A.8 Case Study: Flood Grouting in Lafayette, LA (2003)

This case study gives details of how flood grouting can be performed to seal mainlines, laterals and manholes. The City of Lafayette wanted to try this method and evaluate if it would be as a cost-effective rehabilitation option for stopping infiltration in the city.

Table A-32. Project Summary.

Objective	Sealing (non-structural repair) of manholes, mainlines and laterals to achieve leak-tightness
System used	**Sanipor®** (Flood grouting)
Time	Apr 7-16, 2003
Location	Lafayette, LA
Agency	Lafayette Utilities System (LUS) Steve Rainey (337) 291-5751, srainey@lus.org
Contractor	Insituform Technologies Inc (ITI) and Sanipor Csilla Pall, Sanipor@t-online.de
Soil conditions	Fluvial mud and silty clay from the Mississippi delta
Scope	Sealed 26 whole[42] laterals, together with 5 mainline sections and 7 manholes[43]
Procedure	a) Preliminary inspection and preparation work (2 months prior to rehabilitation) ♦ Mainline CCTV inspection ♦ Installation of cleanouts near the houses b) Sanipor® installation on each section ♦ Mobilization (site setup) ♦ Cleaning of pipes and manholes ♦ Plugging and initial water exfiltration test[44] ♦ Flooding with two proprietary solutions S-1 and S-2 ♦ Demobilization b) After rehabilitation (2-3 weeks after the rehabilitation): ♦ Post-CCTV
QC after rehabilitation	Fluid exfiltration testing ("before" and "after" the rehabilitation)
Financing	Paid by the agency. Portion of total job cost applicable to laterals determined from proportion in volume of rehabilitated laterals vs. rehabilitated mainlines, manholes and laterals[45]
Public relations	Letter to homeowners and authorization form for entering the private property
Rehab effectiveness	No flow monitoring[46]

[42] *From the mainline to the cleanout near the house or the lateral's dead end*

[43] *Sealing was done in 10 sections of sewer system, each consisting of a varied number of mainline segments, manholes and laterals. The total sealed was 5 mainlines (1,473 ' of 8" VCP), 7 manholes (36" and 48" brick, 7 ' deep on average), and 24 active and 2 inactive laterals (1,752 ' of 4" and 6", mainly VCP and partly PVC). The laterals were 30- 120 ' long.*

[44] *In the future, the City will carry this out well before selecting the project.*

[45] *Cost of lateral rehabilitation is an integral part of the total job cost*

[46] *"Before" and "after" flow monitoring will be done in the future.*

A.8.1 Background

Lafayette has serious problems with I/I especially in areas with clay and concrete pipes. The pipes are structurally sound but heavy rains cause infiltration through joints, lateral connections to mainlines, gaps in brick manholes, and cracks in concrete manholes. Based on sewer system inspection (mostly smoke testing, dye testing, and mainline CCTV throughout the system) over the years, sewer laterals are also recognized as a severe source of infiltration. The agency wanted to try a new method of simultaneous sealing of all parts of the pipe system (laterals, manholes and mainlines) in one operation. Sanipor® was selected for evaluation as a potentially cost-effective trenchless rehabilitation option for stopping infiltration in Lafayette.

A.8.2 Selection of Sections Within the Sewer System for Rehabilitation

The pipes selected for rehabilitation were in the residential neighborhood of Lafayette. The pictures in Figure A-89 show that the subdivision had a flat topography.

Figure A-89. Pictures Showing the Neighborhood Selected for Rehabilitation.

The project was designed to isolate flow in five sewer system sections and rehabilitate them by the flood-and-grout method. Flow isolation would be done by inserting plugs in mainlines where they connect to manholes and in laterals at cleanouts near houses. Before the project, there were no such cleanouts and they were installed as close to the houses as possible. The sections chosen for flooding varied in the number of components—depending on the volume to be filled and the grade of infiltration in the manhole (Figure A-90, Table A-33). For efficiency, the sections that include only one manhole were first scheduled for sealing, the sections with one or more laterals were next, and the last were the sections with a mainline.

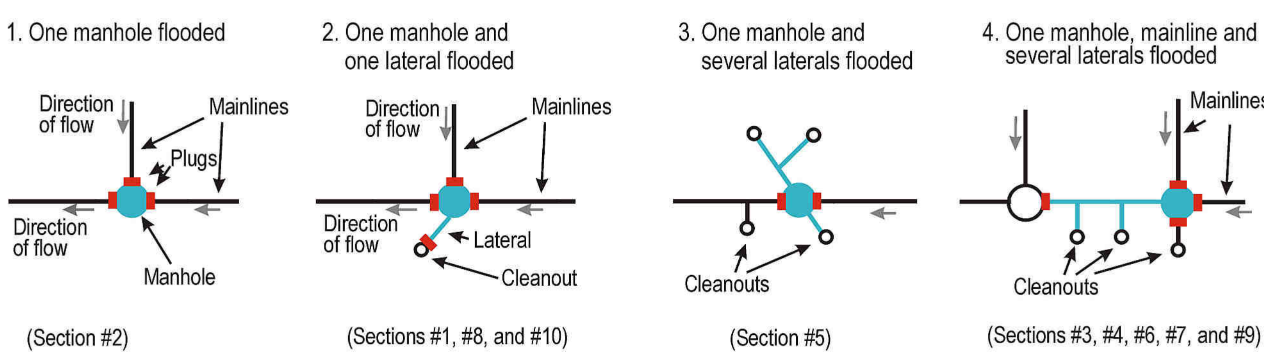

Figure A-90. Types of Plugged Sections with Position of Plugs.

Table A-33. Lafayette, LA, 2003: Sections Selected for Rehabilitation

Section	Street	Mainlines		Manholes		Laterals		
#1	Robert Lee/Ophelia	0		1	(MH 1257)	1	(CO 304 to MH 1257)	Active
#2	Robert Lee/Billeaud	0		1	(MH 1252)	0		-
#3	Robert Lee	1	(MH 1257 to MH 1252)	1	(MH 1257)	2	(CO 302 to main) (CO 300 to main) (CO 304 to main)	Active Active Inactive
#4	Robert Lee	1	(MH 1260 to MH 1257)	1	(MH 1260)	2	(CO 500 to MH 1260) (CO 402 to main) (CO 400 to main)	Inactive Active Active
#5	Ophelia	0		1	(MH 1258)	3	(CO 110 to lateral—from CO 112) (CO 112 to MH 1258) (CO 111 to MH 1258)	Active Active Active
#6	Ophelia	1	(MH 1258 to MH 1257)	1	(MH 1258)	4	(CO 113 to main) (CO 115 to main) (CO 114 to main) (CO 116 to lateral—from CO 114) (CO 117 to main)	Active Active Active Active Active
#7	Beverly	1	(MH 2987 to MH 2986)	1	(MH 2987)	6	(CO 510 to MH 2987) (CO 511 to MH 2987) (CO 513 to main) (CO 512 to main) (CO 514 to main) (CO 515 to main)	Active Active Active Active Active Active
#8	Beverly			1	(MH 2986)	1	(CO 517 to MH 2986)	Active
#9	Beverly	1	(MH 2993 to MH 2992)	1	(MH 2993)	4	(CO 607 to MH 2993) (CO 607b to MH 2993) (CO 602 to main) (CO 604 to main) (Dead End—CO 605 to main)	Active Active Active Active Inactive
#10	Beverly/Primerose	0		1	(MH 1260)	1	(CO 500 to MH 1260	Active
TOTAL:		1		10		24		

A.8.3 Initial Sewer System Inspection and Preparation Work

Mainline CCTV Inspection. The preliminary CCTV inspection was limited to mainlines, which were televised to ensure that the lines were in good shape and had little or no sags. The CCTV was done after the lines were cleaned from roots, grease, debris and sewage, so that the camera could freely pass through the pipes. Laterals were CCTV inspected later when the Sanipor work began, one by one, in order to identify sags, roots, cracks or other potential hindrance for the process.

Installation of Cleanouts. In Lafayette, the distance between the mainline and the property line is typically 10-20' on the short side, and 40-60' on the long side. Before the rehabilitation, there was only one cleanout at the property line. At this time, new cleanouts near the house were installed on each lateral, by open cut construction (Figure A-91). The length of laterals between the new cleanouts and the mainline or manhole was between 20-120'.

Some laterals were over 3' deep and guessing where exactly to place the cleanout was difficult, making this the most time consuming task. In addition, three homes had two laterals that connected into a single lateral at some distance from the house. Without prior CCTV, this was not known ahead of time and thus only one cleanout was installed at each of these addresses instead of two. The municipality is now considering hiring a private company for televising and locating the laterals, where the roof vents or toilets will be used as an access point for the camera into the laterals.

Figure A-91. Newly Installed Cleanout Close to the House.

The installed cleanouts had a two-way access to allow plug insertion downstream or upstream from the cleanout.

A.8.4 Construction

Mobilization (Site Setup). To each site, the crew brought the following equipment: a jetting truck, a CCTV truck, buckets for filling the cleanouts with water, pneumatic plugs, a three-chamber tanker with the two solutions (S-1 and S-2), two hoses, and two separate pumps. Figure A-92 shows typical site setup. At the beginning of project, the contractor did not have the proper pumps for a quick and thorough pumping out of the solutions and therefore not all the chemicals could be recovered out of the manhole, which caused serious delays.

Figure A-92. Typical Site Setup Showing Tanker in the Background and Truck with Equipment in the Front.

Cleaning. Manholes and pipes were again cleaned shortly before each start of Sanipor work to insure that the chemicals used for sealing would not be contaminated by the sewage. A 300-gallon trailer flusher was used for water jetting (Figure A-93).

Figure A-93. Jetting Truck.

Plugging and Initial Water Exfiltration Test. For plugging the lines, 4" and 6" plugs were used in the laterals, and 8" plugs in the mainlines. For the water exfiltration test, the plugged sections were completely flooded to the top of manholes, and the loss of water in 5-minute intervals was measured in the manholes.

The water exfiltration test provided a quantitative order-of-magnitude of the leakage of the chosen section. The amount of exfiltrating water could be compared with the achieved tightness of the pipe system after the Sanipor treatment. Generally, when infiltration is not visible on the CCTV camera, the water exfiltration test is a means of providing reliable data about the leakage in an apparently good sewer system.

Figure A-94. Buckets Were Used for Adding the Water from a Nearby Hydrant Through the Cleanouts[47].

Flooding with Two Sanipor® Solutions. After plugging the sections, the Sanipor process was performed in four steps (Figure A-95).

- The section was completely filled with the solution S-1 from its tanker, i.e. the liquid level in the manhole was brought up to the street level. This created the necessary hydrostatic head for the injection of S-1 through the defects into the soil. While the level of S-1 was gradually sinking, the liquid was being refilled (once or several times) up to street level in order to maintain the hydrostatic head required for exfiltration.
- After a certain time, S-1 was pumped out completely and all pipes flushed with water (the laterals were flushed with the help of buckets and the mainline with a quick interim flush of water with the jetting truck).
- Next, the section was completely filled with the solution S-2 from its tanker in the same manner as previously with the solution S-1. In the soil, two components reacted with each

[47] *Buckets of water were also used in the next step, i.e. during the Sanipor installation to flush the remaining chemicals out of the pipes at the end of each flooding.*

other and the soil particles, stabilizing the soil and creating a watertight isolation layer around the leaks.

- After a certain time, S-2 was pumped out completely and all pipes flushed with water.

A three-chamber tanker was used to transport S-1 and S-2 to site (Figure A-96). Each chemical component had its own hose in order to avoid mixing and polluting S-1 and S-2 with each other (Figure A-97).

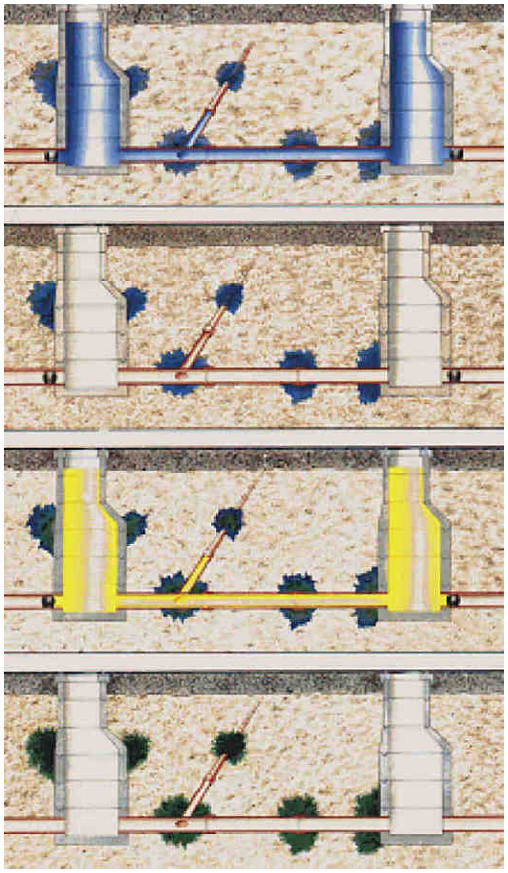

Figure A-95. Four Steps in Flood Grouting Procedure.

Figure A-96. Three-chamber Tanker for Transporting the Chemicals.

Figure A-97. Hoses for Pumping the Chemicals.

Strong and reliable pumps have a very important role in the Sanipor technology (Figure A-98). Having no vacuum pumps on the tankers, two separate pumps were used to pump out the large volumes of the sealing liquids from the sewer sections/manholes (circa 2,000-3,000 gal each).

Figure A-98. Pumps.

Duration of Flooding. The flooding procedure using both components was performed in cycles (one, two or three cycles, as shown in Chapter 8.0). The flooding with either solution within the cycle was typically between 25-40 minutes. During this time, the level of solution in the manhole was decreasing and the system was periodically refilled. At the end of the final cycle, the level of S-2 in the manhole stabilized, and thus the leak tightness was visually confirmed. The drop of solution S-2 level in the manhole was measured with the help of a wooden stick and a folding rule (Figure A-99).

Figure A-99. Manhole Filled with Solution to the Ground Surface.

Loss of Solution. The loss of solution[48] due to sealing was determined after completing each section by calculating the remaining quantity of each solution in the truck. A centrifugal pump was used to pump the unused solution out from the invert and return it into the truck to be reused. A calibrated rod was inserted into the tanker from the opening on the top and the level of solution in the tanker was measured[49]. The centrifugal pump did not pump the solution S-2 out as well as it handled the solution S-1, and thus some of solution S-2 was lost for reuse.

Surface Exfiltration. In several locations, the Sanipor solution reached the surface appearing on the pavement or on the grass (Figure A-100). Surface exfiltration happened because there were channels in the soil (from rainwater draining over time) that extended from rather shallow mainline pipes. These channels were filled and sealed with Sanipor as well. The white stains on the grass show where the Sanipor Silicate gel has formed.

Figure A-100. Left: Exfiltration onto the Pavement (Section #7). Right: Surface Exfiltration onto the Grass (Section #9).

Manhole Sealing. One brick manhole (MH 1252) close to a hydrant was badly leaking whenever the hydrant was opened (section #2). The water was pouring through all gaps between the bricks into the manhole. All gaps in the manhole were successfully sealed with one cycle. White stains in Figure A-101 (MH 1252) show the product of reaction between S-1 (draining from the soil back into the manhole) and S-2 (being filled into the manhole). Five days after the Sanipor sealing, a test was made by opening the nearby hydrant and flooding the surface surrounding the manhole. No infiltration was visible in the manhole anymore.

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[48] *Both solutions exfiltrate into the surrounding soil through cracks and other defects in the pipe and manhole walls. Used quantities are referred to as the "loss of solution" and they depend on the volume of voids in the ground to be filled. Although the loss of solution varies from one section to another, the typical value (order of magnitude) in one project is visible after completing several sections. The loss of solution is important for determining the costs.*

[49] *In Germany, a volume meter is typically installed on the tanker, which gives the loss of solution every day (at least an order of magnitude). Another option to determine the loss of solution is by measuring the weight of tanker before the job (morning) and after (evening). From the weight difference and the specific gravity of each solution, the daily loss of each is calculated. A problem occurs when it rains because the rainwater collects on the surface of big tankers. This distorts the results of weight measurement, adding the weight of water to the net weight of S-1 and S-2 in the tankers.*

Figure A-101. Sealed Gaps on the Manhole Wall (Section #2).

Demobilization. When leak tightness was observed in the manhole, the S-2 component was pumped out of the whole system through the manhole. A last jetting of the main and manhole and a flush of water with buckets at the end of each lateral removed the remaining liquids from the pipes. All plugs were removed from the mainlines and the laterals, and the cleaned sewer section was recommissioned for normal use. The equipment was transported back with the tankers to the working base.

A.8.5 Overview of Performed Work

The following table gives the summary of performed work.

Table A-34. Lafayette, LA, 2003: Overview of Performed Work.

Section	Mainlines				Manholes				Laterals	
	Number		Length	Diameter/Type	Number		Diameter	Depth	Number	Length
#1	0	-	-	-	1	(MH 1257)	48”	8’ 2”	1	27'
#2	0	-	-	-	1	(MH 1252)	48”	8’ 2”	0	-
#3	1	(MH 1257 to MH 1252)	298.5'	8” VCP	0	(~~MH 1257~~)	~~48”~~	~~8’ 2”~~	2	44'
#4	1	(MH 1260 to MH 1257)	254.7'	8” VCP	1	(MH 1260)	48”	7’ 4”	2	80'
#5	0	-	-	-	1	(MH 1258)	36”	8’ 0”	3	288'
#6	1	(MH 1258 to MH 1257)	259.0'	8” VCP	0	(~~MH 1258~~)	~~36”~~	~~8’ 0”~~	4	269'
#7	1	(MH 2987 to MH 2986)	293.9'	8” VCP	1	(MH 2987)	36”	6’ 4”	6	567'
#8	0	-	-	-	1	(MH 2986)	48”	7’ 10”	1	70'
#9	1	(MH 2993 to MH 2992)	266.7'	8” VCP	1	(MH 2993)	36”	7’ 7”	4	320'
#10	0	-	-	-	0	(~~MH 1260~~)	~~48”~~	~~7’ 4”~~	1	30'
TOTAL:	5		1,372.8'		7				24	1,695'
Explanations:	Crossed manholes were sealed as part of some sections rehabilitated earlier (in this project). Individual laterals were 30-120' long.									

A.8.6 Quality Control

As test of reliability and performance of the installed product, a water exfiltration test was performed on sections before the rehabilitation and compared with exfiltration of the remaining Sanipor solution in the closing stages of the rehabilitation. The water exfiltration test “after” was not done because the Sanipor solution (S-2) behaves like water.

All manholes but one in this project have dimensions as shown in Figure A-102. Only the manhole MH 2992 has the cone very shallow (approx 6”) and the full diameter of 4' goes almost to the surface.

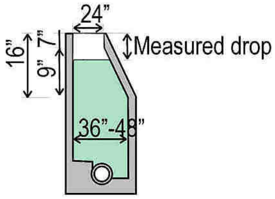

Figure A-102. Manholes in Water Exfiltration Test.

With such geometry, the exfiltrated volume was calculated depending on the depth of the water level drop for up to three distinctive parts of the manhole:

$$E = \Delta E_T + \Delta E_C + \Delta E_B \qquad \text{(A-1)}$$

Where: E......... Total volume of leakage (gal)
ΔE_T .... Exfiltrated volume in the top part of the manhole (D_{MH} =24")
ΔE_C .... Exfiltrated volume in the coned part of the manhole (D_{MH} changes)
ΔE_B .... Exfiltrated volume in the bottom part of the manhole (D_{MH} =36" or 48")

In the top and the bottom part of the manhole, exfiltrated volumes ΔE_T and ΔE_B were calculated using the formula for volume of cylinder:

$$\Delta E = 0.4894 \cdot D_{MH}^2 \cdot \Delta H \qquad \text{(A-2)}$$

Where: ΔD_{MH} . Manhole diameter in given part of manhole (ft)
ΔH .... Drop of water level in given part of manhole (in)
0.4894 Coefficient determined as follows:

$$\frac{D_{MH}^2 \cdot \pi}{4} \cdot \frac{1}{12} \cdot 7.481\,\text{gal/ft}^3 = 0.4894 \cdot D_{MH}^2 \qquad \text{(A-3)}$$

In the coned part of the manhole, the exfiltrated volume ΔE_C was calculated using the formula for volume of frustum of a cone.

Exfiltration Test "Before". The water was introduced into the plugged section through the downstream manhole, which was filled to the street level (Figure A-103). The upstream manhole was filled only partially due to the different elevation of manholes and leaking. Because the water level was sinking in both manholes, the lost volume of water was calculated in both manholes and summed[50]. Table A-35 shows the measured drop of the water level in the manhole in the first 8-15 min of filling the sections with the water.

[50] *The calculation is simplified by assuming that the upstream manhole was filled below the cone.*

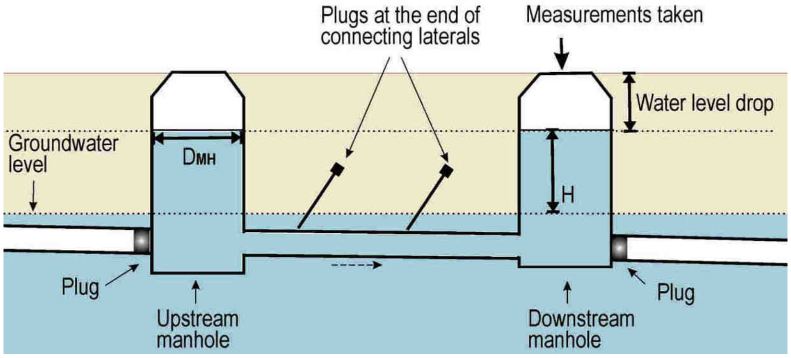

Figure A-103. Water Exfiltration Test "Before".

Table A-35. Lafayette, LA, 2003: Leakage Rates Before Rehabilitation.

	Manholes filled with water:		Water drop measured:	Time interval	Water drop	Leaked volume (gal)			Leakage rate (gpm)
	Upstream:	Downstream:				Downstream manhole:	Upstream manhole:	Total:	
#3	MH 1257 (48")	MH 1252 (48")	MH 1252	8 min	22.5"	105.71	176.18	281.88	35.24
#4	MH 1260 (48")	MH 1257 (48")	MH 1257	10 min	13.5"	37.83	105.71	143.53	14.35
#6	MH 1258 (36")	MH 1257 (48")	MH 1257	8 min	18.5"	52.61	144.86	197.47	24.68
#7	MH 2987 (36")	MH 2986 (48")	MH 2986	15 min	11.0"	23.40	86.13	109.53	7.30
#9	MH 2992[51]	-	MH 2992						

Exfiltration Test "After". The exfiltration test "after" was performed by measuring the water level drop in the upstream manhole. The downstream manhole was plugged off and remained empty during the sealing (Figure A-104).

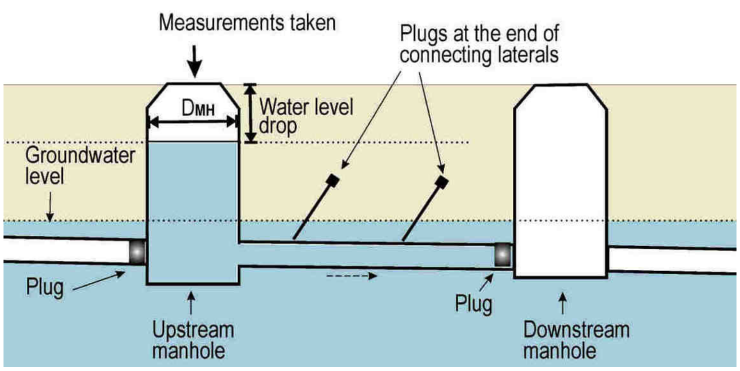

Figure A-104. Water Exfiltration Test "After".

Table A-36 shows the measured drop of the level of solution S-2 in the <u>last five minutes</u> of the sealing, when the level stabilized. Based on the observed level of S-2, sections 3, 4, and 6 did not appear completely sealed but additional cycles were not repeated due to some technical problems with the pumps and equipment. However, as the reaction between two solutions typically continues in the soil, the sealing effect was expected to continue to develop with time and further prevent infiltration into these sections.

[51] *During the water exfiltration test, the water did not reach the upstream manhole as it escaped through the inactive lateral. Section #9 was not therefore tested for exfiltration "before".*

Table A-36. Lafayette, LA, 2003: Leakage Rates After Rehabilitation.

	Manholes filled with water:		Water drop measured:	Time interval	Water drop	Leaked volume (gal)			Leakage rate (gpm)
	Upstream:	Downstream:				Upstream manhole:	Downstream manhole:	Total:	
#3	MH 1257 (48”)	-	MH 1257	5 min	0.25”	0.49	0.00	0.49	0.10
#4	MH 1260 (48”)	-	MH 1260	5 min	0.50”	0.98	0.00	0.98	0.20
#6	MH 1258 (36”)	-	MH 1258	5 min	0.25”	0.49	0.00	0.49	0.10
#7	MH 2987 (36”)	-	MH 2987	5 min	0.00”	0.00	0.00	0.00	0.00
#9	MH 2993 (48”)	-	MH 2993	5 min	0.00”	0.00	0.00	0.00	0.00

Allowable Leakage Rates. One standard that regulates in-situ tests of the required leak-tightness in sewers[52] is the Greenbook SSPWC 306-1.4. According to this standard, the section in a water exfiltration test has to be filled to a point 4' above the invert of the pipe at the center of the upstream manhole, or a minimum of 4' above the average groundwater level (Figure A-105). The allowable leakage is calculated as follows:

- ♦ For mortared joints:

$$E = 0.0001 \cdot L \cdot D\sqrt{H} \qquad \text{(A-4)}$$

Where: E......... Allowable leakage rate (gpm)
L......... Length of mainlines and laterals in the section (ft)
D .... Internal diameter of the tested mainline (in)

- ♦ For all other joints:

$$E = 0.00002 \cdot L \cdot D\sqrt{H} \qquad \text{(A-5)}$$

Where: H .... Difference in the elevation between 1) the water surface in the upper manhole and the invert of the pipe at the lower manhole, or 2) the water surface in the upper manhole and the groundwater at the lower manhole.

---

52 *Some standards that regulate in-situ tests of required leak-tightness in sewers are:*
(1) Greenbook SSPWC 306-1.4 (APWA Southern Californian Chapter), which requires that gravity sewer pipelines 24-in or less in diameter be tested for leakage depending on the difference in elevation between inverts of adjacent manholes:
♦ If the difference is less than 10', the water exfiltration test or water infiltration test should be used, but air pressure test may be used instead.
♦ If the difference is greater than 10', an air pressure test or water infiltration test should be used.
(2) EN 1610: 1997 (European Standard), which requires the leak-tightness be tested with either an air or water pressure test.
(3) AS 2032:1997 (Australian Standard), which requires the leak-tightness be tested with either a hydrostatic test or an air test.

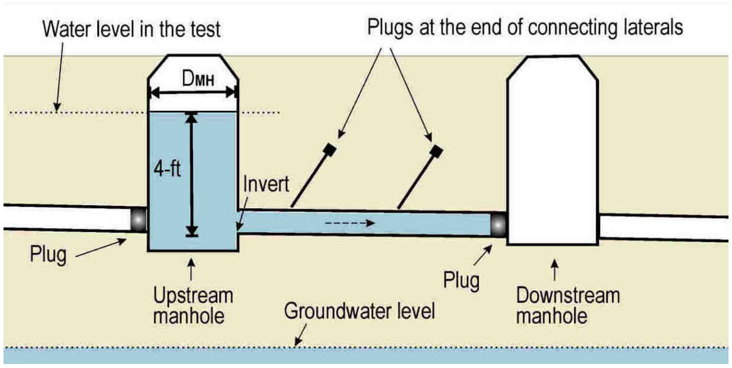

Figure A-105. Greenbook Water Exfiltration Test.

The allowable leakage rate in the Sanipor sealing tests was calculated using formula (4), where ΔH was assumed to be 5' (Figure A-106). The groundwater level in Lafayette is usually deep, however, the project was performed shortly after heavy rains and the groundwater level was approximately at 5'depth. Table A-37 shows the calculated rates that should be allowable in the tests compared with earlier determined rates.

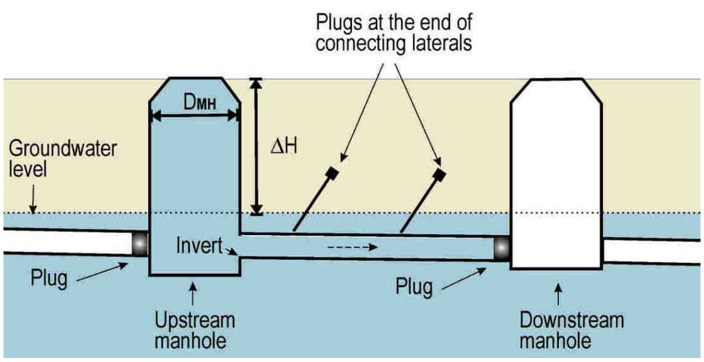

Figure A-106. Allowable Leakage Rates in Sanipor Water Exfiltration Tests.

Table A-37. Lafayette, LA, 2003: Allowable Leakage Rates Compared with Rates "Before" and "After" Rehab.

Section	Upstream Manhole	Length			Mainline Diameter	ΔH	Leakage Rate (gpm)		
		Mains	Laterals	Total			Allowable	"Before"	"After"
#3	MH 1257	298.5'	44.0'	342.5'	8"	5'	0.12	35.24	0.49
#4	MH 1260	254.7'	80.0'	334.7'	8"	5'	0.12	14.35	0.98
#6	MH 1258	259.0'	269.0'	528.0'	8"	5'	0.17	24.68	0.49
#7	MH 2987	293.9'	567.0'	860.9'	8"	5'	0.31	7.30	0.00
#9	MH 2993	266.7'	320.0'	586.7'	8"	5'	0.21	-	0.00

Exfiltration Test 21 Months Later. The test was repeated on 01/18/05, approximately 21 months after the project completion. It was similar to the test "before" having both manholes filled with water[53], however the connecting laterals were not plugged at the cleanouts near the houses and the water was able to leak out at those locations (Figure A-107).

[53] *Again, the upstream manhole was filled below the top due to the different elevation of manholes at the street level.*

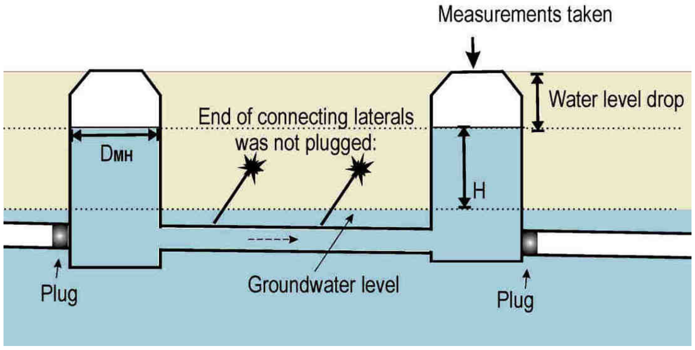

Figure A-107. Water Exfiltration Test 21 Months Later.

Table A-38 shows the measured level drops and calculated values. Two sections had no level drop showing that the installed material was performing well. On three other sections, there was a significant water level drop, which was however was not surprising because the laterals were not plugged.

Table A-38. Lafayette, LA, 2003: Leakage Rates 21 Months After Rehabilitation.

	Section Filled with Water			Water Drop Measurement			Calculated Leaked Volume (gal)			Leakage Rate (gpm)
	Upstream	Downstream	Less	Location	Duration	Drop	Downstream	Upstream	Total:	
#3	MH 1257 (48")	MH 1252 (48")	20"	MH 1252	20 min	4"	31.35	31.42	62.77	3.14
#4	MH 1260 (48")	MH 1257 (48")	9"	MH 1257	20 min	7"	36.28	54.61	90.89	4.54
#6	MH 1258 (36")	MH 1257 (48")	12"	MH 1257	20 min	0"	0.00	0.00	0.00	0.00
#7	MH 2987 (36")	MH 2986 (48")	12"	MH 2986	20 min	0"	0.00	0.00	0.00	0.00
#9	MH 2992 (48")	MH 2993 (48")	12"	MH 2992	20 min	14"	109.97	109.97	219.94	11.00

Explanation: "Less" indicates depth (from the street level) that the downstream manhole was filled to.

A.8.7 Project Duration

The average duration of flood grouting steps and duration of sealing is given in Table A-39, Table A-40, and Table A-41.

Table A-39. Lafayette, LA, 2003: Average Duration of Flood Grouting.

Activity	Average Duration	
Mobilization (tankers from base to site, stoppers inserted)	120 min	2.0 hrs
Cleaning and CCTV (if done on the same day)	180 min	3.0 hrs
Sealing with both solutions (1 cycle)	120 min	2.0 hrs
Demobilization	90 min	1.5 hrs
TOTAL		8.5 hrs

The shortest sealing cycle took only 45 min (section #10) and the longest about four hours (section #6, although the third application of solutions was repeated on the following working day). Overall, the crew was able to rehabilitate one or two sections per day and the project took seven working days, which was a little longer than the initially planned schedule of five days.

Table A-40. Lafayette, LA, 2003: Duration of Sealing and Number of Refills per Cycle.

Section	Date	Cycle 1		Cycle 2		Cycle 3		Total
		S-1	S-2	S-1	S-2	S-1	S-2	
#1	04/08/03	40 min (1)	55 min (2)					95 min
#2	04/09/03	45 min (1)	45 min (0)					90 min
#3	04/09/03	60 min (3)	40 min (2)	40 min (1)	60 min (2)			200 min
#4	04/10/03	45 min (3)	50 min (0)					95 min
#5	04/11/03	30 min (1)	35 min (1)					65 min
#6	04/11/03	30 min (0)	30 min (1)	55 min (3)	60 min (1)			245 min
	04/14/03					40 min (2)	30 min (0)	
#7	04/15/03	5 min (0)	5 min (0)	15 min (0)	35 min (0)			60 min
#8	04/15/03	25 min (0)	25 min (0)					50 min
#9	04/16/03	25 min (0)	50 min (2)	25 min (0)	50 min (0)			150 min
#10	04/10/03	25 min (1)	20 min (0)					45 min
Min								45 min
Max								245 min
Ave								109 min

Explanation: Numbers in parenthesis are the number of refills.

Table A-41. Lafayette, LA, 2003: Duration of Sealing per Day.

Day	Date		Sections Sealed	Duration of Sealing
1	Tue	04/08/03	#1	95 min
2	Wed	04/09/03	#2, #3	285 min
3	Thu	04/10/03	#4, #10	140 min
4	Fri	04/11/03	#5, #6	240 min
5	Mon	04/14/03	#6	70 min
6	Tue	04/15/03	#7, #8	110 min
7	Wed	04/16/03	#9	150 min

The challenges of this project were the following:

- Inexperience was the biggest issue. Without any previous experience with this method, the project was a learning experience for both the contractor and the municipality. The crew was initially slow in changing the solutions, but their speed increased significantly with practice over several days. The required equipment was not immediately available. For example, the contractor did not have a proper pump on the first day, and the municipality had to locate and bring in their hydraulic submersible pump. In the course of the project, the performance of the crew improved due to training and better functioning of the equipment, which reflected in achieving faster and more effective utilization of working time as the project progressed.
- Groundwater conditions were difficult because the sewer system (Beverly Drive area) was heavily surcharged from heavy rain before the project (a 2” event). The heavy rain surcharged the capacity of lift stations: the pumps were operating continuously but slowly, and the manholes were still half-filled with water. The section #7 (MH 2987—MH 2986) had to be plugged and dewatered.
- Multiple houses sharing a common lateral were discovered late at Ophelia Drive. Three homes were with two laterals that connected into a single lateral at some distance from the

home, but this was not known ahead of time because the laterals were not CCTV inspected.

Another comment worth mentioning is that some existing defects could have been repaired with some other method prior to the project to save time and use of chemicals, however Sanipor® ultimately provided a complete solution. For example, one manhole (Beverly MH 2986) had a crack and a large hole in the soil behind the crack. This defect could have been fixed easily with a trowelable mortar. With Sanipor®, the soil and the void behind the manhole were solidified sealing the ground around the manhole as well as the manhole wall and eliminating voids that could cause further deterioration.

A.8.8 Cost Analysis

Table A-42. Lafayette, LA, 2003: Summary of Costs.

	Unit Price	Quantity	Amount	Note
Prior to Sanipor® installation				
Mainline CCTV	$507.60	5	$2,538	
Lateral CCTV	$137.75	36	$2,538	
Installation of cleanouts	$167.04	25	$4,176	
Purchase of plugs[54]				
Water drop test	$200.00	5	$1,000	
Legal fees for letters sent to property owners				
TOTAL			$10,252	Cost to the agency [55]
Sanipor® installation				
Equipment and a 5-people crew	$3,600/day	6.5 days	$23,400	
Chemicals Solution S1	$3.60/gal	2,675 gal	$9,630	
Chemicals Solution S2	$17.99/gal	2,220 gal	$39,938	
TOTAL			$72,968	Cost to the agency was $50,000 (by contract), the rest paid by the contractor
Alternatives to Sanipor® (for comparison)				
CIP relining of mainlines	$22.00/ft	1,473’	$32,406	
Reopening of laterals	$150/ea	24	$3,600	
Rehabilitation of manholes	$56/ft	49’	$2,744	
Rehabilitation of laterals	$3,000/ea	24	$72,000	
TOTAL:			$111,750	

The cost of lateral rehabilitation in this project can be estimated by comparing the volume of laterals and the total rehabilitated volume (mainlines, manholes and laterals together). The approximate calculation is as follows:

Table A-43. Lafayette, LA, 2003: Breaking Down the Total Cost between Mainlines, Manholes and Laterals.

	Diameter	Length	Volume (CF)		Cost	
Mainlines	8"	1,372.8'	479	(40%)	$28,932.95	
Manholes			498	(41%)	$30,080.53	
Laterals	5"	1,695.0'	231	(19%)	$13,954.53	Approx. $580/lateral or $8.25/ft.
TOTAL:			1,208		$72,968.00	

[54] *Plugs had to be purchased but they are reusable and are not considered a relevant item in the cost analysis.*
[55] *These items would have been required with other methods and are not considered a relevant item in the cost analysis.*

A.8.9 Public Relations

Public relations involved sending the homeowners a letter explaining the project and the benefit to the homeowner (having the lateral cleaned and sealed, and a new cleanout installed at no cost to the homeowner). Before any work started, the homeowners had to sign a customer authorization form allowing the city crews to work on the private property.

In addition to signing the authorization form, one homeowner (a lawyer) made his consent contingent upon the municipality signing and returning to him the following indemnities inserted into the form.

"LUS agrees to indemnify and hold harmless the homeowner for any property damage or personal injury arising out of or in any way connected with this project including but not limited to claims of third parties, and so including attorney fees, litigation costs, and all judgments or settlements."