UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

JUL 13 2016

CERTIFIED MAIL 7011 3500 0003 2064 3575
RETURN RECEIPT REQUESTED

City of Memphis
Attn.: Mr. Bobby D. Allen, P.E.
Administrator
Environmental Construction Division
125 North Main Street, Room 620
Memphis, Tennessee 38103-2091

Re: Infrastructure Rehabilitation Program
City of Memphis, Tennessee Consent Decree
Civil Action No.: 2:10-cv-02083-SHM-dkv

Dear Mr. Allen:

The U.S. Environmental Protection Agency Region 4 has consulted with the Tennessee Department of Environment and Conservation upon reviewing the Infrastructure Rehabilitation Program (IRP) pursuant to Section V, Paragraph 10.g. of the Consent Decree noted above. The IRP was submitted on February 25, 2015 by the City of Memphis (Memphis) and received by the EPA on February 26, 2015. The EPA hereby approves the IRP.

Memphis shall submit all related documents to the Public Document Repository as outlined in Section VI of the Consent Decree. If you should have any questions regarding this approval, please contact Mr. Brad Ammons at (404) 562-9769 or via email at ammons.brad@epa.gov.

Sincerely,

Alenda Johnson, Acting Chief
Municipal and Industrial Enforcement Section
NPDES Permitting and Enforcement Branch

cc: See Attached Mailing List

Mailing List:

Ms. Jessica Murphy
Tennessee Department of Environment and Conservation

Ms. Jennifer Dodd
Tennessee Department of Environment and Conservation

Ms. Sohnia Hong
Tennessee Office of the Attorney General

Ms. Shelby R.B. Ward
Tennessee Clean Water Network

Mr. Paul Patterson
City of Memphis

City of Memphis

Infrastructure Rehabilitation Program

Draft:
Subject to EPA and TDEC Review and Comment

February 25, 2015

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.

Bobby D. Allen, P.E.

February 25, 2015
Date

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Section 1
Introduction

On September 20, 2012, the Consent Decree between the City of Memphis (Memphis or "City"), the United States, the State of Tennessee, and the Tennessee Clean Water Network was entered by the United States District Court for the Western District of Tennessee. Within the Consent Decree, a number of programs were set forth for the continued improvement of the City's wastewater collection and transmission system (WCTS). The WCTS is defined in the Consent Decree as the municipal wastewater collection, retention, and transmission system, including all pipes, force mains, gravity sewer lines, lift stations, pumps, manholes, and appurtenances thereto, which are owned or operated by Memphis and service Memphis and which flow to the M.C. Stiles and T.E. Maxson wastewater treatment plants (WWTPs).

An Infrastructure Rehabilitation Program, or IRP, is required as described in paragraph V.10.g. of the Consent Decree. The IRP provides a framework for prioritizing repairs, maintenance, or re-assessment (using approaches as described in the Continuing Sewer Assessment Program, or CSAP) of the components of the WCTS. The purpose of the IRP is to establish a process associated with making rehabilitation decisions. Consistent with the Consent Decree, the IRP does not include deadlines for specific rehabilitation projects. The IRP provides for the City to review information gathered pursuant to the CSAP and other Management, Operation, and Maintenance (MOM) Programs, and using the judgment of trained and qualified wastewater professionals to rate the condition of the WCTS with respect to I/I, structural defects, and other conditions causing, or that are likely to cause, SSOs due to conveyance capacity concerns or structural failure.

1.1 Description of System

The City of Memphis provides sanitary sewer collection, transport, and treatment services to most areas within the city limits. Memphis also receives wastewater generated from municipal satellite systems, including the Horn Lake Creek Basin Interceptor Sewer District (Mississippi), the City of Germantown, portions of the cities of Bartlett, Collierville, Lakeland, and Millington, and from unincorporated areas of Shelby County. The WCTS is a separate sanitary sewer system that serves a total area of 442 square miles, with 314 square miles within the City limits and 128 square miles within suburban areas. The WCTS is divided into six major sewer basins: Loosahatchie River, Wolf River, Front Street, President's Island, Nonconnah Creek, and Horn Lake Creek.

The sewer system in the Memphis service area is predominately gravity based and currently consists of approximately 2,400 miles of sewer lines, including gravity sewers and force mains, approximately 85,000 manholes, and 99 lift stations. This excludes privately owned laterals or private collection systems, such as those lines within gated communities and apartment complexes; these sewers are neither owned nor maintained by Memphis, and, therefore, are not covered by this IRP.

The Maynard C. Stiles WWTP, located near the confluence of the Mississippi and Wolf Rivers, serves the northern portion of the service area, including the Wolf River, Front Street, and Loosahatchie River sewer basins. This WWTP receives flow from two 96-inch diameter interceptors which generally follow the Loosahatchie and Wolf Rivers.

The T. E. Maxson WWTP, located near the confluence of McKellar Lake and the Mississippi River south of President's Island, serves the southern portion of the service area, including the Nonconnah Creek, Horn Lake Creek, and President's Island sewer basins. There are two main interceptors serving the T. E. Maxson WWTP. A 96-inch diameter sewer collects flow from the east, generally following Nonconnah Creek. A second 90-inch diameter sewer serves the area to the south, including the Horn Lake Creek Basin Interceptor Sewer District in Mississippi.

Figure 1-1 is a schematic of the lift stations, treatment plants, and gravity sewers 15 inches in diameter and larger. The IRP only applies to the WCTS as defined in the Consent Decree, which is restated in Section 2.

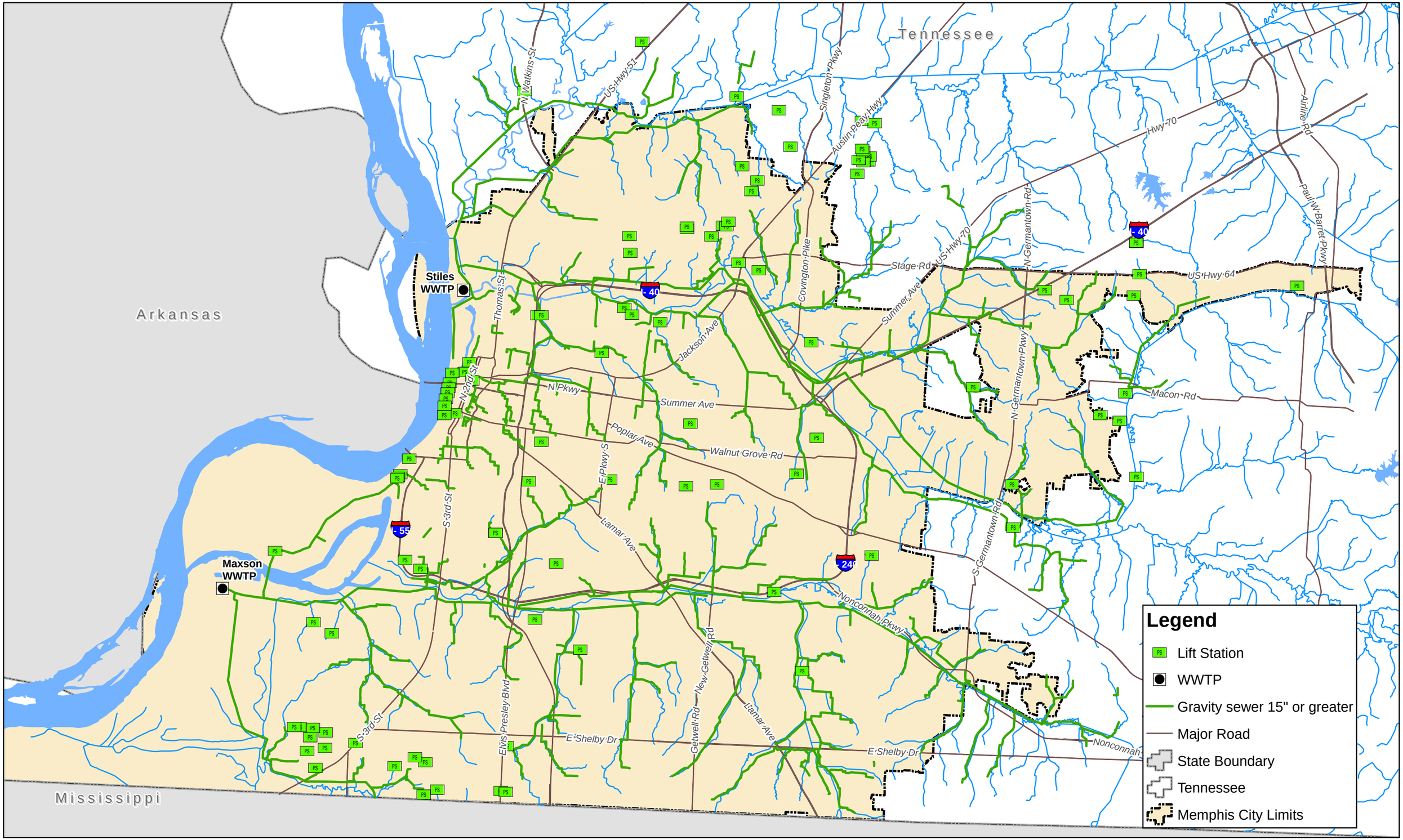

Figure 1-1
Sewer System Overview
Memphis, Tennessee

1.2 Background

The Infrastructure Rehabilitation Program (IRP) is one of seven programs required under the Consent Decree related to the Management, Operation, and Maintenance (MOM) of Memphis's WCTS. These MOM programs include:

- Sewer Overflow Response Plan
- Fats, Oil, and Grease (FOG) Management Program
- Lift Station and Force Main Operations and Maintenance (O&M) Program
- Gravity Sewer O&M Program
- Inter-Jurisdictional Agreement Program
- Continuing Sewer Assessment Program (CSAP)
- Infrastructure Rehabilitation Program (IRP)

The IRP includes the evaluation and decision-making process by which data collected through the CSAP and other MOM programs is assessed based on the condition of an asset with respect to inflow and infiltration (I/I), structural defects, or other conditions causing, or that are likely to cause, SSOs due to conveyance capacity concerns or structural failure. The IRP utilization of this information will provide the basis for evaluating and prioritizing how the City will manage and respond to defects found in the WCTS.

Figure 1-2, which was included in the Consent Decree as a conceptual diagram, describes the overall process for data collection, analysis, and repair or continued assessment of the WCTS. The blocks on the left of the figure show the different data collection methods that may be utilized for assessment of the Memphis WCTS. Note that flow monitoring is not required at this time but the need may arise in the future in the event circumstances so warrant. The information provided through the condition assessment process (through the CSAP and other MOM programs) is reviewed using professional judgment to predict the likelihood of defects worsening to result in structural or capacity concerns prior to the next inspection and therefore will provide a means to prioritize components of the WCTS under the IRP. The blocks on the right of the figure show how the assessment data collected will be analyzed to evaluate the likelihood of failure of an asset, the consequence of failure, and the resulting action required, either rehabilitation, a change in maintenance activities, or further assessment through the CSAP or other MOM programs. This decision-making process and the rehabilitation techniques anticipated to be used comprise the major components of the IRP.

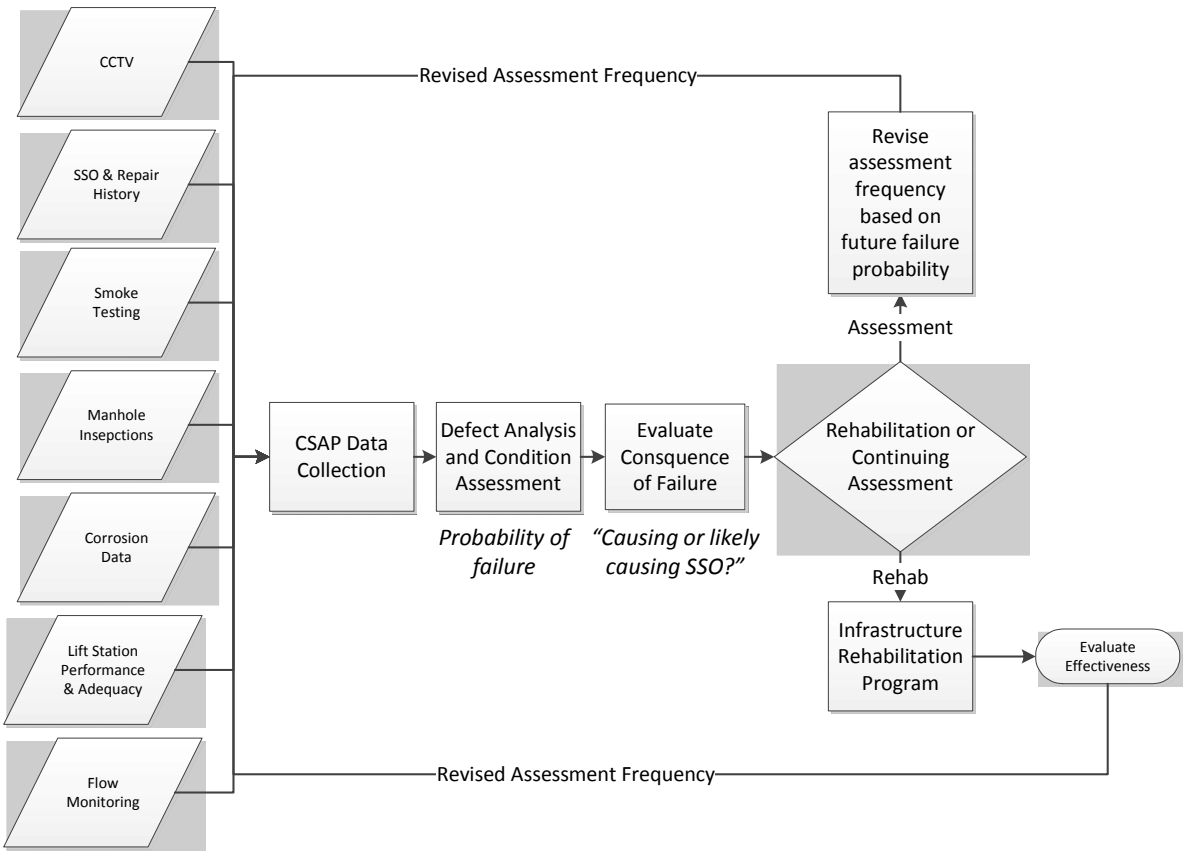

Figure 1-2 – Conceptual CSAP and IRP Process

1.3 Consent Decree Requirements

As stated in paragraph V.10.g of the Consent Decree, the IRP is intended to utilize the information gathered from the CSAP and other MOM programs to provide a process for evaluating and prioritizing rehabilitation efforts, maintenance activities, and CSAP implementation frequencies. As part of the CSAP, approximately ten percent (10%) on average of the WCTS shall be assessed each year, including gravity mains, force mains, and lift stations. As part of the IRP, qualified professionals shall then rate the condition of each WCTS asset with respect to structural defects, I/I, and other conditions likely to result in SSOs. The condition ranking should also take into consideration the likelihood of defects worsening to result in structural or capacity concerns prior to the next CSAP inspection.

In addition to providing a ranking system to prioritize assets in the WCTS in need of maintenance or replacement, the IRP shall establish a process for making rehabilitation or replacement decisions but will not include deadlines for specific projects. Through the IRP, the assessed condition and criticality of each WCTS asset shall be used to prioritize and schedule follow-up actions such as rehabilitation, maintenance activities, or adjustment of CSAP assessment frequencies. The IRP also includes a description of the techniques to be used for rehabilitation of WCTS assets such as cured-in-place pipe lining, manhole lining, pipe or manhole replacement, point repairs, or pipe bursting, as well as to provide flexibility to include other techniques deemed appropriate by Memphis based on the conditions observed. The IRP also provides procedures for the analysis of the effectiveness of the completed rehabilitation and procedures for an IRP information management system.

1.4 Organization of the Report

This report is organized as follows:

- **Section 1 – Introduction:** Provides background information, describes the existing system, and summarizes the Consent Decree requirements.
- **Section 2 – Definitions:** Provides definitions of commonly used terminology referenced in the document.
- **Section 3 – Infrastructure Rehabilitation Prioritization:** Provides the general framework by which condition assessment information about the WCTS will be used to prioritize sewer assets recommended for subsequent actions.
- **Section 4 – Rehabilitation Techniques:** Provides a discussion of the techniques to be considered for rehabilitation of the gravity sewers, manholes, force mains, and lift station assets that comprise the WCTS.

Section 2
Definitions

This section is designed to help familiarize readers with common terms and acronyms used in this document.

Closed-circuit Television (CCTV): Technology by which Memphis and/or its outside contractors use a video camera to visually inspect the internal condition of pipes and sub-surface structures.

Continuing Sewer Assessment Program (CSAP): The Consent Decree deliverable that sets forth the procedures for assessing and analyzing the infrastructure of the WCTS, including the establishment of procedures for setting priorities and schedules for the assessment.

Environmental Protection Agency (EPA): United States Environmental Protection Agency and any of its successor departments or agencies.

Fats, Oils, and Grease (FOG) Program: "FOG" refers to fats, oils and grease, which are generated by residents and businesses processing or serving food and other products. The FOG Program, which was included as an appendix to the Consent Decree, aims to prevent FOG accumulation in the WCTS.

Force Mains: Any pipe that receives and conveys, under pressure, wastewater from the discharge side of a pump. A force main is intended to convey wastewater under pressure.

Geographic Information System (GIS): A system consisting of hardware, software, and data that is designed to capture, store, and analyze geographically-referenced information.

Gravity Sewer Line or Gravity Sewer: Pipes that receive, contain, and convey wastewater not normally under pressure but are intended to flow unassisted under the influence of gravity.

Gravity Sewer Operations and Maintenance (O&M) Program: The Consent Decree deliverable that sets forth the protocols and procedures associated with the operations and maintenance of the gravity sewer system.

Inflow and Infiltration (I/I): The total quantity of water from inflow, infiltration, and rainfall-induced infiltration without distinguishing the source.

Infrastructure Rehabilitation Program (IRP): The Consent Decree deliverable that describes the general framework by which condition assessment information about the WCTS will be used to prioritize sewer assets for subsequent actions.

Lift Station: A facility in the WCTS (not at the WWTPs) comprised of pumps which lift wastewater to a higher hydraulic elevation, including all related electrical, mechanical, and structural systems necessary to the operation of the lift station.

Lift Station and Force Main Operations and Maintenance (O&M) Program: The Consent Decree deliverable that sets forth the protocols and procedures associated with the operation and maintenance of lift stations and force mains.

Manhole or Junction Box: A structure which provides a connection point for gravity lines, private service laterals, or force mains, as well as an access point for maintenance and repair activities.

Memphis: The City of Memphis, Tennessee, Public Works Division, and any successor thereto.

Sanitary Sewer Overflow (SSO): As defined in the Consent Decree, an SSO is an overflow, spill, or release of wastewater from the WCTS or WWTPs, including: (a) unpermitted discharges; (b) overflows, spills, or releases of wastewater that may not have reached waters of the United States or the State; and (c) all Building Backups. For the purposes of the IRP, SSOs are limited to those due to conveyance capacity concerns or structural failure.

Sewer Overflow Response Plan (SORP): The SORP, which was included as an appendix to the Consent Decree, provides structured guidance, including a range of field activities to choose from, for a generalized uniform response to overflows.

Supervisory Control and Data Acquisition (SCADA) System: A system of automated sensory control equipment that monitors the operation of a portion of the lift stations within the collection system. The SCADA system is designed to convey alarms when predetermined conditions occur. Monitoring parameters may include, but are not limited to, power failures, high wet well levels, and pump failures that could potentially cause overflows.

Tennessee Department of Environment and Conservation (TDEC): Tennessee Department of Environment and Conservation and any of its successor departments or agencies.

Unpermitted Discharge: As defined in the Consent Decree, a discharge of pollutants which reaches waters of the United States or the State from (a) the WCTS, (b) WWTPs through a point source not specified in a National Pollutant Discharge Elimination System (NPDES) Permit, or (c) WWTPs which constitutes a prohibited bypass except if the criteria set forth at 40 C.F.R. § 122.41(m)(2) or 40 C.F.R. § 122.41(m)(4)(i)(A) – (C) are met.

Wastewater Collection and Transmission System (WCTS): As defined in the Consent Decree, the municipal wastewater collection, retention, and transmission system including all pipes, force mains, gravity sewer lines, lift stations, pumps, manholes, and appurtenances thereto, which are owned or operated by the City of Memphis and service the City of Memphis and which flow to the Maynard C. Stiles and T. E. Maxson WWTPs.

Wastewater Treatment Plant (WWTP): Devices or systems used in the storage, treatment, recycling, and reclamation of municipal wastewater. For purposes of this document and the Consent Decree, this definition shall refer only to the following treatment facilities: the Maynard C. Stiles WWTP located at 2303 N. 2nd St., Memphis, Tennessee, and the T. E. Maxson WWTP located at 2685 Plant Road, Memphis, Tennessee, and all components of such sewage treatment plants but does not include the WCTS.

Waters of the State: Waters of the State shall have the same meaning as “Waters” defined at TCA § 69-3-103, whereby "Waters" means any and all water, public or private, on or beneath the surface of the ground, that are contained within, flow through, or border upon Tennessee or any portion thereof, except those bodies of water confined to and retained within the limits of private property in single ownership that do not combine or effect a junction with natural surface or underground waters.

Section 3

Infrastructure Rehabilitation Prioritization

In order to identify the rehabilitation needs in the system and to provide a framework for a continuing inspection and rehabilitation strategy, WCTS assets (gravity sewer, manholes, force mains, and lift stations) in the IRP are evaluated based on both criticality (consequence of failure) and condition (likelihood of failure).

The purpose of the prioritization process is to try and maximize the effect of City expenditure of limited resources on the repair or rehabilitation of defects in the WCTS that have caused SSOs or are likely to cause an SSO due to conveyance capacity concerns or structural failure. Rehabilitation of every defect in a sewer system is unnecessary and cost-prohibitive; therefore, a prioritization process is necessary to determine which repairs can provide the most benefit to the WCTS and can lead directly to the reduction of SSOs and/or the consequences of SSOs. The purpose of the IRP is to create a long-term rehabilitation strategy that can be periodically updated and that results in phased rehabilitation of defective system components causing or potentially causing the above-described SSOs.

3.1 Overview of Prioritization Process

One way of identifying WCTS assets that should receive the most immediate rehabilitation is to rank them in terms of their criticality (consequence of failure) and condition (likelihood of failure) ratings. For the purposes of this IRP, "failure" is the occurrence of an SSO due to conveyance capacity concerns or structural failure. Therefore, the criticality rating represents the consequence of an SSO occurring at a given location, and the condition rating describes the likelihood that the observed conditions will cause an SSO. For a given WCTS asset, the combination of the criticality rating and the condition rating define the rehabilitation or re-assessment / maintenance priority.

For instance, assets whose failure would create a large impact on the community and environment and whose condition is the poorest will be identified as a high priority for rehabilitation. An asset that receives lower criticality and condition ratings, meaning that it is less likely to result in an SSO due to conveyance capacity or structural failure and its failure will have a relatively small impact, will receive no immediate action or rehabilitation but will be assigned a re-assessment frequency within the CSAP and/or maintenance frequency through other MOM programs.

The general prioritization process used for the IRP consists of three steps:

- Step 1 is to determine a condition rating for each asset.
- Step 2 is to determine a criticality rating for each asset.
- Step 3 is to use criticality and condition ratings to prioritize assets and determine rehabilitation, re-assessment, or maintenance needs.

WCTS assets assessed through the CSAP or other MOM programs and prioritized under the IRP will be either rehabilitated or replaced, assigned a re-assessment frequency in the CSAP, or will go into one of

the on-going operations and maintenance programs. The goal is to match the WCTS asset with an appropriate level of rehabilitation, condition re-assessment, or maintenance.

3.2 Condition Ratings

For each WCTS asset in the IRP, a condition rating is developed using professional judgment to represent the likelihood of an SSO occurring due to the condition of that WCTS asset. The condition rating varies within an established range of condition ratings. Those portions of the system that have a high condition rating have a higher likelihood of causing an SSO and, therefore, would be a higher priority for re-assessment, rehabilitation, or more frequent maintenance relative to assets that are assigned a lower condition rating.

The following paragraphs describe the general aspects considered as each WCTS asset in the IRP is evaluated to assign a condition rating. The condition rating is primarily assigned using information collected through the CSAP; however, maintenance work orders, customer complaints, and historical SSOs, along with additional information collected through other MOM programs, are also considered when developing condition ratings.

3.2.1 CSAP Data

Condition ratings are primarily based on assessment data collected through the CSAP and other MOM programs. Data gathered for each type of sewer asset (gravity sewer, manhole, force main, or lift station) vary based on the assessment techniques utilized, but available data is utilized, to the extent practical, to determine the condition of the WCTS assets. Defects identified in WCTS assets may include minor cracks observed in pipes, a structural collapse of a manhole, roots inhibiting the conveyance of flow, electrical issues at lift stations, and the presence of large amounts of oil and grease, as examples. Because of the range of potential defects observed, some assets may only require ongoing re-assessment through the CSAP or maintenance activities through other MOM programs while others with more severe structural defects could require repair.

Gravity Sewers and Manholes

Assessment of gravity sewers and manholes will primarily rely on inspection techniques listed in the CSAP such as CCTV inspection data, smoke testing data, and dye water testing data. Individual defects identified during the gravity sewer and manhole inspections are generally categorized based on the Pipeline Assessment and Certification Program (PACP) and Manhole Assessment and Certification Program (MACP) coding systems which are standardized methods of rating sewer and manhole defects by first classifying the defects into categories, such as “Structural” and “Operational and Maintenance”, and then assigning a 1 to 5 ranking to the individual defect based on its severity. By breaking out the defects first into a category, then a ranking, this system allows the City to understand the severity of the defect and to identify the best course of action to address the defect when a repair is needed. Note, however, that the ranking for individual defects should not be confused with the overall condition rating of the pipe segment.

Once rankings are defined for each identified defect, this information is then evaluated for each pipe or manhole in terms of both the structural and operational and maintenance categories. With that and other available information, an overall condition rating for the pipe or manhole is established based on the City’s professional judgment, which also includes an assessment of the likelihood of the defects worsening prior to the next inspection. Pipes and manholes with many low ranking defects identified may be assigned a low condition rating if the cumulative effect of the defects is unlikely to result in an

SSO or if the defects are primarily operational and maintenance issues that require maintenance rather than a capital improvement. Conversely, a pipe with a single, significant structural defect, such as a collapse, may result in a higher condition rating as this defect, if left unrepaired, is more likely to result in an SSO due to structural failure.

Lift Stations

Assessment of the lift stations within the WCTS will rely on lift station survey data, lift station assessment data, and field crew work orders to catalogue and rank the individual defects identified and ultimately determine the overall condition of the station. This data may be collected through the CSAP or other MOM programs. Utilizing professional judgment, the overall assigned condition rating will be based on the evaluation of the severity of the cumulative defects observed and documented at the station and their likelihood to result in SSOs at or upstream of the station. For instance, multiple defects may be observed at a single station but if the overall magnitude of those defects has not and is not believed to be likely to create an SSO in the WCTS, the station will likely receive a low condition rating. In contrast, only one defect may be observed at a different station but if the defect is believed, based on professional judgment, to potentially result in an SSO upstream of the station, the resulting condition rating would be higher (i.e. worse).

Force Mains

Assessment of force mains will rely primarily on inspection techniques listed in the CSAP, although information collected through other MOM programs may also be utilized. Similar to the assessment of gravity sewers, force mains will be assigned a condition rating based on the cumulative effect of the defects observed in the length of the force main and the likelihood of those defects causing an SSO in the system. Using professional judgment, the overall assigned condition rating will be based on the evaluation of the severity of the cumulative defects observed in the force main and their likelihood to result in SSOs. For instance, multiple defects may be observed in a single force main but if the overall magnitude of those defects has not and is not believed to be likely to create an SSO in the WCTS, the force main will likely receive a low condition rating. In contrast, only one defect may be observed in another force main but if the defect is believed, based on professional judgment, to have a high likelihood of creating an SSO, the resulting condition rating would be higher.

3.2.2 Maintenance Work Orders, Customer Complaints, and SSO History

When available, the history of maintenance work orders, along with customer complaints may indicate that a given WCTS asset has a higher likelihood of causing an SSO. Additionally, previously reported SSOs due to a given WCTS asset may indicate a higher probably of an SSO occurring at that location in the future if a permanent solution to address the SSO has not occurred. However, in each case, it is important to understand the root cause of the maintenance work orders, customer complaints, or previous SSOs prior to developing the condition rating. For instance, a location with a history of customer complaints may be the result of residents in that area not differentiating between a stormwater / surface flooding issue and a problem with the WCTS. Additionally, an SSO may occur at a manhole, but the cause of the SSO may be an electrical problem at a pump station located some distance downstream of the overflowing manhole.

As the underlying cause of the SSO is understood from the available information, it is used, as appropriate, in conjunction with other condition data to establish the condition rating for the WCTS asset.

3.3 Criticality Ratings

For each WCTS asset in the IRP, a criticality rating is developed that represents the consequence of an SSO occurring due to the WCTS asset. An SSO potentially can impact public health, the environment, business, transportation, and the City's repair crews depending on where it occurs. The purpose of the rating system is to use professional judgment to differentiate the assets in terms of their consequence of failure based on estimated or predicted impacts. For instance, a large SSO in a densely populated area would potentially have more negative consequences than a small SSO occurring in an undeveloped field in a remote portion of the service area.

The following paragraphs describe the general aspects considered as each WCTS asset in the IRP is evaluated within an established range of criticality ratings. A low criticality rating represents assets with low consequences of failure while a high criticality rating represent a high consequence of failure. The weight of importance assigned to any of these criteria, as well as the ability to consider other elements in the future, will evolve as the program matures and more information is obtained.

Criticality ratings are assigned based on the existing WCTS and surrounding area. If future development causes a change in the criticality of certain areas, such as construction of a new major highway, the levels may be re-evaluated to reflect those changes.

Quantity of Flow Conveyed / Potential size of SSO

In most cases, the consequence of an SSO increases as the size/volume of the SSO increases. Although the volume of wastewater released may vary considerably given the system conditions, field crew response time, etc., WCTS assets capable of conveying large quantities of flow may be assumed to have higher consequences of failure than assets with smaller capacities. When specific flow information is not available, the quantity of flow that a given WCTS asset conveys can be estimated based on the size (diameter) of the gravity pipes or force mains and the capacity of the lift stations. Pipes and force mains with larger diameters typically convey a larger quantity of wastewater than pipes of smaller diameters. Similarly, lift stations with a higher design capacity are capable of conveying more flow than stations with a lower capacity.

Potential Impact to Public Health

A wastewater overflow has the potential to have a negative impact on public health. The purpose of this factor is to differentiate the WCTS assets in terms of the number of people that could be impacted by an SSO. If a WCTS asset fails in a more densely populated area, there is a potential to impact a greater number of people. Therefore, the impact to public health considers (among other things) population density, or the number of people per acre, as determined by the U.S. Census Bureau. Other potential public health-related impacts such as the proximity of the sewer asset to schools, parks, or other public-access areas is also considered.

Potential Environmental Impact

Because SSOs also have the potential to negatively impact the environment, the consequence of failure, or criticality rating, also considers the potential environmental impact, such as the distance from the WCTS asset to a water body or an environmentally sensitive area. The environmental impact criteria also considers WCTS assets that are in close proximity to water bodies included on the TDEC 303(d) list as impaired for pathogens.

Potential Impact to Businesses and Transportation

SSOs also have the potential to negatively impact businesses and transportation depending on the location the SSO. For example, if a WCTS asset fails under a major thoroughfare or a railroad, then the impact to transportation could be greater than if the pipe failed under a smaller street. The exceptions are the pipes in the downtown or central business district areas where WCTS failures may result in a significant disruption to business activity (given the physical constraints of working in the downtown and commercial districts). As such, the criticality rating also considers proximity to railroads, major roadways, and central business districts.

Difficulty of Emergency Repair

Another component of criticality is the ability of City crews to easily repair a WCTS asset if it were to completely fail. If the asset is difficult to repair in an emergency, then there is a greater potential for increased impacts to the community and environment. For assets, the difficulty of emergency repair is measured by accessibility (or how difficult the pipe or lift station is to access by people and equipment).

3.4 Prioritizing Based on Criticality and Condition Ratings

The combination of condition and criticality ratings determines priorities and schedules for rehabilitation, re-assessment through the CSAP, or maintenance through the MOM programs. Figures 3-1 and 3-2 show the process for establishing priorities for WCTS assets based on the combination of condition and criticality ratings using a heat map. Figure 3-1 indicates the rehabilitation priority of an asset based on its condition and criticality rating whereas Figure 3-2 indicates the re-assessment and maintenance priority of an asset based on its condition and criticality rating. In both figures, assets with higher criticality and condition ratings are generally prioritized over those with lower criticality and condition ratings. These two heat maps provide the City with a plan for focusing the available resources and funding on the most immediate needs while continuing to reevaluate conditions.

Based on Figure 3-1, an asset whose condition rating is high, regardless of criticality, will be prioritized for rehabilitation under the IRP. The rehabilitation heat map provides guidance on which repairs will be considered a higher priority; however, because of the limited nature of funding and resources, not all rehabilitation projects can be undertaken immediately. Because of this, assets are also assigned priorities for re-assessment or on-going maintenance activities utilizing the heat map in Figure 3-2.

For example, if an asset is assigned a re-assessment frequency of 2 years and the rehabilitation work identified for that asset is not undertaken in that timeframe or scheduled to occur in the near term, the City will perform the re-assessment as scheduled. The increased assessment frequency allows the City to check if the condition has deteriorated further, indicating that the likelihood of failure has increased to the point that the condition rating would be increased and the asset would be moved into a higher priority repair category under Figure 3-1 of the IRP. Additionally, if the re-assessment indicates that there have been no changes in the condition of defects, the City, using their professional judgment, may determine that the likelihood of the asset worsening to the point of causing an SSO is lower than previously determined and may elect to reduce the asset's condition rating to reflect this reduced likelihood of failure. Similarly, once a WCTS asset is rehabilitated, the condition rating for that asset is adjusted to reflect the asset's current likelihood to cause an SSO. For example, if a sewer pipe with a high criticality rating is also assigned a high condition rating due to severe fractures (therefore in the

top right of the heat maps), but then the pipe is replaced, the condition rating is lowered to reflect the pipe's new condition. The revised condition rating is then used to assign new prioritizations utilizing the heat maps in Figures 3-1 and 3-2, as applicable. In the case of an asset that is repaired, this typically means that the asset falls into the "Not applicable" portion of the heat map shown in Figure 3-1, indicating no repair is needed, and only a re-assessment or monitoring frequency is established in Figure 3-2.

As shown in the heat maps, the IRP approach recognizes that the condition and criticality ratings of an asset will place it along a spectrum of potential priorities. The resulting color-coding generally indicates the priority, with the main categories described below. The specific assessment or rehabilitation techniques will vary based on the type of asset: gravity sewer, manhole, force main, or lift station. Rehabilitation techniques are discussed in Section 4.

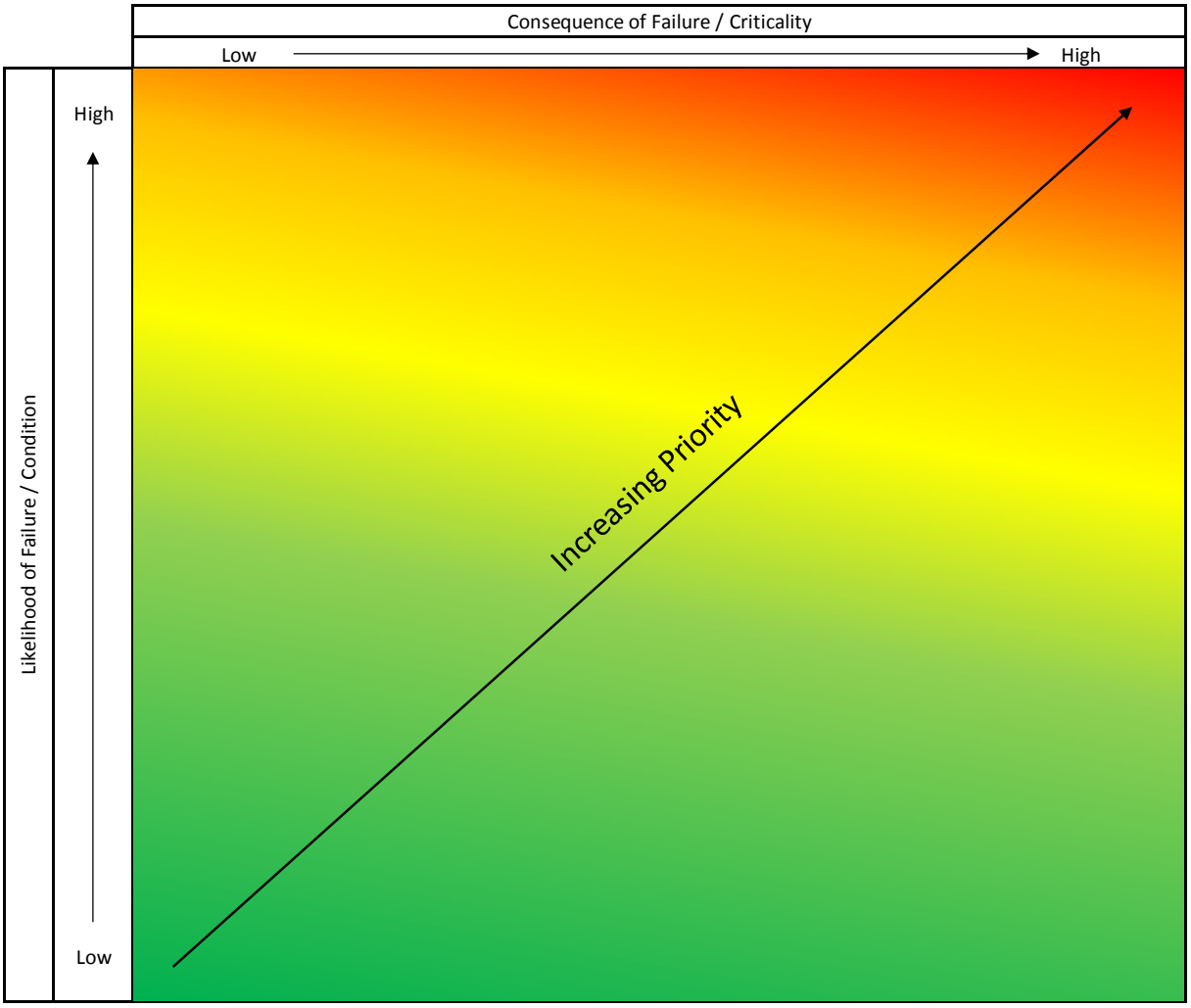

Figure 3-1 - Rehabilitation Course of Action Based on Condition and Criticality Ratings

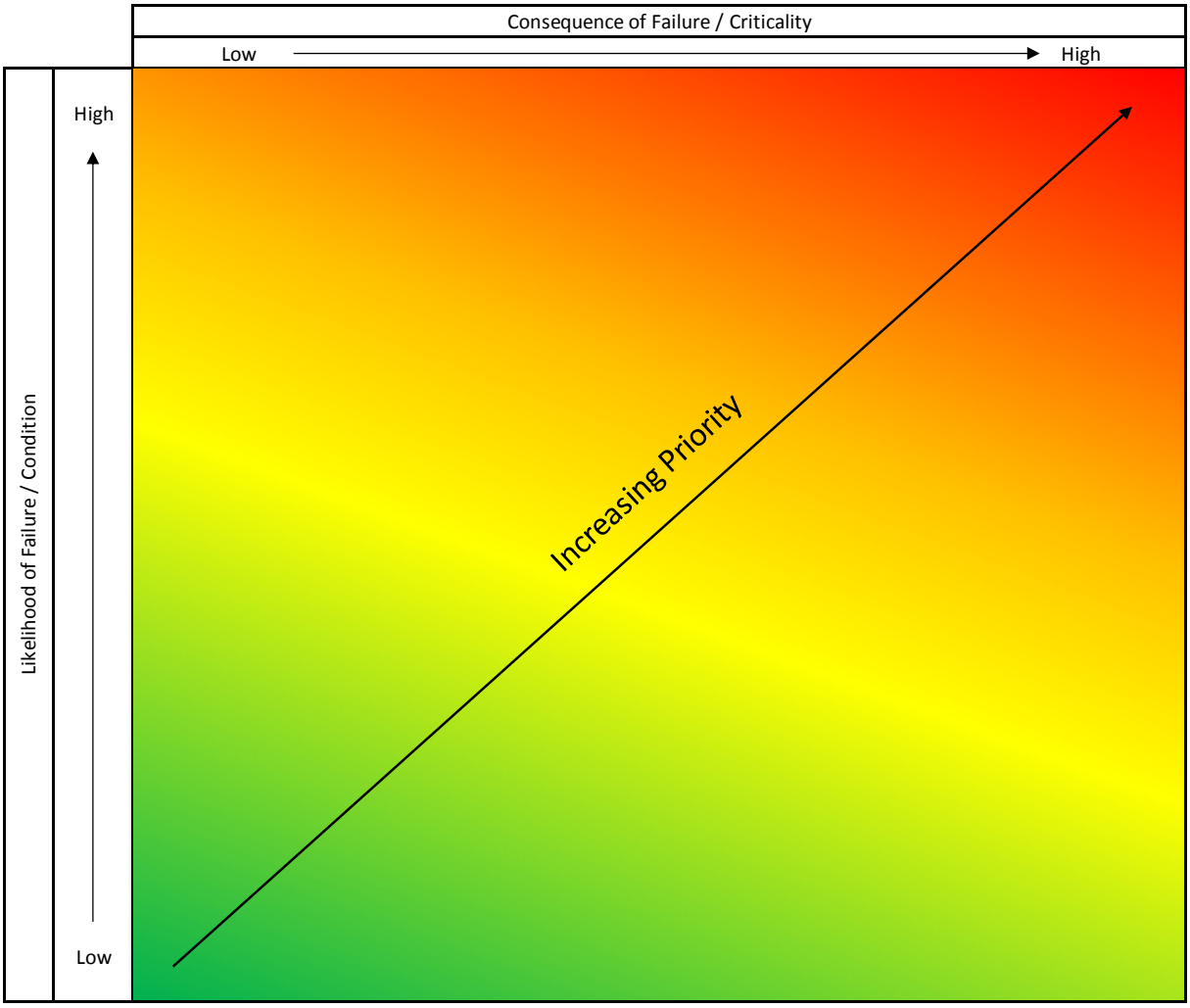

Figure 3-2 - Re-assessment and Maintenance Course of Action Based on Condition and Criticality Ratings

3.4.1 Rehabilitation Program

High Priority Repair

Assets that have a high criticality and a high condition rating are the highest priority for rehabilitation or replacement. These assets, which fall in the red portions of Figure 3-1, have already caused an SSO or are believed to be likely to cause an SSO (i.e., an SSO appears imminent), and they have high consequences of failure.

Medium Priority Repair

Assets that fall within the yellow portions of Figure 3-1 are placed in the "Medium Priority Repair" category. The rehabilitation or replacement of these assets is a medium priority based on the combination of the asset's consequence and likelihood of causing an SSO.

Not Applicable

Assets that fall within the green areas of Figure 3-1 do not require rehabilitation and are thus not assigned a repair priority based on their current condition, regardless of the assigned criticality rating.

3.4.2 Re-assessment Program

High Priority Assessment

Assets that fall within red portions of Figure 3-2 will receive more frequent maintenance activities and/or re-assessment through the CSAP program. The purpose of more frequent assessment is to check whether or not the condition of the asset indicates that the likelihood of causing an SSO due to conveyance capacity concerns or structural failure has changed. If re-assessment determines that the asset has a higher likelihood of causing an SSO, the condition rating is adjusted upward, potentially moving the asset into a higher priority repair category under the IRP. An adjusted condition rating may also change an asset's re-assessment or monitoring frequency.

Medium Priority Assessment

Assets that fall within yellow portions of Figure 3-2 will be considered for increased frequency of maintenance and/or re-assessment through the CSAP program; however, due to their existing condition, the frequency of the assessment and/or maintenance is lower than those assets identified as "High Priority Assessment." As with assets in the "High Priority Assessment" category, the purpose of this re-assessment is to check whether or not the condition of the asset indicates that the likelihood of causing an SSO due to conveyance capacity concerns or structural failure has changed.

Regular Maintenance

Assets that fall within green portions of Figure 3-2 will not necessarily have increased maintenance beyond that ordinarily provided for through other MOM programs.

3.5 Infrastructure Rehabilitation

Using the resulting rehabilitation prioritizations, the City will schedule WCTS assets for the design and construction of appropriate rehabilitation techniques to address the defects that were determined to be likely to cause an SSO. The schedule for completing rehabilitation activities for a given asset is dependent upon the priority assigned to that asset, the complete list of identified rehabilitation priorities, and the City's available budget. For instance, as additional condition assessment data becomes available and is evaluated through the IRP, a newly identified "High Priority Repair" will typically be addressed prior to a "Medium Priority Repair" that was identified previously. For the priority areas identified in Appendix G of the Consent Decree, a list of rehabilitation projects in that area will be developed following the initial assessment work. Those listed projects will be completed within six years and seven months following EPA's approval of the IRP. Rehabilitation needs identified through subsequent re-assessment or monitoring work in the priority areas may not be rehabilitated within that timeframe, but these repairs will be prioritized in accordance with the IRP.

In most cases, the City may choose to combine the rehabilitation of multiple, similar assets into a single rehabilitation project. However, there may also be instances where an individual asset, such as a pump station, is rehabilitated as a single project. When multiple assets are combined into larger rehabilitation projects, the City may choose to include the rehabilitation of adjacent, lower priority assets. For instance, a manhole that was identified as a "Medium Priority Repair" that is adjacent to a "High Priority Repair" manhole may be rehabilitated earlier in order to reduce costs and limit disruption to the community.

3.6 Information Management System

The evaluation and prioritization of assets in the IRP will create a large amount of data that will need to be organized appropriately and will need to remain accessible to continue to make updates and

refine ratings as new data becomes available. To do this, evaluation and prioritization data associated with the IRP will be compiled in a database. A database will have the capability to be edited, sorted, and manipulated to make edits and generate lists and tables of prioritized assets as well as have the capability to be linked with geographic information system (GIS) files as they become available.

Although limited GIS data to describe portions of the WCTS has been developed, Memphis does not have a comprehensive GIS for WCTS assets. A representation of their sewer system is maintained in a collection of 11-inch by 17-inch paper maps, commonly known as the "Sewer Bible." Appendix J of the Consent Decree provides for Memphis to conduct additional GIS work, although it is recognized that any GIS work undertaken by Memphis beyond that required by Appendix J is subject to the City's sole discretion.

Section 4
Rehabilitation Techniques

Section 3 discussed the methodology for prioritizing WCTS assets for rehabilitation, re-assessment, or changes in maintenance frequency. This section will discuss the different techniques to be considered for rehabilitation of the WCTS. These techniques have been grouped into the following four categories based on the type of asset undergoing rehabilitation:

- Gravity Sewer Rehabilitation
- Manhole Rehabilitation
- Lift Station Rehabilitation
- Force Main Rehabilitation

The following techniques are available for use by Memphis in rehabilitation of their WCTS, and Memphis shall use its professional judgment in determining which options to utilize. Additionally, Memphis may continue to evaluate other existing and emerging rehabilitation techniques for use.

4.1 Gravity Sewer Rehabilitation

The selection of appropriate gravity sewer pipe rehabilitation techniques is dependent upon many factors including the existing conditions of the sewer being repaired and surrounding area. The City will use their professional engineering judgment to select appropriate and cost effective rehabilitation techniques for each situation encountered. Gravity sewer rehabilitation methods that may be implemented by the City include, but are not limited to, the following:

- Open Cut Pipe Replacement
- Pipe Bursting
- Cured-in-Place Pipe Lining
- Slip Lining
- Point Repairs (Internal and External)

These techniques vary with regard to their level of disturbance and cost, and they may not be appropriate for the situation encountered. Additional information regarding each of these techniques is presented in the following subsections.

4.1.1 Open Cut Pipe Replacement

Open cut pipe replacement utilizes the same standard techniques that are used to construct a new sewer line. The replacement sewer may be installed in the same location as the existing pipe or an alternate alignment may be used. Open-cut methods have the advantage of being widely used and well understood by a large number of contractors. This generally results in a reliable final product and in increased bidding competition than may be found with other rehabilitation methods that often

require specialty contractors. Open cut pipe replacement is often the most cost-effective method of rehabilitation where extensive point repairs would be required in order to use an alternative rehabilitation technique. Open cut pipe replacement also allows an increase in pipe size where additional capacity is needed. Major disadvantages to open-cut replacement include (1) the increased noise, dust, and debris of construction, (2) restricted access to homes and businesses, and (3) greater surface disturbance.

4.1.2 Pipe Bursting

Pipe bursting employs a pneumatic, hydraulic, or mechanical wedge that is expanded inside the existing pipe, thereby fracturing it and pushing the pieces into the surrounding soil. The new pipe is jacked into place directly behind the wedge. The new pipe is typically high density polyethylene (HDPE) with welded joints (but can be a variety of other materials including PVC, ductile iron, or steel), which facilitates installation of the new pipe from an existing manhole access. With pipe bursting, the hydraulic wedge is guided by the existing pipe. Therefore, the new pipe will follow the grade of the existing pipe. Existing sewers that are free of sags or other hydraulic problems are most appropriate for this technique.

Pipe of the same or greater diameter than the existing pipe may be installed. Prior to pipe bursting, service laterals must be open-excavated and disconnected in order to avoid damaging them with the hydraulic wedge. Depending on the type of pipe bursting technology used, there is also the potential to harm adjacent utilities. Therefore, care must be exercised in equipment selection when other utilities are located near the existing sewer.

Several factors dictate whether pipe bursting is appropriate for the rehabilitation of the sewer line. These considerations include host pipe material, diameter, condition, depth, length, new pipe diameter, soil conditions, peripheral utilities, and service connections.

4.1.3 Cured-in-Place Pipe (CIPP)

Cured-in-place pipe (CIPP) lining, consists of a felt or fabric sock, that is impregnated with a resin that becomes rigid once it is thermally activated or cured. The impregnated liner is typically inserted in the existing pipe by first attaching the liner inside-out at one end of the pipe to be lined, and then feeding the liner through the pipe by inverting it to its original shape. The liner is typically inverted into the existing pipe using water or air pressure. Once the liner is inserted, it is usually cured with the use of hot water or steam that causes the liner to become rigid, although some CIPP lining is cured with ultraviolet light. The resulting liner is seamless and jointless. Service connections are made by using a remote cutting device in conjunction with a television camera to remove the liner from the connection. If the existing service connection is defective, then the connection must be excavated and properly repaired. CIPP lining is a relatively quick method of rehabilitation and generally requires only 24 to 48 hours of bypass pumping. CIPP linings can be designed to handle structural loads, if necessary, where the existing pipe has structural defects or where additional loads are expected in the future.

CIPP lining requires little or no excavation for installation and is suitable for most conditions, especially those where minimal surface disruption is desired. CIPP lining follows the alignment of the existing pipe and thus does not correct dips, sags, or offset joints. Sewers must be cleaned and most obstructions such as roots or protruding service connections must be removed prior to insertion of the liner. If obstructions cannot be removed with the conventional cleaning and cutting equipment, then excavation is necessary at those specific locations.

4.1.4 Slip Lining

Slip lining involves inserting a pipe of smaller diameter into the existing pipe, usually from an excavated insertion pit. The liner pipe must be flexible and is commonly made of HDPE, fiberglass, or polyvinyl chloride (PVC). Liner pipe joints are heat fused or gasketed, with heat-fused joints having the advantage of allowing the liner pipe to be closer in diameter to the existing pipe. From the excavation pit, the liner pipe is typically pulled through the sewer pipe with the assistance of a winch assembly that is installed in the next adjacent manhole. Because pulling the liner pipe often causes it to elongate, the liner pipe must be allowed to contract to its original length before connecting service laterals and sealing manholes. Alternatively, the slip lining can be installed by pushing the liner pipe into the old pipe using a sling or jacking assembly to avoid damage to the liner pipe. Once the slip lining is in place, service connections must be established to the liner pipe. This is performed by excavating each service connection, breaking through the outside pipe, and then making a connection to the liner pipe using sidewall heat fusion or a tapping saddle.

Typically, the void left between the existing pipe and the new pipe is filled with grout. If slip lining is used without filling voids between the liner pipe and the existing pipe with grout, little additional structural benefit is gained from the new liner pipe, and future loading increases to the pipe may result in failure.

Like CIPP lining, sewers undergoing slip lining should have most obstructions such as roots or protruding service connections removed prior to insertion of the liner. If obstructions cannot be removed with the conventional cleaning and cutting equipment, then excavation is necessary at those specific locations.

4.1.5 Point Repairs

Point repairs are intended to repair smaller portions of a gravity sewer as opposed to rehabilitating the full manhole-to-manhole segment. They provide localized rehabilitation or correction of defects including fractured pipe, protruding taps, sheared or dropped joint, broken or deformed pipe, or other similar conditions.

External point repairs, which involve excavation to replace a portion of the existing pipe, have the same potential advantages and disadvantages as open cut pipe replacement. In addition, it is important that the point repair be properly bedded and secured to the existing pipe in order to avoid introducing future pipe settlement issues.

Internal point repairs may also be constructed to address certain types of defects within the gravity sewer system without the need for excavation. Internal point repairs may be performed through the installation of short segments of CIPP lining, mechanical repair sleeves, or other methods. Selection of the type of internal point repair is dependent upon the condition of the existing sewer, including the defect to be corrected.

4.2 Manhole Rehabilitation

Manhole rehabilitation may consist of replacement, manhole lining, or repair of individual manhole components, such as the manhole cover or channel. As with rehabilitation of other WCTS assets, selection of appropriate rehabilitation techniques is dependent upon the observed manhole condition. The City will use their professional engineering judgment to select appropriate and cost effective rehabilitation techniques for each situation encountered.

Manhole rehabilitation methods that may be implemented by the City include, but are not limited to, the following:

- Manhole Replacement
- Manhole Coating or Lining
- Point Repairs

These techniques vary with regard to their level of disturbance and cost, and they may not be appropriate for the situation encountered. Additional information regarding each of these techniques is presented in the following subsections.

4.2.1 Manhole Replacement

It is often most cost-effective simply to replace a manhole when it has become structurally unsound. No point repairs are required when the existing manhole is excavated, demolished, and a new manhole is constructed. Manhole construction has the advantage of being widely performed and well understood by a large number of contractors. This generally results in a reliable final product and in greater bidding competition than may be found with other rehabilitation methods that often require specialty contractors. The major disadvantage to manhole replacement is that it may disrupt traffic and restrict access to homes and businesses.

4.2.2 Manhole Lining

Depending on the materials used, manhole lining involves application of a coating or lining to the interior of the manhole to seal out infiltration, restore structural integrity, and prevent corrosion. In general, this can be performed without excavation, and interference with traffic, utilities, and sewer service is minimized.

- *Cementitious Lining*. Cementitious linings or coatings have been shown to be a cost-effective means of improving minor structural problems when sufficient liner thickness is applied. This is especially true in areas of the system that are less subject to corrosion, such as upstream portions of the system. Coatings, because they are not of great thickness, wear out and reapplication is required on a periodic basis. If the quality of work is good and the proper materials are used, a satisfactory service life could be expected.

  Cementitious coatings are applied using a spray or trowel method to repair the interior of the existing manhole (concrete and brick). The most important aspect of applying linings is surface preparation. Proper surface preparation is essential to creating a bond between the manhole and the coating. This can be accomplished by water or sand blasting or use of mechanical tools. The next step is to stabilize the remaining sound inner wall surface of the manhole using preparations designed for this purpose. Any surface defects such as missing bricks or damaged concrete should be patched with a high strength, quick setting grout. The lining or coating system is applied to complete the renewal.

- *Corrosion Resistant Linings*. In deep manholes and downstream reaches where the sewage is more likely to be septic and oxygen levels in the sewer atmosphere have been depleted, other more corrosion resistant linings, such as epoxy or urethane linings, should be considered. Similar to cementitious linings, corrosion resistant linings can be spray or trowel applied, but

proper preparation of the surface of the manhole prior to installation is critical to achieve adhesion between the coating material and the manhole surface.

- *Structural Repair Liners.* Although cementitious lining and corrosion resistant lining may offer various degrees of structural support, if a manhole is in need of significant structural repair, different manhole lining techniques may be used which essentially create a new manhole structure within the existing manhole. These structural repair liners may include poured-in-place concrete, PVC rib liner, fiberglass-reinforced plastic, cured-in-place, and spiral wound liners. Disadvantages to structural repair liners are that the labor cost involved in cleaning, repairing, and coating is often greater than installation of a new manhole. However, there are cases where challenges associated with the excavation required for manhole replacement warrants consideration of structural repair liners.

4.2.3 Manhole Point Repairs

Point repairs may also be necessary to provide sound rehabilitation of an existing manhole. In general, manhole point repairs focus on addressing individual components of an existing manhole. Multiple repairs may be performed on an individual manhole, and these may be combined with manhole lining. Selection of appropriate manhole point repairs is dependent on the observed condition of the manhole. Manhole point repairs may include, but are not limited to, the following:

- Replace frame and cover
- Reset and/or raise frame and cover
- Rebuild chimney or cone
- Rebuild bench and channel
- Grouting walls, bench, channel, or pipe connection

4.3 Lift Station Rehabilitation

Lift station rehabilitation typically consists of the repair of individual components of a lift station, but when the overall condition of the lift station warrants it, the lift station may be replaced. As with rehabilitation of other WCTS assets, selection of appropriate rehabilitation techniques is dependent upon the observed lift station condition. The City will use their professional engineering judgment to select appropriate and cost effective rehabilitation techniques for each situation encountered.

Lift station rehabilitation may include repairs in the following general categories:

- *Electrical and Instrumentation Improvements.* Repairs to electrical and instrumentation systems may include addressing faulty wiring, improving the station's SCADA system, providing redundant electrical feeds or on-site generators, or correcting other electrical and instrumentation defects that may inhibit the lift station's operability and reliability.
- *Mechanical Improvements.* Mechanical improvements to lift stations may include repairing faulty valves, replacing worn pump impellers, repairing or replacing pumps or motors, or correcting other mechanical defects that may inhibit the lift station's operability and reliability.
- *Structural Improvements*. Lift station structural defects involve the degradation of the lift station housing structure, wet well, and facility surroundings. The improvements associated with the

wet well are similar to manhole rehabilitation and may involve interior lining or replacement of the wet well structure. Structural improvements may also entail improvements to the station's wet well to enhance hydraulic conditions.

- *Capacity Improvements.* In some cases, observations of the station's condition may indicate that the station is undersized relative to existing or projected, future flows. In those cases, improvements to increase the station's capacity may be needed. Depending on the required capacity increase and on the existing station, these may be accomplished through replacing pumps, changing pump impellers, or other minor improvements to the station.

The specific repairs required in each of these categories are dependent on the original design and existing condition of the lift station undergoing rehabilitation. As lift station deficiencies are identified, they may be resolved during regularly scheduled maintenance activities as part of the Lift Station and Force Main O&M Program.

In some cases, the number and extent of repairs needed at a lift station may warrant a complete replacement of the existing station with a new station. In such cases, the new lift station shall be designed according to applicable engineering design standards such that capacity and reliability are adequate to convey peak wastewater flows.

4.4 Force Main Rehabilitation

Force main rehabilitation methods are similar to gravity sewer rehabilitation methods. Force main rehabilitation may consist of open cut replacement, pipe bursting, CIPP lining, or point repairs, as discussed in greater detail in Section 4.1 Gravity Sewer Rehabilitation. Force main rehabilitation may also consist of repair, replacement, or installation of air release / vacuum valves. As with rehabilitation of other WCTS assets, selection of appropriate rehabilitation techniques is dependent upon the observed force main condition. The City will use their professional engineering judgment to select appropriate and cost effective rehabilitation techniques for each situation encountered.

4.5 Post-Construction Rehabilitation Assessment

Monitoring the effectiveness of various rehabilitation techniques to address observed defects in the WCTS is important to the continued cost-effective implementation of the IRP. In most cases, inspections conducted both during and following rehabilitation activities will serve to confirm the effectiveness of the completed rehabilitation activities. This will most often occur through visual inspections, CCTV inspection, and monitoring and testing of the operation of lift stations. Additionally, WCTS assets that have undergone rehabilitation will continue to be monitored through the City's MOM programs.