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CLINCHFIELD BASIN COLLECTION SYSTEM CONDITION ASSESSMENT REPORT

August 30, 2022

PREPARED FOR CITY OF MARION, NORTH CAROLINA

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CLINCHFIELD SEWER BASIN - CONDITION ASSESSMENT REPORT

CITY OF MARION SEWER COLLECTION SYSTEM

City of Marion, North Carolina

I. INTRODUCTION

The City of Marion is experiencing the same problems with their wastewater collection system as many municipalities, authorities, and commissions throughout the country; much of their infrastructure is approaching the end of its design life and maintenance personnel are faced with problems such as increased maintenance requirements, pipe deterioration and failure, in addition to treating large volumes of inflow and infiltration. At the same time, regulatory agencies have responded with more stringent regulations and penalties to protect water quality and public health.

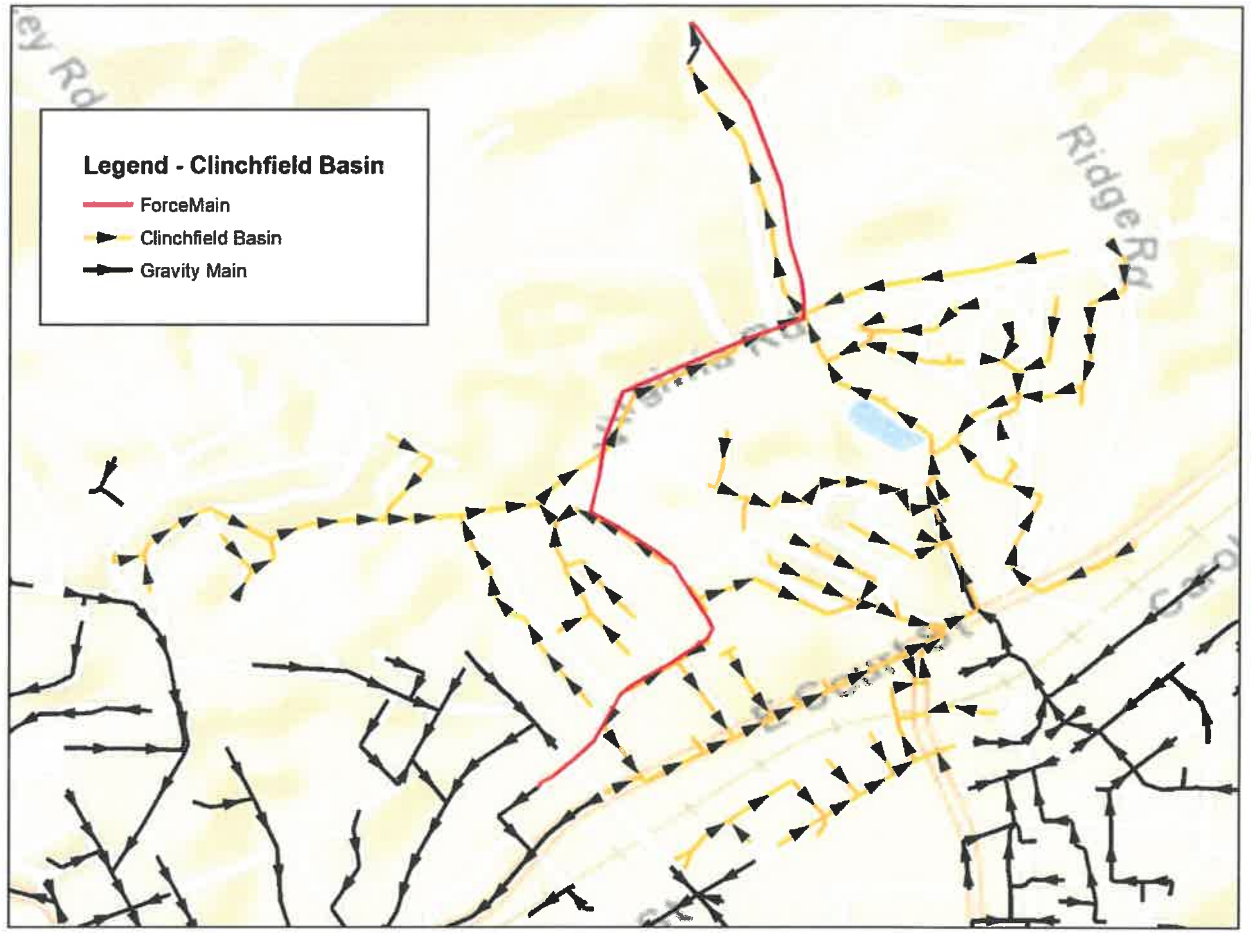
City staff identified high levels of inflow and infiltration (I/I) in the Clinchfield sewer basin. During extreme wet weather events, I/I volume will exceed the capacity of the Clinchfield Pump Station and result in system surcharge and potential overflows. The City of Marion Utilities Department is committed to identifying sources of I/I in the Clinchfield basin and developing a repair plan to ultimately reduce I/I. Therefore, Hydrostructures was obtained to perform sewer investigation and evaluation on the Clinchfield basin.

To accomplish these goals, both field inspection services and professional services were performed as part of our scope of work. Field services included detailed manhole inspections, zoom camera pipe inspections, survey / mapping, smoke testing, and closed-circuit television (CCTV) inspection of the sewer mains. Professional services included condition assessment, GIS mapping, and preparation of desktop repair / replacement / rehabilitation (RRR) recommendations to address deficiencies identified. Cost estimates are included for all recommended repairs. All inventory data, results, recommendations, and map edits are included in the updated GIS files. All supporting data is included with this report on a supplemental digital storage drive. The information gathered during the study has been used to identify specific defects within the system and develop repair/rehabilitation recommendations with cost estimates in order to assist the City of Marion with restoring the structural integrity of these sewer mains and manholes while reducing I/I in the Clinchfield sewer basin.

II. CLINCHFIELD INVENTORY

The Clinchfield basin serves a portion of the City on the north side of Court Street (Hwy 70). The basin is roughly bordered by Court Street, Highland Drive, Virginia Road, and Ridge Road. Figure 1 below shows a map of the Clinchfield basin.

FIGURE 1 – CLINCHFIELD SEWER BASIN



The basin includes approximately 43,190 liner feet of sewer main and approximately 250 manholes. All flow from the basin is received by the Clinchfield pump station and discharges into a manhole on Oak Street. The pipe material in this basin consists of a mix of vitrified clay (VCP), ductile iron (DIP), polyvinyl chloride (PVC), and cast iron (CI). Table 1, below, lists the footage of each diameter and material of pipe found in the study area.

TABLE 1 – PIPING INVENTORY

	Diameter (inches)					
Material	6	8	10	12	15	Total Footage
Ductile Iron Pipe (DIP)		1,297	82			1,379
Polyvinyl Chloride (PVC)	270	7,321				7,591
Vitrified Clay Pipe (VCP)	2,708	12,733	1,160	5,082	121	21,803
Cast Iron Pipe (CI)		625				625
Unknown	1,678	7,708	373	2,035		11,794
Total Footage	4,655	29,683	1,616	7,117	121	43,191

III. RESULTS OF FIELD INVESTIGATIONS

A. Manhole Inspections

Legacy manhole inspection data exists from previous mapping and inspection efforts performed by the City as part of an Asset and Inventory Assessment Grant administered through NC Division of Water Infrastructure. Therefore, for this assessment, we concentrated manhole inspections on portions of the basin without mapping and inspection data. 124 manholes were inspected as part of this assessment. Manhole inspection accomplishes two goals; 1) to collect inventory data to update the GIS and 2) identify defects that contribute I/I and / or jeopardize structural integrity.

The inspections were performed by two-man crews who located, accessed, and scanned the manhole interior using an Ibak Panaramo SI unit. The SI unit produces a 360 degree, high resolution photo image of the interior of the manhole. In addition to the photo image, a point cloud of the interior of the structure is created and used to perform accurate measurements of the various components. Ground cover photos and depth measurements were also captured. City staff assisted with locating manholes and uncovering inaccessible manholes so our crews could return and complete the inspection.

A certified technician performed a detailed inspection using the scan image and point cloud data in the office using PipeLogix software. All inspections were performed according to National Association of Sewer Service Companies' (NASSCO) Manhole Assessment and Certification Program (MACP) requirements. An inspection report was generated to include the following key data:

- Manhole number
- Group name
- Physical location (street address)
- Invert depths
- Material types (manhole and pipes)
- Physical condition (ring and cover, walls, bench, channel, etc.)
- Inflow/Infiltration entry points
- Defect photos, descriptions, and locations according to manhole component
- Invert, ground cover, and pipe connection photos

Based on our evaluations, each manhole was assigned a condition rating using the NASSCO MACP methodology as follows:

- **Priority 5** – Manholes in the worst condition and needing immediate repair and considered emergency status. This priority rating would result from observed structural failure or imminent failure of a critical manhole component. Priority 5 manholes are typically reported during the field inspection and address prior to reporting.
- **Priority 4** – Manholes containing severe defects and / or structural damage, major active leaks, heavy roots, pre-cast manholes with advanced surface corrosion due to hydrogen sulfide gas damage, brick manholes with joint mortar deterioration / missing bricks, severe

offset frames, broken covers, etc.

- **Priority 3** – Manholes with moderate defects that will continue to deteriorate if left un-repaired. Brick manholes with deteriorated joint mortar, minor infiltration leaks or evidence of leaks (stains), pre-cast manholes with minor surface corrosion due to hydrogen sulfide gas damage, deteriorated bench / invert, etc.
- **Priority 2** – Aging manholes in good condition with only minor defects and located in areas less susceptible to I/I.
- **Priority 1** – Manholes with no defects. Priority 1 manholes are typically new pre-cast structures.

Table 2, below, lists the quantity of manholes according to each priority rating. The "Manhole Priority Location Map" in Appendix A provides an illustration of the location and priority rating for all manholes inspected as part of the assessment. Manhole inspection reports for all manholes inspected are included in Appendix B and on the external storage drive in PDF format.

TABLE 2 – MANHOLE PRIORITY RATING SUMMARY

Priority Rating	Quantity
Priority 5	0
Priority 4	1
Priority 3	100
Priority 2	22
Priority 1	1

The manholes were found to be in poor to fair condition overall. Higher scoring (Priority 3 & 4) manholes consist of deteriorated brick manholes and leaking pre- cast manholes. The majority of brick manholes have deteriorated mortar joints which allow for rain induced infiltration and groundwater infiltration to enter through the manhole walls. Loose and missing mortar joints also allow roots intrusion into the interior of the manhole. Priority 3 pre-cast manholes showed active infiltration or evidence of reoccurring infiltration through section joints and pipe connections. Other high priority pre-cast manholes have brick chimneys with deteriorated mortar joints. Miscellaneous defects including off-set manhole frames were also identified.

Manhole SSMH-1630 – Missing Mortar – Mud Infiltration

A Manhole Repair Schedule is included in Appendix B and lists details for each manhole including the manhole number, wall material, depth, location, repair recommendation, and priority rating.

B. Zoom Camera Pipe Inspections

Hydrostructures provided a two-man field crew to perform pole-mounted zoom camera inspections on the sewer mains as part of the project. These Inspections were performed on the upstream and downstream ends of each sewer main, except for dead-in lines with no upstream access. The pole mounted zoom camera was positioned carefully at the mouth of each pipe to complete the inspection. The camera uses zoom technology to create the effect of traveling through the pipe. Inspections typically span from 10-100 feet of the pipe depending on pipe diameter, pipe alignment, and the presence of offset joints or other defects limiting visibility. The videos are stored as MPEGs and are named with a unique ID that corresponds to the pipe facility ID and the MH from which they are taken. The videos vary from 10 seconds to one minute in length. Inspections are limited because the camera only zooms in on its fixed view perspective and does not actually travel through the full length of the pipe as with a typical motorized CCTV camera unit. However, these inspections allow us to verify pipe material, identify defects, and provides us with a quick assessment of the current condition of the sewer main.

In addition to the manholes that Hydrostructures inspected, an additional fifty (50) manholes were selected in the Clinchfield basin using the legacy inspection and condition data. High priority manholes, based on the findings from the previous inspection, were selected and added to the scope of the zoom camera inspection.

This methodology was based on the theory that aging manholes in poor condition are likely to be connected to aging pipes that could potentially be in poor condition.

Videos are reviewed by Engineering staff in order to prioritize the sewer mains based on condition from Priority 1 through 5. Since each pipe (typically) contains two videos, one at each end, the highest priority rating based on the two videos is assigned to the pipe. Our zoom camera priority rating system uses the following methodology.

- **Priority 5** – Sewer mains that are collapsed or broken with more than 30% deformation, offset joints greater than 30% of pipe diameter, missing pipe and/or that have other severe defects. These defects are either presently causing blockages in the sewer main (backup and surcharging) or we expect these defects to cause blockages in the near future.
- **Priority 4** – Sewer mains with severe offset joints, observed holes in pipe wall, severe infiltration, the presence of large root balls, and/or severe debris obstructions.
- **Priority 3** – Sewer mains with minor to moderate defects including the presence of roots, debris or grease buildup, signs of infiltration, slight to moderate offset joints, surface corrosion, and/or fractured and cracked pipe.
- **Priority 2** – Sewer mains with the presence of minor roots and grease or debris buildup.
- **Priority 1** – Sewer main in good condition. No defects observed.

Table 3, below, lists the quantity of pipes according to each priority rating. In total, Hydrostructures identified 77 Priority 1, 262 Priority 2, 168 Priority 3, 60 Priority 4 and 26 Priority 5 sewer mains.

TABLE 3 – ZOOM CAMERA PIPE RATING SUMMARY

Priority Rating	Quantity
Priority 5	26
Priority 4	60
Priority 3	168
Priority 2	262
Priority 1	77

The "Sewer Main Zoom Camera Priority Location Map" in Appendix A provides an illustration of the location and priority rating for all pipes inspected. Appendix C contains the Zoom Camera Summary Spreadsheet. All zoom camera videos are contained on the external hard drive and are hyperlinked to the (digital) Zoom Camera Summary Spreadsheet.

C. Survey and GIS Mapping Update

The majority of the manholes inspected as part of this project were not previously included in City's current GIS mapping. Manholes were first located by the manhole inspection crew and City staff. After the manholes were located and inspected in the field, a survey crew followed to obtain a survey location so the manholes could be accurately incorporated into the GIS mapping.

Hydrostructures surveyed the horizonal and vertical location of the manholes with Trimble R8 GPS receivers or conventional equipment when reliable satellite signal wasn't available. All coordinate data collected is referenced to the North Carolina State Plane Grid, US Survey foot, zone 3200 and horizontal datum NAD83.

Survey data was used to populate the existing GIS with manhole locations. The geodatabase was updated with manhole and pipe inventory information obtained during this assessment. The existing GIS was updated to reflect the results of the new inventory data and condition scores for all assets inspected.

D. Smoke Testing

Approximately 47,090 LF of smoke testing was performed in the Clinchfield basin and Meter Basin MN4. Preliminary flow meter data from the System-wide Flow Monitoring and I&I Analysis directed the use of surplus smoke test budget to basin MN4.

Smoke testing consists of forcing smoke through a portion of the sewer collection system with a motorized blower. The smoke exits the system through defects in the system such as roof or storm drain connections, broken or missing clean-out caps, abandoned sewer connections, structural damage (holes, cracks, etc.), leaking joints, and other miscellaneous defects. These smoke test defects can be major sources of inflow and rain induced infiltration.

During the smoke testing process, Hydrostructures personnel walked each section of line being tested to locate any deficiencies in that section. Each deficiency was photographed and documented to show its location. This information was also entered into Hydrostructures smoke test database.

Summary of Smoke Test Results
The smoke testing identified a total of 118 defects. The breakdown of all defects follows in Table 4.

TABLE 4: SMOKE TEST DEFECTS BY TYPE

Source Description	Number Identified
Cleanout Cap Missing/Broken	10
Cleanout Stack Broken	7
Direct Storm Drain Connection	0
Indirect Storm Drain Connection	6
Main Sewer Line Leak	28
Manhole Leaking	25
Service Lateral Leaking	26
Patio Drain	3
Roof Drain Connection	1
Other	12
Total	**118**

The majority of defects are related to leaking sewer mains, manholes, and service laterals.

Twelve (12) defects are labeled as other. Five (5) consist of smoke leaking out of water meter boxes. These are likely related to an adjacent sewer service lateral. Three (3) are related to open floor drains (or defective piping under the slab) at an abandoned building. Two are on the grounds of a commercial property, one leaking from underneath the concrete pad and one leaking out of the ground (likely defective piping). One is in a yard and another under a retaining wall where the existing sewer mapping cannot confirm the location of public sewer or a sewer lateral. However, these defects are ultimately tied to the City's sewer and contribute inflow during rainfall.

A "Smoke Test Defect Location Map" is included in Appendix D. This map shows the location of all defects identified during testing. A Smoke Test Defect Summary Spreadsheet and Defect Logs are also included in Appendix D. This spreadsheet contains the defect type, location, I/I severity, and photograph references. Digital smoke test defect logs with supporting photographs of all deficiencies found are included on the external storage drive.

E. Cleaning and Internal CCTV Inspection

Hydrostructures and City staff worked together to develop a methodology to select sewer mains to be cleaned and CCTV inspected. Our general goal was to maximize the CCTV budget by concentrating our efforts on high priority sewer mains identified from zoom camera efforts (Priority 4 and 5) and on pipes with mainline smoke test defects.

Approximately 9,960 LF of pipe in the Clinchfield basin was cleaned and CCTV inspected. All lines were cleaned using a high-velocity jet / vacuum truck, and off-road tracked easement machine when needed, in order to remove debris and provide an unobstructed view of the pipe surface. Many of the lines were located in the easement and behind houses with difficult access. The lines contained a heavy amount of debris and root intrusion.

After cleaning, the lines were then visually inspected by means of a closed-circuit television (CCTV) system, which includes a self-propelled tractor and camera unit. The camera is coupled with an inspection system containing both digital video recorders, footage counter, wench, and a laptop equipped with NASSCO PACP compliant video inspection reporting software.

For each line segment, an inspection log was prepared showing the location of any structural defects, offset or separated joints, points of infiltration, roots, etc. The log also shows the location of all service connections and indicates the upstream and downstream manhole numbers. The complete inspection was also recorded on videotape and captured digitally on MPEG files. CCTV Inspection Logs are contained in Appendix E. Digital videos and digital inspection logs for each line segment are included on the external storage drive.

Once all of the lines were cleaned and inspected, the next step was to evaluate each line and prioritize the lines according to condition severity. Based on our evaluations, each defect was assigned a grade rating from 1 to 5. The rating system uses the NASSCO Pipeline Assessment and Certification Program (PACP) methodology described below.

- **Grade 5** – Defects require immediate attention. Pipe has failed or will likely fail within the next five years
- **Grade 4** – Severe defects that will become Grade 5 within the foreseeable future.
- **Grade 3** – Moderate defects that will continue to deteriorate
- **Grade 2** – Defects that have not begun to deteriorate.
- **Grade 1** – Minor defects

NASSCO recognizes two families of defects; structural defects and operation and maintenance (O&M) defects. Structural defects are various types of defects within the structure of the pipe including cracks, fractures, broken pipe, collapsed pipe, offset or separated joints, surface damage from expose to hydrogen sulfide gas, etc. Operation and maintenance defects include deposits (grease, sand), roots, infiltration, obstructions, etc. that affect the system's ability to operate properly.

NASSCO also assigns each structural and O&M defect with a grade rating corresponding to the severity of the defect (5 is the most severe and 1 is the least severe). A grade score is calculated by multiplying the grade rating by the number of occurrences of that grade identified throughout the pipe. The grade scores are summed in their appropriate families (structural and O&M) to calculate the structural defect rating and O&M defect rating. The overall rating is the sum of structural and O&M defect ratings. Each pipe is also assigned a quick rating, which is a four digit number showing the number of occurrences for the two highest severity grades occurring in that pipe (the number is displayed with the grade rating first, followed by the number of occurrences). For example, if the pipe inspected has two grade 5 defects and six grade 4 defects the quick rating would be 5246.

Videos are reviewed by Engineering staff in order to prioritize the sewer mains based on condition. Typically, Hydrostructures assigns a priority ranking based on the severity of the worst defect contained in the sewer main. Therefore, a line containing a structural collapse (grade 5) would be scored as a priority 5. However, engineering judgement is used to assign the final priority rating. A "Priority Sewer Main Location Map" is provided in Appendix A

Table 5: CCTV Inspection and Condition Summary Spreadsheet on the following pages summarizes the results from the CCTV inspections and includes the structural and O&M defects, NASSCO PACP scoring, and final priority rating discussed above for each sewer main. Data for each manhole to manhole section is presented as follows:

- Upstream and downstream manhole number
- Pipe Segment Reference Number
- Physical location description
- Pipe material
- Pipe diameter
- GIS pipe length
- CCTV pipe length
- NASSCO PACP scoring
- Defect Comments / Description
- Rehabilitation Recommendation
- Priority Rating

TABLE 5: SEWER MAIN CONDITION SUMMARY SPREADSHEET

Sewer Line I.D. Number	Upstream Manhole No.	Downstream Manhole No.	Location	Pipe Material	Pipe Diameter (in.)	Surveyed Length (ft.)	Operation & Maintenance Defects / Comments	Structural Defects / Comments	Rating	Rehabilitation Recommendations
SSGM0966	SSMH0361	SSMH0362	ANN ST	Vitrified Clay Pipe	8	312	Fine/Medium roots in multiple joints	Multiple minor offset joints, outside drop @ DSMH, Concrete in pipe @ 312'	3	Install 8" CIPP Liner
SSGM1205	SSMH0367	SSMH0303	STATE ST	Vitrified Clay Pipe	8	152	Multiple infiltration stained joints	Broken pipe @ 3'	3	Install 8" CIPP Liner
SSGM1114	SSMH0302	SSMH0303	STATE ST	Polyvinyl Chloride	8	86	None	Large offset joint @ 64', Sag 64'-70', Material change to DIP @ 75', Hard vertical alignment change @ 75', Surface corrosion metal pipe	5	Excavate and Replace 64'-86' including outside drop
SSGM1122	SSMH1327	SSMH1329	BALDWIN AVE	Ductile Iron Pipe	8	109	Infiltration stained joints @ 70' and 73'	Surface Corrosion metal pipe, coating delaminating, material change to VCP @ 70'	4	Install 8" CIPP Liner
SSGM1305	SSMH1397	SSMH1429	SEVENTH ST	Vitrified Clay Pipe	8	249	Fine/Medium roots in multiple joints	Material change to DIP @ 2'-23', Surface Corrosion/Spalling	4	Install 8" CIPP Liner
SSGM1306	SSMH1429	SSMH0614	E COURT ST	Vitrified Clay Pipe	10	202	None	Minor Sags 10'-15', 28'-38'	2	None
SSGM1197	SSMH1357	SSMH1379	BRANCH ST	Vitrified Clay Pipe	10	497	Multiple joints with infiltration, Fine roots in multiple joints	Joint Separated large w/Soil Visible @ 3', Alignment change @ 3', Hinge Fracture 3'-23', Fracture Longitudinal @ 83', 168'-176'	5	Pipe burst 10" to 10", Install new MH @ 248'
SSGM1199	SSMH1379	SSMH0618	BRANCH ST	Vitrified Clay Pipe	8	407	Multiple infiltration stained joints, Fine/medium roots in multiple joints	Material change to PVC 251'-263', offset joints @ 251' & 253', Hinge crack @ 264', Hinge 3 Fracture 346'-353', Longitudinal Fracture 386'-390'	5	Install 8" CIPP Liner
SSGM1228	SSMH1618	SSMH1380	BRANCH ST	Vitrified Clay Pipe	8	188	Multiple Joints with gushing Infiltration between 160' &190', Fine/medium roosts in multiple joints	None	5	Install 8" CIPP Liner
SSGM1198	SSMH1380	SSMH1379	BRANCH ST	Vitrified Clay Pipe	8	47	None	Large offset joint @ 46' with soil visible, Abandon survey @ 46'	5	Point Repair 46'-60', Install 8" CIPP Liner
SSGM1198	SSMH1380	SSMH1379	BRANCH ST	Vitrified Clay Pipe	8	2	Turn Around	Large offset joint @ 2' with soil visible, Abandon survey @ 2', Abandon survey @ 2'	5	See above
SSGM1270	SSMH1649	SSMH1415	BRANCH ST	Vitrified Clay Pipe	8	13	None	Material Change to PVC 2'-13', Large offset joints @ 2' and 13', Abandon survey @ 13'	5	Point Repair 0'-13', Install 8" CIPP Liner
SSGM1270	SSMH1649	SSMH1415	BRANCH ST	Vitrified Clay Pipe	8	197	Turn Around	Material change to DIP 37'-197', Corrosion/tuberculation in metal pipe, Intruding tap @ 64', Alignment change left @ 81', large offset @ 197', Abandon survey @ 197'	5	Install 8" CIPP Liner
SSGM1272	SSMH1415	SSMH1413	BRANCH ST	Vitrified Clay Pipe	8	99	Fine roots in joint @ 57'	Large offset joint @ 16', Material Change to DIP 24'-43', Surface Corrosion in metal pipe, Coating delaminating in metal pipe	3	Point Repair 14'-18', Install 8" CIPP Liner
SSGM1267	SSMH1413	SSMH1414	BRANCH ST	Vitrified Clay Pipe	8	68	None	Spiral Fracture @ 64'	3	Install 4' CIPP Sectional Liner @ 64'
SSGM1703	SSMH1642	SSMH1416	VIRGINIA RD	Vitrified Clay Pipe	8	36	Bricks and Debris @ 35' 95% blocked	Abandon Survey @ 35', Line appears to be Abandoned	1	None
SSGM1261	SSMH0612	SSMH1408	E COURT ST	Vitrified Clay Pipe	6	231	Roots in fractures and joints, Encrustation @ multiple joints	Fractures Multiple @ multiple locations, multiple offset joints, Material change to PVC 89'-120', Obstacle Intruding vertically through pipe @ 231', Abandon survey @ 231'	5	Pipe burst 6"-8", Install new MH @ 224'
SSGM1261	SSMH0612	SSMH1408	E COURT ST	Vitrified Clay Pipe	6	217	Turn Around	Multiple cracks and fractures, multiple offset joints, Hinge Fractures @ 158', 192', & 211', Abandon survey @ 217'	5	See above
SSGM1262	SSMH1408	SSMH1408A	E COURT ST	Vitrified Clay Pipe	6	12	None	Fracture Multiple 0'-5', Large offset joint @ 12', Alignment Right @ 12'	5	Install new MH @ 12', Excavate and Replace w/8", Bore and Jack

Sewer Line I.D. Number	Upstream Manhole No.	Downstream Manhole No.	Location	Pipe Material	Pipe Diameter (in.)	Surveyed Length (ft.)	Operation & Maintenance Defects / Comments	Structural Defects / Comments	Rating	Rehabilitation Recommendations
SSGM1262	SSMH1408	SSMH1408A	E COURT ST	Vitrified Clay Pipe	6	35	Turn Around, Roots in multiple joints	Large offset @ 6', Material change to PVC @ 30', Alignment change left @ 34', Alignment change right @ 35', Abandon survey @ 35'	5	Install new MH @ 34', Excavate and Replace w/8", CCTV and Evaluate the remainder of the pipe, Bore and Jack
SSGM1206	SSMH0366	SSMH0367	E TATE ST	Vitrified Clay Pipe	6	325	Roots in multiple joints	Fracture multiple @ 3', Separated joints @ 34' & 305', Intruding sealing ring @ 86'	4	Pipe burst 6"-8"
SSGM1339	SSMH0528	SSMH0527	E COURT ST	Vitrified Clay Pipe	8	198	Intruding tap @ 147'	Multiple cracks and fractures, Material change to PVC @ 190'	3	Install 8" CIPP Liner
SSGM1250	SSMH1400	SSMH0527	GILKEY ST	Vitrified Clay Pipe	8	261	Intruding taps @ 8', 80', 190', & 211'	Hinge Fracture 0'-5', Multiple cracks and fractures, Broken w/Soil visible @ 154', offset joint @ 215'	5	Point Repair 0'-5', Install 8" CIPP Liner
SSGM1346	SSMH0530	SSMH0532	E COURT ST	Vitrified Clay Pipe	8	405	None	Multiple cracks and fractures, broken @ 335'	3	Install 8" CIPP Liner
SSGM1680	SSMH1630	SSMH1652	RIDGE RD	Vitrified Clay Pipe	6	34	Encrustation @ joints	Material change to DIP @ 30', surface corrosion in metal pipe, Abandon survey @ 34'	5	Excavate and Replace w/8"
SSGM1680	SSMH1630	SSMH1652	RIDGE RD	Vitrified Clay Pipe	6	161.1	Turn Around	Multiple cracks and fractures, offset joints @ 135' & 151', Material change to PVC 151'-153', Material change to DIP @ 153', Surface corrosion/tuberculation in metal pipe, Abandon survey @ 161' due to tuberculation	5	Excavate and Replace w/8"
SSGM1681	SSMH1652	SSMH1651	RIDGE RD	Vitrified Clay Pipe	6	171	Roots in multiple joints	Fracture multiple @ 6' & 66', Large offset joint w/roots @ 17', Cracks longitudinal hinge 2 @ 38', 42', & 70'	4	Excavate and Replace w/8"
SSGM1723	SSMH1651	SSMH1653	RIDGE RD	Vitrified Clay Pipe	6	206	Roots in multiple joints	Multiple cracks and fractures, multiple offset joints, Broken @ 100'	4	Excavate and Replace w/8"
SSGM1678	SSMH1653	SSMH1640	RIDGE RD	Vitrified Clay Pipe	6	211	Roots in multiple joints	Fracture multiple @ 142', Multiple offset joints, Broken w/Soil visible @ 196' & 210', Alignment change left @ 211', Abandon survey @ 211'	4	Pipe burst 6"-8", Install new MH @ 211'
SSGM1678	SSMH1653	SSMH1640	RIDGE RD	Vitrified Clay Pipe	6	13	Turn Around	Large offset joint @ 7', alignment change right @ 13'	4	See above
SSGM1675	SSMH1627	SSMH1631	SCHOOL ST	Vitrified Clay Pipe	6	136	Roots in multiple joints	Material change to PVC @ 107', Size change to 4" @ 136'	4	Pipe burst 6"-8", Install new MH @ 107'
SSGM1673	SSMH1626	SSMH1628	SCHOOL ST	Vitrified Clay Pipe	8	537	Roots in multiple joints	Small hole w/soil visible @ 68', Material change to PVC 148'-160', Large offset joint @ 160', Fracture Spiral @ 249'	3	Install new MH @ 268', Install 8" CIPP Liner
SSGM1674	SSMH1628	SSMH1650	SCHOOL ST	Vitrified Clay Pipe	8	544	Roots in multiple joints	Large offset joint @ 540', Abandon survey @ 540'	4	Install new MH @ 272', Point Repair @ 540', Install 8" Liner
SSGM1700	SSMH1650	SSMH1632	SCHOOL ST	Vitrified Clay Pipe	8	130	None	None	2	None
SSGM1692	SSMH1646	SSMH1643	VIRGINIA RD	Vitrified Clay Pipe	8	62	None	None	2	None
SSGM1697	SSMH1660	SSMH1661	CIRCLE C ST	Vitrified Clay Pipe	6	144	Roots in multiple joints	Broken w/soil visible @ 140'	5	Excavate and Replace w/8"
SSGM1698	SSMH1661	SSMH1662	CIRCLE C ST	Vitrified Clay Pipe	6	190	Roots in multiple joints	Fracture Hinge 4 from 85'-88', Fracture longitudinal @ 149', Broken w/soil visible @ 187	5	Excavate and Replace w/8"
SSGM1687	SSMH1657	SSMH1642	MAIN ST	Vitrified Clay Pipe	6	18	None	Large offset @ 5', 40% Collapsed 8'-13', Broken w/soil visible @ 17', 100% blocked @ 18', Abandon survey @ 18'	5	Abandon
SSGM1699	UNKNOWN BOTTOM RIGHT PIPE	SSMH1642	MAIN ST	Vitrified Clay Pipe	6	55	None	Multiple offsets, 90% blocked @ 53', Abandon survey @ 53'	2	Abandon
16	UNKNOWN BOTTOM LEFT PIPE	SSMH1642	MAIN ST	Vitrified Clay Pipe	6	30	Abandon survey due to debris	Crack multiple @ 20', Fracture longitudinal @ 26'	2	Abandon
17	SSMH1642	SSMH1642A	MAIN ST	Vitrified Clay Pipe	6	104	Roots in multiple joints, Heavy encrustation @ multiple joints	Fracture spiral @ 10', Sag 60'-68', Large offset @ 94'	4	Pipe burst 6"-8"

Sewer Line I.D. Number	Upstream Manhole No.	Downstream Manhole No.	Location	Pipe Material	Pipe Diameter (in.)	Surveyed Length (ft.)	Operation & Maintenance Defects / Comments	Structural Defects / Comments	Rating	Rehabilitation Recommendations
18	SSMH1642A	SSMH1648	VIRGINIA RD	Vitrified Clay Pipe	6	256	Roots in multiple joints	None	3	Pipe burst 6"-8"
SSGM1624	SSMH1679	SSMH1676	DOGWOOD LN	Vitrified Clay Pipe	8	190	Roots in multiple joints, Infiltration stains @ multiple joints, Infiltration runners @ multiple joints	None	4	Install 8" CIPP Liner
SSGM1625	SSMH1677	SSMH1676	YANCEY RD	Vitrified Clay Pipe	8	265	Roots in multiple joints	Cracks multiple 260'-265'	3	Install 8" CIPP Liner
SSGM1666	SSMH1609	SSMH1610	5TH C ST	Vitrified Clay Pipe	6	157	Roots in multiple joints	Small hole @ 124', Cracks multiple @ 124', Crack longitudinal @ 126', Material change to PVC 153'-157'	3	Pipe burst 6"-8"
SSGM1652	SSMH1636	SSMH1637	VIRGINIA DR	Vitrified Clay Pipe	12	476	Roots in multiple joints, Infiltration stains @ multiple joints, Infiltration drippers @ 20' & 96', Infiltration runners @ 231', Intruding tap @ 231'	Multiple cracks and fractures, Broken longitudinal w/ soi visible 66'-72', broken w/void visible @ 71', Fracture hinge 3 from 323'-327', Sag 400'-418', Fracture longitudinal 429'-433'	5	Point Repair 64'-74', Cut intruding tap @ 231', Install 12" CIPP Liner, Install 4 Lateral Seals
SSGM1639	SSMH1668	SSMH1669	OAKWOOD DR	Vitrified Clay Pipe	8	72	None	Intruding sealing ring and grout @ 68'	3	Robotically remove Sealing ring and grout @ 68', Install 4' CIPP sectional liner @ 68'
SSGM1627	SSMH1675	SSMH1675A	YANCEY RD	Vitrified Clay Pipe	12	221	Roots in multiple joints	None	3	Install 12" CIPP Liner
SSGM1627A	SSMH1675A	SSMH1673	YANCEY RD	Vitrified Clay Pipe	12	171	Roots in multiple joints	Fracture Circumferential @ 168'	3	Install 12" CIPP Liner
SSGM1628	SSMH1673	SSMH1674	YANCEY RD	Vitrified Clay Pipe	12	52	None	None	2	None
SSGM1629	SSMH1674	SSMH1680	YANCEY RD	Vitrified Clay Pipe	12	402	Roots in multiple joints, Infiltration stained joint @ 372', Infiltration dripper @ 377' & 383'	None	4	Install 12" CIPP Liner
SSGM1642	SSMH1672	SSMH1680	OAKWOOD DR	Vitrified Clay Pipe	8	36	None	Material Change to DIP @ 17', Minor surface corrosion	2	None
SSGM1644	SSMH1696	SSMH1694	VICTORY DR	Polyvinyl Chloride	6	236	None	None	2	None
8	UNKNOWN	SSMH1657	CIRCLE LN	Vitrified Clay Pipe	6	1	None	Abandon survey 1' due to angle of pipe in MH	3	Abandon

The CCTV was concentrated on mains that scored as high priority based on the zoom camera results and/or mains that showed smoke leaks above ground. Therefore, we would expect that the poor condition would be confirmed by the mainline video inspection. The majority of pipes inspected were VCP (51 VCP segments, 2 PVC segments, and 1 DIP segment). The VCP was found to be in poor condition with severe O&M and structural defects. O&M defects consistently included root instruction through pipe joints, infiltration stains, active infiltration and joint encrustations. These O&M defects indicate that these pipes are susceptible to rain induced and groundwater infiltration. Structural defects were also quite severe including cracks, hinge fractures, holes and broken pipe, and severe offset joints. These structural defects could eventually result in complete collapse. Combined the O&M and structural defects increase maintenance, are sources of I/I, and jeopardize pipe structure and reliability.

SSGM1198 – Large Offset Joint

SSGM1197 – Separated Joint

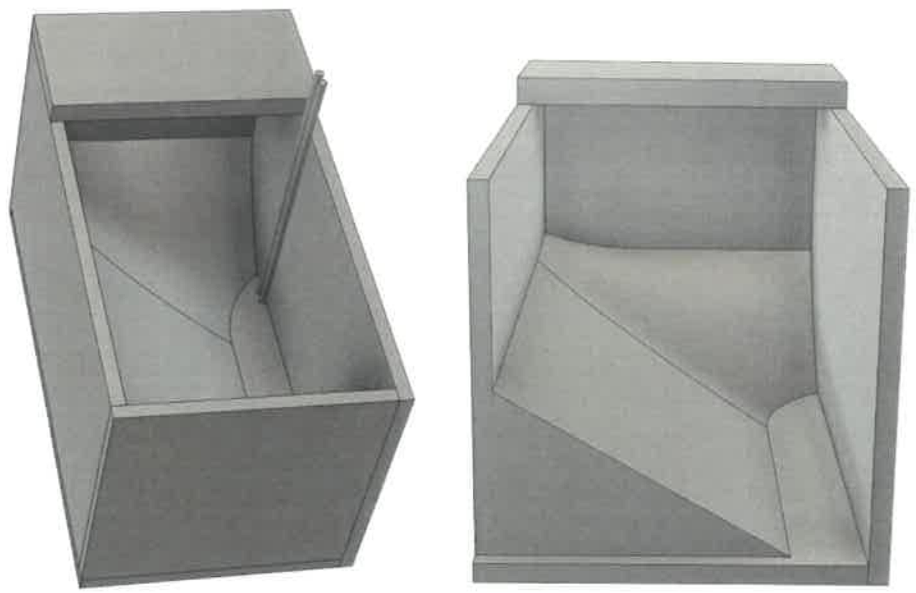
SSGM1261 – Hinge Fracture

F. Drawdown Test – Clinchfield Pump Station

During extreme wet weather events, I/I volume will exceed the capacity of the Clinchfield Pump Station and result in system surcharge and potential overflows. Hydrostructures performed a drawdown test of the Clinchfield pump station in order to estimate the average pumping capacity of the pump station. The results can be compared to design flows to determine if the station is under performing design capacity. Under performance can indicate pump wear or force main restrictions and the need for improvements.

A drawdown test consists of measuring the volume of wastewater pumped out of the wet well over a precise period of time (volume/time = rate of flow). First, the wet well dimensions must be accurately measured. The Clinchfield wet well is a more complicated geometry than most standard round or rectangle wet wells. Figure 2, below, shows a sketch of the wet well.

FIGURE 2: CLINCHFIELD WET WELL SKETCH



Our field crew and surveyor captured accurate measurements and the wet well was sketched with a 3D modeling program and AutoCAD to assist with our volume estimates. A test for each pump running independently and both pumps running simultaneously was performed. The water level drop was recorded for each test and the corresponding volume was calculated. Inflow into the wet well was also observed and calculated over a precise period of time. The rate of inflow is added to the pump drawdown rate. Table 6, below, details the results of the test.

TABLE 6: CLINCHFIELD PUMP STATION DRAWDOWN RESULTS

Pump	Volume (gals)	Time (minutes)	Drawdown Rate (GPM)	Inflow (GPM)*	Total Pump Flow Rate (GPM_
Pump 1	381	2	191	118	309
Pump 2	411	2	206	118	324
Pump 1&2	493	2	247	118	365
Pump 1&2 (second test)	523	2	262	118	380

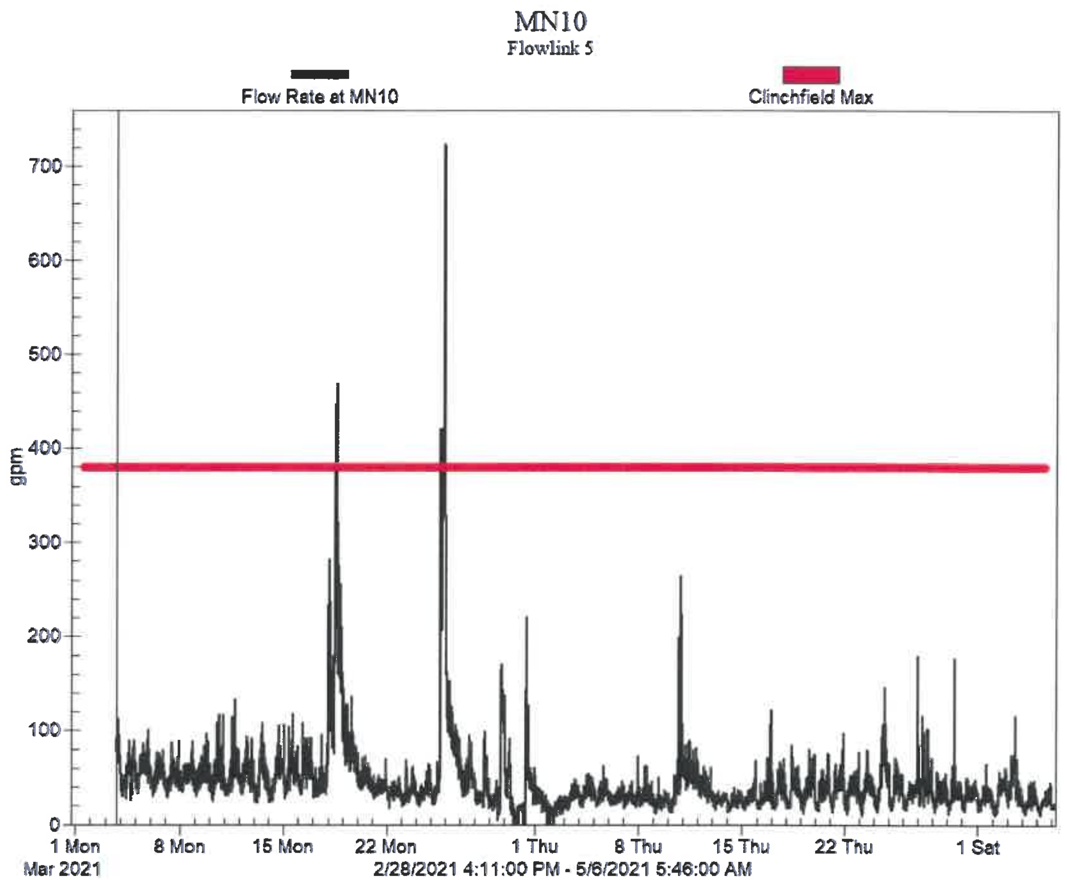
* *Inflow = 1,189 gallons filled over 10 minutes.*

The discharge rate for both pumps operating simultaneously shows only a slight improvement compared to a single pump operating alone. This likely indicates a pump imbalance or a restriction in the force main. The force main serving the pump station is 8-inch diameter pipe, which has a capacity of more than 700 gpm while not exceeding a velocity of 5 feet per second, so it does not appear that there is a force main capacity issue. At the measured flow rates shown in Table 6 above, the velocity in the force main is less than 3 feet per second so head loss should not be excessive. We recommend that a more in-depth hydraulic analysis be performed on the Clinchfield Pump Station to determine if it is operating at its maximum efficiency.

The Clinchfield basin was monitored during the System-wide Flow Monitoring and I&I Analysis, with flow meter MN10 being located one manhole upstream of the

Clinchfield pump station. Graph 1, below, shows the flow into the Clinchfield pump station over the course of the flow monitoring period in gallons per minute (black line). The red line is the maximum capacity estimate during the drawdown test with both pumps running simultaneously (380 GPM).

GRAPH 1: CLINCHFIELD INFLOW VERSUS MEASURED CAPACITY



As shown in Graph 1, flow into the Clinchfield pump station only exceeded the capacity of the pump station during the two major rain events observed during the monitoring period. Flow did not exceed the pumping capacity during minor rain events or during normal dry weather flow conditions. Based on this, we feel that this is more of an I-I problem than a pumping capacity problem and eliminating I-I through rehabilitating the collection system will reduce overflows in the Clinchfield basin.

IV. ALTERNATIVES EVALUATION

Several methods and technologies are available for the rehabilitation of sewer mains, service laterals, and manholes. This section discusses the available and most commonly recommended / implemented rehabilitation methods.

A. Sewer Main – Replacement / Rehabilitation

1. Cured-In-Place Lining

In the CIPP method of rehabilitation, a resin-impregnated felt liner is pulled or inverted through the original pipe, inflated with water and/or air to form it against the walls of the host pipe, and allowed to cure into a structurally sound "pipe within a pipe". Active service connections are reinstated using a remote controlled cutter machine, or can be reconnected using a saddle if the existing connection is defective.

The major advantage to CIPP rehabilitation is that it is virtually trenchless, meaning disruption to the surrounding area is minimized. Also, construction time for CIPP rehabilitation is much quicker compared to open-cut replacement. Typically, a CIPP lining contractor can rehabilitate an entire sewer main, including restoring service to customers, within one day. The major disadvantage is that it cannot eliminate alignment problems or offset joints. CIPP is so widely available now that it is typically less expensive than open-cut or other main line restoration methods.

The CIPP method is recommended in areas where damage to the pipe is widespread throughout the length of pipe.

- **Estimated Cost:** **8" – 12" = $30.00 - $65.00/LF**
  15" – 18" = $65.00 - $120.00/LF

2. Pipe Bursting

Pipe bursting is accomplished by guiding a pneumatic or hydraulic bursting head through the existing pipe, breaking it apart and displacing the fragments into the surrounding soil. Simultaneously, a new high-density polyethylene (HDPE) pipe is pulled in place by wrench to replace the original pipe.

There are several advantages to this method. Pipe bursting is semi-trenchless, it allows pipes to be increased by one or two nominal pipe sizes depending on conditions, and it can be used to repair areas where collapsed pipe or offset joints have created blockages that decrease the flow capacity of the pipe.

It is the most expensive of the trenchless rehabilitation methods, but remains competitive with open-cut replacement due to the reduction of environmental impacts, permitting, and extensive engineering design associated with open-cut replacement. Pipe bursting is recommended in areas where the original pipe is undersized, where the flow capacity has been reduced by collapses or offsets, and/or where numerous point repairs would be required to install a CIPP liner

- **Estimated Cost:** **6" to 8" = $60.00/LF**
  8" up to 12" = $65.00 - $100.00/LF
  12" up to 18" = $105.00 - $150.00/LF

3. Open-cut Replacement

This method of repair consists simply of excavating a damaged section of pipe and replacing it with a new pipe within the same trench. Historically, this has been the preferred method of repairing old sewer mains. It allows for an entirely new sewer system to be installed in accordance with current construction specifications and standards. However, with the development of various trenchless rehabilitation methods, the use of the open-cut replacement method has been greatly diminished. The major disadvantages with this method are the disruption of the surrounding area, risk of damaging other utilities, and slow construction time. Residents must cope with being without sewer service for an

extended period of time and traffic rerouting resulting from closed streets and blocked driveways.

- **Estimated Cost:** **8" – 12" = $65.00 - $125.00/LF**
  15" – 18" = $115.00 - $175.00/LF*

4. Open-cut Point Repairs

A point repair consists simply of excavating down to a damaged section of pipe and replacing the damaged section with new pipe. It is used when damage is isolated to one particular area of the pipe, generally less than twenty feet in length. It is also used to repair pipe collapses, sags, and/or offset joints prior to manhole-to-manhole trenchless rehabilitation by CIPP. It can be very disruptive to the surrounding area, especially if the pipe is deep or underneath pavement. It can also be extremely expensive depending upon the location and/or depth of the repair.

- **Estimated Cost:** **8" – 12" = $7,000 - $10,000**
  15" – 18" = $10,000 – $15,000

5. Internal CIPP Sectional Liner (CIPP Spot Repair)

Sectional cured-in-place spot repairs are ideal for patching holes and other isolated, non-deformed structural defects. Spot repair patches can be used for infiltration control when hydrophilic O-rings or caulk is used between the host pipe and ends of the repair patch. Most manufactures have repair patches available up to 42-inches and lengths of 2, 4, and 8-feet are common. Patches are fiberglass with epoxy resin or typical felt with vinylester resin.

Spot repairs are installed with a flow through bladder. The patch is secured to the inflatable bladder, pulled into place, the bladder pressurized to form the patch tightly to the pipe surface and allowed to cure ambiently. Because the bladder is flow through, little or no flow control is required during installation

- **Estimated Cost: 8" – 12" = $4,000 – $8,500**
  15" – 18" = $10,000 - $12,000

B. Manhole Rehabilitation and Repairs

This section discusses the different types of defects typically encountered in the manholes and the recommended methods of repair. Cost estimates are provided for each repair.

1. Pipe Connection Infiltration

Pipe connections between the manhole wall and the influent and effluent piping are sometimes found to be sources of infiltration and root intrusion. These connections may lack a boot (typically older brick manholes) and not be adequately grouted or the boot was not properly seated and tightened around the pipe during installation. Infiltration is especially prevalent in deeper manholes, where the hydrostatic pressure from high groundwater levels can cause significant leaks through relatively small cracks and holes.

We recommend that leaking pipe connections be sealed by injecting chemical grout pumped through drilled injection ports into the crack or void from the inside of the manhole. The grout will penetrate to the exterior of the manhole, where it will fill any voids and seal the leak from the outside. After the void has been filled with chemical grout, cementitious grout should be used to seal the pipe connection from the inside of the manhole.

- **Estimated Cost: $300.00 per Pipe Connection (Chemical Grout Injection)**
- **Estimated Cost: $150.00 per Pipe Connection (Cementitious Grout Only)**

2. Section Joint Infiltration

Section joint infiltration is a result of improper installation of pre-cast manholes. The barrel section joints were most likely not wrapped on the outside with butyl rubber mastic and not grouted on the inside. These joint leaks allow groundwater or roots to easily infiltrate into the manhole.

To repair the joints between pre-cast sections, we recommend applying cementitious grout to the section joint. Any active leaks at the joint should first be stopped by injecting chemical grout as described in the pipe connection section above. After the joint area is dry, cementitious material should be hand applied and troweled to a smooth finish to reinforce the repair.

- **Estimated Cost: $200.00 per Section Joint (Chemical Grout Injection)**
- **Estimated Cost: $100.00 per Section Joint (Cementitious Grout only)**

3. **Poor/Non-existent Bench and Channel**

Deterioration of the bench and channel can inhibit flow into or through the manhole and cause debris buildup. We recommend eroded manhole benches and channels be repaired using a two-step process. First, the bench and channel should be reconstructed using bricks and concrete mortar. Once the mortar sets, the repair can be completed by applying a layer of calcium aluminate or other Hydrogen Sulfide resistant material, which is troweled to a smooth finish.

- **Estimated Cost: 500.00 per Bench and Channel.**

4. **Leakage Below Manhole Frame**

The joint between the manhole frame and the cone section is a weak point that can allow significant quantities of water and sand to infiltrate into the collection system. This problem is especially prevalent in manholes located in paved areas where traffic loads can loosen or break the seal between the frame and cone. As

the problem worsens, it can also cause pavement cracking and settling around the manhole and allow sand and grit infiltration.

To address the problem of leaking manhole frames, we recommend that a flexible sealing material be used to seal the joint between the frame and cone section. Because they are flexible, they move when exposed to traffic loads, freeze/thaw expansion and contraction, and differential settlement in the surrounding soil.

- **Estimated Cost: $350.00 per manhole**

5. **Frame Below Grade**

Buried manholes and manholes with a rim elevations lower than the surrounding grade need to be raised. Because these manholes are below grade, they are subject to inflow as a result of rain water runoff. Buried manholes provide no access unless uncovered and raised. The addition of grade adjustment rings is the quickest and least expensive way to raise manhole rims.

- **Estimated Cost:$400.00 - $1,200 per manhole depending on depth and ground cover**

6. **Multiple Defects / Entire Manhole Failing**

As the mortar in brick manholes deteriorates, it begins to crack and loosen. The resulting voids are easy entry points for groundwater infiltration and roots. They also reduce the structural stability of the manholes, increasing the likelihood of collapse. To repair such extensive damage on brick manholes, the best long term alternative to costly excavation and replacement is to rehabilitate the manhole using a sprayed-applied cementitious coating resistant to hydrogen sulfide damage. For manholes subjected to hydrogen sulfide, the manholes should receive a top coat of epoxy liner as an additional layer of protection. Pre- cast manholes with surface deterioration caused by exposure to hydrogen sulfide gas are also a candidate for rehabilitation using a combination of a cementitious back-build and epoxy top coat.

- **Estimated Cost: $250 per vertical foot cementitious liner**
  $500 per vertical foot epoxy liner

C. Service Lateral Rehabilitation

The following section discusses service lateral rehabilitation methods including connecting service laterals to the main line. Cost estimates for each method are provided based on similar rehabilitation projects.

1. Open-cut Replacement

This method of repair consists of excavating the defective service lateral and replacing it with a new lateral within the same trench. This method is the most cost effective to rehabilitate shallow service laterals in low traffic areas. Although

- **Estimated Cost: $1,200.00 per service lateral**

(If the replacement of the lateral includes the replacement or installation of a cleanout and reconnection to the main line, the total cost is usually between $2,000 and $3,000.)

2. CIPP Lateral Seal

Full Wrap Lateral Seal rehabilitation is a trenchless service connection rehabilitation method used to seal leaking service connections and restore structurally integrity. Full wrap lateral seals are recommended when conflicts or depth increase the difficulty and cost of excavation. A full wrap later seal includes a polyester felt tube with a sewn flange that covers up to 16-inches of the mainline in a full wrap. The use of hydrophilic sealants and silicate resins

it obviously requires more excavation, it is the most frequently recommended method for service rehabilitation. Service lateral replacement is only performed from the sewer main to the right-of-way (location of the cleanout).

- **Estimated Cost: $2,000.00 per service lateral**

(If the replacement of the lateral includes the replacement or installation of a cleanout and reconnection to the main line, the total cost is usually between $3,000 and $5,000.)

3. **Pipe Bursting Service Laterals**

Pipe bursting of services is accomplished using the same process as pipe busting main lines. A pneumatic or hydraulic bursting head is guided through the existing service lateral, breaking it apart and displacing the fragments into the surrounding soil. Simultaneously, a new high-density polyethylene (HDPE) pipe is pulled in place to replace the original pipe. An entry point must be excavated behind an existing cleanout or at the point which a cleanout will be installed (right-of-way). An exit point must also be excavated at the sewer main where the existing service lateral is connected. This pit is used to guide the bursting head and to reconnect the service lateral.

There are several major advantages of the pipe bursting method. First, the result is a completely jointless service lateral as all joints are fused from the main line to the clean out. Second, it can be used to rehabilitate any service lateral. The bursting head can easily break cast iron pipe and is not restricted by offset joints in clay service laterals. Third, it has been cost competitive with the open-cut replacement method on recent bids. The only disadvantage of this method is the excavation required at the entry and exit pits, which is far less excavation required than if the entire service was excavated and replaced. Less excavation translates to less pavement cutting and removal, and thus, less asphalt replacement. The cost of pavement removal/asphalt replacement for pipe bursting verses excavation and replacement could make pipe bursting the least expensive option, especially if the service is long and/or under several layers of concrete and asphalt.

applied to the backside of the full warp connection enhances the watertight seal. Typically, this wrap includes 2-feet of lateral liner to extend up into the service lateral. Ambient cure polyester or vinylester resins are used. Diameters of 4- inch and 6-inch service lateral rehabilitation are possible with 8-inch to 24-inch mainline wraps.

During installation, the mainline must be cleaned and free of all debris. Roots and other debris are removed from the lateral connection. The full wrap lateral seal is loaded on a silicone bladder installation lateral train, and inserted through the downstream manhole. When the lateral train reaches the connection (as confirmed by standard CCTV equipment), the bladder is inflated and held at the recommended air pressure while the connection seal is allowed to cure. Once cured, the bladder is removed and the service is returned it use.

- **Estimated Cost: $ 4,500.00 per CIPP lateral seal**

4. **Reconnecting Laterals to Main Line**

   This process consists of reconnecting a lateral to a sewer main by use of a saddle or fitting. It is used to repair break-in taps or other defective connections, which are very common in older collection systems. These connections are very susceptible to ground water infiltration and root intrusion. It is recommended that break-in taps be replaced by a saddle connection.

   - **Estimated Cost: $1,500.00 per service lateral**

5. **Installation of Clean-outs**

   Many older service laterals were installed without clean-outs at the property line (right-of-way). Without them, it can be very difficult to remove blockages that can occur in the laterals. If a clean-out on private property is used, it can be difficult to determine whether the responsibility for removing a blockage lies on the property owner or the municipality. To allow for easier maintenance, we recommend that all service laterals have clean-outs installed at the property line or edge of right-of-way.

   - **Estimated Cost: $500.00 per clean-out**

V. REPAIR / REPLACEMENT / REHABILITATION (RRR) RECOMMENDATIONS WITH COST ESTIMATES

There are two types of rehabilitation strategies currently being used by system owners: comprehensive rehabilitation and selective rehabilitation. Comprehensive rehabilitation consists of focusing on a specific basin or sub-basin, and repairing all manholes, sewer mains and defective service laterals within the area. Comprehensive rehabilitation is more expensive, but this approach removes most maintenance problems and has been proven to significantly reduce inflow and infiltration. Selective rehabilitation consists of fixing the highest priority (worst condition) sewer mains and manholes throughout the system and typically does not include rehabilitating services laterals. This approach is recommended if an owner wants to rehabilitate the worst scoring assets (manholes and sewer mains) throughout the entire sewer collection system in order to maximize funding and eliminate severe defects that compromise structural integrity and allow significant I/I. Selective rehabilitation does eliminate immediate structural and maintenance issues but typically does not achieve as much I/I reduction as comprehensive rehabilitation.

Since the Clinchfield basin is large and the assessment results have identified a surplus of repairs, selective rehabilitation is recommended.

A. RRR Recommendations

1. Main Line Repairs

The specific recommended repairs for each line segment are listed on the CCTV Inspection and Condition Summary Spreadsheet, above, in Section III. Cured-in-Place Pipe lining is the preferred RRR method and was recommended for defective pipes where widespread structural damage and infiltration has been identified. Point repairs were recommended to repair broken pipe, offset joints, isolated deformations, or partially collapsed sections of pipe and when necessary to repair structural issues to allow for the installation of cured-in-place pipe liner. Pipe bursting is recommended when multiple point repairs would be required in order for the liner to be successfully installed and / or when upsizing from 6-inch to 8-inch is recommended.

Excavation and Replacement (open-cut) was recommended when severe structural damage and infiltration has been identified, the existing pipe is 6-inch and should be upsized to 8-inch, and the existing pipe is too close to houses and building to safely pipe burst. These pipes are primarily located behind Circle C Street and between Church Street and Ridge Road.

Sectional cured-in-place liners were recommended for infiltration control when infiltration was isolated to one spot (joint, hole, etc.) in the sewer main.

Full wrap service lateral seals are recommended to address defective / leaking service lateral connections.

2. Smoke Test Defect Repairs

The repair of smoke test defects is a good way to reduce inflow and rain induced infiltration. The majority of defects identified are related to main line, manholes, and sewer laterals. The rehabilitation recommendations address repair of these assets.

3. Manhole Repair / Rehabilitation

In our experience, rehabilitating manholes significantly reduces I/I during wet weather. As the mortar deteriorates in a brick manhole, the manhole becomes more prone to rain induced infiltration percolating through the ground and entering through the deteriorated mortar joints. Failing brick manholes are scheduled to be lined with calcium-aluminate cementitious liner at a specified thickness of 1-inch. Chemical injection grout must be used to stop active leaks prior to the application of the cementitious liner. Flexible frame seals should be installed on rehabilitated manholes located in the pavement and subject to traffic.

Leaking manhole components in pre-cast structures should be injected with chemical grout to stop infiltration and grouted with repair mortar to reinforce the repair.

All manhole repairs are detailed in the Manhole Repair Schedule included in Appendix B.

B. COST ESTIMATES

The NASSCO rating system is the most accepted method to prioritize the sewer mains and manholes within a sewer collection system. This prioritization method will allow the City to utilize the available funds to focus on the worst problem areas first, then proceed to other lower priority areas as additional funding becomes available. For situations similar to the Clinchfield Basin when I-I reduction is the major goal of a project, we recommend that all priority 3-5 defects be addressed. The reason for this is many significant I-I defects receive a NASSCO defect rating of 3 so not including the priority 3 repairs can significantly reduce the effectiveness of the project in eliminating I-I. The following tables present construction cost estimates for the recommended priority 5, priority 4 and priority 3 lines within the study area. Priority 4 and 3 manhole rehabilitation costs are also presented below.

TABLE 7: PRIORITY 5 – SEWER MAIN RRR COST

ITEM	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT PRICE	TOTAL
1	CIPP Rehabilitation of 8" Sewer	LF	1,120	$50.00	$56,000.00
2	CIPP Rehabilitation of 12" Sewer	LF	480	$95.00	$45,600.00
3	Pipe burst existing 6" to 8"	LF	450	$60.00	$27,000.00
4	Pipe burst existing 10" to 10"	LF	500	$75.00	$37,500.00
5	Point Repair 8" Sewer Pipe up to 12' in Length Including Service Connection	EA	3	$10,000.00	$30,000.00
6	Point Repair 12" Sewer Pipe up to 12' in Length Including Service Connection	EA	1	$12,000.00	$12,000.00
7	Excavate and Replace 8" with 8" Sewer	LF	25	$150.00	$3,750.00
8	Excavate and Replace 6" with 8" Sewer	LF	580	$100.00	$58,000.00
9	Bore and Jack 16" Steel Casing	LS	1	$45,000.00	$45,000.00
10	Install New 4' Dia. MH	EA	4	$9,500.00	$38,000.00
11	Cut Intruding Services, Sealing Ring, or Grout Using Robotic Cutter	EA	6	$400.00	$2,400.00

12	Reinstate Service Using Robotic Cutter and Brush Smooth 100%	EA	6	$250.00	$1,500.00
13	Reinstate Service 50% Using Robotic Cutter	EA	4	$225.00	$900.00
14	Disconnect/reconnect service lateral for Pipe burst or Excavate and Replace of Main	EA	5	$1,200.00	$6,000.00
15	Install CIPP Service Lateral Seal with 8" to 12" Main Line Connection (including approx. 1-foot or lateral liner)	EA	4	$2,500.00	$10,000.00
16	Replace 8" Outside Drop	EA	1	$8,000.00	$8,000.00
17	Asphalt Cut and Patch	SY	100	$200.00	$20,000.00
18	Concrete Curb and Gutter/sidewalk	LF	20	$150.00	$3,000.00
19	Restoration	LS	1	$7,000.00	$7,000.00

Priority 5 Sewer Main RRR Cost	$411,650.00
Contingencies (10%)	$41,165.00
Engineering and Inspection (15%)	$61,747.50
Total Priority 5 Rehab Project Cost	**$514,562.50**

TABLE 8: PRIORITY 4 – SEWER MAIN RRR COST

ITEM	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT PRICE	TOTAL
1	CIPP Rehabilitation of 8″ Sewer	LF	1,100.0	$50.00	$55,000.00
2	CIPP Rehabilitation of 12″ Sewer	LF	405.0	$95.00	$38,475.00
3	Pipe burst existing 6″ to 8″	LF	800.0	$60.00	$48,000.00
4	Point Repair 8″ Sewer Pipe up to 12′ in Length Including Service Connection	EA	1.0	$10,000.00	$10,000.00
5	Excavate and Replace 6″ with 8″ Sewer	LF	400.0	$100.00	$40,000.00
6	Bore and Jack 16″ Steel Casing			$45,000.00	$0.00
7	Install New 4′ Dia. MH	EA	3.0	$9,500.00	$28,500.00
8	Cut Intruding Services, Sealing Ring, or Grout Using Robotic Cutter	EA	2.0	$400.00	$800.00
9	Reinstate Service Using Robotic Cutter and Brush Smooth 100%	EA	10.0	$250.00	$2,500.00
10	Disconnect/reconnect service lateral for Pipe burst or Excavate and Replace of Main	EA	6.0	$1,200.00	$7,200.00
11	Asphalt Cut and Patch	SY	50.0	$200.00	$10,000.00
12	Concrete Curb and Gutter/sidewalk	LF	20.0	$150.00	$3,000.00
13	Restoration	LS	1.0	$7,000.00	$7,000.00

Priority 4 Sewer Main RRR Cost	$250,475.00
Contingencies (10%)	$25,047.50
Engineering and Inspection (15%)	$37,571.25
Total Priority 4 Rehab Project Cost	**$313,093.75**

TABLE 9: PRIORITY 3 – SEWER MAIN RRR COST

ITEM	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT PRICE	TOTAL
1	CIPP Rehabilitation of 8" Sewer	LF	1,970.0	$50.00	$98,500.00
2	CIPP Rehabilitation of 12" Sewer	LF	392.0	$95.00	$37,240.00
3	Pipe burst existing 6" to 8"	LF	420.0	$60.00	$25,200.00
4	Point Repair 8" Sewer Pipe up to 12' in Length Including Service Connection	EA	1.0	$10,000.00	$10,000.00
5	Install New 4' Dia. MH	EA	1.0	$9,500.00	$9,500.00
6	Cut Intruding Services, Sealing Ring, or Grout Using Robotic Cutter	EA	1.0	$400.00	$400.00
7	Reinstate Service Using Robotic Cutter and Brush Smooth 100%	EA	37.0	$250.00	$9,250.00
8	Disconnect/reconnect service lateral for Pipe burst or Excavate and Replace of Main	EA	4.0	$1,200.00	$4,800.00
9	Install 4' CIPP Sectional Liner Repair Patch	EA	2.0	$3,500.00	$7,000.00
10	Asphalt Cut and Patch	SY	20.0	$200.00	$4,000.00
11	Concrete Curb and Gutter/sidewalk	LF	20.0	$150.00	$3,000.00
12	Restoration	LS	1.0	$7,000.00	$7,000.00

Priority 3 Sewer Main RRR Cost	$215,890.00
Contingencies (10%)	$21,589.00
Engineering and Inspection (15%)	$32,383.50
Total Priority 3 Rehab Project Cost	**$269,862.50**

TABLE 10: PRIORITY 3 & 4 MANHOLE REHABILITATION COST

ITEM	ITEM DESCRIPTION	UNIT	ESTIMATED QUANTITY	UNIT PRICE	TOTAL
1	Complete Rehabilitation w/ 1-Inch Cementitious Liner	VF	464.0	$400.00	$185,600.00
2	Inject Sectional Joint with Chemical Grout	EA	7.0	$450.00	$3,150.00
3	Inject Lift Hole with Chemical Grout	EA	2.0	$200.00	$400.00
4	Inject Pipe Connection with Chemical Grout	EA	3.0	$250.00	$750.00
5	Grout Chimney	VF	20.0	$450.00	$9,000.00
6	Grout Sectional Joint	EA	3.0	$350.00	$1,050.00
7	Grout Pipe Connection	EA	3.0	$250.00	$750.00
8	Grout Lift Hole	EA	6.0	$150.00	$900.00
9	Grout 4' Precast Cone Section	VF	4.0	$400.00	$1,600.00
10	Grout Patch Reinforcing Steel	EA	2.0	$400.00	$800.00
11	Build Bench and Invert	EA	12.0	$750.00	$9,000.00
12	Reset Manhole Frame	EA	2.0	$600.00	$1,200.00
13	Replace Existing Frame and Cover	EA	1.0	$1,500.00	$1,500.00
14	Raise Manhole to Grade	EA	3.0	$1,500.00	$4,500.00
15	Seal Frame	EA	5.0	$500.00	$2,500.00
16	Install 8" PVC Inside Drop	EA	1.0	$5,000.00	$5,000.00

Priority 3 & 4 Manhole Rehab Cost	$227,700.00
Contingencies (10%)	$22,770.00
Engineering and Inspection (15%)	$34,155.00
Total Manhole Rehab Project Cost	**$284,625.00**

VI. CONCLUSION

This report presents the data, results, and recommendations from assessment of the Clinchfield sewer basin. The rehabilitation recommendations and cost estimates included in this report were presented in a format to aid City staff in phasing projects to meet budget requirements and begin with the RRR of the highest priority assets.

We encourage the City to move forward with the recommendations presented in this study. Following these recommendations will reduce I/I treated at the treatment facilities, reduce the probability of SSOs at the Clinchfield Pump Station, and eliminate a significant number of O&M issues. Furthermore, tending to these issues now before they deteriorate further will help prevent future failures and subsequently more expensive emergency repairs

Hydrostructures, P.A. has extensive experience with rehabilitation engineering and we would welcome the opportunity to assist the City with the implementation of RRR proposed in this report