BLUEFIELD SANITARY BOARD
MERCER COUNTY, WEST VIRGINIA

SANITARY SEWER EVALUATION STUDY

AUGUST 2015

THRASHER ENGINEERING PROJECT # 505-020-1363

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1. INTRODUCTION

In September, 2014, the Thrasher Group, Inc. (Thrasher) was selected to conduct a Sanitary Sewer Evaluation Study (SSES) by the Bluefield Sanitary Board (BSB). The evaluation performed by Thrasher was based upon potential problem areas known by BSB in their gravity sanitary sewer system. BSB is conducting this study in an effort to reduce Inflow and Infiltration (I&I) into the collection system which ultimately flows to both the ADA and Westside wastewater treatment plants.

This study will define problems and problem areas found through the SSES, and discuss recommendations and suggestions for reducing I&I.

2. Executive Summary

Thrasher worked hand in hand with the BSB to identify I & I areas throughout the collection system. Areas without cost estimates need further studies completed to generate more exact repair estimates. Areas with cost estimates are areas with highest I&I flows and areas that need repair or complete replacement to get rid of the most I&I from BSB's system. The areas have been broken down and summarized below.

MIDWAY

Thrasher performed a video camera investigation and smoke tested this area. Based on the findings from the smoke testing and camera investigations, Thrasher recommends BSB remove gutter downspouts, replace main line and laterals, disconnect storm drains from sanitary system, remove all ventilated manhole lids and replace with water tight manhole lids, and perform further I & I investigation in this area. The estimated repair cost of this area is $1,505,400.

OAKHURST AVENUE, EDGEWOOD AND HEATHERWOOD ROADS

After reviewing the flow meter data , the estimated I&I from Edgewood and Heatherwood Road contributes approximately 95% of the I&I at the outlet of the Oakhurst Sewer shed. Therefore, correcting I&I problems in the Edgewood and Heatherwood areas, will potentially lower sanitary sewer flows from the Oakhurst System. Thrasher completed a camera investigation study and smoke test study on this area, and all problems identified were added to the GIS database of the City. After completing the study on this area, Thrasher recommends that BSB remove connected gutter downspouts, remove connected storm drains from the sanitary system, replace 8" and 6" main lines with new 8" main lines, remove and replace ventilated manhole lids with water tight manhole lids. The estimated repair cost of this area is $1,160,835.

UNION STREET

After completing the smoke test study on this area, Thrasher performed video camera investigation on approximately 10% of the main lines on Union Street. As a result of these studies, Thrasher recommends that BSB remove gutter downspouts from the sanitary system, replace the 8" main line, remove connected storm drains from the sanitary system, repair or replace leaking manholes, remove and replace ventilated manhole lids with water tight manhole lids, and perform further I & I investigation of this area. The estimated repair cost of this area is $1,518,010.

WINTERCREEK DRIVE

The flow meter data shows an estimated 62.15 GPM of I&I in the Wintercreek Drive system. The smoke test didn't identify many problems, due to sags in sewer lines and having high levels of flow during the smoke test. Thrasher recommends further video camera investigation of this area to determine the condition of lines and determine replacement of the system or repair. Thrasher recommends removal and replacement of ventilated manhole lids with water tight manhole lids. The estimated repair cost of this area is $530,010.

FREDERICK STREET

Through the smoke test, Thrasher found 27 potential I&I problems in this area. Additional problems were found through video camera investigations, and are listed in the GIS database of the City. Thrasher recommends removing connected storm drains from the sanitary system, removing gutter downspouts, repairing or replacing leaking manholes, and replacing broken main lines. The estimated repair cost of this area is $259,935.

COLLEGE AVENUE

Thrasher recommends all connected storm drains be removed from the sanitary system, broken lines be repaired or replaced, disconnect gutter downspouts from sanitary system, repair and replace leaking manholes, replace all ventilated manhole lids with water tight manhole lids, and perform further I&I studies in this area. Thrasher also recommends correcting I&I problems on Frederick Street, Oakhurst Avenue, and Union Street to decrease flows on College Avenue. Upon reviewing the flow meter data collected along College Avenue, the majority of the I&I problems on College Avenue are coming from the Union Street and Oakhurst Avenue areas. These two areas contribute an estimated 130 GPM of I&I flowing from these areas during rain events. The other areas studied in this section that flow into College Avenue only produce an estimated 73 GPM of I&I during rain events. The Frederick Street system also flows into the College Avenue main line, producing 43 GPM of I&I.

GRASSY BRANCH ROAD

Thrasher performed a smoke test on the Grassy Branch Road area. During the smoke test, the main line along Grassy Branch Road had high flow levels making it difficult for smoke to travel through the lines and making the smoke test ineffective. Thrasher recommends repairing / replacing broken sections of line and leaking manholes. Thrasher recommends further studies on this area to find I&I problems and to prepare repair estimates of this area.

HORTON ROAD

The smoke test on Horton Road did not identify enough potential I&I problems to make up for the amount of I&I shown on the flow meter data. Thrasher located one (1) broken lateral line during the smoke test. After not finding any problems from the smoke test, Thrasher began opening manhole lids in this area after a rain event, and tracked the problem to where the Horton Road line goes under Route 460, and was unable to find any manholes after this point. Thrasher recommends more I & I investigation in this area.

TIFFANY MANOR

The 8" line at the outlet of the Tiffany Manor sewer shed was flow monitored. The flow monitor results showed an I&I problem in this area. Thrasher recommends further I & I investigation in this area.

NORTH SIDE

The North Side was smoke tested, video camera investigated and flow monitored during this SSES study. Thrasher recommends disconnecting storm drains from the sanitary system, repairing or replacing broken lines. Thrasher studied part of the North Side Area, and recommends further studies throughout the rest of this area.

VIRGINIA AVENUE

Thrasher performed video camera investigations and smoke testing on the Virginia Avenue area. This area has a force main from another area flowing into it. Thrasher recommends further studies of this area and the area from where the sewage is being pumped.. Thrasher also recommends removing and replacing any ventilated manhole lids in this area with water tight manhole lids, along with removing connected gutter downspouts.

MOUNTAIN LANE

Thrasher smoke tested and flow monitored the Mountain Lane area. The flow meter installed at the end of the Mountain Lane line kept being pushed out of the line due to high flow levels and was not able to collect accurate flow data. Thrasher recommends repairing / replacing the broken lines in this area, along with repairing the leaking manhole and removing connected storm drains. Thrasher recommends further studies on this area to investigate conditions of existing lines.

3. SCOPE OF INVESTIGATIVE WORK

The scope of investigative work was discussed and agreed upon with BSB. Problem areas were identified by BSB, and investigations of these areas were performed accordingly. This study consisted of flow monitoring, smoke testing, and video camera inspection of specific drainage areas identified by BSB. The flow monitoring determined whether there was an I&I problem in the area, based on a comparison of flow data to rainfall data. Each area identified as a problem area was then smoke tested and problems found were located through GPS and loaded into the City GIS database. Areas where I&I issues were not found through the smoke test were then video camera inspected to identify problems and document conditions of existing lines. BSB has approximately 150 miles of sanitary sewer lines. During this study, approximately 50 percent of the system was evaluated.

The methods used to identify I&I problems are listed below and will be further described in this report.

- GIS mapping of existing system
- Flow Metering Smoke testing
- Video Camera Investigation

This SSES report identifies I&I problems in areas of the gravity collection system. Improvement projects are being proposed in this report which will reduce I&I in the system.

4. FLOW MONITORING

A. Narrative

As part of the SSES study, a determination was needed for dry weather flow rates and flow rates resulting from storm events. Thrasher installed flow meters to determine actual flows within the

system in various potential problem areas. After each flow meter had received enough rainfall, the data was retrieved and the flow meters were relocated. The flow meters were installed between September 2014 and February 2015. During this study, Thrasher installed flow meters in 27 different locations throughout BSB's system. The flow meter data was compared to rainfall data to determine I&I problems and the amount of I&I flows in each location. This information was used to determine if the area needed further investigation. Graphs were created from the flow meter data, showing rainfall vs. daily flow vs. average flow. In most graphs, there was a direct correlation between rainfall and spikes in daily flow, which indicates an I&I problem. Flow monitoring data collected from this study, has been entered into the GIS database of the City, and digitally attached to each manhole investigated.

During the time flow meters were installed, each was inspected periodically for any issues that could cause the meter to record false readings. One meter, in particular, placed on Mountain Lane in Bluefield, Virginia, was continuously pushed out of the 10" PVC sanitary line from I&I flows, which caused lack of flow meter data for this location. Flow meter graphs for each location are attached in the City's GIS database.

B. Daily Flow Versus Rainfall Analysis

Each flow meter setup produces readings for daily flow. These daily flow amounts were uploaded into excel spreadsheets along with rainfall data for the period the flow meter was installed. Graphs were then created to show correlation of rainfall and daily flow. Daily Flow Versus Rainfall Analysis graphs are attached in Appendix A of this report.

C. Amount of I&I Per Area Analysis

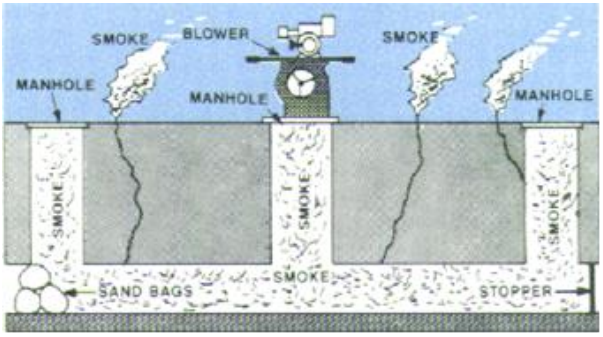
In each area where flow meters were installed, Thrasher was able to do an analysis on estimated amounts of I&I. Using the flow meter data, Thrasher estimated amounts of I&I by taking an average of peak flows during rain events, using Equivalent Dwelling Unit (EDU) counts to find average sanitary flow, and subtracting the two to find the estimated amount of I&I. This estimate of I&I was used to find BSB's highest priority problem areas to repair. This data was then used to calculate an estimated amount of savings from plant and pump station operations by reducing I&I flows in these areas. Each flow metered area is broken down in the Recommendations section of this report.

5. SMOKE TEST

A. Narrative

One of the methods Thrasher utilized to aid in determining the extent of I&I is the smoke testing method. Smoke testing is a cost effective method to locate a number of ways that I&I may be entering into the sanitary sewer. The following are some common ways I&I can be found entering the sewer system.

1. Downspouts
2. Broken main line and service lateral pipes
3. Faulty Manholes
4. Storm Drains
5. Driveway and yard drains
6. Faulty Cleanouts



Thrasher utilized the findings of the flow monitoring to determine which areas of the existing collection system to smoke test. The areas picked for flow monitoring were then smoke tested based upon discussions with the BSB Staff. Approximately 50% of Bluefield's sanitary system was smoke tested during this study. Problems found during the smoke test were GPS located along with pictures, addresses, and description of problems. The information collected was entered into the City GIS database.

6. VIDEO CAMERA INVESTIGATION

A. Narrative

Video camera investigation was used to further investigate potential problem areas in the BSB system. During this study, 14,974 linear feet of gravity sewer lines were investigated. Camera investigations provide video and pictures of defects along with location of the problems within the pipe. Video camera inspection can also find potential maintenance problems such as roots, grease, and other blockages in lines. Each line was documented by manhole number that the

camera was placed into, and linear feet of line distance the camera traveled from manhole to manhole. During this study, approximately 10% of problem areas were investigated to give good representations of the conditions of lines in these areas, and to help pin point areas I&I problems. The problems found from these investigations have been located and separated by problem type and entered into the CCTV module in the City GIS database.

7. GIS

A. Narrative

The BSB provided Thrasher's GIS Personnel with AutoCADD drawings and other data to import into a geodatabase. This database contains the spatial location of assets, such as manhole and line locations, along with additional attribute data, such as: asset conditions, size, material, etc. This base map then allowed Thrasher to perform the study of the system.

Manholes, which had flow meters placed in them, have been identified in the GIS database. An attribute table was created and linked to the manholes that housed the flow meters, with the installation and removal dates of the flow meters. A hyperlink to the PDFs showing the graphs of the flow rate, level, and total flow was added to the table for ease of reference.

The flow meter data allowed BSB and Thrasher to determine the best areas to focus resources for smoke testing. During the smoke testing, the problem location and the problem description was collected through handheld GPS data collectors. After the smoke test data was complete, the data was then added to the geodatabase and used to create maps and reports for ease of reporting problem locations. BSB personnel were also able to mark whether a problem had been corrected or not. This will allow for better visual representation of where problems have been corrected or need corrected, along with showing where problems have occurred in the past.

After the smoke testing was complete, Thrasher began video camera investigation of the existing sewer lines. The data from the video camera investigation was entered into the geodatabase of the City, through the ESRI CCTV module. The module has attributes distinguished by problem type with different problem types color coded. Thrasher collected the data noting the distance of the problem from the manhole where the camera entered into the sanitary sewer line. These distances were entered into the geodatabase along with problem types, to aid in locating problems underground.

8. I&I ANALYSIS & RECOMMENDATION PER AREA

A. Narrative

During this SSES study, Thrasher installed flow meters, performed smoke testing, and camera investigations in multiple areas throughout Bluefield's existing sanitary system. The results from these tests give indications as to how the I&I is entering into the sanitary system. Per West Virginia Department of Health Regulations, the infiltration allowance per capita design flow is two hundred (200) gallons per inch diameter of pipe per mile per day. With flow meter data from various areas, Thrasher was able to calculate estimated amounts of I&I in these areas, and by comparing to smoke test and camera data, was able to give recommendations of how to possibly eliminate the most I&I from the system. In this section, each area will be broken down by amount of problems, the amount of I&I for areas with flowmeter data, and each area is listed in accordance to order of most I&I. A power savings analysis for each flow monitored area is also included with each flow break down in this section. The average 1411.62 KWH/MG used through the power savings analysis in this section, was based on existing average monthly power usage and average monthly treated flows from the Westside Plant.

B. Midway

The Midway area is a known problem area for BSB. The DEP has issued an administrative order for this area indicating I&I levels need to be reduced. Thrasher provided smoke testing and camera investigation in this area. Since it was a known problem area, BSB requested the smoke test be performed instead of flow metering this area. Below is a list of potential I&I problems found during the Midway smoke test.

- 23 Broken Lateral Lines
- 2 Broken Main Lines
- 6 Storm Drains
- 2 Connected Downspouts
- 4 Broken Cleanouts
- 2 Abandoned House Connections

While performing the smoke test on this area, Thrasher noticed a considerable amount of I&I in this system. The main lines were flowing at roughly half capacity and the lines had sags in them, which made it difficult for the smoke to travel through the lines and pinpoint problems. Thrasher then camera investigated this area to give representation of the condition of existing lines, and to find possible I&I problems.

Based on the findings from the smoke testing and camera investigations, Thrasher recommends that BSB remove gutter downspouts, replace main line and laterals, disconnect storm drains from sanitary system, and remove all ventilated manhole lids and replace with water tight manhole lids. The cost estimate below is for replacement of the main gravity sewer lines in Midway. Further studies of this area during the design phase of a project will result in detailed estimates.

Bluefield Sanitary Board
Midway Replacement
Estimated Construction Costs

SANITARY SYSTEM

ITEM DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL PRICE
8" Gravity Sewer Pipe	11,000	LF	$ 60	$ 660,000
8" Gravity Sewer Road Bore	200	LF	$ 250	$ 50,000
4" Lateral Sewer Pipe	550	LF	$ 40	$ 22,000
4" Service Cleanouts	20	EA	$ 750	$ 15,000
Lateral Connections	140	EA	$ 900	$ 126,000
Manholes	60	EA	$ 4,000	$ 240,000
Cleanouts	5	EA	$ 800	$ 4,000
Asphalt Overlay	20	Ton	$ 200	$ 4,000
Asphalt Replacement	200	LF	$ 60	$ 12,000
Mobilization	1	LS	$ 25,000	$ 25,000
Total Estimated Construction Costs				$ 1,158,000
Number of Customers				140
Estimated Cost / Customer				$8,271

Project Cost Estimate = 1.3 X Construction Costs (1.3 = Soft Costs)

$1,505,400 =1.3 X1,158,000

C. Oakhurst Avenue including Edgewood and Heatherwood Road

During this study, Thrasher completed flow metering, smoke testing, and camera investigations on Oakhurst Avenue, along with Edgewood and Heatherwood Road. Upon removing manhole lids during these tests, and visually inspecting lines and line sizes inside manholes, Thrasher recognized the lines sizes are not constant along Oakhurst Avenue. The Edgewood and Heatherwood Road 8" gravity sewer lines flow into the Oakhurst Avenue gravity line. On Oakhurst Avenue, Thrasher noticed the line size was 8" gravity sewer line at the intersection of Edgewood and Heatherwood Road, and dropped to 6" gravity sewer line throughout various sections toward the outlet of Oakhurst Avenue. This 6" line can cause choke points in the Oakhurst system, which can potentially cause sewer lines to back up and manholes to overflow. As recognized by BSB, the Oakhurst area is an I&I problem, and the manhole at the outlet of the Oakhurst Avenue Sewer shed, overflows during rain events. Below is the flow meter data collected from manholes in the Oakhurst Avenue Sewer shed.

Manhole WSS-0822 (Oakhurst Sewer Shed Outlet)

EDU - **250**

Average Flow per # of EDU's - (210 GPD * 250 EDU)= **52,500 GPD**

Average Flow per # of EDU's in GPM - (52,500 GPD / 1440 Min/Day)= **36.5 GPM**

Average Flow during Rain Event (Flow Meter Data) – **114 GPM**

Estimated amount of I&I – 114 GPM – 36.5 GPM= **77.5 GPM**

Amount of I&I per day – 77.5 GPM * 1440 Min/Day = **111,600 GPD**

Estimated Average Power Savings at 50% I&I removal=

(1411.62 KWH/MG) *0.05580 MG/Day= **78.77 KWH/Day**

Manhole WSS-0849 (Edgewood Road)

#EDU- **26**

Average Flow per # of EDU's - (210 GPD * 26 EDU)= **5,460 GPD**

Average Flow per # of EDU's in GPM - (5,460 GPD / 1440 Min/Day)= **3.79 GPM**

Average Flow during Rain Event (Flow Meter Data) – **20 GPM**

Estimated amount of I&I – 20 GPM – 3.79 GPM= **16.21 GPM**

Amount of I&I per day – 16.21 GPM * 1440 Min/Day = **23,342 GPD**

Estimated Average Power Savings at 50% I&I removal=

(1411.62 KWH/MG) *0.011671 MG/Day= **16.48 KWH/Day**

Manhole WSS-0849 (Heatherwood Road)

#EDU- 66

Normal Flow per # of EDU's - (210 GPD * 75 EDU)= **13,860 GPD**

Normal Flow per # of EDU's in GPM - (13,860 GPD / 1440 Min/Day)= **9.63 GPM**

Average Flow during Rain Event (Flow Meter Data) – **66.5 GPM**

Estimated amount of I&I – 66.5 GPM – 9.63 GPM= **56.87 GPM**

Amount of I&I per day – 56.87 GPM * 1440 Min/Day = **81,892 GPD**

Estimated Average Power Savings at 50% I&I removal=

(1411.62 KWH/MG) *0.0409 MG/Day= **57.80 KWH/Day**

After reviewing the flow meter data, the estimated I&I from Edgewood and Heatherwood Road contributes to approximately 95% of the I&I at the outlet of the Oakhurst Sewer shed. Therefore, correcting I&I problems in the Edgewood and Heatherwood areas, will potentially lower I&I flows from the Oakhurst System. During the smoke test on this area, Thrasher found 86 potential I&I problems which are listed below.

- 31 Broken Main Lines
- 22 Broken Lateral Lines
- 17 Storm Drains
- 8 Connected Gutter Downspouts
- 4 Leaking Manholes
- 3 Broken Cleanouts
- 1 Connected Basement Drain

Thrasher completed a camera investigation study on this area and all problems identified were added to the GIS database of the City. After completing the study on this area, Thrasher recommends that BSB remove connected gutter downspouts, remove connected storm drains from sanitary system, replace 8" and 6" main lines with new 8" main lines, and remove and replace ventilated manhole lids with water tight manhole lids. The following is a preliminary cost estimate for replacing the main lines in these areas. Further studies of the area during the design phase of a project will result in detailed estimates.

Bluefield Sanitary Board
Oakhurst Ave., Edgewood and Heatherwood Rd. Replacement
Estimated Construction Costs

SANITARY SYSTEM

ITEM DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL PRICE
8" Gravity Sewer Pipe	8,300	LF	$ 60	$ 498,000
8" Gravity Sewer Road Bore	250	LF	$ 250	$ 62,500
4" Service Lateral Sewer Line	500	LF	$ 40	$ 20,000
4" Service Cleanouts	35	EA	$ 750	$ 26,250
Lateral Connections	90	EA	$ 900	$ 81,000
Manholes	38	EA	$ 4,000	$ 152,000
Cleanouts	4	EA	$ 800	$ 3,200

Asphalt Overlay	20	Ton	$ 200	$ 4,000
Pavement Replacement	350	LF	$ 60	$ 21,000
Mobilization	1	LS	$ 25,000	$ 25,000
Total Estimated Construction Costs				$ 892,950
Number of Customers				250
Estimated Cost / Customer				$3,572

Project Cost Estimate = 1.3 X Construction Costs (1.3 = Soft Costs)

$1,160,835 =1.3 X $892,950

D. Union Street

Union Street is a known problem area for BSB. Thrasher provided smoke testing, camera investigation and flow metered sections of the Union Street system. The flow meters were placed on the Preston Street line, incoming to the Union Street system and on the "Out of City Limits" line incoming to the Union Street System. The I&I analysis based on flow meter data and EDU counts for this area are listed below.

Manhole WSS-0464

EDU – **12**

Average Flow per # of EDU's - (210 GPD * 12 EDU)= **2520 GPD**

Average Flow per # of EDU's in GPM - (2520 GPD / 1440 Min/Day)= **1.75 GPM**

Average Flow during Rain Event (Flow Meter Data) – **21 GPM**

Estimated amount of I&I – 21 GPM – 1.75 GPM= **19.25 GPM**

Amount of I&I per day – 19.25 GPM * 1440 Min/Day = **27,720 GPD**

Estimated Average Power Savings at 50% I&I removal=

(1411.62 KWH/MG) *0.01386 MG/Day= **19.57 KWH/Day**

Manhole WSS-0508

EDU - **28**

Normal Flow per # of EDU's - (210 GPD * 28 EDU)= **5880 GPD**

Normal Flow per # of EDU's in GPM - (5880 GPD / 1440 Min/Day)= **4.083 GPM**

Average Flow during Rain Event (Flow Meter Data) – **41 GPM**

Estimated amount of I&I – 41 GPM – 4.083 GPM= **36.92 GPM**

Amount of I&I per day – 36.92 GPM * 1440 Min/Day **= 53,164 GPD**

Estimated Average Power Savings at 50% I&I removal=

(1411.62 KWH/MG) *0.0266 MG/Day= **37.55 KWH/Day**

Based on the flow meter data, during an average rainfall event, the two sections of Union Street listed above produce 56.17 GPM of I&I. These two areas were recognized by BSB as possible I&I problem areas. These areas are approximately 30% of the sewer shed on Union Street. To find out how much additional I&I is contributed by the rest of the sewer shed area of Union Street, a flowmeter will need to be installed at the bottom of the sewer shed on Union Street.

During the smoke test on Union Street, there was 55 potential I&I problems found, these problems are listed below.

- 24 Broken Main Lines
- 8 Broken Lateral Lines
- 12 Storm Drains
- 5 Connected Gutter Downspouts
- 3 Leaking Manholes
- 3 Abandoned House Connections

After completing the smoke test study on this area, Thrasher camera investigated approximately 10% of the main lines on Union Street. As a result of these studies, Thrasher recommends that BSB remove gutter downspouts from the sanitary system, replace 8" main line, remove connected storm drains from sanitary system, repair or replace leaking manholes, remove and replace ventilated manhole lids with water tight manhole lids. Below is a preliminary cost estimate based upon complete replacement of the main lines in the Union Street System. Further studies of this area during the design phase of a project will result in detailed estimates.

Bluefield Sanitary Board
Union Street Replacement
Estimated Construction Costs

SANITARY SYSTEM

ITEM DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL PRICE
8" Gravity Sewer Pipe	11,500	LF	$ 60	$ 690,000
8" Gravity Sewer Road Bore	180	LF	$ 250	$ 45,000
4" Service Cleanouts	10	EA	$ 750	$ 7,500
4" Service Lateral Sewer Line	100	LF	$ 40	$ 4,000
Lateral Connections	180	EA	$ 900	$ 162,000
Manholes	28	EA	$ 4,000	$ 112,000
Cleanouts	5	EA	$ 800	$ 4,000
Asphalt Overlay	20	Ton	$ 200	$ 4,000
Pavement Replacement	300	LF	$ 60	$ 18,000
Mobilization	1	LS	$ 25,000	$ 25,000
Total Estimated Construction Costs				$ 1,071,500

Number of Customers	180
Estimated Cost / Customer	$5,953

Project Cost Estimate = 1.3 X Construction Costs (1.3 = Soft Costs)
$1,392,950 =1.3 X $1,071,500

E. Wintercreek Drive

Thrasher completed smoke testing and flow monitoring on Wintercreek Drive. The smoke test included the complete Wintercreek Drive Sewer shed. Thrasher was unable to do any camera investigations on this area, due to the size of manholes not being able to accommodate the camera. The flow meter data showed an I&I problem in this area. The flow meter data for this area is attached below.

Manhole WS-791

EDU - 50

Normal Flow per # of EDU's - (210 GPD * 50 EDU)= **10,500 GPD**

Normal Flow per # of EDU's in GPM - (10,500 GPD / 1440 Min/Day)= **7.29 GPM**

Average Flow during Rain Event (Flow Meter Data) – **69.44 GPM**

Estimated amount of I&I – 69.44 GPM – 7.29 GPM= **62.15 GPM**

Amount of I&I per day – 62.15 GPM * 1440 Min/Day = **89,496 GPD**

Estimated Average Power Savings at 50% I&I removal=

(1411.62 KWH/MG) *0.0447 MG/Day= **63.10 KWH/Day**

The flow meter data shows an estimated 62.15 GPM of I&I in the Wintercreek system. The smoke test didn't show many problems, due to sags in lines and having high levels of flow during the smoke test. The potential I&I problems found through the smoke test are listed below.

- 2 Broken Main Lines
- 1 Leaking Manhole
- 1 Broken Lateral Line
- 1 Broken Cleanout

Thrasher recommends further camera study on this area to determine the condition of lines and determine replacement of the system or repair. Thrasher recommends removal and replacement of ventilated manhole lids with water tight manhole lids. An estimated cost of repairs is attached below.

Bluefield Sanitary Board
Wintercreek Dr. Replacement
June, 2015
Estimated Construction Costs

SANITARY SYSTEM

ITEM DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL PRICE
8" Gravity Sewer Pipe	4,000	LF	$ 60	$ 240,000
8" Gravity Sewer Road Bore	30	LF	$ 250	$ 7,500
Lateral Connections	30	EA	$ 900	$ 27,000
Manholes	20	EA	$ 4,000	$ 80,000
Cleanouts	4	EA	$ 800	$ 3,200
Asphalt Overlay	20	Ton	$ 200	$ 4,000
Pavement Replacement	350	LF	$ 60	$ 21,000
Mobilization	1	LS	$ 25,000	$ 25,000
Total Estimated Construction Costs				$ 407,700
Number of Customers				50
Estimated Cost / Customer				$8,154

Project Cost Estimate = 1.3 X Construction Costs (1.3 = Soft Costs)

$530,010=1.3 X $407,700

F. Frederick Street

Frederick Street was noted as a problem area by BSB and then further investigated by smoke testing, flow monitoring, and camera investigations. The following is the flow meter data Thrasher collected from this area.

Manhole WSS-0171

EDU - 65

Normal Flow per # of EDU's - (210 GPD * 65 EDU)= **13,650 GPD**

Normal Flow per # of EDU's in GPM - (13,650 GPD / 1440 Min/Day)= **9.48 GPM**

Average Flow during Rain Event (Flow Meter Data) – **53 GPM**

Estimated amount of I&I – 53 GPM – 9.48 GPM= **43.52 GPM**

Amount of I&I per day – 43.52 GPM * 1440 Min/Day = **62,668 GPD**

Estimated Average Power Savings at 50% I&I removal=

(1411.62 KWH/MG) *0.0313 MG/Day= **44.18 KWH/Day**

Through the smoke test, Thrasher found 27 potential I&I problems in this area. These problems are listed below.

- 8 Storm Drains
- 4 Broken Main Lines
- 5 Broken Lateral Lines
- 1 Connected Gutter Downspout
- 1 Leaking Manhole
- 8 Abandoned House Connections

Additional problems were found through camera investigations, and are listed in the GIS database of the City. Thrasher recommends removing connected storm drains from the sanitary system, remove gutter downspouts, repair or replace leaking manholes, and replace broken main lines. A preliminary cost estimate of replacing the broken main lines in the Frederick Street Sewer shed follows this section.

Bluefield Sanitary Board
Frederick Street Line Replacement
Estimated Construction Costs
SANITARY SYSTEM

ITEM DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL PRICE
8" Gravity Sewer Pipe	1,200	LF	$ 60	$ 72,000
4" Service Lateral Sewer Line	550	LF	$ 40	$ 22,000
4" Service Cleanouts	25	EA	$ 750	$ 18,750
Lateral Connections	28	EA	$ 900	$ 25,200
Manholes	6	EA	$ 4,000	$ 24,000
Asphalt Overlay	20	Ton	$ 200	$ 4,000
Pavement Replacement	150	LF	$ 60	$ 9,000
Mobilization	1	LS	$ 25,000	$ 25,000
Total Estimated Construction Costs				$ 199,950
Number of Customers				155
Estimated Cost / Customer				$1,290

Project Cost Estimate = 1.3 X Construction Costs

(1.3 = Soft Costs)

$259,935 =1.3 X $199,950

G. College Avenue

During the SSES study, Thrasher performed smoke testing, camera investigations, and flow metering along College Avenue. College Avenue consists of 15" main line with multiple streets flowing into it. Thrasher studied most streets that flow into the College Avenue system from the intersection of College Avenue and Bland Street to the intersection of College Avenue and Leatherwood Lane. BSB recognized the College Avenue Sewer Shed as a known I&I problem, and told Thrasher they have problems with manholes overflowing and pushing manhole lids off in the street. The College Avenue sewer shed also includes Frederick Street, Union Street, Oakhurst Avenue, Edgewood and Heatherwood roads. These areas will not be reviewed in this section since a separate analysis of these areas is included in a previous section of this report. Below is the flow meter data collected from the College Avenue sewer shed. Upon reviewing flow meter data from manhole WSS-0335 (East River Avenue), the data seemed to be incorrect when compared to normal flow, and visual inspections of the flow on East River Avenue showed greater levels of flow than was reported from the flow meter. Manhole WSS-0335 flow meter was removed from this report as a result.

Manhole WSS-0121

EDU - 50

Normal Flow per # of EDU's - (210 GPD * 50 EDU)= **10,500 GPD**

Normal Flow per # of EDU's in GPM - (10,500 GPD / 1440 Min/Day)= **7.29 GPM**

Average Flow during Rain Event (Flow Meter Data) – **17 GPM**

Estimated amount of I&I – 17 GPM – 7.29 GPM= **9.71 GPM**

Amount of I&I per day – 9.71 GPM * 1440 Min/Day = **13,982 GPD**

Estimated Average Power Savings at 50% I&I removal=

(1411.62 KWH/MG) *0.00691 MG/Day= **9.75 KWH/Day**

Manhole WSS-0236

EDU - 65

Normal Flow per # of EDU's - (210 GPD * 65 EDU)= **13,650 GPD**

Normal Flow per # of EDU's in GPM - (13,650 GPD / 1440 Min/Day)= **9.48 GPM**

Average Flow during Rain Event (Flow Meter Data) – **30 GPM**

Estimated amount of I&I – 30 GPM – 9.48 GPM= **20.52 GPM**

Amount of I&I per day – 20.52 GPM * 1440 Min/Day = **29,548 GPD**

Estimated Average Power Savings at 50% I&I removal=

(1411.62 KWH/MG) *0.014774 MG/Day= **20.86 KWH/Day**

Manhole WSS-0396

EDU - 48

Normal Flow per # of EDU's - (210 GPD * 48 EDU)= **10,080 GPD**

Normal Flow per # of EDU's in GPM - (10,080 GPD / 1440 Min/Day)= **7.0 GPM**

Average Flow during Rain Event (Flow Meter Data) – **8.5 GPM**

Estimated amount of I&I – 8.5 GPM – 7.0 GPM= **1.5 GPM**

Amount of I&I per day – 1.5 GPM * 1440 Min/Day = **2,160 GPD**

Estimated Average Power Savings at 50% I&I removal=

(1411.62 KWH/MG) *0.00108 MG/Day= **1.52 KWH/Day**

Manhole WSS-0107

EDU - 25

Normal Flow per # of EDU's - (210 GPD * 25 EDU)= **5,250 GPD**

Normal Flow per # of EDU's in GPM - (5,250 GPD / 1440 Min/Day)= **3.65 GPM**

Average Flow during Rain Event (Flow Meter Data) – **25 GPM**

Estimated amount of I&I – 25 GPM – 3.65 GPM= **21.35 GPM**

Amount of I&I per day – 21.35 GPM * 1440 Min/Day = **30,744 GPD**

Estimated Average Power Savings at 50% I&I removal=

(1411.62 KWH/MG) *0.0154 MG/Day= **21.74 KWH/Day**

Manhole WSS-0096

EDU - **25**

Normal Flow per # of EDU's - (210 GPD * 25 EDU)= **5,250 GPD**

Normal Flow per # of EDU's in GPM - (5,250 GPD / 1440 Min/Day)= **3.65 GPM**

Average Flow during Rain Event (Flow Meter Data) – **23 GPM**

Estimated amount of I&I – 23 GPM – 3.65 GPM= **19.35 GPM**

Amount of I&I per day – 19.35 GPM * 1440 Min/Day = **27,864 GPD**

Estimated Average Power Savings at 50% I&I removal=

(1411.62 KWH/MG) *0.0139 MG/Day= **19.63 KWH/Day**

Thrasher smoke tested the 15" main line along College Avenue, along with Jefferson Street, Wythe Avenue, Washington Street, East River Avenue, Ferndell Avenue, Augusta Street Extension, Walton Avenue, Dearborn Avenue, Hemlock Hill, and the North Street Area. Below are the potential I&I problems found during the smoke test for each area studied along College Avenue.

Jefferson Street

- 3 Broken Lateral Lines
- 7 Broken Main Lines
- 1 Leaking Manhole

Washington Street

- 4 Broken Main Lines
- 3 Storm Drains
- 1 Leaking Manhole

Wythe Avenue

- 3 Broken Lateral Lines
- 5 Broken Main Lines
- 5 Storm Drains
- 1 Leaking Manhole

East River Avenue

- 12 Broken Lateral Lines
- 3 Broken Main Lines
- 2 Storm Drains
- 2 Connected Downspouts

Dearborn Avenue & Hemlock Hill

- 3 Broken Lateral Lines
- 6 Broken Main Lines
- 4 Connected Downspouts
- 3 Storm Drains

North Street Area

- 5 Broken Lateral Lines
- 2 Broken Main Lines
- 9 Storm Drains
- 1 Leaking Manhole

Ferndell Avenue

- 2 Storm Drains

Augusta Street Extension

- 1 Broken Main Line

College Avenue Main Line

- 4 Broken Main Lines
- 1 Leaking Manhole
- 6 Storm Drains

The smoke test of the College Avenue main line was performed during dry times in hopes of having less water in the main lines to make the smoke test more effective. Even though the smoke test was completed at a dry time, there were still high flow levels in the line, which made the smoke test not be as effective as it possibly could. After seeing this, Thrasher camera investigated the main line and found more problems than the smoke test produced.

Upon reviewing the flow meter data collected along College Avenue, Thrasher has come to the conclusion that most of the I&I problems on College Avenue is coming from the Union Street and Oakhurst Avenue areas, with an estimated 130 GPM of I&I flowing from these areas during rain events. The other areas studied in this section that flow into College Avenue only produce an estimated 73 GPM of I&I during rain events, all combined together. The Frederick Street system also flows into the College Avenue main line, producing 43 GPM of I&I. Correcting the I&I problems on Oakhurst Avenue, Union Street, and Frederick Street will greatly decrease the I&I flows in the main line along College Avenue.

Thrasher recommends that all connected storm drains be removed from the sanitary system, broken lines be repaired or replaced, disconnect gutter downspouts from sanitary system, repair/ replace leaking manholes, replace all ventilated manhole lids with water tight manhole lids, and further I&I studies in this area. Thrasher also recommends correcting I&I problems on Frederick Street, Oakhurst Avenue, and Union Street to decrease I&I flows on College Avenue.

H. Grassy Branch Road

Thrasher smoke tested and flow monitored the lines from the intersection of Grassy Branch Road and Princeton Avenue to the intersection of Grassy Branch Road and Cumberland Road. The flow meter data showed that there was an I&I problem, and BSB recognized that this was a possible I&I problem area. Attached below is the flow meter data from this area.

Manhole A-072

EDU - 203

Normal Flow per # of EDU's - (210 GPD * 203 EDU)= **42,630 GPD**

Normal Flow per # of EDU's in GPM - (42,630 GPD / 1440 Min/Day)= **29.6 GPM**

Average Flow during Rain Event (Flow Meter Data) – **80 GPM**

Estimated amount of I&I – 80 GPM – 29.6 GPM= **50.4 GPM**

Amount of I&I per day – 50.4 GPM * 1440 Min/Day = **72,576 GPD**

Estimated Average Power Savings at 50% I&I removal=

(1411.62 KWH/MG) *0.0363 MG/Day= **51.24 KWH/Day**

Manhole A-177

EDU - 77

Normal Flow per # of EDU's - (210 GPD * 77 EDU)= **16,170 GPD**

Normal Flow per # of EDU's in GPM - (16,170 GPD / 1440 Min/Day)= **11.23 GPM**

Average Flow during Rain Event (Flow Meter Data) – **10 GPM**

Estimated amount of I&I – 10 GPM – 11.23 GPM= **0 GPM**

Amount of I&I per day – 0 GPM * 1440 Min/Day = **0 GPD**

Estimated Average Power Savings= 0 KW

Flow meter data from Manhole A-021 is located below Grassy Branch Road at the intersection of Princeton Avenue and Ingleside Road, and is included in this section of the SSES study on this area.

Manhole A-021

EDU - 14

Normal Flow per # of EDU's - (210 GPD * 14 EDU)= **2,940 GPD**

Normal Flow per # of EDU's in GPM - (2,940 GPD / 1440 Min/Day)= **2.04 GPM**

Average Flow during Rain Event (Flow Meter Data) – **20.5 GPM**

Estimated amount of I&I – 20.5 GPM – 2.04 GPM= **18.46 GPM**

Amount of I&I per day – 18.46 GPM * 1440 Min/Day = **26,582 GPD**

Estimated Average Power Savings at 50% I&I removal=

(1411.62 KWH/MG) *0.0133 MG/Day= **18.77 KWH/Day**

Thrasher performed a smoke test on the Grassy Branch Road area. During the smoke test, the main line along Grassy Branch Road had high flow levels, and the smoke test was not as effective as it would've been without the high flows. The potential I&I problems found during the smoke test are listed below.

- 2 Broken Lateral Lines
- 4 Broken Main Lines
- 1 Leaking Manhole
- 1 Abandoned House Connection

Thrasher recommends repairing / replacing broken sections of line and leaking manholes. Thrasher also recommends further studies on this area to find more I&I problems.

J. Horton Road

Thrasher smoke tested and flow monitored the Horton Road area. BSB recognized this area as a problem area, due to the high flow levels at the Horton Road pump station. The flow meter data for this area is attached on the following page.

Manhole 5-001

EDU - 109

Normal Flow per # of EDU's - (210 GPD * 109 EDU)= **22,890 GPD**

Normal Flow per # of EDU's in GPM - (22,890 GPD / 1440 Min/Day)= **15.90 GPM**

Average Flow during Rain Event (Flow Meter Data) – **56.5 GPM**

Estimated amount of I&I – 56.5 GPM – 15.90 GPM= **40.6 GPM**

Amount of I&I per day – 40.6 GPM * 1440 Min/Day = **58,464 GPD**

Estimated Average Power Savings at 50% I&I removal=

(1411.62 KWH/MG) *0.0292 MG/Day= **41.22 KWH/Day**

The smoke test on the Horton Road area didn't find enough potential I&I problems to make up for the amount of I&I shown on the flow meter data. Thrasher found one (1) broken lateral line during the smoke test. After not finding any problems from the smoke test, Thrasher began opening manhole lids in this area after a rain event, and tracked the problem to where the Horton Road line goes under Route 460, and was unable to find any manholes after this point. The Horton Road line begins at the entrance to Quality Inn off of Route 460, and crosses under Route 460 to Cumberland Road, then flowing down Horton Road. Upon visual inspections, Thrasher noted the problem on Horton Road to be between Cumberland Road and Quality Inn, due to seeing the same flow levels from the pump station to this point. Thrasher recommends more studies on this area to find the I&I problems.

K. Tiffany Manor

The SSES study on this area consisted of flow metering. The flow meter was installed at the end of the line flowing from this area. The flow meter data is attached below.

Manhole WSN-168

EDU - 132

Normal Flow per # of EDU's - (210 GPD * 132 EDU)= **27,720 GPD**

Normal Flow per # of EDU's in GPM - (27,720 GPD / 1440 Min/Day)= **19.25 GPM**

Average Flow during Rain Event (Flow Meter Data) – **55 GPM**

Estimated amount of I&I – 55 GPM – 19.25 GPM= **35.75 GPM**

Amount of I&I per day – 35.75 GPM * 1440 Min/Day = **51,480 GPD**

Estimated Average Power Savings at 50% I&I removal=

(1411.62 KWH/MG) *0.0257 MG/Day= **36.28 KWH/Day**

Thrasher recommends further studies on this area to find I&I problems.

L. North Side

The North Side was smoke tested, camera investigated and flow monitored during this SSES study. The flow meter was placed at the outlet of the line from the North Side area. The flow meter data collected is attached below.

Manhole WSN-0490

EDU - 70

Normal Flow per # of EDU's - (210 GPD * 70 EDU)= **14,700 GPD**

Normal Flow per # of EDU's in GPM - (14,700 GPD / 1440 Min/Day)= **10.21 GPM**

Average Flow during Rain Event (Flow Meter Data) – **33 GPM**

Estimated amount of I&I – 33 GPM – 10.21 GPM= **22.79 GPM**

Amount of I&I per day – 22.79 GPM * 1440 Min/Day = **32,818 GPD**

Estimated Average Power Savings at 50% I&I removal=

(1411.62 KWH/MG) *0.0164 MG/Day= **23.15 KWH/Day**

The potential I&I problems found during the smoke test of this area are listed below.

- 6 Storm Drains
- 1 Broken Main Line

Thrasher also camera investigated parts of this area. The problems found from camera investigations are listed in the GIS data.

Thrasher recommends disconnecting storm drains from the sanitary system, repairing or replacing broken lines, and further studies on this area.

M. Virginia Avenue

The area of Virginia Avenue was flow monitored, camera investigated and smoke tested. Upon reviewing the flow meter data from this area, data from manhole WS-143 (Thistle Foundry) was removed from this report due to flow meter error. The flow meter data from this area is attached below.

Manhole WS-146

EDU - 208

Normal Flow per # of EDU's - (210 GPD * 208 EDU)= **43,680 GPD**

Normal Flow per # of EDU's in GPM - (43,680 GPD / 1440 Min/Day)= **30.33 GPM**

Average Flow during Rain Event (Flow Meter Data) – **25 GPM**

Estimated amount of I&I – 25 GPM – 3.65 GPM= **21.35 GPM**

Amount of I&I per day – 21.35 GPM * 1440 Min/Day = **30,744 GPD**

Estimated Average Power Savings at 50% I&I removal=

(1411.62 KWH/MG) *0.0154 MG/Day= **21.74 KWH/Day**

Thrasher performed camera investigations and smoke testing on the Virginia Avenue area. The potential problems found through camera investigations are listed in the GIS database. The potential problems found during the smoke test are listed below.

- 2 Broken Lateral Lines
- 2 Broken Cleanouts
- 3 Connected Gutter Downspouts

This area has a force main from another area flowing into it. Thrasher recommends further studies of this area and the area where the force main comes from. Thrasher also recommends removing and replacing any ventilated manhole lids in this area with water tight manhole lids, along with removing connected gutter downspouts.

N. Mountain Lane

Thrasher smoke tested and flow monitored the Mountain Lane area. The flow meter installed at the end of the Mountain Lane line kept being pushed out of the line due to high flow levels and was not able to collect good flow data. Thrasher used the flow meter data while the meter was in the line to estimate I&I amounts. The flow meter data is attached below.

Manhole WS-811

EDU - 248

Normal Flow per # of EDU's - (210 GPD * 248 EDU)= **52,080 GPD**

Normal Flow per # of EDU's in GPM - (52,080 GPD / 1440 Min/Day)= **36.17 GPM**

Average Flow during Rain Event (Flow Meter Data) – **56 GPM**

Estimated amount of I&I – 56 GPM – 36.17 GPM= **19.83 GPM**

Amount of I&I per day – 19.83 GPM * 1440 Min/Day = **28,555 GPD**

Estimated Average Power Savings at 50% I&I removal=

(1411.62 KWH/MG) *0.0143 MG/Day= **20.19 KWH/Day**

During the SSES study, Thrasher smoke tested the Mountain Lane area. The potential I&I problems found during the smoke test are listed below.

- 2 Broken Lateral Line
- 6 Broken Main Lines
- 1 Storm Drain
- 1 Leaking Manhole

Thrasher recommends repairing / replacing the broken lines in this area, along with repairing the leaking manhole and removing connected storm drains. Thrasher recommends further studies on this area to investigate conditions of existing lines and find more I&I problems.

O. Pine Hill Park

During this study, Thrasher smoke tested and camera investigated parts of the Pine Hill Park system. 26 potential I&I problems were found during the smoke test, and are listed below.

- 4 Broken Lateral Lines
- 8 Broken Main Lines
- 2 Broken Cleanouts
- 1 Storm Drain Pipe
- 3 Gutter Downspouts connected
- 1 Main Line Cleanout
- 1 Leaking Manhole
- 6 Storm Drains

The problems found during camera investigations are in the GIS database of the city. Thrasher found during the camera investigations that the main line running through Pine Hill Park had multiple root intrusions. The root intrusions can cause the main line to back up and manholes to overflow.

Thrasher recommends removing connected gutter downspouts and storm drains from the sanitary system, repairing / replacing broken lines, and repairing / replacing leaking manhole.

P. Brushfork

The entire sewer shed of the Brushfork system was smoke tested during this study. Parts of this area were also camera investigated. Brushfork was recognized as a problem area by BSB. Upon completing the smoke test, 92 potential I&I problems were found and are listed below.

- 14 Abandoned Lateral connections
- 2 Main line cleanouts
- 25 Broken Lateral Lines
- 4 Broken Main Lines
- 20 Broken Cleanouts
- 9 Gutter Downspouts connected
- 3 Storm Drains
- 15 Leaking Manholes

Thrasher suggests flow monitoring in this area to find which part of the Brushfork system is creating the most I&I. Thrasher also recommends repairing / replacing broken lines, removing connected gutter downspouts and storm drains from the sanitary system, repairing main line cleanouts, and repairing / replacing leaking manholes.

9. Appendices

Appendix A - Daily Flow Versus Rainfall Analysis Graphs