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Northcrest-Afton Sewer Rehabilitation Project

Multiple Technologies -- Maximum Flow Reduction

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Abstract
Northcrest and Afton are two neighborhoods in New Castle County, Delaware, USA. Determined through a multi-step hydraulic condition assessment to be badly leaking, rehabilitation project to greatly reduce I/I was needed.
This presentation discusses how the physical condition assessment drove the selection of rehabilitation technologies, how specific technologies were selected, how the construction of these was accomplished, and how effective these methods were in reducing I/I.
Specific technologies used on this 7,200 LF project include CCTV, pipe joint testing and grouting, mainline cured in place lining, lateral tee lining, lateral lining to manholes, new cleanout installation, cured in place point repairs, manhole replacement, fiber-reinforce cement lining of manholes, and injection grouting of leaking manholes.
Data includes cost data for several rehabilitation methods and pre- and post- rehab effectiveness flow data.

Keywords:
Lateral Lining, Main Line Lining, Cured in Place Lining, Manhole Rehabilitation, Grouting, Logiball, Infiltration, Inflow, Rehabilitation Effectiveness

1. BACKGROUND

New Castle County Department of Special Services (NCC) owns and operates a sewer system that contains approximately 1,800 miles of gravity sewer and interceptors, 38,000 manholes, and more than 150 pump stations. Included in this system is the Brandywine Hundred Sewer System, which account for 420 miles of the system and are located in the County's most densely populated area and contain the oldest and most problematic sewers in NCC's inventory.

To safeguard the aging, yet valuable infrastructure investment represented by the Brandywine Hundred Sewer System and to address the changing operational and maintenance requirements represented by both the current aged condition of the system, NCC is implementing a 25 year comprehensive program to identify and prioritize operational and capital improvements to its wastewater infrastructure. This program, called the Brandywine

Hundred Sewer Rehabilitation and Capacity Assurance Program, has a goal of preventing sufficient amounts of groundwater and rainwater entry (i.e., infiltration and inflow, or I/I) into the collection system to achieve a significant reduction in basement sewage backups, the occurrence of wet weather-related SSOs, and interceptor surcharging.

This comprehensive program includes significant planning, budgeting, scheduling, and public involvement components, in addition to the engineering and construction aspects of the work. The program includes sewer flow monitoring, inspections, internal testing, and engineering evaluations to identify and prioritize those sections of the Brandywine sewer sheds that need to be repaired or replaced (R&R) and to provide a benchmark for determining the effectiveness of implemented solutions. A complete baseline condition assessment of the existing system, which included development of monitoring programs intended to identify the nature, extent, and sources of I/I, cross connections, and structural failures, was accomplished through a multi-part process. First, a multi-step Hydraulic Condition Assessment (HCA) was used to identify the sections of the system that leak the most. Extended flow metering; nighttime weiring; above-grade storm inflow observations; door-to-door basement inspections; smoke testing; data mining through asset management software, and transfer of knowledge through interviews with operations staff were used for this. For segments found to be leaking badly, a follow-up Physical Condition Assessment (PCA) was conducted to identify the best method of rehabilitation to use based on the pipe, lateral, and manhole's structural condition. In-pipeline inspections using digital, state-of-the-art CCTV cameras were used.

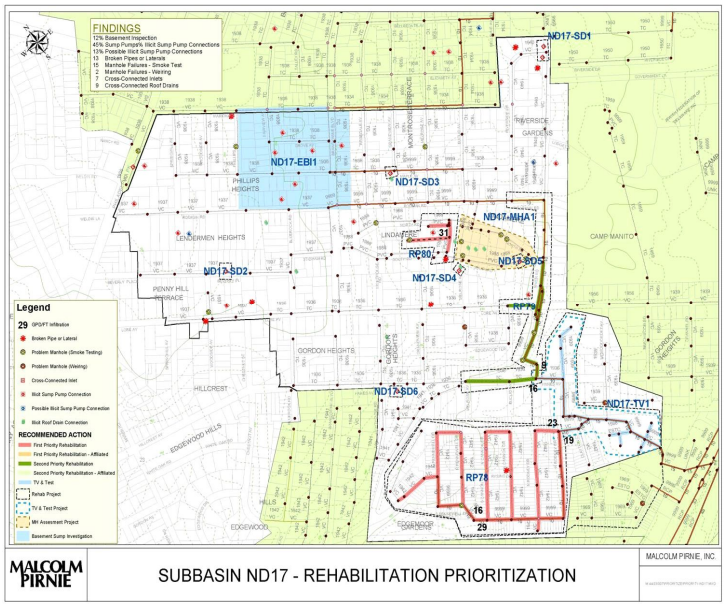

Figure 1: HCA Figure – Northcrest-Afton

Based on the baseline hydraulic condition assessment, each area of the system was given a prioritization for rehabilitation based on contribution of I/I, anticipated failure period, and operational criteria. This rehabilitation prioritization identified projects requiring R&R, which are in turn being scoped, budgeted, designed, and constructed.

2. NORTHCREST – AFTON ––– THE PROBLEMS

The Northcrest – Afton area sewer system was one area identified as having major infiltration and inflow (I/I) problems. The primary objective of the project was to rehabilitate the sewers, laterals, and manholes of these two adjacent neighborhoods high in the system so as to significantly reduce the amount of I/I entering them. Removal of I/I from areas high in the system was given higher priority because the I/I would not need to be carried through the entire system.

The HCA confirmed reports from NCC's Operations Department that the sewers of these two neighborhoods leaked badly. Flow meter data suggested these sewers suffered extended rainfall-induced infiltration and illegal sump pump or punctured floor drain impacts during and after storms. Night-time weiring showed baseline infiltration during normal springtime generally exceeded 10 gpm/linear feet of sewer main, and in some cases many times that rate.

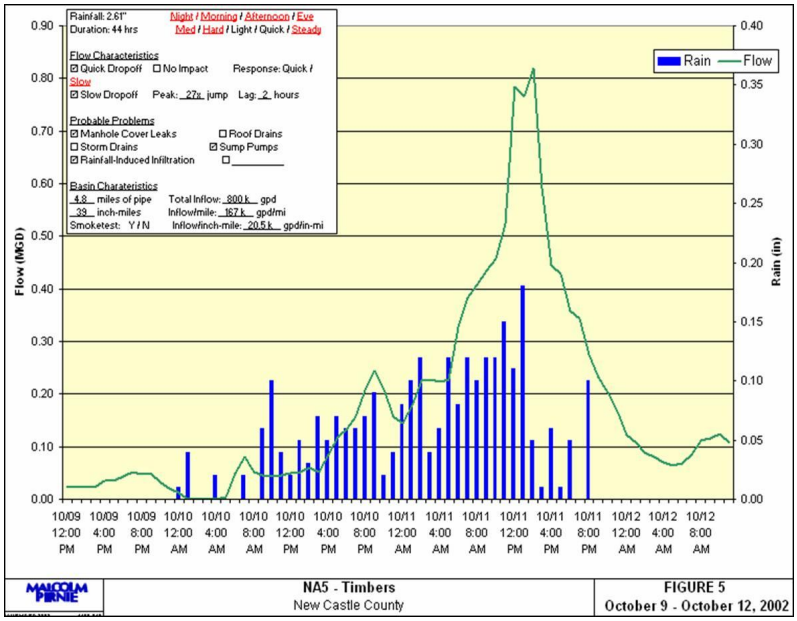

Figure 2: Storm Hydrograph

Smoke testing confirmed that there were no roof drains or cross-connected sewers, but door-to-door basement inspections confirmed the presence of illegal sump pumps and punctured floor drains. Most of these were found to be from the original construction of the homes. In a neighborhood with shallow bedrock under clay, many natural springs, and basements with underlying sewer laterals, this spelled high flows during wet and dry flow conditions.

Figure 3: Punctured Floor

Figure 4: Illegal Sump **Pump**

Once determined to be a *Leaker*, the sewers of NCA were inspected to determine the most appropriate rehab methods to use to reduce the I/I. This involved [1]NASSCO PACP-coded CCTV inspection. As expected, the predominantly terracotta clay sewer showed numerous cracks and fractures, and several instances of broken, distorted, or collapsed pipe. Unexpectedly, many of the segments of terracotta pipe were in perfect structural condition, suffering only from leaking joints.

Figure 5
Structurally Compromised Pipe

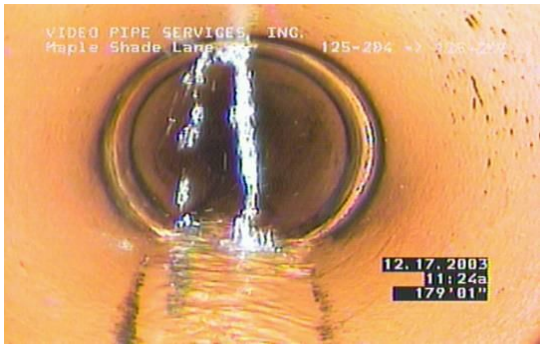

Figure 6
Structurally Sound, but Leaking Joint

It is important to note that while the flow metering and weiring work clearly demonstrated leakage, actual video recording of leakage during CCTV was limited to a single instance. CCTV alone is simply not an effective method for identifying leakage.

3. NORTHCREST – AFTON ––– THE REHAB

Based on these various conditions of the pipe, economic factors and site constraints, four primary rehabilitation technologies were selected for the pipes. B. Frank Joy of Maryland served as General Contractor for this project and was assisted by a host of subcontractors.

Packer injection grouting, or test and seal, was selected for those pipe segments that had no structural defects. Video Pipe Services of New Jersey used Avanti's AV-100® chemical grout, which, mixed with Dichlobenil for root retardation and Avanti's IcoSet® for strength retention, proved sufficient to seal the leaking joints. This was so much the case that lateral taps that had not been leaking prior to mainline grouting began leaking afterward. Approximately 3,900 linear feet of mainline pipe had its joints tested and sealed. Joint failure rate was 15%.

Figure 7: Grout Rig

For laterals connected to segments receiving Test and Seal, lateral taps were grouted to their second joint (6' Logiball). 53 tap connections were tested. With a failure rate of 33%, 17 taps were grouted. Four laterals connected to manholes upstream of segments receiving Test and Seal were grouted to the property line with a push packer to minimize transferring the I/I further upstream.

Figure 8: Logiball Packer

Figure 9: Manhole Push Packer

Cured-In-Place-Pipe-Lining (CIPPL) was selected for rehabilitation of the sewer mains with structural defects. Approximately 3800 linear feet of mainline pipe was lined. Polyester resins combined with non-woven tube and cured with steam by Am-Liner East, Inc. provided strong, smooth plastic pipes to function as pipe replacements or pipe liners inside cracked, fractured, and broken terracotta pipe. CIPPL liners for this project were all conservatively designed for fully deteriorated host pipe conditions under fully saturated soil conditions under highway loading. To prevent the leakage in the annular space between the host pipe and the liner from coming out at the manholes, Hydrotite® end seals were employed at every manhole and drop connection.

Figure 10: CIPPL Restrained Pipe Sample

To design the thickness of the liners, actual ASTM D2990 data of the resin were used to determine the long term creep modulus. To prove the installed product would provide the minimum design life of 50 years, restrained pipe samples of the installed product were tested for thickness, ASTM D2990 long term creep modulus, and ASTM D790 short term flex modulus.

To prevent the leakage in the annular space between the host pipe and the liner from coming out at the tap connection cuts, for laterals connected to segments receiving CIPPL, each lateral tap received a cured-in-place lateral liner (CIPLL) using LMK T-Liners®. The T-Liner® provides a full mainline wrap, integrally sewn and cured with the lateral pipe liner, and installed with its own double layer of hydrophilic end bands to prevent annular space leakage from coming into the pipe.

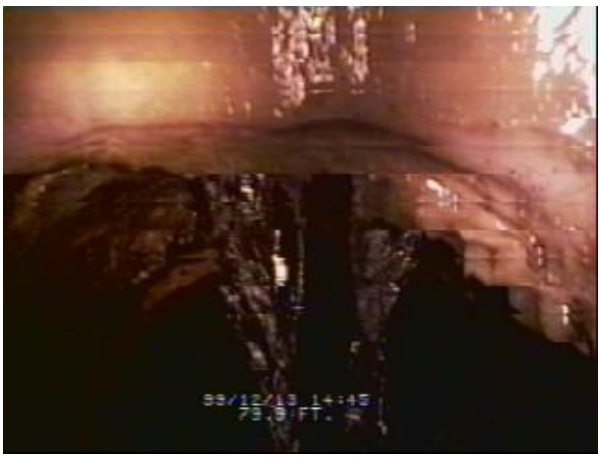

Figure 11: Leaking CIPPL Tap Cut

The T-liners® were installed to at least the edge of the property line and, where agreeable to the property owner, as close to the building foundation as was convenient. To install T-Liners®, a cleanout is required, but because none of the houses of Northcrest or Afton were constructed with exterior cleanouts, the design team first had to locate these laterals. This was done using a mainline-launched sonde. Roots, slip-in 4"-6" transitions, broken and collapsed laterals, and 90º bends sometimes limited how far the sonde could travel up the lateral. The cleanouts were installed as close to the house as was practical While NCC owns the lateral only to the property line, it was decided that the interest of the general public were best served by lining beyond the property line, and this was done when permitted, via legal agreement, by the property owner. Approximately 80% of the homes were lined beyond the property line.

Figure 12
Sonding Laterals for Cleanout Location

A variety of subcontractors installed and restored the sites of 50 cleanouts/risers. Because the original lateral construction backfilled the trench with native materials, including large rock and small boulders, only open-cut installation of cleanouts was possible. Impacts on private property were minimized by using smaller excavation equipment with matting.

Figure 13: Cleanout Excavation

Once cleanouts were installed, the lateral was cleaned and televised to confirm there were no obstructions and measurements were taken of each lateral. These measurements were sent to the factory where each liner was specifically manufactured for each lateral, including coning of the liner for the 4"-6" transitions and preparation of specific mixtures of the two part polyester resin for each lateral.

Figure 14: Mixing Resin

Figure 15: Inserting LCS into Mainline

B. Frank Joy conducted the lateral lining installation, which involved bypass pumping in the mains, wetting out the liner on-site, transporting to the mainline tap connection, inverting the liner through a special packer assembly, and steam curing of the liner for about 15 minutes. 53 CIPLLs for laterals connected to the mainline sewer (LCS) were installed. An additional 7 laterals were lined in a similar fashion, less the mainline wrap connection, from manholes (LCMs). Of the 60 installed CIPLL's, 3 failed to invert and/or cure and needed to be excavated and either redone or finished with new PVC pipe. An additional 4 had wrinkles larger than allowed by the specifications, but were accepted by NCC on a reduced payment schedule. In no cases was any excavation in the roadway required.

Finally, a number of manholes were rehabilitated, and one entirely replaced. Trenchless manhole methods employed by D&S Contractors of Virginia included fibre-reinforced cement lining (SewperCoat®) and chemical injection grouting (Avanti's AV-202®).

4. NORTHCREST – AFTON ––– THE COSTS

It took 2 months of submittal preparation and review time and 6 months of field time to complete the work. The Contractor's initial bid of $1.26M was modified via post-award value engineering proposals to $1.14M. All construction work is complete. Warranty inspections are scheduled to take place in spring 2008. Final constructed cost after post warranty inspections is expected to be $991,465.00. Table 1 is a table of key unit prices used on this project.

Item No.	Description	Estimated Quantity	Units	Price per Unit
4	Cured-in-Place Lining (8-inch)	3,477	LF	$ 42.00
5	Cured-in-Place Pipe Lining (10-inch)	231	LF	$ 49.00
6	Cured-in-Place Point Repair (8-inch) – Six Feet Long	1	EA	$ 4,100.00
7	Cured-in-Place Point Repair (8-inch) – Eight Feet Long	2	EA	$ 4,225.00
9	Lateral Tap Reinstatement	64	EA	$ 139.00
10	Cured-in-Place Lateral Renewal (from sewer): 0 – 30 Feet	61	EA	$ 6,485.00
11	Cured-in-Place Lateral Renewal (from manhole): 0 – 30 Feet	7	EA	$ 5,100.00
12	Additional Cured-in-Place Lateral Renewal	1750	LF	$ 37.80
13	Install New Cleanout & Riser	63	EA	$ 3,550.00
14	Testing of 8" Pipe Joints	788	EA	$ 12.50
15	Packer Injection Grouting of 8" Pipe Joints	592	EA	$ 28.00
16	Testing and Chemical Sealing of Laterals Connected to the Mainline Sewer	56	EA	$ 500.00
17	Testing and Chemical Sealing of Laterals Connected to Manholes	4	EA	$ 500.00
18	Grout	1000	GAL	$ 8.00
20	Manhole Rehabilitation by Fiber Reinforced Cementitious Lining	94	VF	$ 305.00
21	Injection Grouting of Manhole Base	3	EA	$ 1,320.00
22	Injection Grouting of Manhole Wall Joint	9	EA	$ 625.00
23	Manhole Bench/Flow Channel Repair	5	EA	$ 600.00

Table 1: Key Unit Prices

5. NORTHCREST – AFTON ––– THE RESULTS

To determine the rehabilitation effectiveness for this project, the control basin method was used. The flows in the Northcrest-Afton basin ("Rehab Basin") are compared with the flows in a similar basin where no rehabilitation work is occurring ("Control Basin"). After rehabilitation work is complete, the relationship of the pre and post rehabilitation flows between the Control Basin and the Rehab Basin are expected to be different. This method removes variability between storm events by comparing concurrent flow parameters measured during each rainfall event in the Rehab Basin and the Control Basin. Percent reduction is determined by the measuring the difference between the pre-rehabilitation and post-rehabilitation trend lines at a chosen point. For wet weather flow rates, the chosen point was determined by identifying the average daily non-rainfall impacted flow in the Rehab Basin and applying a 3X peaking factor, which approximates the peaking factor used in NCC's SECAP model (traditionally referred to as

the Baltimore Curve by NCC). This point is found on the pre-rehabilitation trend line and reduction calculated as the percent difference between the pre-rehabilitation and post-rehabilitation trend lines at this point.

Data from thirteen pre-rehabilitation storms and from six post-rehabilitation storms were collected and analyzed. Because this project's goal was to reduce total volume and peak flow volume, both flow characteristics were evaluated.

As shown in Figure 16, total flow resulting from rainfall events was lowered by 73%.

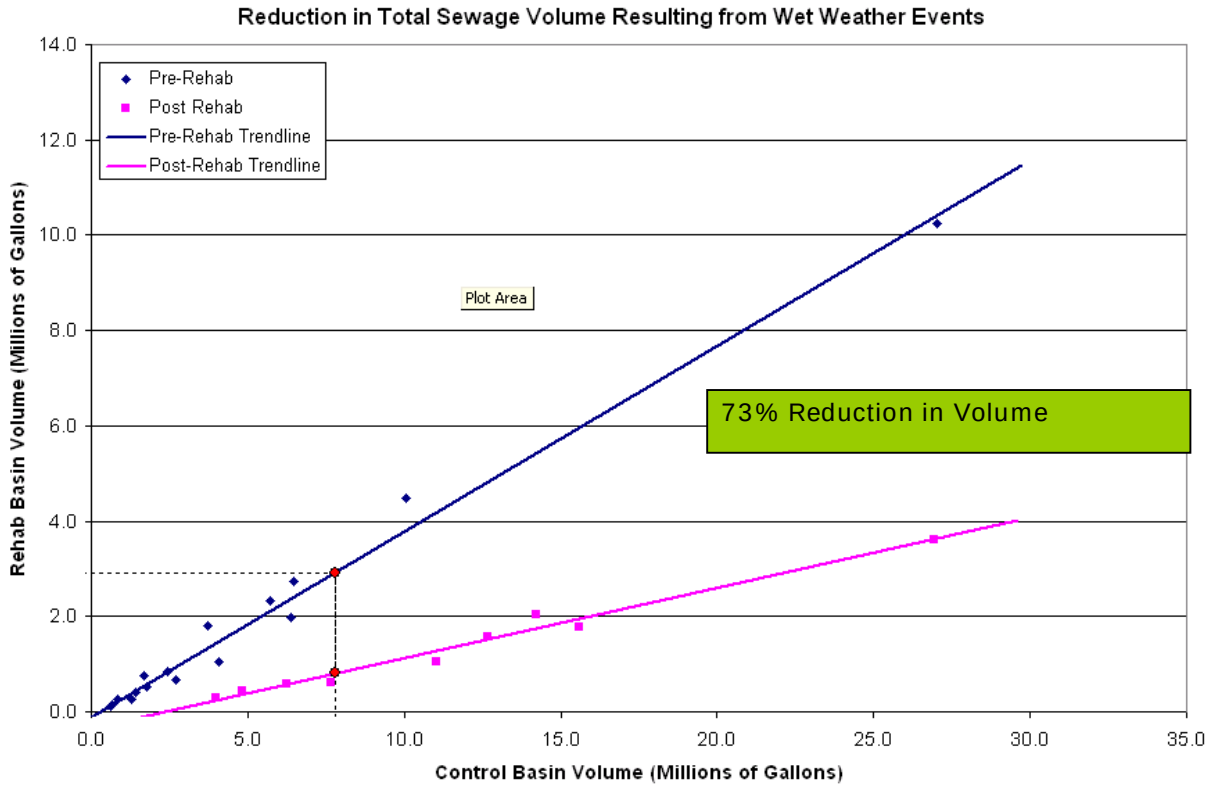

Figure 16: Total Flow Reduction – Control Basin Method

As shown in Figure 17, peak flow rates resulting from rainfall events was lowered by 55%.

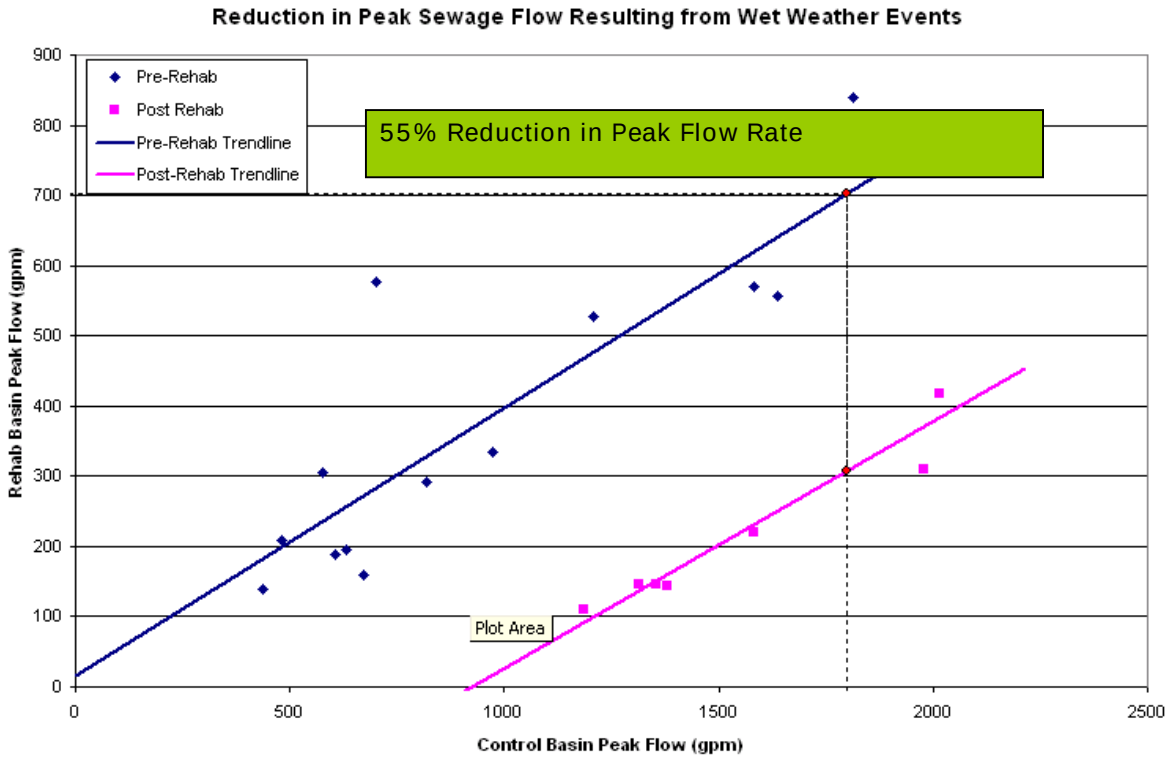

Figure 17: Peak Flow Reduction – Control Basin Method

6. REFERENCES AND ACKNOWLEDGEMENTS

[1]National Association of Sewer Service Companies Pipeline Assessment Certification Program