbers shall be placed between tiers and chocks, affixed to each other in order to prevent movement. The timbers shall be large enough to prevent contact between the pipes in adjacent tiers.

Part 2 Products

2.01 Pipe

- A. Pull Method
 - 1. High Density Polyethylene (HDPE) Pipe
 - a. Gravity or Force Main Applications
 - i. Pipe and Fittings: The pipe shall meet the requirements of AWWA C906. Pipe shall be in ductile iron pipe sizes (DIPS). The pressure rating shall be 160 psi with a maximum dimension ratio (DR) of 11. Laying lengths shall be 40-ft standard.
 - ii. Pipe and fittings shall be marked as prescribed by AWWA C906. Pipe markings shall include nominal size, OD base (i.e., 12-inch ductile iron pipe sizing, DIPS), dimension ratio, pressure class, AWWA C906, manufacturer's name, production code and extrusion date.

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- iii. HDPE gravity sewer shall also have a light interior color.
 - iv. HDPE sewer force main pipe shall have a green colored stripe along the exterior length of the pipe.
2. Fusible Polyvinyl Chloride (FPVC) Pipe
- a. Gravity Applications
 - i. Fusible PVC pipe shall be permitted for only 4-inch through 16-inch diameter gravity sewer pipe.
 - ii. Pipe 15-inch diameter or smaller shall conform to ASTM D 3034; pipe larger than 15-inch diameter shall conform to ASTM F 679.
 - iii. Fusible polyvinylchloride pipe may instead conform to AWWA C900 or AWWA C905, if applicable. Testing shall be in accordance with AWWA standards for any of these pipe types. If the AWWA standards are used, pipe diameters shall be in Ductile Iron Pipe Sizes (DIPS).
 - iv. Rework material shall be allowed per ASTM D3034, ASTM F679, AWWA C900 or AWWA C905 standards.
 - v. All pipe shall have an SDR of 35 and a minimum pipe stiffness of 46 psi when tested in accordance with ASTM D 2412. Where pipe depth is greater than 20 ft., provide pipe in SDR 26 with minimum pipe stiffness of 115 psi.
 - b. Force main applications
 - i. Fusible PVC pipe shall be permitted for only 4" through 16" diameter sewer force main pipe.
 - ii. Fusible polyvinylchloride pipe shall conform to AWWA C900 or AWWA C905. Rework material shall be allowed per AWWA C900 and AWWA C905 standards.
- B. Push Method
- 1. Ductile Iron Pipe (DIP) and Fittings
 - a. Lined and polyethylene (PE)-wrapped DIP shall conform to AWWA C150 and C151. Nominal pipe laying lengths shall be 20 feet.
 - b. Fittings shall be ductile iron conforming to the requirements of AWWA C153 or AWWA C110 and shall have a minimum pressure rating of 250 psi.

2. Fiberglass Reinforced Polymer (FRP) Pipe and Fittings
 - a. Pipe shall be manufactured in accordance with ASTM D3262, with gaskets meeting ASTM F477, and interior surface resin in contact with wastewater meeting ASTM D3681.
 - b. All FRP joints shall meet the performance requirements of ASTM D4161 with gaskets meeting ASTM F477.
 - c. Stiffness class of FRP pipe shall satisfy design requirements but shall not be less than 46 psi.
- C. General: Pipe installed by the pipe bursting method shall be high density polyethylene (HDPE) pipe unless otherwise indicated on the Drawings. All pipe shall be made of virgin material. No rework except that obtained from the manufacturer's own production of the same formulation shall be used. The pipe shall be homogenous throughout and shall be free of visible cracks, holes, foreign material, blisters, or other deleterious faults.
- D. HDPE Pipe: Wall thickness shall be minimum SDR 17 (DIPS) per ASTM F714. HDPE pipe shall be manufactured in accordance with ASTM F 714. Joints shall be of the butt-fusion type. Pipe shall be light or opaque in color to facilitate closed-circuit television inspection.
- E. Conventional fusion saddles as manufactured by Central Plastics, Phillips Driscopipe, Plexco or approved equal and shall be installed in accordance with the manufacturers recommended procedures.
- F. Pipe Joining: The polyethylene pipe shall be assembled and joined at the site using the butt-fusion method to provide a leak proof joint. Threaded or solvent-cement joints and connections are not permitted. All equipment and procedures used shall be used in strict compliance with the manufacturer's recommendations. Fusing shall be accomplished by personnel certified as fusion technicians by a manufacturer of polyethylene pipe and/or fusing equipment. The butt-fused joint shall be true alignment and shall have uniform roll-back beads resulting from the use of proper temperature and pressure. The joint shall be allowed adequate cooling time before removal of pressure. The fused joint shall be watertight and shall have a tensile strength equal to that of the pipe. All joints shall be subject to acceptance by the Engineer prior to insertion. Terminal sections of pipe that are joined within the insertion pit shall be connected with Central Plastics Electrofusion Couplings or approved equal connectors with tensile strength equivalent to that of the pipe being joined.

2.02 Manholes

Manholes shall be as specified in Section 33 30 00 of these Specifications, and of a class equal to that shown on the Drawings.

2.03 Equipment

- A. Bursting/Towing Tool: The tool shall have an outside diameter greater than the outside diameter of the new pipe. Additionally, the outside diameter of the tool shall not be greater than the outside diameter of the new pipe plus 1-inch. The tool shall be capable of fragmenting the pipe and compressing the old pipe sections into the surrounding soil as it progresses. The bursting head shall incorporate a shield or expander to prevent collapse of the hole ahead of the polyethylene pipe insertion. The burster shall have its own forward momentum while being assisted by winching. A hydraulic winch shall give the burster friction by which it can move forward.
- B. Only pneumatically operated equipment with either front or rear expanders for the proper connection to the polyethylene pipe will be allowed for use. The pneumatic tool must be used in conjunction with a constant tension/variable speed winch. The winch shall have twin cable pulling capstans with twin hydraulic drive motors and twin gear boxes for independent operation of 5, 10 or 20 tons. The size of the winch will be dependent on the diameter of the pipe to be replaced. In no case will the constant tension on the winch exceed 20 tons.

Part 3 Execution

3.01 General

- [] A. All construction activities shall be contained within the existing [20] foot wide permanent easement, which is centered over the existing sewer. Trees shall not be disturbed, except as absolutely necessary for performing this work.
- B. The tool shall be pushed or pulled through the bore of the existing pipe such that the existing sewer pipe is broken into small fragments. The tool shall drive these fragments into the surrounding pipe zone.
- C. The tool shall produce a tunnel along the vertical and horizontal alignment of the existing sewer. The tool shall also construct the new sewer by pushing or pulling the new pipe into the tunnel.
- D. The new sewer shall be constructed straight and along the same horizontal and vertical centerline as the existing sewer.
- E. Flow in the existing sewer shall be pumped around during installation and testing of the new sewer per Section 33 30 00, Article 3.09. The Contractor is responsible for paying all fines imposed for overflows during construction.
- F. Where it is not practical to use a pump around line, upstream flow may be pumped into a suitable tanker(s) for storage, transportation and gradual release downstream of the section of pipe being burst. The Contractor shall obtain specific approval for this method of flow bypass prior to proceeding with the work at such location.
- G. HDPE Pipe: After the new sewer has been installed to its final position, the pipe shall be allowed to relax to relieve stresses prior to being trimmed at manholes. Service

connections to the new sewer shall accommodate movement of the sewer which is experienced during the pipe relaxation process.

- H. Where upheaval of the existing ground surface occurs above the pipe bursting work, regrade the ground surface to provide the original ground elevations and surface conditions.
- I. Traffic Control: The Contractor shall be responsible for traffic control during the course of each phase of the Work. Prior to beginning Work, Contractor shall submit a traffic control plan for each section of Work for the review and approval. It is the intent that this Work is to be accomplished with as little disturbance to traffic, private property, and the public as is reasonably possible, consistent with timely completion thereof. The traffic control plan shall reflect such requirements where applicable. Signs, signals, and detours shall conform to the local and state requirements for streets and highways. The Contractor shall have and maintain on site a sufficient supply of traffic cones and other traffic signaling devices, including trained and properly equipped flagmen, to safely control all traffic through the work zone(s). Road closures and / or detours will require advance scheduling and prior approval by the Engineer.
- J. Line Obstructions: If Pre-Installation CCTV inspection reveals an obstruction in the existing sewer that was not evident in the Survey inspection (heavy solids, dropped joints, collapsed pipe, etc.), that will prevent completion of the pipe bursting process, and the obstruction cannot be removed by conventional sewer cleaning equipment, then an obstruction removal will be performed by the Contractor, with the approval of the Engineer.
- K. Sags In Line: If Pre-Installation CCTV inspection reveals a sag in the existing sewer that is equal to or greater than one-quarter of the diameter of the existing pipe, it shall be the Contractor's responsibility to install the replacement pipe to result in an acceptable grade without the sag. The Contractor shall take the necessary measures to eliminate these sags by the method of pipe replacement, digging a sag elimination pit and bringing the bottom of the pipe trench to a uniform grade in line with the existing pipe invert, or by other measures. If a sag elimination pit is required, the Contractor shall utilize it as the insertion pit for that segment of pipe replacement.

3.02 By-Pass Pumping

- A. The installation methodology contemplated requires the temporary blocking and back-ups of sewers and sewage. Contractor shall be responsible to limit the extent and duration of such blockages and back-ups so that overflows and spillage onto public or private property and into storm sewers, waterways, and streets does not occur. In the event that such spillage or overflows do occur during the course of or as a result of the Work, the Contractor performing the Work shall immediately eliminate the spillage or overflow and, as necessary, remove the blockage and eliminate the back-up. On elimination of the spillage or overflow, the Contractor is to clean up and disinfect the area. Work to stop or contain such events is to be deemed emergency in nature and sufficient justification for total mobilization of resources, the use of overtime or double time, and any other reasonable measures

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to assure correction of the problem without delay. Damages arising from blockages, back-ups, spillage, or overflows of sewage during the course of the Work or because of the Work shall be the sole responsibility of the Contractor.

- B. Sewage flow shall be pumped around segments during the installation and testing of pulled or pushed replacement pipe, the televising of sewers and lateral service reinstatement.
- C. Pumping equipment shall have the capacity to convey 100% of peak flows around the construction area. The flow shall be intercepted at the upstream end of the construction area and shall be pumped through temporary piping of adequate size. The flow shall be discharged into a manhole on the downstream side of the construction area, thus by-passing the sewer segment(s) under construction. The Contractor shall be required to contact all residential and commercial customers whose service lines connect to the sewer main being bypassed and inform them that they will be temporarily out of service. The Contractor shall also advise those customers against water usage until the mainline is back in service. After completing the necessary work on the main line to allow its reuse, the Contractor shall advise those customers that the sewer main is back in service. The Contractor shall maintain a high degree of professionalism, both in workmanship and appearance, at all times. Should a condition arise that the Contractor cannot restore service within 12 hours of service interruption; the Contractor shall make provisions for pumping all flows within the service interruption area at no cost to the Owner.
- D. Open channels or trenches shall not be used to convey flow.
- E. A standby pump of the same capacity shall be required on site.
- F. The Contractor is responsible for paying all fines imposed for overflows or spills during construction.

3.03 Pits

- A. Construct insertion pits, service pits and hydraulic machine pits as required to accomplish the work. The size and quantity of pits shall be the minimum necessary to accomplish the work.
- B. Location: In the determination of pit locations, the Contractor shall give consideration of other uses of the excavations, such as for services access and manholes, wherever possible. Pits shall be contained within acquired construction easements or existing permanent sanitary sewer easements.
- C. Pits shall be centered over the existing sewer.
- D. Pits shall be sloped and/or shored as necessary to comply with all regulatory requirements.
- E. Pits shall be provided with proper erosion and sedimentation control measures.

3.04 Manhole Connections

- A. If the new sewer is to be constructed through an existing manhole with the manhole not being used as a machine or insertion pit, the manhole wall shall be modified at the existing pipe connections such that the manhole will not be damaged by the tool passing through the manhole. The manhole shall be restored to have a smooth grouted flow pattern through it, with watertight seals around the pipe connections.
- B. If an existing manhole is demolished, cracked or its structural integrity is otherwise degraded as a result of the pipe bursting work, the Contractor shall provide a new manhole in accordance with Section 33 30 00 of these Specifications, at no additional cost to the Owner.

3.05 Services

- A. All services shall be located and exposed before the replacement operation begins for any given length of pipe being pulled or pushed.
- B. All service laterals shall be completely disconnected and isolated from the existing sewer before the replacement operation begins for that particular segment of sewer.
- C. Flow shall be bypassed to prevent accumulation of flow in laterals.
- D. Service laterals shall not be reconnected to the new sewer until the segment of the new sewer downstream of the service is complete, tested and accepted.
- E. Saddles for reconnection of service laterals shall be compatible with the new sewer pipe material. Electrofusion saddles shall be installed in accordance with the HDPE pipe manufacturers recommended procedures.

3.06 Acceptance

- A. The leading section of the new pipeline shall be pulled or pushed into a pit for inspection after completion of the replacement operation for each pipeline segment. Each such section shall be clearly marked and, if requested by the Engineer, made available to the Engineer for inspection.
- B. Sewer segments shall be tested between manholes by the air test method. These tests shall be performed and the section of line accepted prior to connecting any services or the main line flow.
 - 1. Prior to air testing, the section of sewer between manholes shall be thoroughly cleaned and wetted. Immediately after cleaning or while the pipe is water soaked, the sewer shall be tested with low-pressure air. At the Contractor's option, sewers may be tested in lengths between manholes or in short sections (25 feet or less) using inflatable balls pulled through the line from manhole to manhole. Air shall be slowly supplied to the plugged sewer section until internal air pressure reaches approximately 4.0 psi. After this pressure is reached and the pressure allowed to stabilize (approximately two to five minutes), the

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pressure may be reduced to 3.5 psi before starting the test. If a 0.5 psi drop does not occur within the test time, then the line has passed the test. If the pressure drops more than 0.5 psi during the test time, the line is presumed to have failed the test, and the Contractor will be required to locate the failure, make necessary repairs, and retest the line. Minimum test time for various pipe sizes is as follows:

Approximate Pipe I.D., Inches	T (Time Min/100) Feet
6	5.7
8	7.6
10	9.4
12	11.3
15	14.2
18	17.0
21	19.8
24	22.8

2. Required test equipment, including inflatable balls, braces, air hose, air source, timer, rotameter as applicable, cut-off valves, pressure reducing valve, 0-15 psi pressure gauge, 0-5 psi pressure gauge with gradations in 0.1 psi and accuracy of \pm two percent, shall be provided by the Contractor. Testing equipment shall be equal to Cherne Air-Loc Testing Systems.
 3. The Contractor shall keep records of all tests made. Copy of such records will be given to the Engineer or the Owner. Such records shall show date, line number and stations, operator, and such other pertinent information as required by the Engineer.
 4. The Contractor is cautioned to observe proper safety precautions in performance of the air testing. It is imperative that plugs be properly secured and that care be exercised in their removal. Every precaution shall be taken to avoid the possibility of over-pressurizing the sewer line.
- C. Each sewer segment between manholes shall be accepted upon successful completion of the air leakage test.
- D. Post CCTV of Completed Pipe Sections: Post-installation videos shall be conducted and submitted to the Engineer in accordance with Section 33 01 30.16 of these Specifications.
- E. Smoke Testing of Service Lateral Connections: Once the pipe bursting operation is complete and services re-established, the Contractor shall perform a smoke test of the service laterals prior to backfilling. Leaks detected during testing must be repaired as part of the pipe bursting operation and shall be considered incidental and included in the cost of pipe bursting.

3.07 Customer Notifications

- A. The Contractor shall contact all residential and commercial customers whose service is to be interrupted by rehabilitation work or who may be affected by upstream or downstream rehabilitations. The customer shall be informed that they will be temporarily out of service. This notification shall be made a minimum of 24 hours prior to beginning rehabilitation work. **[See the Drawings and Section 01 35 00 Unique Requirements regarding any additional notification requirements.]**
- B. For all residences the Contractor shall leave a door hanger detailing the service outage and providing contact information. Door hanger samples shall be submitted to the Engineer for review and approval. The Contractor shall also advise those customers against water usage until the mainline and lateral are back in service. After completing the necessary work on the main line and lateral to allow their reuse, the Contractor shall advise those customers that the sewer is back in service. Should a condition arise that the Contractor cannot restore service within 12 hours of service interruption; the Contractor shall make provisions for pumping all flows within the service interruption area at no cost to the Owner.

END OF SECTION

Subsurface Manhole Rehabilitation

Part 1 General

1.01 Scope

- A. The scope of this section of the Specifications includes requirements for furnishing all labor, material and equipment to provide for the reconstruction of existing manholes, manhole benches and inverts using an approved method of non-disruptive rehabilitation within an existing structure, which has generally maintained its original shape.
- B. The work performed under this section of the Specifications is deemed to be Specialty Subcontractor Work and is subject to the provisions of [Section 00 72 00, Article General Conditions, Article 10, Paragraph (b)].
- C. Supply all products and perform all work in accordance with applicable American Society for Testing and Material (ASTM), American Water Works Association (AWWA), American National Standards Institute (ANSI), or other recognized standards. Latest revisions existing on advertisement date of all standards are applicable. Where discrepancies exist between this Specification and referenced product/process standards, this Specification shall govern.

1.02 Specialty Subcontractor and Qualifying Superintendent Experience

- A. The Specialty Subcontractor performing the work shall be fully qualified, experienced and equipped to complete this work expeditiously and in a satisfactory manner. The Specialty Subcontractor shall be an approved installer as certified and licensed by the manufacturer. The Contractor must certify that the proposed product/process to be used is the exact system for which any and all submittals and certifications were made. No substitutions will be allowed, and misrepresentations or omissions may be grounds for Contract termination with the Contractor waiving any and all claims against the Owner for work performed or costs incurred.
- B. The proposed qualifying superintendent of the Specialty Subcontractor for the work under this Section shall have successfully installed a manhole lining product of the type specified in a minimum of 500 manholes/structures over the last ten years as documented by verifiable Owner references. The Owner must approve both the Specialty Subcontractor and the Qualifying Superintendent to perform this work. The approved superintendent shall be on-site during the execution of all lining operations including prep work and vacuum testing. The lining installation and/or vacuum testing shall cease whenever the superintendent is not on-site.

1.03 Storage, Handling and Protection

Care shall be taken in shipping, handling and storage to avoid damaging the lining materials. Any lining product damaged in shipment, showing deterioration, or which has been exposed to any other adverse storage condition that may have caused

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damage, even though no such damage is evident, shall be marked as rejected and removed at once from the job site. While stored, the lining products shall be adequately packaged, protected and stored in accordance with the manufacturer's recommendations.

1.04 Submittals

- A. The Contractor shall submit for all products to be installed under this section of the Specifications the following:
1. Description, layout, and application sequencing plan.
 2. Rehabilitation system application requirements including material handling and storage requirements, mixing and proportioning requirements (as applicable), maximum pot life, film/coating thickness, curing, testing and certification requirements of all rehabilitation materials. Product Material Safety Data Sheets (MSDS).
 3. Detailed instructions and methodology for finishing all pipe and manhole connections to rehabilitated manholes to prevent infiltration and exfiltration.
 4. Wastewater Flow Control/Bypassing Plan.
 5. Confined Space Entry Plan/Permit.
 6. Plan for capturing extraneous debris during rehabilitation processes and debris disposal.
 7. Liner and vacuum test results.
- B. The Contractor shall submit evidence of meeting the requirements of meeting the requirements of Article 1.02 above.
- C. The Contractor shall provide bond strength data on the cured cementitious lining based on ASTM test methods referenced in this Specification.
- D. The Contractor shall provide test data on shrinkage of the cured cementitious lining based on ASTM test methods referenced in this Specification.
- E. The Contractor shall submit complete shop drawings of the manhole lining system(s) to demonstrate compliance with these Specifications, materials and detailed installation procedures. Testing procedures and quality control procedures shall also be submitted. Certifications that the lining system was manufactured in accordance with these Specifications and the applicable ASTM standards shall be submitted with each material shipment.

1.05 Warranty

The coatings/linings manufacturer shall warranty the entire project to include any

and all aspects of the surface preparation, base material installation and protective coating/lining applications for a period of ten (10) years from the date of acceptance by the Owner. The warranty shall make no distinction between installation practices and material performance and shall not be prorated with respect to elapsed time for the entire warranty period. Manufacturer shall, within a reasonable period of time after receipt of written notice thereof by the Owner [period not to exceed sixty (60) calendar days], repair defects in materials or workmanship during said ten (10) year period, and any damage to other work caused by such defects or repairing of same at his own expense and without cost to the Owner.

Part 2 Products

General

The rehabilitation of manholes is divided into two product classes: cementitious products and polymer resin-based products.

Where specified, cementitious products will be used when there is little or no evidence of sewer gas deterioration. Polymer resin-based products shall be specified where the presence of sewer gas deterioration and attack is evident or anticipated.

2.01 Cementitious Lining

- A. The cementitious lining system shall be pumpable Portland-based cement or fused calcium aluminate cement. The lining shall be applied via low-pressure spray or trowel application only. The materials shall be suitable for all specified design conditions. The final product shall not deteriorate, corrode, or lose structural strength in any manner. Mortar shall be made of one part Portland cement and two parts clean sharp sand. Cement shall be Type 1 and shall conform to ASTM C 150. Sand shall meet the requirements of ASTM C 144.
- B. The cementitious lining shall be installed on manhole benches, inverts and walls unless otherwise directed by the Engineer.
- C. The materials used in the cementitious lining systems shall be mixed on-site according to the manufacturer's recommendations. Water shall be added to the materials only during the mixing process and prior to material pumping or spray application. No water shall be added at the nozzle.
- D. The cementitious liner, when cured, shall have the following minimum characteristics at 28 days as measured by the applicable ASTM standards referenced in this Specification:
 1. Minimum compressive strength of 6,000 psi.
 2. Minimum tensile strength of 600 psi

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3. Minimum flexural strength of 1,000 psi
 4. Minimum bond strength of 200 psi.
 5. Shrinkage of less than 0.05%
- E. The cured cementitious lining shall be continuously bonded to all brick, mortar, concrete, chemical sealant, grout, pipe and other substrates inside the manhole.
- F. Patching Material: A quick setting fiber reinforced cementitious material shall be used as a patching material and is to be mixed and applied according to manufacturer's recommendations.
- G. Hydraulic Cement: A rapid setting, high-early-strength, cementitious product specifically formulated for leak control shall be used to stop water infiltration. The material shall be mixed and applied according to the manufacturer's recommendations.
- H. Chemical sealants or grouts used to seal active manhole leaks, patch holes or cracks, fill voids and to otherwise prepare the manhole surface for lining shall be suitable for wastewater system service and chemically resistant to any chemicals or vapors normally associated with domestic wastewater installations.
- I. Cementitious linings shall be compatible with existing thermal conditions in the manhole.
- J. Cementitious products shall be applied with a one inch finished thickness and shall be one of the following products:
1. Strong Seal MS-2A, as manufactured by Strong Seal Systems
 2. QM-1s Restore or Alumaliner as manufactured by Quadex
 3. Permacast MS-10,000 or CR-5000 as manufactured by APM, Inc.
 4. Sewpercoat PG as manufactured by Kerneos, Inc., Chesapeake, Virginia
 5. Mainstay ML-72 Restoration Mortar as manufactured by Madewell Products Corp.
 6. Substrate Surfacer No. F-121FBR as manufactured by Sauereisen
 7. MSM as manufactured by AW Cook
 8. Reliner MSP as manufactured by Standard Cement Products

2.02 Polymer Resin-Based Linings

A. Type 1 Polymer resin-based liners shall be 100% solids by volume, volatile organic compound (VOC) free and shall conform to the minimum physical properties listed in the following table:

Compressive Strength	ASTM D695	10,500 psi
Tensile Strength	ASTM D638	7,000 psi
Flexural Strength	ASTM D790	12,000 psi
Flexural Modulus (Initial)	ASTM D790	730,000 psi
Density		87 ± pcf
Bond		Exceed tensile strength of substrate

B. The structures lined with polymer resin-based liners shall be resistant to corrosion caused by:

1. Hydrogen Sulfide
2. 20% Sulfuric Acid
3. 17% Nitric Acid
4. 5% Sodium Hydroxide
5. All common ingredients normally associated with sanitary sewer environments and an environment of pH of 0.5 or higher.

C. The finished liner shall have long-term (50-year) flexural modulus of elasticity value of 500,000 psi and shall be certified by independent third-party testing.

D. Polymer resin-based linings shall be compatible with existing thermal conditions in the manhole.

E. The final product shall not deteriorate, corrode, or lose structural strength in any manner.

F. The system shall be designed to operate at ambient temperatures up to 140 degrees F with excellent abrasion resistance.

G. The Type 1 Polymer resin-based lining system shall be a resin-based lining system applied with a minimum 250 mil (1/4-inch) finished thickness meeting the requirements of paragraph 2.02 above and shall be one of the following products:

1. Spraywall or Sprayshield as manufactured by Sprayroq, Inc.
2. S-301 Epoxy Spray System as manufactured by Warren Environmental, Inc.
3. Dinjer SG Mastic as manufactured by Pilgrim Permocoat Inc.
4. Raven 405 as manufactured by Raven Lining Systems

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5. SLS-60™ by Citadel Technologies
 6. Cor+Gard FC as manufactured by APM Permaform
- H. The Type 2 Polymer resin-based lining system shall be a multi-layer lining system in accordance with the following requirements:
1. Lining system shall be Spectrashield as manufactured by CCI Spectrum, Inc.
 2. The liner system shall be a multi-component stress skin panel liner system as described below:

<u>Layer</u>	<u>Material</u>	<u>Minimum Thickness</u>
Moisture Barrier	Modified Polymer	100 mils
Surfacer	Polyurethane/Polymeric blend foam	500 mils
Corrosion barrier	Modified Polymer	150 mils
Total Installation		750 mils

3. The modified polymer shall be sprayable, solvent free, two-component polymeric, moisture/chemical barrier specifically developed for the wastewater environment with the following physical properties:

<u>Parameter</u>	<u>Method</u>	<u>Value</u>
Tensile Strength, psi	ASTM D412	>2,400
Elongation, %	ASTM D412	>300
Tear Strength, PSI	ASTM D624	>500
Shore A Hardness	ASTM D2240	>96
Flexural Modulus	ASTM D522	>2,400

4. The polyurethane/polymeric blend foam shall be a rigid structure foam, low viscosity two-component blend with the following physical properties:

<u>Parameter</u>	<u>Method</u>	<u>Value</u>
Density, lbs/ft ³	ASTM D1622	4-10
Compression Strength, psi	ASTM D1621	90-150
Closed Cell Content, %		>95
Shear Strength, psi	ASTM C273	225-250

Part 3 Execution

3.01 General

- A. The Contractor shall notify all property owners who discharge sewage directly into the manhole being rehabilitated at least 48 hours in advance, giving the date, starting and estimated completion time for the work being conducted and any anticipated impact to the property owner. Notification shall consist of a door hanger and/or letter. A sample of the proposed door hanger or letter shall be submitted to the Engineer for review and approval.
- B. The Contractor shall bypass pump sewage flows around the manhole being rehabilitated while the work is being performed complying with Section [01 51 43] of these Specifications. A detailed bypass plan shall be submitted to the Engineer for approval before any work shall take place.
- C. Covers or plugs shall be placed over all pipe openings to prevent excess material from entering the wastewater collection system.
- D. Manhole walls and benches shall be monolithically coated to the required thickness by spray-on methods in a single pass or application. Sprayed cementitious linings shall be trowelled smooth after application.
- E. All invert channels shall be coated with grout or cementitious mortar to build up the invert to the invert elevations of new liner pipes (if applicable and as directed by the Engineer); to fill all cracks, voids, holes, etc.; and to form a smooth flow channel. The entire channel shall be coated with the channel coating being a minimum ¼-inch thick.
- F. A complete watertight seal shall be provided at the pipe and manhole wall connections. The Contractor shall submit details of how watertight connections shall be made to the Engineer for approval prior to performing any work.
- G. Manhole lining shall not be installed until all required mainline sewer rehabilitation and/or other manhole work is completed.
- H. Application of the spray applied material must be completed in one mobilization in order to minimize the disruption and cost of bypass pumping, pipeline plugging, traffic control and other ancillary services.
- I. The finished manhole may be returned to service immediately upon completion of the spray application.
- J. Appropriate personal protection equipment shall be used with supplied air being utilized to the spray technician and other personnel in direct contact with the spray environment.
- K. The spray shall be applied so that the entire structure receives a structurally sound,

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monolithic liner. The finished invert surfaces shall be smooth, free of ridges and bumps and will be sloped in the direction of flow. Special care shall be taken to ensure a smooth transition between the new manhole invert and intersecting pipeline inverts so that flow will not be impaired.

- L. The cured surfacing thickness shall be smooth, even (without ridges or bumps) and continuous with proper sealing connections to any non-rehabilitated areas.
- M. The monolithic lining shall completely cover the interior of the existing manhole including the benches and invert unless otherwise directed by the Engineer. The lining shall effectively seal the interior surfaces of the manhole and prevent any penetration or leakage of ground water infiltration.
- N. The Contractor shall adhere to all of the lining manufacturer's installation requirements including environmental conditions (ambient temperature, moisture, etc.) and curing times.

3.02 Surface Preparation (All Lining Systems)

- A. The Contractor shall clean each sewer manhole to be restored and shall dispose of any debris or resulting material in a manner and place suitable to the Owner. Cleaning shall be performed using a high-pressure jet wash at a minimum of 3,500 psi water pressure to remove all dust, biological growths, grease, oils or any other surface contaminants or coatings.
- B. The Contractor shall immediately notify the Engineer of any coatings that cannot be removed or substrates which cannot be cleaned and, upon the approval of the Engineer, may use a blast abrasive in these area(s) to rough up the surface sufficient to obtain and ensure adequate bonding of the liner. Roots shall be removed by manually cutting them from inside the manhole.
- C. The Contractor shall conduct a visual inspection of each manhole after it is cleaned. All active leaks shall be plugged or sealed with an appropriate grout compatible with the lining. Injection grouting may be required to seal active leaks including existing leaks in invert channels and benches. All loose mortar and rubble of existing benches, walls and inverts shall be removed.
- D. The Contractor shall prepare the manhole to receive lining as necessary by reshaping and repairing benches, inverts and walls where required including smoothing out irregular shaped corbel and chimney sections prior to any spray application. All interior surfaces shall be prepared as recommended by the lining system manufacturer. Minimum requirements of the Specification are as follows:
 - 1. All cracks and voids must be repaired and filled with suitable non-shrinking cements, sealants or grouts, including all voids between existing sewer pipes and manhole walls. All patch repairs shall be smooth and even with the manhole wall.
 - 2. All voids around existing manhole rungs, steps and anchors shall be filled.

3. All surfaces shall be suitably prepared for the required bonding of the liner as recommended by the manufacturer and acceptable to the Engineer.
- E. Prior to lining, the Engineer shall inspect and approve the surface preparation work. The Contractor shall notify the Engineer when the manholes are ready for inspection. The Contractor shall take digital photographs of the invert, bench and pipe openings and present them to the Engineer in order to document the readiness of the manhole for lining application in these areas. The manhole lining shall be performed immediately after the Engineer's inspection or the manhole may need to be re-cleaned and dried prior to lining application to remove accumulated debris on walls and benches.

3.03 Additional Requirements for Polymer Resin-Based Lining Systems

- A. Application of the liner shall not be made unless the ambient temperature inside the structure is 50 degrees F or higher and expected to be the same or rise during the next 72 hours.
- B. The liner shall be manually sprayed to all surfaces by a factory-certified, trained technician experienced in the application of a spray applied resin.
- C. No other products such as grouts, cements or sealants may be considered as part of the structural restoration. However, said products may be used as part of the repair and surface preparation process as specified in Section 3.02 of this Specification.
- D. The wall of the Polymer resin-based system shall be structurally designed to withstand the hydraulic load generated by the groundwater table.

3.04 Acceptance Testing

- A. Field Acceptance
 1. Field acceptance of manhole lining shall be based on the Engineer's field inspection and evaluation of the appropriate installation and curing test data. The lining shall provide a continuous monolithic surfacing with uniform thickness throughout the manhole interior. If the thickness is not uniform or is less than specified, it shall be repaired or replaced at no additional cost to the Owner.
 2. If the Engineer has to enter the manhole to inspect the work, the Contractor shall provide forced air ventilation, gas monitors, harnesses, lights, confined space entry, etc., for the Engineer to enter the manhole and perform the inspection in strict and complete accordance with OSHA requirements at no additional cost to the Owner.
- B. Cementitious Test Samples
 1. Samples shall be taken of the installed liner each day that the cementitious lining

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is installed in the following manner:

Quantity of Manholes Lined in One Day	Quantity of Samples Required
1 – 5	1
6 – 10	2
11 – 15	3
16 or more	4

2. Samples shall be taken at equally spaced intervals throughout the workday. The frequency of tests may be increased by the Engineer and performed by the Contractor at no additional cost to the Owner when the required tests indicate that the installed lining does not meet the Specification.
- C. Cementitious Lining Strength and Bonding Testing Procedures: Samples shall be cube samples. A minimum of six cubes shall be taken for each sample testing. The samples shall be tested in accordance with the applicable ASTM standards, including ASTM C109, to verify that the installed liner meets the compressive strength requirements specified herein and the lining manufacturer's published product data. Tests shall include 7-day and 28-day strength tests (3 cubes for each time period per sample). Shrinkage and bond strength tests shall be performed on each batch or lot of material shipped to the Contractor. Testing shall be performed by an independent laboratory as determined by the Owner with all associated costs paid by the Contractor. The test results shall be submitted to the Engineer immediately when available and no later than 30 days after lining installation.
- D. Vacuum Testing (Cementitious Lining Manholes)
1. All manholes rehabilitated with cementitious products shall be vacuum tested when all manhole rehabilitation is completed. Manholes shall not be tested until at least 7 days after installation of lining.
 2. Vacuum testing shall be performed in accordance with ASTM C1244 with all associated costs paid for by the Contractor and included in the bid price for manhole lining.
 3. The Engineer shall be present for all testing. The Contractor shall notify the Engineer 48 hours prior to testing.
 4. The Contractor shall submit test reports of the testing which include: the Project name, manhole tested, testing data (vacuum pressure, duration of test, etc.), and whether the manhole passed or failed the test. Test reports must be submitted citing the reason for failure noted on the report.
 5. Any manhole failing the test shall be repaired and retested immediately by the Contractor at no additional cost to the Owner.
- E. Spark Arrestor (Holiday) Testing (Polymer Resin-Based Lining Manholes)
1. All polymer resin-based manhole linings shall be spark tested prior to being placed in service. Spark testing shall be required of the entire surface area of the

manhole (field and joint) and shall be conducted in accordance with the liner system manufacturer's recommendations.

2. Results of the spark tests will be logged in duplicate and a copy of this log submitted to the Engineer.
3. Equipment systems used to perform spark testing shall be compatible with the materials to be tested. Spark testing equipment shall provide a visual as well as audible indicator to identify pinholes or splits in the liner system.
4. Spark testing shall be performed in accordance with ASTM D4787. Contractor shall maintain calibration records certifying the spark testing equipment has been calibrated within 12 months of the current date.
5. For polymer resin-based manhole lining products meeting the requirements of Article 2.05, Paragraph C, spark testing shall be performed on the complete three layer lining system.

F. Adhesion Testing (Polymer Resin-Based Lining Manholes)

1. The adhesion tests shall be performed on a minimum of one or 20% of all polymer resin-based rehabilitated structures, whichever is greater.
2. Adhesion testing shall be conducted after the lining or coating system has cured per manufacturer instruction and in accordance with ASTM D4541 (Steel) or ASTM 7234 (Concrete). A minimum of one 20 mm dolly shall be affixed to the lined surface of the structure at the upper section or cone area, mid section and at the bottom, unless otherwise specified or directed by the Engineer. Each testing location shall be identified by the Engineer.
3. Selection of the adhesive used to attach the dollies to the liner shall be the Contractor's responsibility. Adhesive shall be rapid setting with tensile strength in excess of the liner material, suitable for the environmental conditions anticipated in a sanitary sewer manhole, and permitted to cure in accordance with manufacturer recommendations. The lining material and dollies shall be adequately prepared to receive the adhesive.
4. Prior to pull test, the Contractor shall utilize a scoring device to cut through the coating until the substrate is reached. Extreme care shall be required while scoring to prevent micro cracking in the coating, since cracks may cause failures at diminished strengths.
5. Failure due to improper dolly adhesive or scoring shall require retesting. The pull tests in each area shall meet or exceed 200 psi and shall include subbase adhered to the back of the dolly or no visual signs of coating material in the test hole.
6. Pull tests with results between a minimum 150 psi and 200 psi shall be acceptable if more than 50% of the subsurface is adhered to the back of the

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dolly. A test result can be discarded, as determined by the Engineer, if there is a valid non-statistical reason for discarding the test results as directed by Sections 8.4 and 8.5 of ASTM D4541 and ASTM D7234.

7. If any test fails, a minimum of three additional locations in the section of the failure shall be tested, as directed by the Engineer. If any of the retests fail, the structure shall be deemed to have failed. All loosely adhered or unadhered liner in the failed area, as determined by the Engineer, shall be removed and replaced at the Contractor's expense.
8. The mil thickness will be measured and confirmed with the scored and pulled test samples. If the measured thickness of any adhesion test samples is under the specified value, a minimum of three additional locations in the same structure shall be tested, as directed by the Engineer. All areas found to be less than the specified thickness shall be corrected through additional application of lining material.
9. If a structure fails the adhesion test based on adhesion value or mill thickness, one additional structure or 10% of the initial number of structures selected for testing, whichever is greater shall be tested at the discretion of the Engineer.
10. The liner shall be repaired at all pull test locations following testing.
11. The Engineer shall be present for all adhesion testing.
12. Adhesion testing shall be performed as the work progresses. If adhesion testing has not been performed on a minimum of 20% manholes lined to date at any given time, Engineer may prohibit the continued application of manhole lining until the required adhesion testing is completed.
13. For Type 2 polymer resin-based lining systems described in Article 2.05 Paragraph C, adhesion testing shall be performed on the complete three layer lining. For the purpose of thickness verification, additional core samples shall be taken from the outer corrosion barrier layer for every base layer adhesion test performed.

G. Finished Lining Systems

1. There shall be no groundwater infiltration or other leakage (active or previously active) through the manhole walls, benches, inverts or pipe connections at the manhole after it has been lined.
2. If leakage is detected, it shall be eliminated with an appropriate, grout or sealant as recommended by the manufacturer, over coated with epoxy or approved polymer-based lining material and approved by the Engineer at no additional cost to the Owner. Injection grouting may be required to stop leaks around or in invert channels, pipe connections and benches.
3. The Engineer's decision regarding acceptable repair methods for defective linings shall be final. If any lining is found to be defective after it has been

Subsurface Manhole Rehabilitation

installed or during the warranty period, it shall be repaired or replaced in a manner satisfactory to the Engineer and at no additional cost to the Owner.

END OF SECTION

Surface Manhole Rehabilitation

Part 1 General

1.01 Scope

- A. Furnish all labor, material and equipment to provide for the rehabilitation of existing manholes, using an approved method of non-disruptive rehabilitation within an existing structure, which has generally maintained its original shape. The selected rehabilitation products were selected to minimize or prevent extraneous water from entering the sanitary sewer system. This Specification covers the general requirements for the referenced specifications, product requirements and installer qualifications, submittal and guaranty guidelines, materials, installation and testing procedures.
- B. Supply all products and perform all work in accordance with applicable American Society for Testing and Material (ASTM), American Water Works Association (AWWA), American National Standards Institute (ANSI), or other recognized standards. Latest revisions existing on advertisement date of all standards are applicable. Where discrepancies exist between these Specifications and referenced product/process standards, these Specifications shall govern.

1.02 Contractor and Qualifying Superintendent Experience

The Contractor performing the work shall be fully qualified, experienced and equipped to complete this work expeditiously and in a satisfactory manner. The qualified Contractor shall be an approved installer as certified and licensed by the manufacturer. The installing Contractor must certify that the proposed product/process to be used is the exact system for which any and all submittals and certifications were made. No substitutions will be allowed, and misrepresentations or omissions may be grounds for contract termination with the Contractor waiving any and all claims against the Owner for work performed or costs incurred.

Part 2 Products

2.01 General

- A. Manhole Inflow Dish Inserts - Shall effectively reduce or prevent surface water inflow through manhole covers. The insert shall also prove effective in keeping dirt, sand, salt, chemical spills, foreign objects, road oils, etc. from entering the manhole and collection system lines.
 - 1. Dish Materials - Shall be manufactured from a durable High Density Polyethylene Copolymer material that meets ASTM D-1248 Class A, Category 5, Type III Specification. This material shall have a minimum impact brittleness temperature of -105 degrees Fahrenheit in accordance with ASTM D 746-70. The dish shall have a tensile strength of 3,700 psi and an elongation factor of

Surface Manhole Rehabilitation

- 800% meeting all requirements of ASTM D 638-71A. The thickness shall be a uniform 1/8-inch.
2. Lifting Straps - The dish shall have a lift strap made of woven polypropylene web or corrosion resistant material and attached to the bowl of the dish by corrosion resistant hardware. All cut edges shall be seared to insure against raveling.
 3. Ventilation - Ventilation for relieving gas and/or vacuum pressure from the manhole shall be accomplished by one of the following methods: 1) Installation of no more than two vent holes 3/16-inch in diameter installed 180 degrees apart approximately 1-inch from the top of the insert. 2) Installation of a valve, or valves, manufactured from a polypropylene ethylene compound that is corrosion and wear resistant and designed to release gas pressure at 1 psi and vacuum pressure at 2 psi. The method of ventilation shall not be affected by grit accumulation, nor have moving parts subject to corrosion. The venting system shall not allow water to completely fill the insert that during cold weather that could freeze and cause lifting of the manhole cover. The method of ventilation shall allow a maximum release of 5 gallons of water per 24 hours. Sewer gas shall be vented at 1 psi or less.
 4. Gaskets - All inserts shall have a closed cell neoprene gasket or have a closed-cell cross-linked polyethylene foam gasket and meet the requirements of ASTM D395, D3574, D624 and D1667. The gasket shall be factory installed.
 5. Size - The depth of insert shall be such that the manhole cover shall swing freely and not come in contact with the valves or the insert body when flipped during removal or replacement. The Contractor shall be responsible for obtaining the exact field measurements for each manhole so that the inflow dish shall securely fit within the manhole frame rim.
 6. Acceptable manufacturers are Parson Manhole Insert as manufactured by Parson Environmental Products, Inc, Cretex Inflow Dish as manufactured by Cretex Specialty Products or No Flow In Flow Dish with valve system as manufactured by Sealing Systems, Inc.
- B. Manhole Frame-Chimney Seal – Frame seals shall be designed to prevent leakage of water through the frame-chimney joint area of brick and block manholes and the entire chimney area of precast, fiberglass and plastic manholes throughout a 50-year design life. The seal shall remain flexible throughout this period, allowing repeated vertical movements of the frame of not less than 2-inches and/or repeated horizontal movement of not less than 1/2-inch, at rates not greater than 1/10-inch per minute. Frame seals shall consist of a flexible rubber sleeve, extensions and stainless steel expansion bands, all conforming to the following requirements:
1. Rubber Sleeve and Extension - The flexible rubber sleeve and extensions shall be extruded or molded from a high grade rubber compound conforming to the applicable material requirements of ASTM C923, with a minimum 1,500 psi tensile strength, maximum 18% compression set and a hardness (durometer) of 48+5. The rubber sleeve shall be double, triple or quadruple pleated with a minimum unexpanded vertical height of 8-inches, 10-inches or 13-inches

respectively and a minimum thickness of 3/16 inches. The top and bottom section of the sleeve that compresses against the manhole frame casting and the chimney/cone shall have an integrally formed expansion band recess and a series of sealing fins to facilitate a watertight seal. These sealing fins shall have teardrop holes or air pockets to allow the sealing area to conform to minor surface irregularities that may be encountered. The top section of the extension shall have a minimum thickness of 3/32-inches and shall be shaped to fit into the bottom band recess of the sleeve under the bottom chimney seal band and the remainder of the extension shall have a minimum thickness of 3/16-inches. The bottom section of the extension shall contain an integrally formed expansion band recess and multiple sealing fins matching that of the rubber sleeve. Any splice used to fabricate the sleeve and extension shall be hot vulcanized and have a strength such that the sleeve shall withstand a 180 degree bend with no visible separation.

2. Expansion Bands - The expansion bands used to compress the sleeve against the manhole shall be integrally formed from 16 gauge stainless steel conforming to the applicable material requirements of ASTM A240, Type 304, with no welded attachments and shall have a minimum width of 1-3/4-inches. The bands shall have a minimum adjustment range of 2-1/2 diameter inches and the mechanism used to expand the band shall have the capacity to develop the pressures necessary to make a watertight seal. The band shall be permanently held in place with a positive locking mechanism which secures the band in its expanded position after tightening.
3. Size - The Contractor shall be responsible for obtaining the exact field measurements so that the proper sized frame-chimney seal can be ordered and installed in each manhole as required by the plans.
4. Acceptable Manufacturers are Cretex Specialty Products or Pre-Approved Equal.

2.02 Delivery and Storage

Care shall be taken in shipping, handling and storage to avoid damaging the materials. Any products damaged in shipment, showing deterioration, or which has been exposed to any other adverse storage condition that may have caused damage, even though no such damage is evident, shall be marked as rejected and removed at once from the job site. While stored, the products shall be adequately packaged, protected and stored in accordance with the manufacturer's recommendations.

Part 3 Installation

3.01 Surface Preparation

- A. The Contractor shall clean each sewer manhole to be rehabilitated and shall dispose of any debris or resulting material in a manner and place suitable to the Owner. Cleaning shall be performed using a high-pressure jet wash at a minimum of 3,500 psi water pressure to remove all dust, biological growths, grease, oils or any other surface contaminants or coatings. Manhole frames shall be brushed with a wire brush to ensure that surfaces are reasonably smooth, clean and free of any form of material that would prevent the manhole inflow dish and cover from sealing. Manhole chimney and cone sections shall be clean and free of any form of offsets or excessive honeycomb. The top internal portion of the manhole cone shall have a minimum 3-inch high vertical sealing surface. The preparation of this vertical surface when none exists shall be performed by placement of non-shrink cementitious repair mortar to create a 3-inch to 4-inch uniform vertical bottom sealing surface. Cementitious grout shall be a premixed, non-metallic, high strength, non-shrink grout which meets the requirements of ASTM C191 and C287 as well as CRD-C588 and C621. When mixed to a mortar or "plastic" consistency, it shall have a minimum one day and 28-day compressive strength of 6,000 and 9,000 psi, respectively.
- B. The Contractor shall immediately notify the Engineer of any coatings that cannot be removed and, upon the approval of the Engineer, may coarse sand the area(s) in order to remove any coatings and smooth the surface sufficient to obtain and insure adequate bonding of the chimney seal or manhole insert. Roots shall be removed by manually cutting them from inside the manhole.
- C. The Contractor shall conduct a visual inspection of each manhole after it is cleaned. All active hydrostatic leaks shall be plugged or sealed with an appropriate grout compatible with the cementitious lining. Injection grouting may be required to seal active leaks around the frame and chimney.
- D. Prior to installation of manhole inserts or chimney seals, the Engineer shall inspect and approve the surface preparation work. The Contractor shall notify the Engineer when the manholes are ready for inspection. The installation of the chimney seals or manhole inserts shall be completed immediately after the Engineer's inspection or the manhole may need to be re-cleaned.

3.02 Installation of Manhole Inflow Dish

- A. The Contractor shall ensure that all confined space entry regulations are followed, as well as applicable local and state regulations regarding traffic control for those structures lying within or along roadways.
- B. The manhole rim shall be cleaned of all dirt and debris before placing the inflow dish upon the rim.

- C. The dish shall be fully seated around the manhole frame rim.
- D. The manhole cover is replaced as before.

3.03 Installation of Chimney/Frame Seals

- A. The Contractor shall ensure that all confined space entry regulations are followed, as well as applicable local and state regulations regarding traffic control for those structures lying within or along roadways.
- B. After surface preparation is completed (see Article 3.01), the internal frame seals and extensions shall be installed in accordance with the manufacturer's installation instructions.
- C. At the conclusion of the Project, the Contractor shall supply the Owner with 3 full sets of the manufacturer's recommended tools for removing and re-installation of the internal frames and seals.

3.04 Field Acceptance

- A. Field acceptance of manhole chimney/frame seals and inflow dish inserts shall be based on the Engineer's field inspection of each installation and evaluation of the appropriate installation.
- B. Acceptance Testing - Manhole frame seals shall be visually inspected after installation to insure that the seal is properly positioned, tight against the manhole and frame surfaces, that no voids or leakage points exist and that the bands are securely locked in place. Any seals failing this test shall be reworked as necessary and retested at no additional cost to the owner. Any seals not passing this visual inspection may, at the Contractor's option, be tested for leakage using a method approved by the Engineer.
- C. If the Engineer has to enter the manhole to inspect the work, the Contractor shall provide forced air ventilation, gas monitors, harnesses, lights, confined space entry, etc. for the Engineer or Owner to enter the manhole and perform the inspection in strict and complete accordance with OSHA requirements at no additional cost to the Owner.

END OF SECTION

Appendix K
Pump Station and Force Main Inspection Forms
Pump Station Inspection Form
Force Main Inspection Form



PUMP STATION/STRUCTURE CONDITION AND INSPECTION FORM

GENERAL AND LOCATION **Asset Name/ID** _____

Date of Inspection: _____ **Inspection Personnel:** _____ **Contact Phone/E-mail:** _____

Facility Type: Pipe Valve Other (describe) _____ **Facility Coordinates (N/E):** _____

Development / System Owner (if applicable): _____ **GPS (long/lat):** _____

Municipality / Facility Name: _____ **Pump Station/Structure Type:** wet/dry pit submersible
Physical Address: _____ "can" ejector diversion/flow control other _____

Nearest Cross Streets: _____ **Est. Date of Damage / Failure** _____

Inaccessible – No Survey Conducted **Pump Station Service:** Water Sewer Stormwater Other

Pipe Crossing: Stream (name) _____ Road/Rail (name) _____ **Supports:** Piers Bridge Other (describe/photo)

FACILITY CONDITION (check all that apply) *Describe in more detail under Comments* Station is in service out of service

<u>Pipe/Structure</u>	<u>Pumps</u>	<u>Supports</u>	<u>Environment</u>
<input type="checkbox"/> Excessive Corrosion	<input type="checkbox"/> Leaking	<input type="checkbox"/> Deficient Support	<input type="checkbox"/> Hazardous Location
<input type="checkbox"/> Delaminated Steel	<input type="checkbox"/> Failed	<input type="checkbox"/> Support Damage / Corrosion	<input type="checkbox"/> Debris Build-up
<input type="checkbox"/> Pipe Damaged		<input type="checkbox"/> Inadequate Support Spacing	<input type="checkbox"/> Submerged in Water
<input type="checkbox"/> Cracks			<input type="checkbox"/> Exposed to Vehicle Impact
<input type="checkbox"/> Concrete Spalls	Valves <input type="checkbox"/> accessible, working <input type="checkbox"/> accessible, non-working		<input type="checkbox"/> Not Secured from Public

FACILITY ASSESSMENT

Poor (Immediate Action Required) Poor (No Immediate Action Required) Good Excellent

Adjacent Facilities Condition: Erosion Structure Collapse/Damage Access Damage Overhead Power/Utilities Down Property Damage Other (describe) _____

COMMENTS

Use the following space for general observations and to comment on any selected conditions



PHOTOS *Attach other photos as needed*

Photo 1

Photo 2

SKETCH

SKETCH CHECKLIST

- Cross Streets
- FM and influent sewer (incl terminal MH)
- Valve/vault Locations
- Control/switchgear Locations (if exterior)
- Transformer/electrical feed Locations
- Generator/Plug-in Locations (if applicable)
- Odor control/screening Locations (if applicable)
- Deficiency Locations
- Photo Orientation
- Security/vandalism access Prevention



GIS MAP AND/OR AERIAL



FORCE MAIN/GRAVITY SEWER CONDITION AND INSPECTION FORM

GENERAL AND LOCATION **Asset Name/ID** _____

Date of Inspection: _____ **Inspection Personnel:** _____ **Contact Phone/E-mail:** _____

Facility Type: Pipe Valve Other (describe) _____ **Facility Coordinates (N/E):** _____

Development / System Owner (if applicable): _____ **GPS (long/lat):** _____

Municipality / Facility Name: _____ **Pipe Material:** DI CI AC

Pipe size (in): _____ **Est. Date of Damage** _____ PVC HDPE RCP

Nearest Cross Streets: _____ **Approx. Crossing Length:** _____ L.F. PCCP ST Other

Pipe Underground – No Survey Conducted **Pipe Service:** Combined Sewer Sewer Pressure Gravity
Pipe Crossing: Stream (name) _____ Road/Rail (name) _____ **Supports:** Piers Bridge Other (describe/photo)

FACILITY CONDITION (check all that apply) *Describe in more detail under Comments* **Pipe is** in service out of service

<u>Pipe</u>	<u>Joints</u>	<u>Supports</u>	<u>Environment</u>
<input type="checkbox"/> Excessive Corrosion	<input type="checkbox"/> Leaking	<input type="checkbox"/> Deficient Support	<input type="checkbox"/> Hazardous Location
<input type="checkbox"/> Delaminated Steel	<input type="checkbox"/> Failed/separated	<input type="checkbox"/> Support Damage / Corrosion	<input type="checkbox"/> Debris Build-up
<input type="checkbox"/> Pipe Damaged	<input type="checkbox"/> Restraint/bond	<input type="checkbox"/> Inadequate Support Spacing	<input type="checkbox"/> Submerged in Water
<input type="checkbox"/> Cracks	straps damaged	(Estimated max. span(s) ___ ft.)	<input type="checkbox"/> Exposed to Vehicle Impact
<input type="checkbox"/> Concrete Spalls	Valves <input type="checkbox"/> accessible, working <input type="checkbox"/> accessible, non-working		<input type="checkbox"/> Not Secured from Public
<input type="checkbox"/> Lacks Insulation	If pressurized, indicate approx. operating pressure _____ psi		

FACILITY ASSESSMENT

Poor (Immediate Action Required) Poor (No Immediate Action Required) Good Excellent
Adjacent Facilities Condition: Stream bank erosion Bridge Collapse/Damage Pavement Failure Overhead Power/Utilities Down Property Damage Other (describe) _____

COMMENTS

Use the following space for general observations and to comment on any selected conditions



PHOTOS *Attach other photos as needed*

Photo 1

Photo 2

SKETCH

SKETCH CHECKLIST

- Cross Streets
- Pipe Size
- ARV and Other Valve Locations (for inspected segment)
- Support Locations
- Deficiency Locations
- Photo Orientation
- Security/vandalism access prevention



GIS MAP AND/OR AERIAL

Appendix L

Table 5.1 Background Data Collection

Table 5.2 Field Investigation Preparation

Table 5.1 Background Data Collection

Collected Data	Description	Notes
“Hard” Data	Digital or hard-copy form	
Record Documents	“As Built” drawings, lay sheets, specifications, submittals	Preferably updated with changes over time
System Maps	Lines, sizes, materials, valves, hydrants	Tagging/ID system
Geographic Information System (GIS)	Asset, other utilities, property boundary, topo, road/ROW layers & attributes	Use with aerial data to display current and projected data
Pressure/Flow Monitoring	Pump discharge, system, pressure zones	Transient pressures, surge analysis
Hydraulic Model	Network, dynamic or desktop	Preferably calibrated
Asset Mgt Platform	Data outside of GIS, risk scores	Ideally, repository for data that can be displayed
CMMS Platform	Maintenance, repair histories, open work orders, DMOM	Reports, trends, predictive analysis
Repair/Replace Records	Non-digital or history outside of CMMS	Additional data points
“Soft” Data	Non- or loosely document form or “Indirect” sources	
Operations Interviews	Distribution ops, pump station, tanks, contractors	How system operates, anecdotal background
Engineering Interviews	Design guidance, service standards	Current, proposed and past practice
“Special” Information	Useful background for forensics and planning investigation	
Valve Control/Access	Flow re-routing, redundancy, critical valve schedule	Inventory of working valves & flow control
Emergency Response	Procedures for notification and restoring service	Utility & inter-agency coordination
Main Cleaning	Schedule, reverse flow	Coordination with fire services
Prior Repair/Replace	Pipe segments, coupons	Include any analysis of retained materials
Corrosion Investigation	Soils, water, adjacent protected utilities	Close interval surveys, impressed current sys
Prior Condition Assess	Geotechnical, manned/visual inspections	Reports
Agency Planning	Utility and affected agency/asset plans	CIP, roadways, utility relocation

Table 5.2 Field Investigation Preparation

Item/Activity	Description	Considerations
Work Plan	Order of operations, sites, data delivery/QA/QC	Ties to schedule – this is the sequencing plan
Schedule	Overall, short-term, CPM with WBS	Emphasis on operating hrs, nights, weekends, holidays. Daily, weekly activities.
Valves	Location, access, working, full-closure, connectivity	Control flow and allowing inspection tools to pass
Excavations	Plan, sequence, site restoration details	Includes 811 notification; locate for “repeatability”
Tool Insertion	Disinfection protocol, connections/taps	Who creates access
Data Management	Collection, processing, QA/QC of field data	How raw data will be housed
Maintenance of Traffic (MOT)	Lane control, signage, night-time ops, public notification	Build off utility’s standard MOT process; who develops MOT – consultant, contractor, approval
Utility Encroachment	Plan, sequence, site restoration details for excavation and other operations within ROW	Generally req’d for State/Federal funded/ controlled roadways
Utility Support	Providing access, temporary services, operations	Key contacts, tie to ERP
Outside Support	Any temporary construction, operation, restoration	On-call or specialty contractors
Easements	Access, temporary construction, operation, restoration	Survey or recorded
Return to Service	Pressure test (if req’d due to length of outage)	Owner’s SOP or design specifications
Emergency Response Plan (ERP)	Communications Plan, Shift Schedule, SOPs, repair “kits”, inventory pipe, valves, etc.	Build off of utility’s current ERP; must be in writing
Permits	Excavations, MOT, pavement cut, site restoration, E&SC/stormwater control, others	Who gets and how paid for, “exhibits”/applications, waivers, processing time, approvals
Public Notification	Property owners, businesses, residents, general public	Use multiple outlets: meetings, print, electronic, radio, TV. Determine direct notification via door tags, letters, electronic alerts
Inter-Agency Coordination	Roads, Public Works, Fire Services, EMA	Coordination meetings, schedule updates

Appendix M

Reference Standards

Reference Standards

American Petroleum Institute (API) Standard 570, *Piping Inspection Code: In-service Inspection, Rating, Repair, and Alteration of Piping Systems* (2009)

National Association of Corrosion Engineers (NACE) ANSI/NACE SP0502, *Pipeline External Corrosion Direct Assessment Methodology* (2010)

National Association of Sewer Service Companies (NASSCO) *Pipeline Assessment & Certification Program (PACP) v6.0.1* (2010)

Wastewater Committee of the Great Lakes--Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers (Ten States Standards) *Recommended Standards for Wastewater Facilities* (2004)

Tennessee Department of Environment & Conservation (TDEC), Division of Water Resources, *Design Criteria for Sewage Works*

Water Environment Federation (WEF) Manual of Practice FD-4 *Design of Wastewater and Stormwater Pumping Stations* (1993)

Water Environment Research Foundation (WERF) *Inspection Guidelines for Wastewater Force Mains 04-CTS-6URa* (2010)