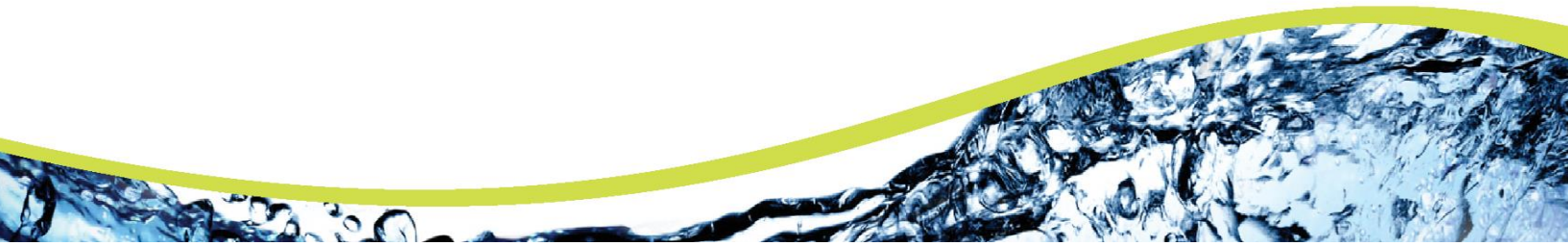
Clean Water 2020 Program

INFRASTRUCTURE REHABILITATION PROGRAM (IR Program)

July 2016

We Are Columbia



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Acronyms

ARV – Air Release Valve

CAP – Capacity Assurance Program

CCTV – Closed Circuit Television

CD – Consent Decree

CIP – Capital Improvements Program

CIPP – Cured-in-Place Pipe

CMMS – Computerized Maintenance Management System

CSAP – Continuing Sewer Assessment Program

CW2020 – City's program, Clean Water 2020, to manage the consent decree compliance

EPA – United States Environmental Protection Agency

FOG – Fats, Oils and Grease

GIS – Geographic Information System

I/I – Inflow and Infiltration

IMS – Information Management System

IR – Infrastructure Rehabilitation

MACP – Manhole Assessment and Certification Program

NASSCO – National Association of Sewer Service Company

O&M – Operations and Maintenance

PACP – Pipeline Assessment and Certification Program

SCADA – Supervisory Control and Data Acquisition

SCDHEC – South Carolina Department of Health and Environmental Control

SMP – Sewer Mapping Program

SSO – Sanitary Sewer Overflow

WCTS – Wastewater Collection and Transmission System

Program Summary and Intent

The City of Columbia (City) has developed an Infrastructure Rehabilitation Program (IR Program) to describe policies and procedures for implementing rehabilitation measures to address inflow and infiltration (I/I), structural issues in the City's wastewater collection and transmission system (WCTS) and other conditions causing sanitary sewer overflows (SSOs), with the goal of eliminating future SSOs.

This IR Program has been prepared in accordance with the requirements of Paragraph 15 of the Consent Decree (CD) entered by order dated May 21, 2014 in *The United States of America and State of South Carolina by and through the Department of Health and Environmental Control vs. The City of Columbia*, Civil Action No. 3:13-2429-TWL, DOJ Case Number 90-5-1-1-00954.

Table 0-1 is a list of the CD requirements for the IR Program and the sections of this document that address each requirement.

Table 0-1 – Summary of Consent Decree Requirements for the IR Program

CD Section	CD Requirements	IR Program Section
V. 15. Main paragraph	"The IR Program shall include procedures for Columbia to prioritize rehabilitation measures based upon relative likely human health and environmental impact risks, SSO frequencies, and SSO volumes."	Section 2
	"The IR Program may also provide for implementation of line and other small-scale repairs on a 'find and fix' basis."	Section 2.4
15.a.	"Gravity Sewer Line Rehabilitation. For all gravity sewer lines and related appurtenances, including city-owned laterals, that are identified as in need of rehabilitation under the CSAP, the IR Program shall include procedures for: Setting gravity sewer line rehabilitation priorities and schedules."	Section 2.1
	"Maintaining an ongoing inventory of Gravity Sewer Line rehabilitation projects already performed, scheduled to be performed, and needing to be scheduled and performed, including identification of the rehabilitation techniques used on completed projects."	Section 3
	"Analyzing the effectiveness of completed rehabilitation projects."	Section 5
15.b.	"Manhole Rehabilitation. For all manholes that are identified as in need of rehabilitation under the CSAP, the IR Program shall include procedures for: Setting manhole rehabilitation priorities and schedules."	Section 2.1
	"Maintaining an ongoing inventory of manhole rehabilitation projects already performed, scheduled to be performed, and needing to be scheduled and performed, including identification of the rehabilitation techniques used on completed projects."	Section 3
	"Analyzing the effectiveness of completed rehabilitation projects."	Section 5
15.c.	"Pump Station Rehabilitation. For all Pump Stations that are identified as in need of rehabilitation under the CSAP, the IR Program shall include procedures for: Setting Pump Station rehabilitation priorities and schedules."	Section 2.2
	"Maintaining an ongoing inventory of Pump Station rehabilitation projects already performed, scheduled to be performed, and needing to be scheduled and performed, including identification of the rehabilitation techniques used on completed projects."	Section 3
	"Analyzing the effectiveness of completed rehabilitation projects."	Section 5
15.d.	"Force Main Rehabilitation. For all Force Mains that are identified as in need of rehabilitation under the CSAP, the IR Program shall include procedures for:	

CD Section	CD Requirements	IR Program Section
	Setting Force Main rehabilitation priorities and schedules."	Section 2.3
	"Maintaining an ongoing inventory of Force Main rehabilitation projects already performed, scheduled to be performed, and needing to be scheduled and performed, including identification of the rehabilitation techniques used on completed projects."	Section 3
	"Analyzing the effectiveness of completed rehabilitation projects."	Section 5
15.e.	"Standard procedures for an IR Program information management system."	Section 6
	"Standard procedures for inspecting and documenting the quality of new construction and rehabilitated work for warranty and other purposes."	Section 4
	"Procedures for analysis of the effectiveness of completed rehabilitation."	Section 5

Section 1 Introduction

The City of Columbia wastewater collection and transmission system (WCTS) currently consists of approximately 1,070 miles of gravity sewer with diameters ranging from 6-inches in diameter to 60-inches in diameter, 56 pump stations, and approximately 40 miles of force main located both inside the City limits and in portions of Richland and Lexington Counties.

The Infrastructure Rehabilitation Program is one of several programs required under the CD for continued improvement of the WCTS with the goal of eliminating future SSOs. The IR Program includes the evaluation process by which WCTS condition data collected through the Continuing Sewer Assessment Program (CSAP) or other programs is utilized with factors such as relative likely human health and environmental impact risks, SSO frequencies, and SSO volumes to prioritize and implement rehabilitation measures. The IR Program also includes procedures for maintaining an inventory of rehabilitation projects and analyzing the effectiveness of completed rehabilitation projects.

Section 2 Infrastructure Rehabilitation Prioritization

This section describes the City of Columbia's procedures for setting rehabilitation priorities and schedules for WCTS components (gravity sewer lines, manholes, pump stations, and force mains) that are identified as in need of rehabilitation based on information collected under the Continuing Sewer Assessment Program, as required in Paragraph 15.a. through 15.d. of the Consent Decree (CD).

The purpose of the prioritization process is to devote the appropriate level of available resources to address I/I, structural issues in the WCTS, and other conditions causing SSOs. In general, the prioritization considers both the condition (probability of failure) of the WCTS component as determined from CSAP assessment and SSO history; and the criticality (consequence of failure) of the WCTS component based on relative likely human health, environmental and other impacts. Since a "failure" may result in the occurrence of an SSO, the criticality rating represents the consequence of an SSO occurring at a given location. For a given WCTS asset, the combination of the condition rating and the criticality rating define the rehabilitation priority.

The infrastructure rehabilitation prioritization procedures are discussed in the following sections for gravity sewer lines and manholes (**Section 2.1**), pump stations (**Section 2.2**), and force mains (**Section 2.3**). In addition to prioritized infrastructure rehabilitation projects, the City may also implement small-scale rehabilitation or repairs on a "find and fix" basis as the defects are identified as defined in Paragraph 15 of the CD. Find and Fix rehabilitation is described in **Section 2.4**.

2.1 Gravity Sewer Lines and Manholes

Gravity sewer lines and manholes are prioritized for rehabilitation using the same process, and are generally grouped into projects which may include multiple assets. Rehabilitation priorities for gravity sewer lines and manholes will be determined using the following steps:

- Step 1: Determine condition rating (**Section 2.1.1**)
- Step 2: Determine criticality rating (**Section 2.1.2**)
- Step 3: Prioritize based on condition and criticality ratings (**Section 2.1.3**)
- Step 4: Develop gravity sewer rehabilitation projects (**Section 2.1.4**)

For the purposes of setting priorities for the IR Program, city-owned laterals, which extend from the gravity sewer line to the property line, are considered as part of the connecting gravity sewer line and are not assigned individual condition and criticality ratings. If a gravity sewer line is identified for rehabilitation, the city-owned laterals on that pipe will be rehabilitated or repaired, as necessary, based on available lateral condition data and professional judgment. If a City lateral is identified as defective and not located on a sewer to be rehabilitated, then the city-owned lateral will be rehabilitated or repaired, as necessary, based on lateral condition data and professional judgement.

2.1.1 Condition Ratings

A condition rating for each gravity sewer line or manhole is developed to represent the probability that the WCTS asset will fail. The condition rating is a numerical value, with low values assigned to represent a good condition and high values assigned to represent a poor condition. Condition ratings for gravity sewer and manholes are tied to a particular asset ID and will be stored in the City's Information Management System (IMS), as described in **Section 6**. The condition rating is primarily assigned using information collected through the CSAP and based on professional judgement; however, historical SSO frequency is also considered when developing condition ratings.

CSAP Data

Assessment of gravity sewers and manholes will rely on assessment methods listed in the CSAP such as flow monitoring, video inspection, manhole inspection, smoke testing, dye water testing, or desktop evaluation.

For gravity sewer and manhole field inspections, individual defects are generally categorized based on the National Association of Sewer Service Company's (NASSCO) Pipeline Assessment and Certification Program (PACP) and Manhole Assessment and Certification Program (MACP) coding systems. These coding systems are standardized methods of grading sewer and manhole defects by first classifying the defects into one of two categories - structural or operational and maintenance (O&M), and then assigning a 1 to 5 grade to the individual defect based on its severity. An overall PACP/MACP rating is assigned for each pipe or manhole based on a compilation of the observed structural and O&M defects.

The PACP/MACP overall ratings can then be translated into a condition rating for the pipe or manhole based on professional judgment. Pipes and manholes with low grade defects may be assigned a low condition rating if the cumulative effect of the defects is unlikely to result in a failure. Conversely, a pipe with a significant structural defect may result in a higher condition rating as this defect, if left unrepaired, is more likely to result in a failure.

For other gravity sewer and manhole assessment methods (flow monitoring, desktop evaluation, etc.), condition ratings will be assigned after review of data based on professional judgement.

SSO Data

Previously reported SSOs related to a given manhole or gravity sewer pipe (including city-owned laterals on that gravity sewer pipe) may indicate a higher probability of an SSO occurring at that location in the future if a permanent solution to address the past SSO has not occurred. However, it is important to understand the root cause of the SSOs prior to developing the condition rating. For instance, 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. If the underlying cause of an SSO is attributable to the gravity sewer line or manhole condition, the location and frequency of recent historical SSOs will be used, as appropriate, in conjunction with CSAP condition data and professional judgement to establish the condition rating for gravity sewer lines and manholes.

2.1.2 Criticality Ratings

A criticality rating for each gravity sewer line or manhole is developed to represent the relative consequence of a failure (resulting in an SSO) on that gravity sewer line or manhole. The criticality rating

is a numerical value, with low values assigned to represent a low consequence of failure and high values assigned to represent a high consequence of failure. Criticality ratings will be tied to a particular asset ID and stored in the City's IMS, as described in **Section 6**. The criticality rating is assigned considering the following factors and other information, as appropriate.

Quantity of Flow Conveyed / Potential SSO Volume

In many cases, the consequence of an SSO increases as volume of the SSO increases. Depending on given system conditions, field crew response times, etc., the volume of wastewater released may vary considerably. However, in general, gravity sewer lines capable of conveying large quantities of flow may be assumed to have higher consequence of failure than assets with smaller capacities. The quantity of flow can be estimated based on the size (diameter) of the gravity pipes or flow information, as appropriate, with the assumption that larger diameter pipes typically convey a larger quantity of wastewater than pipes of smaller diameters.

Potential Impact to Public Health

All SSOs have the potential to negatively impact public health. The purpose of this factor is to differentiate the WCTS assets in terms of the population that could be impacted by an SSO in a particular area. If a WCTS asset fails in a more densely populated area or an area subject to greater public exposure, such as a park or school, there is a potential to impact a greater number of people than a failure on a remote easement. The impact to public health will be determined based on professional judgement, considering factors such as population density, proximity to public-access areas, or proximity to other critical populations.

Potential Environmental Impact

All SSOs also have the potential to negatively impact the environment. Therefore, the criticality rating considers the relative environmental impact of an SSO due to failure of the WCTS asset. The environmental impact will be determined based on professional judgement, considering factors such as proximity to water bodies or environmentally sensitive areas, or potential impacts to regulated areas.

2.1.3 Prioritizing Based on Condition and Criticality Ratings

Infrastructure rehabilitation is prioritized based on the combination of condition and criticality ratings as illustrated in **Figure 2-1**.

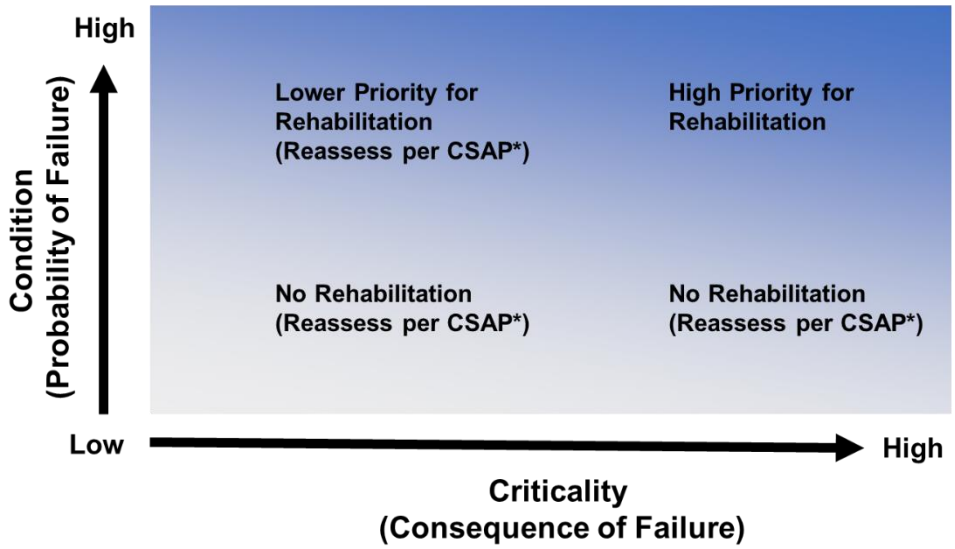
Gravity sewer lines and manholes determined to be in poor condition will be considered for rehabilitation under the IR Program. Of those gravity sewer lines and manholes in poor condition, rehabilitation is prioritized based on the condition (probability of failure) rating and the criticality (consequence of failure) rating. The highest priority for rehabilitation is assigned to gravity sewer lines and manholes whose failure would result in the largest SSO volumes and create the largest impact on public health and the environment (highest criticality rating) and whose condition is the poorest (highest condition rating).

Gravity sewer lines and manholes in poor condition but with a lower criticality rating will be tracked in decreasing priority according to decreasing criticality rating. These gravity sewer lines and manholes will be considered for potential future infrastructure rehabilitation after the higher priority projects are addressed, since a failure of these assets would represent a smaller impact to public health and the environment. If they are not scheduled for rehabilitation, these assets will be reassessed, based on the

frequencies given in the CSAP, to determine if the condition has deteriorated to the point that the asset would be moved into a higher priority rehabilitation category under the IR Program.

Gravity sewer lines and manholes in fair or good condition are prioritized for re-assessment rather than rehabilitation. These assets will be reassessed, based on the frequencies given in the CSAP, to determine if the condition has deteriorated to the point that the asset would be moved into a higher priority rehabilitation category under the IR Program.

Figure 2-1 – Prioritization Matrix



*Assets that are not scheduled for rehabilitation should be reassessed, as needed, based on the frequencies given in the CSAP.

2.1.4 Gravity Sewer Rehabilitation Projects

Based upon the gravity sewer and manhole priorities, gravity sewer rehabilitation projects will be scheduled for design and construction. In most cases, the City may choose to combine the rehabilitation of multiple gravity sewer lines and manholes into a larger rehabilitation project. When grouping assets into a single rehabilitation project, consideration will be given to include rehabilitation of adjacent, lower priority assets in order to avoid future costs of coming back into an area and limit disruption to the community. In particular, for rehabilitation projects where I/I reduction is a major goal, adjacent pipes, manholes, and city-owned laterals may be grouped based on location and rehabilitated as a single project, even if some of the assets fall into a lower priority category for rehabilitation.

In addition, if a gravity sewer line is identified for rehabilitation, the city-owned laterals on that pipe may be rehabilitated, as necessary, based on available lateral condition data and professional judgment.

Rehabilitation will be performed using the appropriate techniques to accomplish project goals and address the defects that were determined to be likely to cause a failure based on professional judgement.

Table 2-1 lists some of the potential gravity sewer rehabilitation techniques that may be used under the IR Program to address project goals.

Table 2-1 – Summary of Gravity Sewer Rehabilitation Techniques

Rehabilitation Technique	Address Structural Defects	Provide I/I Reduction
Open Cut Pipe Replacement	X	X
Pipe Bursting	X	X
Cured-in-Place Pipe (CIPP) Lining	X	X
Point Repairs (Internal and External)	X	X
Manhole Replacement	X	X
Manhole Coating or Lining	X	X
Manhole Point Repairs	X	X

Gravity sewer rehabilitation projects will be identified and scheduled according to priority, and tracked in the City's IMS, as described in **Section 3** of this report.

2.2 Pump Stations

Rehabilitation priorities for pump stations are determined using the following steps:

- Step 1: Determine condition rating (**Section 2.2.1**)
- Step 2: Determine criticality rating (**Section 2.2.2**)
- Step 3: Prioritize based on condition and criticality ratings (**Section 2.2.3**)
- Step 4: Develop pump station rehabilitation projects (**Section 2.2.4**)

2.2.1 Condition Ratings

A condition rating for each pump station is developed using professional judgment to represent the probability of a failure occurring due to the condition of that pump station. The condition rating is a numerical value, with low values assigned to represent a good condition and high values assigned to represent a poor condition. Condition ratings are tied to a particular asset ID and will be stored in the City's IMS, as described in **Section 6**. The condition rating is primarily assigned using information collected through the CSAP; however, historical SSO frequency is also considered when developing condition ratings.

CSAP Data

Assessment of pump stations within the WCTS will rely primarily on the evaluation of pump station conditions described in the CSAP, along with other CSAP assessment techniques to catalogue and rank the individual defects identified and ultimately determine the overall condition of the station. Each asset at a pump station (pumps, meters, valves, panels, generators, etc.) is assigned an individual condition score. The overall condition rating assigned to a pump station will be determined based on professional judgement and take into account the individual asset ratings, severity of the cumulative defects observed

and documented at the station, and the relative likelihood of those defects 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 likely to result in a failure in the WCTS, the station will likely receive a low condition rating, indicating the condition is fair. 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 high.

SSO Data

Previously reported SSOs related to a given pump station may indicate a higher probability of an SSO occurring at that location in the future if a permanent solution to address the past SSO has not been implemented. However, it is important to understand the root cause of the SSOs prior to developing the condition rating. For instance, an SSO may occur at a pump station as a result of high flow due to I/I entering the upstream gravity sewer instead of due to poor condition of the pump station. If the underlying cause of an SSO is attributed to pump station condition, the frequency of recent historical SSOs will be used, as appropriate, in conjunction with CSAP condition data to establish the condition rating for the pump station.

2.2.2 Criticality Ratings

A criticality rating for each pump station is developed to represent the relative consequence of a failure (resulting in an SSO) at that pump station. The criticality rating is a numerical value, with low values assigned to represent a low consequence of failure and high values assigned to represent a high consequence of failure. Criticality ratings will be tied to a particular asset ID and stored in the City's IMS, as described in **Section 6**. The criticality rating is assigned to pump stations considering the following factors and other information, as appropriate.

Quantity of Flow Conveyed / Potential SSO Volume

In most cases, the consequence of an SSO increases as the volume of the SSO increases. Although the volume of wastewater released may vary considerably given system conditions, field crew response time, etc., pump stations 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 can be estimated based on the total design capacity of the pump station, with the assumption that pump stations with a higher total design capacity are capable of conveying more flow than stations with a lower capacity.

Potential Impact to Public Health

All SSOs have the potential to negatively impact public health. The purpose of this factor is to differentiate the WCTS assets in terms of the population that could be impacted by an SSO in a particular area. If a WCTS asset fails in a more densely populated area or an area subject to greater public exposure, such as a park or school, there is a potential to impact a greater number of people than a failure on a remote easement. The impact to public health will be determined based on professional judgement considering factors such as population density, proximity to public-access areas, or proximity to other critical populations.

Potential Environmental Impact

All SSOs also have the potential to negatively impact the environment. Therefore, the criticality rating considers the relative environmental impact of an SSO due to failure of the WCTS asset. The environmental impact will be determined based on professional judgement considering factors such as proximity to water bodies or environmentally sensitive areas, or potential impacts to regulated areas.

2.2.3 Prioritizing Based on Condition and Criticality Ratings

Infrastructure rehabilitation is prioritized based on the combination of condition and criticality ratings as illustrated in **Figure 2-1**.

Pump stations determined to be in poor condition will be considered for rehabilitation under the IR Program. Of those pump stations in poor condition, rehabilitation is prioritized based on the condition (probability of failure) rating and the criticality (consequence of failure) rating. The highest priority for rehabilitation is assigned to pump stations whose failure would result in the largest SSO volumes and create the largest impact on public health and the environment (highest criticality rating) and whose condition is the poorest (highest condition rating).

Pump stations in poor condition but with a lower criticality rating will be tracked in decreasing priority according to decreasing criticality rating. These pump stations will be considered for potential future infrastructure rehabilitation after the higher priority projects are addressed, since a failure of these assets would represent a smaller impact to public health and the environment. If they are not scheduled for rehabilitation, these assets will be reassessed, based on the frequencies given in the CSAP, to determine if the condition has deteriorated to the point that the asset would be moved into a higher priority rehabilitation category under the IR Program.

Pump stations in fair or good condition are prioritized for re-assessment rather than rehabilitation. These facilities will be reassessed, based on the frequencies given in the CSAP, to determine if the condition has deteriorated to the point that the asset would be moved into a higher priority rehabilitation category under the IR Program.

2.2.4 Pump Station Rehabilitation Projects

Using the resulting pump station priorities, rehabilitation projects will be scheduled for design and construction. Pump station rehabilitation typically consists of the repair of individual components of a pump station, but when warranted due to the overall condition of the pump station, the station may be replaced. As with rehabilitation of other WCTS assets, selection of appropriate rehabilitation techniques is dependent upon the type of defects that are identified and is based on professional judgement.

Pump station rehabilitation projects 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.

Pump station rehabilitation projects will be scheduled according to priority and tracked in the City's IMS, as described in **Section 3** of this report.

2.3 Force Mains

Rehabilitation priorities for force mains are determined using the following steps:

- Step 1: Determine condition rating (**Section 2.3.1**)
- Step 2: Determine criticality rating (**Section 2.3.2**)
- Step 3: Prioritize based on condition and criticality ratings (**Section 2.3.3**)
- Step 4: Develop force main rehabilitation projects (**Section 2.3.4**)

2.3.1 Condition Ratings

A condition rating for each force main is developed using professional judgment to represent the probability of a failure occurring due to the condition of that WCTS asset. The condition rating is a numerical value, with low values assigned to represent a good condition and high values assigned to represent a poor condition. Condition ratings are tied to a particular asset ID and will be stored in the City's IMS, as described in **Section 6**. The condition rating is primarily assigned using information collected through the CSAP; however, historical SSO frequency is also considered when developing condition ratings.

CSAP Data

Assessment of force mains will rely on the assessment methods listed in the CSAP. For desktop assessments, condition ratings will be assigned after review of data based on professional judgement. For field inspections, 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 relative likelihood of those defects causing a failure of the force main, based on professional judgement. For instance, multiple defects may be observed in a single section of force main but if the overall magnitude of those defects has not and is not believed to be likely to cause a failure in the WCTS, the force main section will likely receive a low condition rating, indicating the condition is fair. In contrast, only one defect may be observed in another section of force main but if the defect is believed, based on professional judgment, to have a high probability of causing a failure, the resulting condition rating for that section would be high.

SSO Data

Previously reported SSOs related to a given force main may indicate a higher probability of an SSO occurring at that location in the future if a permanent solution to address the past SSO has not been implemented. However, it is important to understand the root cause of the SSOs prior to developing the condition rating. If the underlying cause of an SSO is attributed to force main condition, the frequency of recent historical SSOs will be used, as appropriate, in conjunction with CSAP condition data and professional judgement to establish the condition rating for the force main.

2.3.2 Criticality Ratings

A criticality rating for each force main is developed to represent the relative consequence of a failure (resulting in an SSO) on that force main. The criticality rating is a numerical value, with low values assigned to represent a low consequence of failure and high values assigned to represent a high consequence of failure. Criticality ratings will be tied to a particular asset ID and stored in the City's IMS, as described in **Section 6**. The criticality rating is assigned to pump stations considering the following factors and other information, as appropriate.

Quantity of Flow Conveyed / Potential SSO Volume

In most cases, the consequence of an SSO increases as the volume of the SSO increases. Although the volume of wastewater released may vary considerably given system conditions, field crew response time, etc., force mains capable of conveying large quantities of flow may be assumed to have higher consequences of failure than assets with smaller capacities. The quantity of flow can be estimated based on the size (diameter) of the gravity pipes or flow information, as appropriate, with the assumption that larger diameter pipes typically convey a larger quantity of wastewater than pipes of smaller diameters.

Potential Impact to Public Health

All SSOs have the potential to negatively impact public health. The purpose of this factor is to differentiate the WCTS assets in terms of the population that could be impacted by an SSO in a particular area.

If a WCTS asset fails in a more densely populated area or an area subject to greater public exposure, such as a park or school, there is a potential to impact a greater number of people than a failure on a remote easement. The impact to public health will be determined based on professional judgement considering factors such as population density, proximity to public-access areas, or proximity to other critical populations.

Potential Environmental Impact

All SSOs also have the potential to negatively impact the environment. Therefore, the criticality rating considers the relative environmental impact of an SSO due to failure of the WCTS asset. The environmental impact will be determined based on professional judgement considering factors such as proximity to water bodies or environmentally sensitive areas, or potential impacts to regulated areas.

2.3.3 Prioritizing Based on Condition and Criticality Ratings

Infrastructure rehabilitation is prioritized based on the combination of condition and criticality ratings as illustrated in **Figure 2-1**.

Sections of force mains determined to be in poor condition will be considered for rehabilitation under the IR Program. Of those force mains in poor condition, rehabilitation is prioritized based on the condition (probability of failure) rating and the criticality (consequence of failure) rating. The highest priority for rehabilitation is assigned to force mains whose failure would result in the largest SSO volumes and create the largest impact on public health and the environment (highest criticality rating) and whose condition is the poorest (highest condition rating).

Sections of force mains in poor condition but with a lower criticality rating will be tracked in decreasing priority according to decreasing criticality rating. These force mains will be considered for potential future infrastructure rehabilitation after the higher priority projects are addressed, since a failure of these assets would represent a smaller impact to public health and the environment. If they are not scheduled for rehabilitation, these assets will be reassessed, based on the frequencies given in the CSAP, to determine if the condition has deteriorated to the point that the asset would be moved into a higher priority rehabilitation category under the IR Program.

Sections of force mains in fair or good condition are prioritized for re-assessment rather than rehabilitation. These facilities will be reassessed, based on the frequencies given in the CSAP, to determine if the condition has deteriorated to the point that the asset would be moved into a higher priority rehabilitation category under the IR Program.

2.3.4 Force Main Rehabilitation Projects

Using the resulting force main priorities, rehabilitation projects will be scheduled for design and construction. In some cases, the City may choose to combine the rehabilitation of multiple force main segments into a single rehabilitation project. When grouping assets into a single rehabilitation project, consideration will be given to include rehabilitation of adjacent, lower priority assets in order to avoid future costs of coming back into an area and limit disruption to the community.

As with rehabilitation of other WCTS assets, force main rehabilitation will be performed using the appropriate techniques to accomplish project goals and address the defects that were determined to be likely to cause a failure based on professional judgement. Force main rehabilitation methods are similar to gravity sewer rehabilitation methods, and may consist of open cut replacement, pipe bursting, cured-in-place pipe (CIPP) lining, or point repairs. Force main rehabilitation may also consist of repair, replacement, or installation of air release/vacuum valves.

Force main rehabilitation projects will be scheduled according to priority and tracked in the City's IMS, as described in **Section 3** of this report.

2.4 Find and Fix Program

In addition to infrastructure rehabilitation projects, which are identified and prioritized as described in **Sections 2.1 through 2.3** of this report, the City may also perform small-scale rehabilitation or repairs on a Find and Fix basis as the defects are identified. Find and Fix repairs are intended to promptly address assets that are discovered, through the course of continuing WCTS inspections, to be in poor condition with a high probability of failure. Those assets determined to be in poor condition (based on professional judgment and PACP/MACP ratings for gravity pipes and manholes, or similar condition evaluation ratings for pump station stations or force mains) are scheduled to be repaired without being prioritized and

grouped into scheduled rehabilitation projects. Find and Fix repairs are tracked in the City's IMS, as described in **Section 3** of this report.

Section 3 Infrastructure Rehabilitation Project Inventory

The infrastructure rehabilitation projects identified through the prioritization process described in **Section 2** will be inventoried and tracked within the City's IR Program IMS described in **Section 6**. Projects are updated as they move from prioritization through final completion. The following subsections describe the procedures the City will use to track rehabilitation projects.

3.1 Completed Rehabilitation Projects

Information on infrastructure rehabilitation that has already been performed will be maintained on an asset level in the City's Geographic Information System (GIS) and Computerized Maintenance Management System (CMMS). This includes both prioritized rehabilitation projects and repairs conducted as part of the City's Find and Fix activities. As rehabilitation is completed, asset information is updated in the City's IMS to indicate the type and date of rehabilitation. Completed rehabilitation is inventoried for each type of WCTS component as follows.

- **Gravity Sewer Lines** – Information indicating if a pipe has been rehabilitated and the most recent rehabilitation date are stored within the City's GIS database. Additional information including the rehabilitation technique, location of point repair, or other pertinent details are stored in an asset table with unique GIS identifiers for the pipe asset, which can be queried and used to develop location maps. City-owned laterals, which extend from the gravity sewer line to the property line, may be added to the GIS database as information is available. Rehabilitation of city-owned laterals will be tracked by GIS identifiers for the lateral (if available) or tracked according to the connecting gravity sewer pipe asset ID.

- **Manholes** – Similar to the gravity sewer lines, information indicating if a manhole has been rehabilitated and the most recent rehabilitation date are stored within the City's GIS database. Additional information including the rehabilitation technique, type of point repair, or other pertinent details are stored in an asset table with unique GIS identifiers for the manhole asset, which can be queried and used to develop location maps.

- **Pump Stations** – All maintenance, repair, and rehabilitation of pump stations is stored and tracked in the CMMS along with dates and description of repairs or rehabilitation. Pump station rehabilitation information can be linked to the corresponding GIS asset identifier and displayed geographically in GIS.

- **Force Mains** – Similar to the gravity sewer lines, information indicating if a force main has been rehabilitated and the most recent rehabilitation date are stored within the City's GIS database. Additional information including the rehabilitation technique, type of point repair, or other pertinent details are stored in an asset table with unique GIS identifiers for the pipe asset, which can be queried and used to develop location maps.

3.2 Ongoing Inventory of Projects Scheduled and To Be Scheduled

Rehabilitation projects identified through the prioritization process described in **Section 2** for all WCTS components (gravity sewer lines, manholes, pump stations, and force mains) are tracked and scheduled according to priority in the City's master schedule and budget. The list of prioritized projects is reviewed and updated annually as part of the City's Capital Improvements Program (CIP) planning process.

Section 4 Inspection and Documentation of the Quality of Construction

Inspection and testing to verify the quality of construction is performed for gravity sewer line, manhole, pump station, and force main rehabilitation after construction and before final acceptance of the project.

4.1 Inspection and Testing Methods

Inspection and testing methods are dependent on the type of rehabilitation that is performed and the rehabilitation techniques that are used. Inspection and testing methods that may be used for each type of WCTS component are described below.

4.1.1 Gravity Sewer Lines

The methods and procedures for gravity sewer line testing are described in the City's specifications. The City periodically updates the specifications to provide clarification and maintain consistency with current industry practice. New and rehabilitated gravity sewer lines and laterals (city-owned portion) may be inspected using one or a combination of the following methods, as given in the specifications and based on professional judgement:

- **Visual Inspection** – Visual inspection is conducted for leaks, pipe defects, active infiltration, and adherence to line and grade.
- **Leakage Testing** – Leakage testing is performed using vacuum tests, infiltration tests, or hydrostatic testing.
- **Internal Video Inspection** – Post-construction closed circuit television (CCTV) inspection is performed to thoroughly document the internal condition of sewers and service lateral connections. The condition of the gravity sewer and any defects are documented using the NASSCO PACP standard codes.
- **Deflection Testing** – Deflection testing is conducted after the pipe is backfilled.
- **CIPP Liner Curing Data** – CIPP liner curing data is reviewed for conformance with the specifications.
- **Certified Laboratory Testing** – Testing of installed CIPP liner samples is performed by a certified independent testing laboratory to determine the installed CIPP liner flexural properties and CIPP liner thickness.

4.1.2 Manholes

The methods and procedures for manhole testing are described in the City's specifications. The City periodically updates the specifications to provide clarification and maintain consistency with current industry practice. New and rehabilitated manholes may be inspected using one or a combination of the following methods, as given in the specifications:

- **Visual Inspection** – Visual inspection is conducted for defects, active infiltration, and adherence to specifications.
- **Leakage Testing** – Leakage testing is performed using vacuum tests.
- **Liner Thickness Testing** – Liner thickness testing is performed to confirm the cured thickness of the lining is uniform and meets the minimum specifications.
- **Liner Adhesion Testing** – In-place testing is performed to verify the adhesion of the liner to the existing manhole substrate using a calibrated pull test.
- **Liner Defect Testing** – Testing for liner defects is performed using vacuum tests, holiday detection tests, or ultrasonic testing.

4.1.3 Pump Stations

The testing and inspection of pump station rehabilitation work depends on the specific type of repairs and rehabilitation performed at the station. Pump station testing and inspection primarily consists of visual inspection and operations testing and monitoring. Pump station rehabilitation work and testing is performed in accordance with the *City of Columbia Utilities and Engineering Regulations Manual: Part 3.3 (Specification for Design of Pump Stations)*.

4.1.4 Force Mains

Testing and inspection methods for new and rehabilitated force mains are similar to those for gravity sewer lines (**Section 4.1.1**). In addition, force mains may be pressure tested for leakage using hydrostatic testing at specified pressures.

4.2 Documentation

The results of inspection and testing to verify the quality of construction are reviewed for adherence to the applicable specifications prior to acceptance of rehabilitation construction work. If necessary, additional work shall be performed to correct defects prior to final completion of the project. Testing results are documented and archived as part of the construction project files.

Post-rehabilitation video inspections documenting the condition of the newly constructed or rehabilitated pipes are documented in a digital PACP-compliant database of the inspection along with digital photographs and videos, referencing the City of Columbia pipe identification numbers. Post-rehabilitation video inspections are stored within the City's IMS, as described in **Section 6** of this report.

Section 5 Analyzing Effectiveness of Completed Rehabilitation

Monitoring the effectiveness of various rehabilitation techniques to address observed defects in the WTCS is important to the continued cost-effective implementation of the IR Program. The effectiveness of the City's IR Program may be evaluated based on SSO reduction, I/I reduction, or other factors as appropriate.

5.1 SSO Reduction

The primary objective of the IR Program is to reduce the occurrence of SSOs in the WCTS; therefore, one of the key assessments of both individual rehabilitation projects and the overall IR Program will rely on whether SSO occurrences have been reduced on rehabilitated WCTS assets or in the areas directly affected by the rehabilitation. SSO location, frequency, and type is tracked as part of the City's IMS and mapped in accordance with the SMP. Data will be analyzed to determine if SSOs attributable to rehabilitated assets have been reduced. In the event a constructed project does not reduce the occurrence of SSOs, the inspection data will be reassessed and the assumed cause of the SSOs will be reevaluated using professional judgment.

5.2 Inflow and Infiltration Reduction

For gravity sewer rehabilitation projects that target inflow and infiltration (I/I) reduction, the I/I in the areas affected by the project will be assessed before and after construction using flow monitoring data. Data will be compared to estimate the amount I/I reduction that is achieved. As projects are completed and data on I/I reduction is analyzed, the City's approach to gravity sewer rehabilitation or selection of rehabilitation techniques may be reevaluated, using professional judgment, to achieve effective I/I reduction.

Section 6 IR Program Information Management System

The IR Program Information Management System (IMS) incorporates several information tracking platforms under the City of Columbia's overall IMS Program. Details of the IMS Program are described in the IMS Program Plan Document. The implementation of the IR Program will rely upon information gathered from CSAP assessments and other CD programs. The data that is generated and tracked under the IR Program are stored within the City's IMS under the following applications.

Computerized Maintenance Management System (CMMS) – The City is in the process of implementing a CMMS using Azteca Software's Cityworks® Server Asset Management System. Cityworks® is integrated with GIS and will serve as the City's single IMS repository for information related to corrective and preventive maintenance history, asset inventory and attributes. Information related to the IR Program that will be maintained in Cityworks® includes the following:

- Data collected through CSAP assessments, as applicable
- Condition ratings generated for WCTS assets to be used for infrastructure rehabilitation prioritization
- Work order information for completed Find and Fix rehabilitation/repairs
- Information on completed rehabilitation, as applicable
- System maintenance data, including sanitary sewer overflow (SSO), service request, and work order frequency and location
- Post-rehabilitation video inspection data
- This information will be periodically reviewed and updated as CSAP assessments and infrastructure rehabilitation projects are completed.

GIS Geodatabase – This centralized database will be used to store, manage and distribute both spatial (GIS) and various datasets, including CSAP inspection and IR Program rehabilitation databases that are not stored within Cityworks®. Information in the databases is linked to GIS based on the City's previously defined and implemented unique asset identification number that exists on each asset in the GIS. Information related to the IR Program that will be entered or maintained in the GIS geodatabase include the following:

- Data collected through CSAP assessments, as applicable
- Criticality ratings generated for WCTS assets to be used for infrastructure rehabilitation prioritization
- Information on completed rehabilitation, as applicable
- Post-rehabilitation video inspection data

Document Management System – Other data that are not specific to a single asset will be stored within the IR Program IMS on a centralized document management site. Information related to the IR Program that will be entered and maintained in databases or files stored on the document management system includes the following:

- City's master budget and schedule used for tracking infrastructure rehabilitation projects
- Prioritized list of projects needing to be scheduled and performed
- I/I reduction and flow monitoring data analysis

Data Integration

IR Program information will also be integrated with the following applications as available:

Hydraulic Model – Information on completed rehabilitation will be used to update the hydraulic model of the WCTS as necessary.

Sewer Mapping Program – The Sewer Mapping Program Report describes procedures that are used to integrate CSAP assessment data with the GIS, as well as procedures for integrating, tracking, and mapping infrastructure rehabilitation projects in GIS.