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MEMORANDUM

TO: Commissioners, WLSD
FROM: Vonnie Reis, Paul Dombrowski
DATE: February 10, 2012
RE: Infiltration/Inflow Evaluation

The following memo documents the work conducted to date by Woodard & Curran (W&C) to identify infiltration and inflow (I/I) sources in the District's sewer system. The District's system has some unique circumstances that influence flow patterns, specifically:

1. A large length of pipe compared to total flow. Obviously, the longer the length of pipe, the more opportunity for leaking joints, leaking manholes, etc. As a result, a modest rain event can cause a large percentage increase in flow.
2. Many of the homes (approximately 30-50%) in the system are used seasonally or only on weekends and holidays. This factor creates variations from normal flow patterns.
3. Flow records indicate the system experiences moderate amounts of I/I under normal seasonal (i.e., springtime) and wet weather conditions. However, there is a threshold point where flow increases quickly and dramatically in the system. This points to a significant inflow source that is somehow "activated" when a certain amount of rain and/or groundwater infiltration is reached.

W&C's efforts to identify and quantify both normal and excessive I/I in the system are described in more detail below. Specific recommendations to remove I/I sources from the system and recommendation for additional investigation are also included.

Introduction

Woodridge Lake Sewer District (WLSD) is a small sewer system located in the Town of Goshen, Connecticut. The properties in the District are residential, with the exception of a clubhouse that serves the development. The system contains approximately 16 miles of gravity sewer pipe and eight pump stations. Approximately one-third of the properties served rely on grinder pumps, due to low elevations. Specifically, some of these properties are at an elevation equal to or close to the elevation of the lake, indicating high groundwater potential. All properties with gravity connections to the sewer main have a clean-out structure located in the yard. These clean-out structures can become an I/I source if damaged. All flows in the system are pumped from the "plant pump station" to the wastewater treatment plant. The average daily flows at the wastewater treatment plant are 80,000-100,000 gallons per day (gpd). Flow patterns in the system experience seasonal variation in part because the service area contains a large number of second homes. During significant wet weather events (i.e., more than 2-inches of rain), flows at the plant can increase suddenly to 300,000 gpd or more, indicating an inflow (I/I) problem. Review of flow data indicates a more modest seasonal infiltration effect from high groundwater levels.

The purpose of this work is to identify I/I sources in the system and recommend actions to mitigate I/I flows. The WLSD has conducted some work over the past 10-15 years to isolate I/I problems in the system and that work was reviewed to develop initial recommendations for this study. The system was divided into subareas associated with each pump station to better help isolate the sources of I/I. The current investigation has included review of current pump station flow data, flow isolation and CCTV inspection in Subareas 6, 7, and 8 (for infiltration); building inspections in portions of all subareas (for inflow); and smoke testing and dye testing in portions of Subareas 3, 5, 6, and 8 (for inflow). The

rationale for choosing where to conduct various types of investigation is discussed in each section below.

This memo includes a review of previous work completed by others for WLSD; a review of flow data for 2011 compared to precipitation and graphical representation of those results; discussion of I/I investigation work conducted, including flow isolation, CCTV inspections, building inspections, smoke testing and dye testing, and presentation of the results of those investigations; and recommendations for repairs to the system and future investigation work.

Previous Work

Previous CCTV and manhole inspection work was conducted primarily between 2003 and 2008 for the WLSD. The CCTV and manhole inspections identified several locations where sewer pipe and manhole structures were damaged and allowing I/I to enter the sewer system. Accurate estimation of the amount of I/I observed was not provided in the CCTV inspection reports. Pipe repairs were conducted at several locations, as summarized in Attachment 1, Previous CCTV and Repairs (2003-2008).

Short liner repairs should still be preventing infiltration into the system. Pipe sections and service connections that were grouted should be checked to see if the repairs are still preventing infiltration. This inspection should be conducted using CCTV methods.

Manhole inspections were performed on approximately 213 manholes in the system in 2009-2010 by WLSD staff. The recommendations from the inspections include the cleaning of 14 manholes to remove debris that may cause backups in the system, the monolithic lining of 38 manholes to prevent infiltration, and the raising of three manhole frames and covers above grade to prevent inflow. This work has not been conducted to date and completion of these repairs is recommended. Using an estimate of 0.5 to 1 gallons per minute (gpm), the 41 manholes requiring work other than cleaning are estimated to contribute 29,500 - 59,000 gpd of wet weather I/I. A schematic of manhole inspection results is included in Attachment 2, Previous Manhole Inspections.

Completion of inspection of the remaining manholes by WLSD staff is recommended, along with estimates of I/I observed. Repairs to documented I/I sources are recommended. Documentation of repairs should include estimates of infiltration/inflow removed where possible.

W&C Work

Overview

Woodard & Curran initiated I/I work in 2011. The previous work was conducted primarily in reaction to documented problems or concerns in the system. W&C's approach makes an effort to assess the sewer flows, and response of the available system flow data, especially during wet weather and high flow periods. The entire system was divided into subareas, with flow from each subarea flowing to one of the eight pump stations. A summary of the linear feet of pipe and inch-diameter-miles of pipe in each subarea is presented in **Table 1** below.

The relevance of the unit of gallons per day-inch-mile (gpdim) is to be able to assess I/I contribution, regardless of the size or length of pipe in a subarea. For example a larger subarea with larger I/I may have the same relative magnitude of problem as a smaller subarea, but a larger overall volume of I/I. The unit of gpdim is recommended by DEP for identification of areas with excessive I/I.

Table 1
Woodridge Lake Sewer District
Sewer and Force Main Piping

Sub Area	Sewer Pipe Diameter (in)	Sewer Pipe (mi)	Sewer (in-diam-mi)	Force Main[2] (mi)	Force Main (in-diam-mi)
1	8	0.78	6.2	0.34	1.4
2	8	0.93	7.4	0.11	.5
3	8	1.69	13.6	0.14	0.6
5	8	6.17	49.4		
5	15	1.00	15.0	0.27	1.1
6	8	2.61	21		
6	12	0.45	5		
6	15	0.21	3.2	0.45	1.8
7	8	1.53	12	0.22	0.9
8	8	0.81	6.5	0.35	1.4
Total:		16.17	140.0	1.89	7.6

The W&C Scope of Work consisted of the following tasks, as described in more detail below:

- Review and analysis of pump station records to identify flow patterns in each subarea compared to precipitation and groundwater levels
- Flow isolation and CCTV in selected areas to identify specific pipe segments with leaking pipe joints and to quantify the amount of infiltration in each subarea
- Building Inspections to identify internal and external inflow sources, such as sump pumps, roof leaders, and yard drains
- Smoke testing and dye testing to verify suspected inflow sources such as roof leaders, catch basin connections, and leaking manholes

Industry standards identify "wet weather" as any precipitation event over 0.5-inches. "High groundwater" is defined as the springtime rise in groundwater levels compared to summertime groundwater levels. A "dry day" is defined as a period of no precipitation for the preceding 72 hours. For the purpose of this evaluation, a "significant wet weather event" is one that resulted in more than 2-inches of precipitation.

Review of Pump Station Records

The pumping records from each pump station were evaluated with respect to seasonal and wet weather impacts to the flow patterns. The subarea approach was used in order to isolate flows associated with specific subareas. No formal flow metering program was conducted and it should be noted that pump station data has limitations in accuracy. However, plotting of this information over the course of a year provides an adequate approach to identify where the flow issues are experienced in the system.

For the year 2011, significant wet weather events (more than 2-inches of rain) occurred on March 6, April 16, and September 29. It should be noted that Hurricane Irene occurred on August 28-29, 2011 in New England, but the rain gauge recorded very little rainfall (0.1-inch). Plant staff reported the gauge was clogged by debris. This was a significant rain event and all pump station graphs indicated spikes in flow for this range of dates.

In general, all pump station flows indicate a moderate increase to base flows during high groundwater season and a subsequent decrease during low groundwater season. This is indicative of infiltration. All subareas also indicate an increase in flows in the month of December, which may be due to an increased service population over the holiday season. The Subareas that show the largest spikes in flow (as a percentage of flow) due to wet weather are 3 and 6. In terms of volume, Subarea 5 has the highest peak flows. Subareas 1, 2, and 8 demonstrated the least impact to flows from wet weather.

Graphs of flow vs. rain and season are included as Attachment 3, Historical Flow Data. Graphs of Subareas 3, 5, and 6 and total flow are also plotted for October 2010 through January 2011 and for October 2011 through January 2011 to demonstrate the rise in flow between Thanksgiving and New Years.

Additionally, Jim Mersfelder conducted a separate statistical analysis on the Pump Station data. This analysis identified the subareas with the greatest standard deviation from the norm, based on the plant pump flow records. This analysis indicated that Subarea 6 seems to be the most impacted by wet weather flows, primarily indicating inflow issues.

Flow Isolation and CCTV

The first step completed to quantify infiltration in the sewer system was to flow isolate during high groundwater season (March-May, 2011). Flow isolation is conducted on each individual pipe segment in Subareas 6, 7, and 8 between midnight and 6 AM on dry days to measure the flow contributed by infiltration. This resulted in the evaluation of approximately 5.5 miles of pipe. Flow isolation and CCTV inspection mapping and results are included in Attachment 4, Flow Isolation and CCTV Investigations 2011.

The flow isolation results indicated modest infiltration in these subareas, based on the length of pipe investigated. The flow isolation results were analyzed by grouping pipe segments into 1,000-foot sections and prioritizing them based on the amount of total infiltration in gpdim. Pipe segments with more than 1,000 gpdim were recommended for CCTV investigation. (The industry standard for "excessive" infiltration is 4,000 gpdim, but given the small size of this system a lower number was used)

A total of 48 pipe segments and 15 groupings were chosen for investigation. The highest flows measured (in gpdim) were on East Hyerdale (Subarea 7) and Paxton Court (Subarea 8). Since completion of the CCTV work, WLSD staff reported that CIPP lining was completed on Paxton Court. The exact locations will need to be compared to the CCTV results.

The flow isolation and CCTV identified locations where significant infiltration was present. For this reason, it is recommended that flow isolation followed by CCTV (as necessary) be conducted on the remainder of the system. This may be conducted as a phased program.

Building inspections

Building inspections were conducted to identify direct sources of inflow such as sump pumps, roof leaders, and driveway drains. As such, building inspections were not conducted on a subarea basis, but rather on specific areas where suspect sources were most likely. Properties with grinder pumps were viewed as likely suspects, as well as homes in low-lying areas. The properties inspected are listed as the highest priority on the map in Attachment 5, Building Inspections 2011. Results are also presented in this attachment.

Exterior building inspections were conducted on 193 properties and interior inspections were conducted on 104 properties (access was not always available). Ten sump pumps were identified, but seven were

verified as not connected to the sewer. Three remained potential sources. In general, it does not appear that sump pumps are a significant inflow source in the areas investigated. Several roof leaders and driveway drains were noted with "discharge point unknown". These locations warranted additional investigations (see smoke and dye testing below). Exterior building inspections also identified a number of broken or suspect sewer cleanouts (15 total) and potentially leaking grinder tank covers (9 total). Leaking cleanouts or grinder tank covers could be a significant source of inflow. The contribution from these sources is dependent upon topography and the contributing drainage area; using a conservative estimate of 500-1,000 square feet per location and a conservative estimate of a 1-inch storm, these sources have the potential to contribute 7,200-14,400 gallons per event.

Positive sources identified during building inspections are shown on a Figure in Attachment 5. It is recommended that ALL broken cleanouts or grinder tank covers be repaired and an estimate of inflow be included with the repair documentation. Sump pumps do not appear to be an issue in the District, therefore no additional interior building inspections are recommended. Exterior inspections are recommended in the remainder of the properties in the District.

Smoke and Dye Testing
Smoke testing was conducted on suspected sources in Subareas 3, 5, and 6 identified during the building inspections. Approximately 22,500 linear feet of smoke testing was conducted. Three weeping manholes, one apparent drain pipe, and two broken cleanouts were identified. These sources are estimated to contribute 13,500-14,100 gallons per event of inflow, based on the same assumptions used above for the two clean-outs and field observations for the remainder of the sources. Smoke testing locations and results are presented in Attachment 6, Smoke Testing 2011.

Dye testing was planned for 25 locations; however field crews chose not to dye test some locations due to the presence of grinder pumps or other visual information that ruled out inflow sources. Dye testing was conducted at 20 locations where roof leaders had an unknown discharge point where houses did not smoke. No direct connections were identified by dye testing.

At this time, no additional smoke or dye testing is recommended.

Summary of Results
The investigations conducted by subarea are summarized below in **Table 2**. The summary of identified I/I sources and a range of contributing flow is summarized in **Table 3**.To summarize, the following recommendations are presented with the goal of identifying the large sources of I/I that may still exist in the system.

Priority Recommendations:

- Replace or repair broken cleanouts and grinder tank covers. Measure drainage areas to estimate inflow potential at each location. District staff may conduct this work as availability allows.
- Complete repairs/rehabilitation of known sources, including sewer pipes and manholes.
- Flow isolate and (if needed) CCTV easement in Subarea 7 and along East Hyerdale in Subareas 5 and 6 for evidence of infiltration (previously CITS repaired).
- Flow isolate all of Subarea 3 and 5 for infiltration and CCTV 1000-foot pipe segments with excessive infiltration.
- Review and document locations on Paxton Court where CIPP lining was recently conducted.

Follow-up recommendations:

- Re-inspect all other areas previously repaired by grouting of pipe for service connections by CCTV
- Complete manhole inspections in the system (by District staff)
- Flow isolate all remaining subareas for evidence of infiltration and CCTV 1000-foot pipe segments with excessive infiltration
- Conduct exterior building inspections on all remaining subareas
- Based on the results of the building inspections, additional smoke or dye testing may be recommended
- Develop a rotational system cleaning program that will clean the entire system every 3-4 years

We would like to discuss the schedule for conducting this work and how we might assist the District in advancing these recommendations.

TABLE 2

SUMMARY OF WORK CONDUCTED TO DATE

	Subarea						
Investigation Method	**1**	**2**	**3**	**5**	**6**	**7**	**8**
Previous Repairs	X			X	X	X	X
Manhole Inspections	X S	X S	X S	X S	X S		X S
Pump Station data:							
Evidence of infiltration	X	X	X	X	X	X	X
Evidence of inflow (peaks)			X	X	X		
Flow Isolation					X	X	X
CCTV Inspection					X S	X S	X S
Building Inspections:							
Interior	X	X	X	X	X	X	X
Exterior	X	X S	X	X S	X S	X S	X
Smoke Testing			X S	X S	X S		X
Dye Testing				X	X		

NOTES: X = WORK COMPLETED; S = SOURCE IDENTIFIED

TABLE 3

IDENTIFIED I/I SOURCES - 2010 INVESTIGATION PROGRAM

Investigation Method	Finding/Subarea	Infiltration or Inflow	Estimated I/I	Recommendation/ Priority
Building Inspections	3 sump pumps Subareas 5 & 6	Inflow	1,800 gpd	Redirect sump pumps 3
	15 loose/damaged cleanouts Subareas 5 & 6	Inflow	4,500-9,000 gpd	Repair cleanouts 1
	9 leaking grinder pump covers Subareas 2, 5, &7	Inflow	2,700-5,400 gpd	Repair covers/tanks 1
CCTV	20 MH-MH segments with leaking sewer pipes Subareas 6, 7, & 8	Infiltration	26,000 gpd	Grout or line pipe 1
Smoke testing	4 sources Subarea 5	Inflow	12,900 gal	Repair manholes & remove drain pipe 2
	2 Open Cleanouts Subarea 3	Inflow	600-1,200 gpd	Repair cleanouts 1
Manhole inspections	14 manholes need cleaning 38 manholes need repairs 3 raise F&C All subareas	Infiltration Inflow	27,300-54,700 gpd 2,200-4,400 gpd	Repair manholes 1

Estimated Infiltration Identified = 53,300 - 80,700 gpd
Estimated Inflow Identified = 24,700 - 34,700 gpd