2014 Village of Brown Deer

Sanitary Sewer Dye Testing Project

Milwaukee County, Wisconsin

February 2015

R.A. Smith National

Beyond Surveying and Engineering

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Milwaukee County, Wisconsin

Prepared by
Christopher M. Stamborski, P.E.
R.A. Smith National
16745 W. Bluemound Road, Suite 200
Brookfield, WI 53005-5938

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Introduction to Dye Water Flooding

Dye water flooding is a traditional practice that has proven to be an effective method for a variety of purposes. As with this particular project, dye water flooding is performed in conjunction with closed circuit televising (CCTV) of the sewer to confirm I/I sources within the sanitary sewer on both public and private property. In some cases, the dye testing can provide quantitative results to defects that were identified as part of other investigation methods. (i.e. sanitary sewer smoke testing, manhole inspections, standard CCTV inspections, and flow monitoring) Dye water flooding aids in verifying both the presence and quantification of specific defects during an evaluation.

The procedure consists of forcing non-toxic bright colored dye into defects by flooding the roadside ditch. A combination of sand bags and sewer plugs, like the one shown in the photo on the right, were used to isolate ditch sections. By isolating sections of the roadside ditch we are able to limit adverse impacts to the sanitary sewer caused by large sources of inflow and infiltration. The goal is to view significant defects in isolation, and allow the existing sanitary sewer to be unaffected by any small sampling of these defects.

Culverts were filled with sand bags or plugged with sewer plugs and filled to the top of the culvert. This creates a pressure head on the defects within the sanitary sewer system. The photo to the right is of a ditch line in the Village during the flooding process. Dyed water leaking into the ground is replenished with additional water to maintain a steady pressure head on the system. The surcharged ditch sections simulate a storm event that would produce a similar reaction in the sanitary sewer. We are assuming that this surcharged condition would occur during a 5 to 10-year recurrence interval storm event.

Using CCTV inspection, the path of the dyed water was observed and documented within the sanitary sewer system, with rate of infiltration estimates given for each dye entry noted. The dye water entries noted during the testing are noted later in the report, and summaries on total flow originating from both public and private property are also noted.

Dye Water Flooding Results

The dye water flooding indicated that there are both public and private defects that are causing clearwater to enter the sanitary sewer system during large rain events. The following parameters were used when determining whether a defect was public or private in the system:

- A public defect is defined as a dye water entry within a publically owned utility. More specifically: sanitary sewer manholes, sanitary sewer mainlines, capped lateral connections (at the mainline sewer connection), storm sewer manholes or catch basins, etc.

- A private defect is defined as a dye water entry from a sanitary sewer lateral connection to the mainline sanitary sewer or sanitary sewer manhole. In the Village of Brown Deer, the sanitary sewer lateral becomes private property at the right-of-way line, but for the purposes of this report, any green dye that was entering through a lateral connection was considered a private property defect.

The following table summarizes the total public and private dye water entries noted in gallons per minute (gpm) for the study area:

Public Defect (gpm)	Private Defect (gpm)
11.5	**142.6**

Detailed results for the above can be found in the exhibits and tables included with this report. The Summary Exhibit on the following page illustrates the locations of the all dye water entries witnessed during the testing process (public and private sources) in each of the study areas. The appendix of this report includes detailed information on the quantity of both public and private leaks witnessed in each area.

Sanitary Sewer Flow Monitoring

The Village has been performing ongoing flow monitoring in various areas of their system to better understand how it operates during wet weather events. The Village had a flow meter installed in the most downstream manhole of our study area in 2013, which will we use for comparison purposes in the text below. We will use the data collected by the flow meter to quantitatively compare the excess I/I witnessed during similar storm events to what we created with the ditch flooding process.

Darnel Ave Dye Testing Study Project
Village of Brown Deer, WI

Legend

- Manhole with Leak
- Blockage
- Leak Location
- Sanitary Sewer Manhole
- Sanitary Main with Dye
- Property with Dye Water Entry Through Lateral into Sanitary Sewer
- Property Where Lateral Teevising Performed
- Sanitary Sewer

Total Sewer Lateral Connections
353

Total Sewer Mainline Length
16,460 ft

Estimated Leaks (gpm)	
Public Leaks	Private Leaks
11.7	142.6

N

0 100 200
Feet

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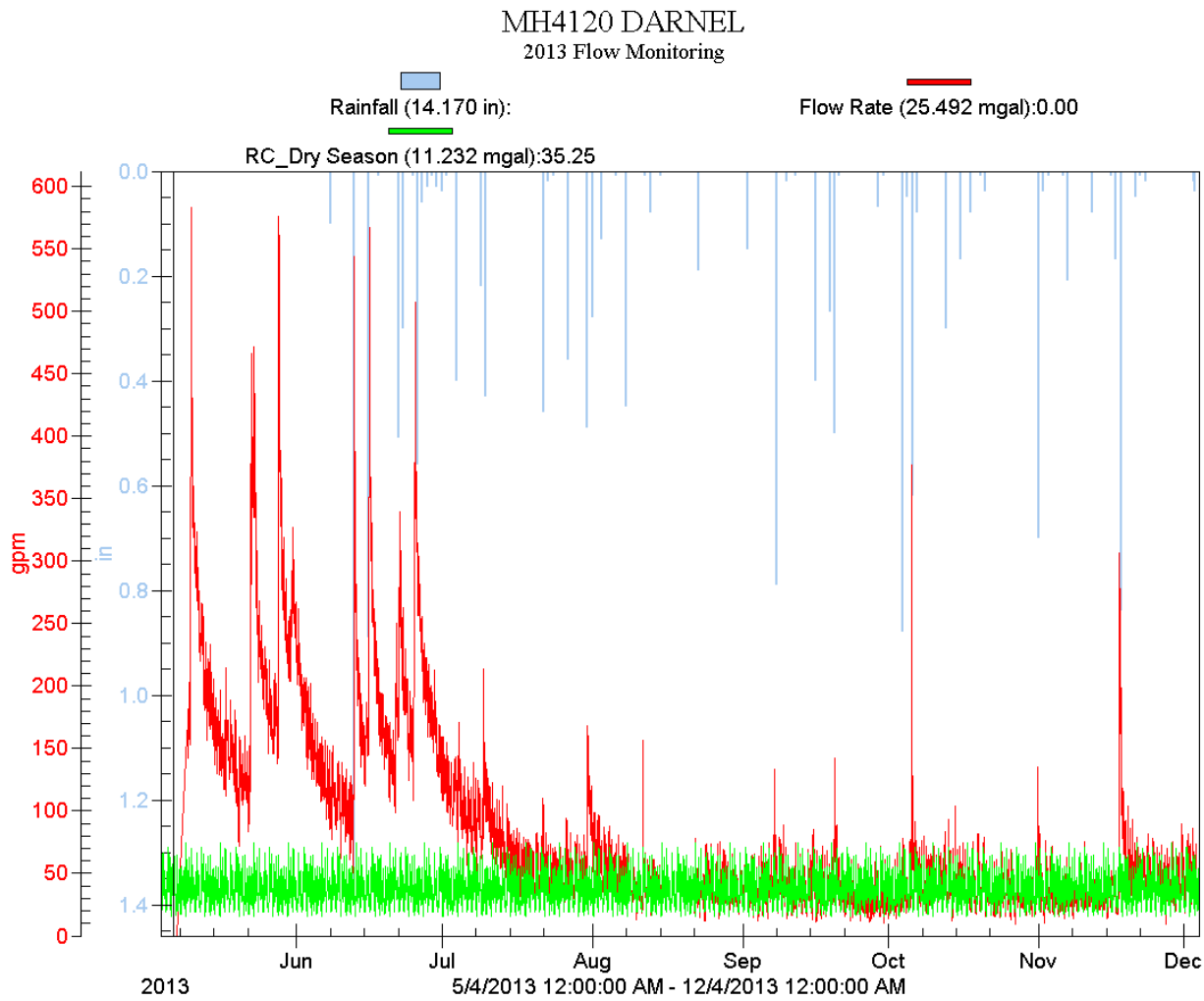
The graph below illustrates all data collected during the 2013 flow monitoring period. The graph includes: the flow rate in gallons per minute (gpm) in red, rainfall in inches (in) shown light blue, and the base flow (gpm) in green. The base flow is determined by selecting a seven day period of flow during a dry weather period. In this case, the base flow was taken from the flow rates recorded from August 15th through August 22nd. The legend includes figures within parentheses. These represent the total flow or rain for the entire period shown. In this case, 14.170 inches of rainfall was recorded between May and December 2013.



As can be seen above, the spring, summer, and fall average flows are very different. The average base flow in spring is around 100 gpm, while the average base flow in fall is around 40 gpm, indicating a steady I/I source is present, and is most likely driven by groundwater and ambient soil moisture conditions. The higher spring flows begin to taper off in July, and appear to reach their lower fall/winter flow pattern around August. Because our dye testing work was completed in September of 2014, we'll use the fall average base flow of 40 gpm in our analysis of how this data compares to the simulation testing we did for this project.

The graph below gives a snapshot of the excess flow during the June 2013 storm event. The excess flow was determined by assuming that 40 gpm represents the normal base flow

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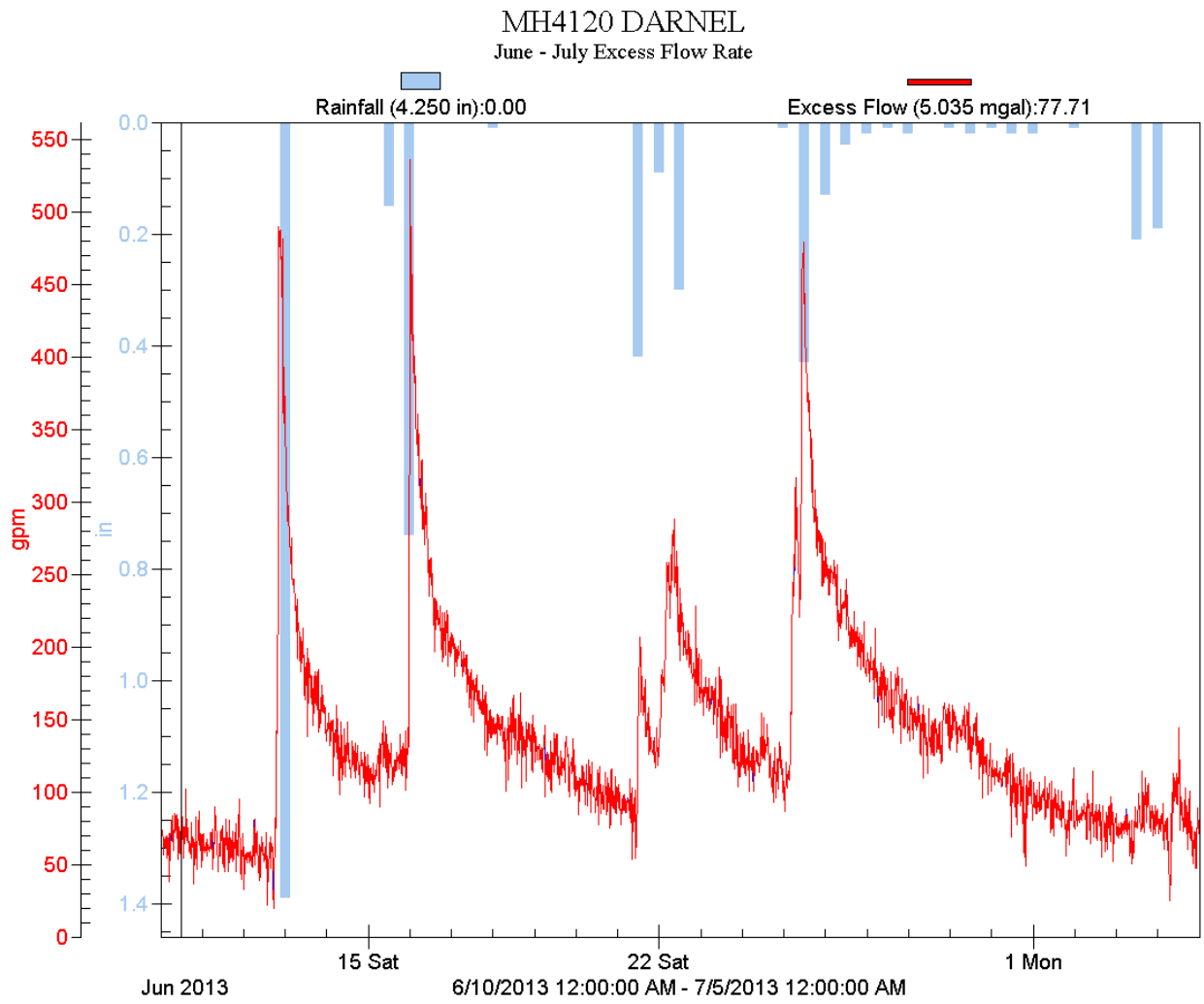
conditions, which were removed from the graph below to show only what is considered "excess" flow in the sanitary sewer system. The June 2013 storm event was a significant, high intensity rainfall that caused a number of problems in the sewer system. But, it does provide a good analysis of just how much excess water exists in the sewer system (public and private) compared to what we witnessed during our dye testing effort.

After several days of non-rain events, the excess flow starts at around 60 gpm on June 10, 2013. After each of the four separate rain events, this excess flow settles to about the 100 gpm in early July. Based on this, it appears as though 60 to 100 gpm can be attributed as non-rainfall derived I/I in the system, or steady infiltration that occurs in the system during wet weather seasons.

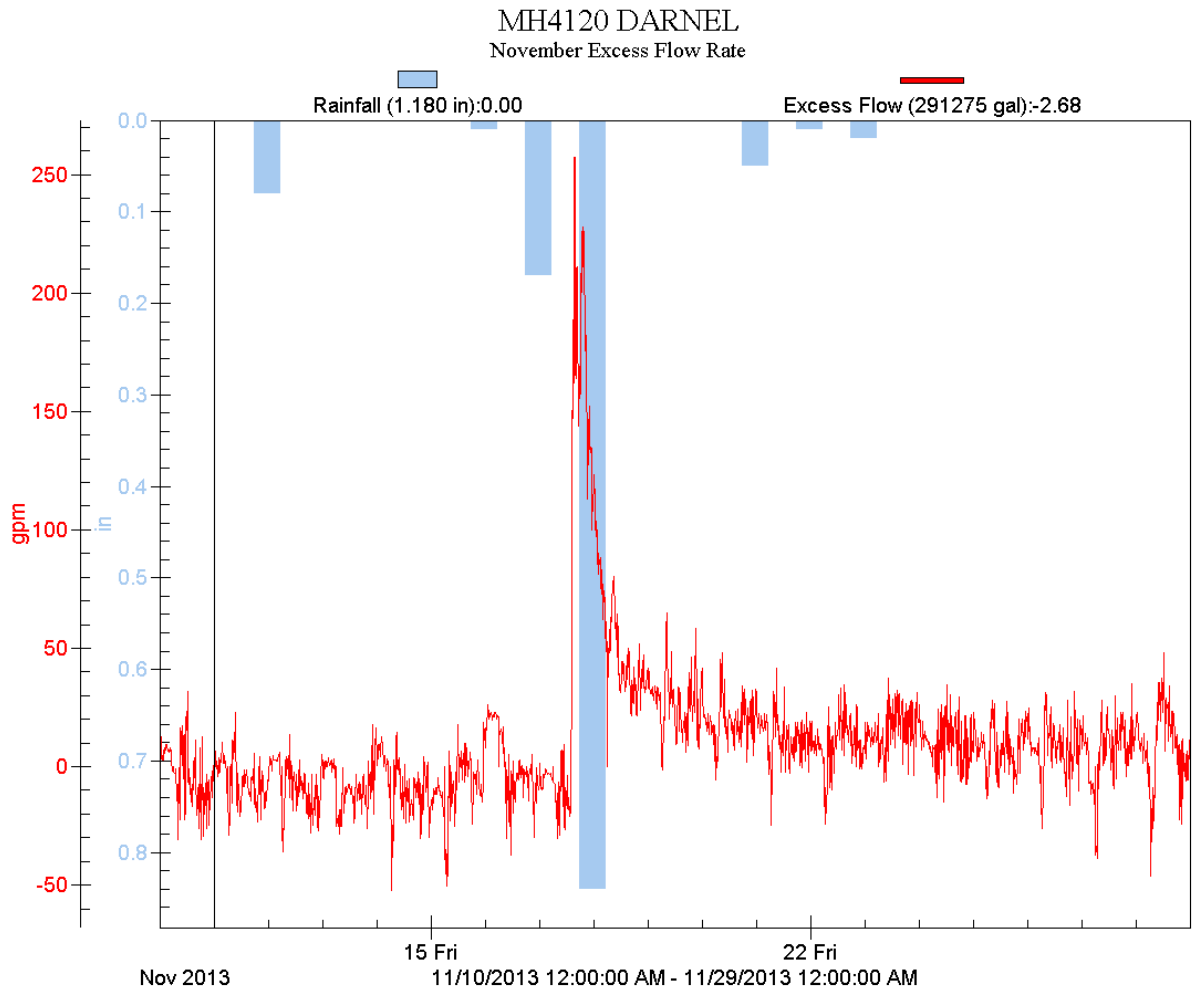


The excess flows for the three major rainfall intensity periods above reach about 480 to 500 gpm. Our dye testing identified about 154 gpm (or approximately 30%) of the excess I/I within the right-of-way portion of the sewer system (which includes laterals and mainline sewers and manholes). It is probably safe to assume that the dye testing results may have been even greater had we performed the same testing during saturated soil conditions. However, the above results

indicate that there is additional I/I that was not accounted for in the dye testing effort, which is most likely originating from beyond the right-of-way in our project area.

We also compared the dye testing results to a smaller storm event that occurred later in 2013, when average sanitary sewer flows, and soil conditions (dry) were at a similar condition to what we were experiencing during our dye testing project. The graph below shows the results from a November 17/18, 2013 storm event, and more accurately shows the effect that rain falling on dry soil and into ditches would have on the system. In this scenario, only the right-of-way portion of the sanitary sewer system (both laterals and mainline sewer included) are subjected to the effects of the dye testing, which is probably another reason why the peak flows experienced are much lower.

The excess flows experienced during this storm event reaches about 250 gpm. This is much closer to the dyed water infiltration of 154 gpm (~60% of excess flows) witnessed during the testing. Even this scenario does indicate that additional I/I is most likely coming from upstream of our testing area in private property.



Defects Noted During Dye Testing

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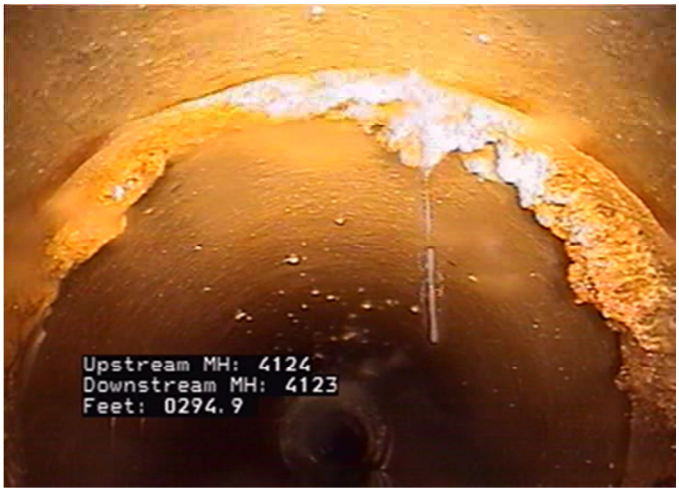
Listed below are brief descriptions of the types of defects that were witnessed during the dye flooding process. These defects occurred on both public and private sides of system. Each of the defects noted can be rehabilitated to remove the clearwater entry from the system, but multiple factors need to be considered when choosing the appropriate repair method. These factors include: overall impact of repair to the system (i.e. does a public sewer repair result in a private sewer issue), customer disruption (open cut versus trenchless solutions), budget considerations (are the leaks noted cost-effective to repair using a given repair/replacement technology), and impact to private property (who is responsible, and how will private property work be funded). Each of these issues is addressed later in this report.

Sanitary Sewer Manholes

A total of 3 sanitary sewer manholes were leaking dyed water during the dye testing process. The cumulative leaking rate of the manholes was approximately 0.3 gpm, originating primarily from the walls of the manholes. The manhole leaks witnessed represent approximately 0.2% of the total leaks noted. Traditionally, manholes are the most cost-effective public repair, which makes addressing these defects easier to accomplish.

The photo on the right shows a 0.1 gpm leak in Manhole 4134. The leak is coming from the joint in the barrel section above a lateral. This is the same type of leak noted for the other manholes.

Sanitary Sewer Mainline



Approximately 16,460 lineal feet of sanitary sewer was televised during the dye testing process. The sanitary sewer consisted of 8-inch and 12-inch Vitrified Clay Pipe (VCP).

A total of 12 sanitary sewer mainline leaks were identified during the testing in 10 different mainline sewer segments. The leaks varied in dye water intensity and amount, but in total accounted for 11.2 gpm, or just over 7% of the I/I witnessed during our testing process. The photo on the left is an example of a mainline joint leak. The clear water is leaking from a joint between two pipe segments. This leak is consistent with other leaks found during the investigation. These types of leaks are estimated at around 0.1

gpm, and would most likely not be visible unless the sewer was televised during a significant rainfall event.

Other mainline leaks contributed significantly more I/I as shown in the photo on the right. In this case the leak was estimated to contribute approximately 10 gpm of excess I/I to the sanitary sewer system during similar types of rainfall events.

Sanitary Sewer Services (House Laterals)

A total of 200 sanitary sewer services were leaking varying amounts of dyed water during the testing. We estimated the laterals accounted for approximately 143 gpm of dyed water leaking into the sewer during our testing process. As mentioned earlier in this report, sanitary sewer services are owned by the Village within the road right-of-way, but are considered private property outside of that area.

This project allowed us to identify the laterals that are contributing I/I within the right-of-way area during storm events, will help the Village better understand the magnitude of a targeted private property I/I rehabilitation project in this area.

Over half of the total laterals within the study area were found to be leaking at some amount, with the largest estimated leak at 5 gpm. However, the combined effect of the smaller leaks result in a significant amount of I/I as it moves downstream through the sanitary sewer system. The two photos on the right are examples of laterals with significant dyed water infiltration. Each of these leaks is approximately 3.0 gpm.

Lateral Televising During Dye Testing

We were able to televise several of the sanitary sewer laterals that we witnessed leaking dyed water as part of this project. The lateral televising provided a combination of things, which included: condition assessment of the lateral, location of the leaking witnessed, and a way to quantify which segments of the lateral (i.e. within or outside of the right-of-way area) were leaking. This became especially important when trying to correlate the results of the lateral grouting effort from 10-plus years ago with the performance of the laterals during our testing.

The photo on the right was taken from one of the laterals we televised. It shows a significant leak within the lateral originating from a crack in the side of the pipe. It also shows that the joint upstream of the crack is also leaking, which together contribute additional unwanted I/I to the sanitary sewer system during rain events.

Condition Assessment of Sanitary Sewer (Non-Dye Testing Related)

An added benefit in performing the dye testing is the operational and maintenance work the Village received on the sanitary sewers. Each sanitary sewer segment was cleaned and televised, limiting work that the Village staff would have otherwise needed to perform. The inspection also provided a general structural, operational and maintenance assessment of the sewers, which is helpful in determining areas that may need attention in the future. The results explained later in this section illustrate a collection of the structural defects discovered during the investigation, along with recommendations as to when these defects need to be addressed to avoid disruption in sewer service or potential impact to private property if a failure would occur.

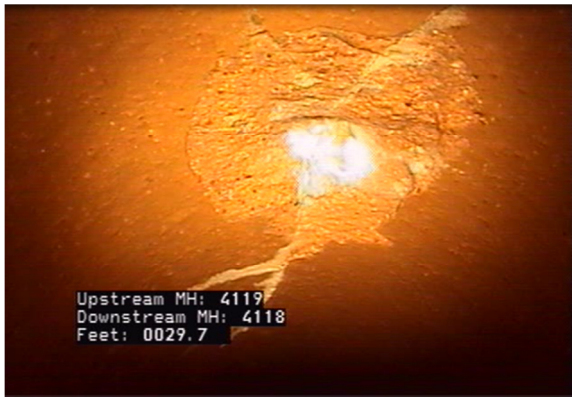
In general, televising sanitary sewer systems can reveal defects that can significantly impact the hydraulic performance of a sewer system. The defects are identified and rated based upon their severity and impact to the system. Typical defects found include, pipe joint leaks, mineral deposits, roots, pipe cracks and sags between pipe lengths. More severe problems are sometimes encountered such as a broken or collapsed pipe that need to be addressed quickly, as a disruption in service could be imminent. Each of these defects can contribute to problems such as sewer backups during rain events and constant infiltration in high ground water areas.

We contracted with 'Visu-Sewer' to complete the sanitary sewer cleaning, televising, dye flooding and NASSCO rating of the sanitary sewer. All of the detailed investigations used the specified NASSCO (National Association of Sewer Service Companies) formatting standards. The use of this coding standard allows the Village to make a comparative analysis of the sewers to determine where attention is needed both now and in the future. This standardization of coding also will allow the Village to see how the pipe condition changes over time, giving an idea of when future maintenance or rehabilitation could be necessary. Below is a brief description of NASSCO rating system.

NASSCO Pipeline Assessment and Certification Program (PACP)

In the NASSCO rating system, conditions that are encountered in the televised pipelines are separated into two code categories; structural defect codes and then operational and maintenance codes.

Structural Defect Codes



As defined by NASCCO, structural defect codes are conditions that relate directly to the overall integrity of the sanitary sewer pipe itself. Depending on severity, the defect gives an indication of the remaining useable life of the pipe, and a suggestion as to how quickly it may need to be addressed in the future. Similar to I/I-related defects, one defect can be severe enough to require pipe replacement or rehabilitation, but multiple less-significant defects could also result in the same recommendation. Typical defects that are included in this grouping are: cracks, fractures, holes, collapses, surface damage, and pipe joint offsets.

The photos on this page are examples of the structural defects that were found during televising of the Village's sewers. The upper photo displays a section of pipe that has a fracture in the crown of the pipe. This defect does not need immediate attention, but needs to be noted to determine if the defect is worsening during the next televising.

The middle photo shows multiple fractures at the top of the pipe. Over time, this defect will become more significant, and the broken pieces of pipe will eventually fall into the bottom of the mainline pipe, causing potential disruption in service and exposing the crown of the pipe for material entry into the sewer, or excess I/I to enter the system. Defects such as these should be fixed in the near future to avoid a more expensive emergency repair.

The photo on the right is of an offset joint created by what appears to be a new service connection or lateral connection to the mainline sewer. The repair appears to connect the clay and PVC pipe with a Fernco® coupling designed to create a watertight seal between the two pipe materials. This is typically a potential I/I location during past dye testing projects, but this connections is performing as it should resulting in no additional attention needed to this item.

Operational and Maintenance Codes

As defined by NASCCO, specific operational and maintenance codes are codes that relate to various types of foreign objects that are found in sewers that may interfere with the operations of the system. Unlike structural defect codes, the O&M codes do not relate to the condition of the pipe itself, they relate to the capacity of the pipe. Depending on severity, the defect gives an indication of the remaining useable capacity of the pipe, and a suggestion as to how quickly it may need to be addressed in the future. Typical items that are included in this grouping are: deposits, roots, infiltration, obstacles/obstructions, and vermin. Below are examples of the operational and maintenance codes that were found during televising of the Village's sewers.

Settled Deposits. These were not found often in the project area. Settled deposits are typically composed of gravel and silt, formed in slow flow conditions that prevent the transport of these particles downstream in the pipe. These deposits then become settled in the bottom of the pipe, sometimes creating a hydraulic issue with the remaining sewage attempting to flow to the downstream location. If left unattended, these deposits may create a bottleneck in the system that could lead to capacity issues in these areas.

While settled deposits were not a significant issue in this area, there was an object that should be removed at some point in the future. The above photo shows what appears to be a brick in the flow line. This will most likely not cause any significant issues, but is still a location where debris will collect. Village crews should be able to address this issue as part of their ongoing cleaning and televising program in the future.

Attached Deposits. These were noted frequently during the dye flooding project. These mineral deposits build up over time from groundwater slowly leaking into the pipes through joints or cracks. This groundwater contains minerals that attach to the sides of the pipe and form a hard deposit. These deposits can impact the hydraulics of the pipe as they grow, as they begin to occupy the existing cross-sectional area of the pipe. More often than not, these deposits actually seal themselves over time, but when removed again will reveal the steady like that created it in the first place. With that, it becomes important to seal the pipe after these are removed to prevent them from forming again at the same location.

The photo on the right shows a mineral deposit noted in our study area. While this defect only occupies 10% of the pipe area, the defect will grow over time and eventually will need to be removed. The middle photo shows a private lateral with large mineral deposits at the connection to the mainline pipe. The mineral deposit in this lateral occupies about 40% of the pipe area, and is most likely reducing the overall capacity of the lateral and mainline pipe in this location. This defect does not need to be addressed immediately, but the deposit creates a place for debris to collect, which can cause backups into the home.

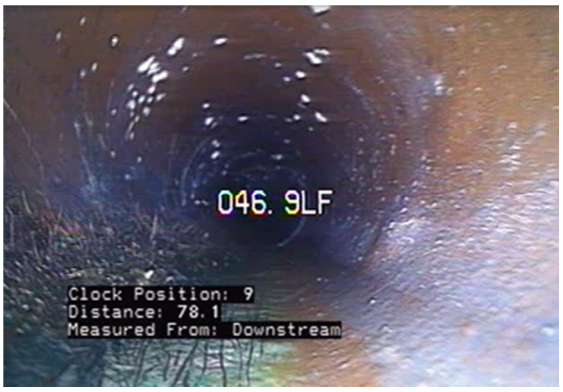
Roots. Roots have grown into the sanitary sewer causing obstructions in three locations in our project area. These are a direct result of nearby trees extending their roots down to the level of the sewer in search of air and water.

(Any root balls noted in laterals during our project were brought to the attention of the property owner where they occur, as the problem should be addressed to prevent potential issues in the future. The Village should still consider contacting each of these property owners to make sure that they took care of the problem, or at least are on record that the Village attempted to notify them that this potential issue is there.)

In some instances, the roots grow thick enough and create root balls or masses. These large root balls can lead to the breakdown of pipe structure, create a reduction in pipe capacity, or even cause a blockage of flow as they continue to collect debris and prevent the efficient passage of solids in the pipe.

The photo just above on the right is an example of a root ball found in the lateral near the connection to the mainline sewer. This root ball is blocking a significant portion of the pipe, and could potentially cause a backup in the future if not addressed.

The lower photo on the right was taken during the televising of one of the laterals in our project area. As you can see, roots are present in the line, but they are not currently causing any disruption in flow. Because they are running longitudinally in the line, they are less likely to form a root ball, but this is still an issue that should be noted by the Village and property owner, as it could cause an issue in the future. The picture also shows that the root entry appears to be the source of the dyed water leak as well.



Conclusions

Performing sanitary sewer televising has been a proven method to inventory the current condition of the sanitary pipes in the sewer system for quite some time. The end result is a report into the structural integrity of the sanitary sewer pipe, and a look into what general operation and maintenance needs could be performed in the future (i.e. cleaning, obstruction removal, etc.). But, this method may not give an accurate look into the performance of the pipe during wet weather events if performed at the wrong time of the year.

The addition of sewer dye testing provides a value-added benefit to the above. It continues to provide the benefits listed above, but adds an effective way to locate and quantify leaking defects within the sanitary sewer system at the same time. Both public and private leaks are identified by simulating the maximum storm sewer design capacity (typically a 5 or 10-year equivalent storm event) in the adjacent storm sewer or roadside ditch. Often the water fills the sanitary sewer trench (which is typically the deepest installed utility in the street) and inundates the pipes and manholes. Deficiencies in the manholes or pipes (including private laterals) allow the water to enter the sanitary sewer, which leads to increases in flow in the sewer. These increases in flow potentially cause problems with the sanitary sewer capacity in that given area. Problems with system capacity are directly related to sewer backup issues in private property.

While the dye water flooding helps us understand the impact of both public and private deficiencies of the sanitary sewer system, it does not necessarily show us how other private property issues outside of the right-of-way are impacting the sanitary sewer system. For example, the dye water testing process will not verify the presence of illegal sump pump or downspout connections to the sanitary sewer. Eliminating clearwater contributions from sump pumps and downspouts will need to be addressed separately from this study and these recommendations.

Recommendations

Settled Deposits

Settled Deposits in the mainline sewer can impact the hydraulic performance of the sanitary sewer and give an indication of where possible bottle necks in the sewer system exist. Theses flat sewer segments may have issues conveying peak flows and cause the sewer system to surcharge. The settled deposits present in the project area can most likely be addressed by Village crews during their normal maintenance of the system.

Roots

Roots in the mainline sewer can also impact the hydraulic performance of the sanitary sewer. There are three locations in the project area where masses of roots partially blocked the flow of the sanitary sewer. As these roots continue to grow, they lead to more severe issues that can cause backups in the sewer system. Roots and infiltration can also be correlated, as they provide an entry point into the sanitary sewer. Similar to the above, we believe that Village crews will be able to address the root locations during normally scheduled maintenance to the system.

Sanitary Sewer Manholes

The dye testing revealed several leaks in sanitary sewer manholes throughout our study areas. All of the manhole leaks witnessed during the testing can be addressed by chemically grouting each of the defects within the manhole. Similar to the sanitary sewer and lateral testing described earlier in this report, the leaks witnessed in the manholes may not have been present had the dye flooding not occurred at the same

time, thus adding to the benefit of performing manhole inspection during wet ground, or rain conditions. By discovering these leaks now, this source of I/I can be prevented during future rain and high ground water periods. The following is an approximate cost for grouting all manhole defects noted during the testing:

Number of Defective Manholes	Approx. Cost per Manhole	Total Cost (+15% Cont.)
3	**$650.00**	**$1,950**

Sanitary Sewer Mainline

One of the more cost-effective means to remove I/I from the mainline system is to test and seal grout the mainline joints in each pipe segment. *(A method that the Village is very familiar with from past projects in the study area.)* The process consists of testing every joint to determine whether or not a sewer joint is watertight. The determination is used by subjecting each sewer joint to a specified level of air pressure over a set time limit. If the air pressure is maintained, no further action at that joint is necessary, but joints that do not pass the air test need to be addressed. To address deficient sewer joints, grout is forced into the deficient joint to seal any potential gaps, creating a watertight seal. After the grout is injected, the joint is air tested again. If the joint does not pass the air test, the process is repeated until the joint passes. This process is then repeated for every joint in the sanitary sewer segment. The following is an approximate cost to test and seal all noted mainline sewer deficiencies noted during the dye water testing:

Total Length of Deficient Sewer (ft)	Test and Seal Cost per Foot	Total Cost (+15% Cont.)
2,495	$12	$34,431

An alternative to testing and sealing the mainline sewer would be the performed cured-in-place (CIPP) lining of the pipes. Below is an approximate cost to perform this in the study area:

Total Length of Deficient Sewer (ft)	CIPP Cost per Foot	Total Cost (+15% Cont.)
2,495	$35	$100,424

The CIPP lining is more expensive, but provides a more permanent fix with the added benefit of extending the structural lifespan of the mainline sewer pipe.

Sanitary Sewer Services (House Laterals)

The majority of the leaks witnessed were from private sanitary sewer laterals. The leaks ranged from minimal to moderate in nature, and will need to be addressed if the Village wants to continue to reduce the overall I/I impact to the public sanitary sewer system. The Village has performed rehabilitation work on private property in the past to address I/I, however, many of these rehabilitated laterals were shown to still have leaks of varying magnitudes during our testing.

We were able to televise a sampling of the leaking laterals during our project, which gives an idea of where the leaks are occurring within select laterals. Televising of other private laterals may be necessary to determine the best solution for each lateral, as the method of rehabilitation would be decided on a case-by-case basis. It will also be important to review the cost of varying methods of private property rehabilitation methods too, as varying technologies exists, each of which vary in price tremendously. The following are a selection of the rehabilitation methods that are being used today:

CIPP Lining

One rehabilitation method has been chosen most often when looking to rehabilitate deficient laterals, trenchless rehabilitation. Using a trenchless CIPP lining process is a way to avoid restoration costs associated with open cut installation work. This becomes more important when working on private property, as each property is essentially a new project area with its own set of conditions and work environment. This minimally invasive lining method would need to establish a near-watertight, or watertight, connection to the mainline sanitary sewer pipe in addition to the entire length lateral rehabilitated. There are different types of lining technologies, all of which should be considered to meet the desired outcome of the project.

Even though this is a trenchless technology, the lining process may not be entirely non-invasive. To successfully install a CIPP liner, the installer needs a point of access of each side of the installation to work from. The downstream side of the repair will start from the connection to the mainline sanitary sewer, but the upstream side may not exist, or be easily accessible with equipment. Every connection should have a cleanout located just inside the basement or interior wall of the structure, but it may not be accessible or desirable to access for this purpose. It often becomes necessary to establish a new private property access point to allow for the completion of the rehabilitation without entering the structure on private property. This will add expense to the project, but should be considered when weighing the liability risks of entering private property that any other technologies may require.

When considering the above, it is important to note that the majority of the residential homes do not have a sanitary sewer lateral clean-out location outside of their home, which means that installing one would be necessary to accommodate some rehabilitation methods. Typically an external cleanout can be installed by vacuum-excavating the soil that is above the lateral connection, allowing for the installation of a "tee" connection to create a point of access to the sanitary sewer lateral. This tee connection is then extended vertically to a point just below the existing yard grade. (These are typically left low, as they are abandoned once the project has been completed. This is presently a requirement to meet the state plumbing code, as these are not legal cleanouts that can be used at a later date.) The above method limits the amount of restoration work necessary, which is attractive when working in private property. The table below presents an approximate cost estimate to reline each defective lateral found in the project area. In this approximation the total length is the length from the home to the mainline sewer (we are assuming 65 feet on average). If this option is to be considered, further estimation on a case-by-case basis would be needed to determine the best method of rehabilitation.

Number of Defective Sewer Laterals Noted	Cost for CIPP Lateral Relining	Total Lining Length	Cost for Access Point Installation	Total Cost
185	$75/ft	~ 12,000 ft	$1,200	$1,122,000
Total Cost (incl. 15% Cont.)				**$1,290,000**

This estimate is intended to give a cost of a "worst-case" scenario. In this estimate, every lateral that showed dye water infiltration would be lined for the entire length from the mainline sewer to the house. The laterals would need to be analyzed on a case-by-case basis to determine the appropriate solution. However, this is a good starting point when considering CIPP lining.

As an alternative to installing the access point described above, the Village could coordinate access to the internal cleanout in homes where work is proposed. In either case, permission from property owners would need to be granted to allow access into the lateral, or home, but this added level of coordination

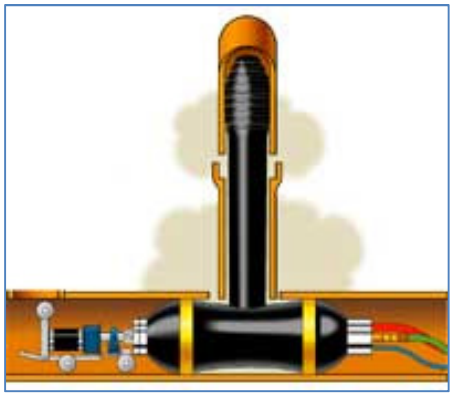
could result in a cost savings for the Village, and lessen the footprint of the project by avoiding the installation of the access point near the foundation of the home as well. While it does potentially decrease cost, it also increases the potential liability of the project, as now you would have people entering individual properties, which increases the chance of claims to the Village. This alternative can be discussed in further detail as a potential project moves forward.

Open Cut Excavation

This method involves installing a brand new lateral pipe from the mainline sewer to an upstream point in the property. Similar to the above, this replaces the old lateral with a new one, but it much more invasive in terms of the footprint required to complete the work. Consideration to the existing street condition, size and location of trees, private property landscaping, etc. come into play when considering this method, and often prevent this from being a chosen alternative.

Chemical Grouting of Laterals

This is a completely trenchless technology that is similar to the mainline sanitary sewer grouting mentioned earlier in this report, and is one that the Village used in the majority of this study area over 10 years ago. A grouting packer is used to "test and seal" the joints within the sanitary sewer lateral using equipment launched from the mainline sanitary sewer. (The exhibit on the right shows the lateral packer inside the mainline pipe, extending into the lateral to grout the defective joints.) It is important to understand the current condition of the pipe when considering this technology, as it will be effective on pipes that are otherwise structurally sound, but have deficiencies that allow for clearwater to enter the lateral. It may be necessary to pre-CCTV the laterals in advance of performing this type of work, as it will help to determine which laterals are good candidates for this type of rehabilitation work, and which ones need an alternate technique to accomplish I/I reduction goals.



In general, this methodology is much cheaper than the ones mentioned above, and would allow the Village to complete the rehabilitation of more laterals than any of the other methods mentioned above. However, this method may not have the lasting success that some of the other methods do, as you will see discussed in the next section of the report. Below is a budgetary cost estimate for this type of rehabilitation work:

Number of Defective Sewer Laterals Noted	Cost for Grouting Sanitary Sewer Laterals	Total Cost
185	$2,000	$370,000
	Total Cost (incl. 15% Cont.)	**$425,500**

The grouting method would allow for approximately four times more laterals to be addressed than other rehabilitation techniques for a much larger coverage area that the other methods.

Other construction alternatives may surface that will help to reduce the overall cost of the rehabilitation work, and each should be explored as the Village looks for options to address the private property issues they have. Each method will have the challenge of working with private property owners to address the leaking pipe, which is an important consideration when looking into any project at all.

Previous Lateral Rehabilitation

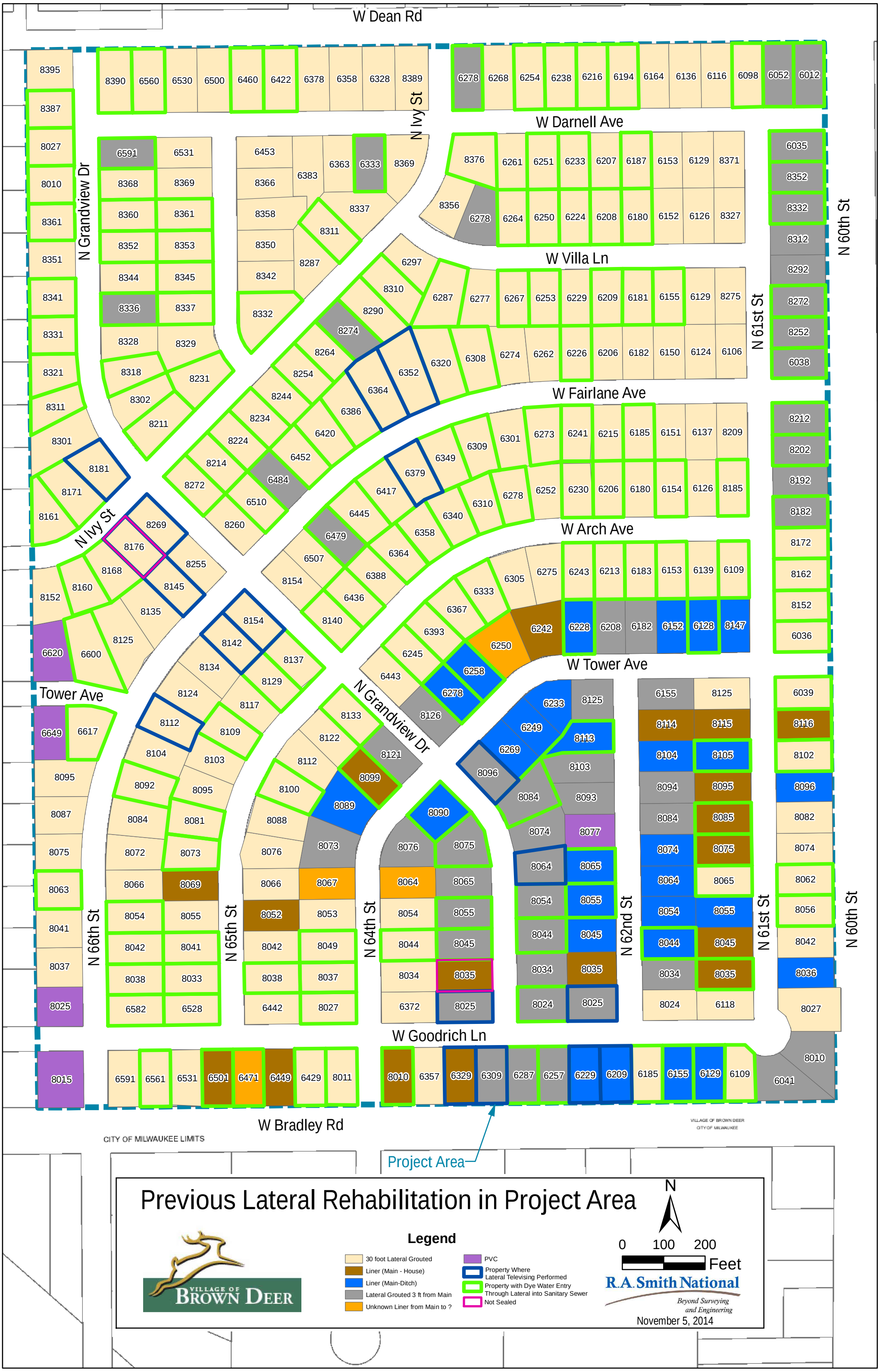
All of the laterals in our study area had various forms of rehabilitation performed on them in the past in an attempt to reduce clearwater entry of water into the sanitary sewer system. The chart below gives a summary of the various improvements, and listing of how each performed during the dye testing work. The majority of the work focused on the portion of the sanitary sewer lateral within the Village right-of-way. The exhibit on the following page illustrates the above table.

Study Area Laterals				
	Total (% of Total)	Dye Witnessed (% of Total)	% Total Leaking Laterals	Laterals Televised During Study
CIPP Lined from Main to House	18 (5%)	9 (50%)	5%	1
CIPP Lined from Main to ROW	28 (8%)	14 (50%)	7%	2
Lateral Grouted 3ft from Main	54 (15%)	29 (54%)	15%	5
Unknown Liner from Main to Unknown	4 (1%)	0 (0%)	0%	
Lateral Grouted 30ft from Main	244 (69%)	142 (58%)	74%	10
PVC Relay	5 (1%)	0 (0 %)	0%	
Totals	353	191		18

The majority (69%) of the laterals in our study area were chemically grouted in Summer/Fall 2004 from the mainline sewer to the right-of-way line at the property (~30 feet) using a 30-foot grouting packer similar to the one shown on the previous page. The dye testing showed that 58% of these 30-foot grouted laterals were leaking some level of dyed water, and further that the leaks from these 30-foot grouts represented almost three quarters of the leaks we witnessed in our study period. Although it represents a smaller sample size, the performance of the PVC relayed and CIPP lined laterals indicate that they performed much better during our dye testing study, and may be a better long-term solution for lateral rehabilitation as well.

We were able to televise a selection of the grouted laterals during our testing to determine where the leak was occurring. A total of 10 of these laterals were televised, and in each case the leaks were within the section of the lateral that was previously grouted. It is possible that the grouting did have a positive impact within this section of the lateral, as these same leaks could very well have been higher in magnitude then witnessed during our testing, but the overall data shows that these portions of the lateral are still a large contributor to the overall I/I witnessed in the study area.

As shown in the above table, the CIPP lined laterals were either from the mainline sewer to the right-of-way line or from the mainline sewer to the house. Half of these lined laterals were witnessed leaking during our testing, but the three we televised indicated that the leaks were originating from a point upstream of the lined section, with no leaks occurring within the liner itself. This supports the theory that water will always seek its next point of entry once a downstream area is closed off, meaning there is more value in sealing the lateral all the way to the home when performing rehabilitation work.


W Dean Rd
W Darnell Ave
W Villa Ln
W Fairlane Ave
W Arch Ave
W Tower Ave
W Goodrich Ln
W Bradley Rd
N Grandview Dr
N Ivy St
N 60th St
N 61st St
N 62nd St
N 64th St
N 65th St
N 66th St
Tower Ave
CITY OF MILWAUKEE LIMITS
VILLAGE OF BROWN DEER
CITY OF MILWAUKEE
Project Area
Previous Lateral Rehabilitation in Project Area
Legend
30 foot Lateral Grouted
Liner (Main - House)
Liner (Main-Ditch)
Lateral Grouted 3 ft from Main
Unknown Liner from Main to ?
PVC
Property Where Lateral Televising Performed
Property with Dye Water Entry Through Lateral into Sanitary Sewer
Not Sealed
N
0 100 200
Feet
VILLAGE OF BROWN DEER
R.A. Smith National
Beyond Surveying and Engineering
November 5, 2014

Summary

Dye testing proved to be an effective method to identify where leaks are occurring in the sanitary sewer system within the right-of-way of the Village, which includes sanitary sewer laterals that are owned by the Village within this area. However, the dye testing did not appear to identify all of the clearwater sources that exist in the system based on ongoing flow monitoring efforts that the Village has conducted. The following are our recommendations for the Village based on the findings of this study:

- The testing identified mainline sewer and manholes that selective locations that were leaking. Since none of these leaks were considered major, we feel as though the Village can include these areas as part of a separate effort rather than trying to address these on their own. The following findings should be investigated further by Village staff:

    - The largest mainline sewer leak appears to be originating near the Brown Deer Elementary School, which should be investigated further by Village crews.

- Sanitary sewer laterals contributed the majority of I/I that we witnessed during the dye testing process. However, reviewing historic sanitary sewer flow monitoring information reveals that we may have only witnessed around 20% of the total I/I that occurs during a similar storm event for this area. The Village could consider a targeted lateral rehabilitation project for this area to remove the dye tested deficiencies we witnessed, but other sources may need to be removed to fully address the I/I experienced in this area.

- The Village want to consider home inspections prior to moving forward with a lateral rehabilitation program, as it may help to discover some of the additional I/I sources that we may not have captured with the dye testing process. The home inspections could occur as follows:

    - Start with an external survey of homes to verify where their downspouts and sump pump lines discharge in the property. These inspections would not require coordination with the property owner, and would not require any entry into the home.

    - Properties with unknown sump pump and downspout discharge locations should require an in-home inspection to verify where these are occurring. Any illegal cross connections of either of these should be eliminated, as they have a large impact on the I/I that this area experiences during both wet weather season average flows and rainfall derived events.

MMSD PPII Funding

The Village should be above to utilize MMSD funding designating for PPII to both continue to investigate and rehabilitate private property I/I sources in the Village. Because the MMSD funding source is limited, it may be important for the Village to look into how they could subsidize this program if they feel it needs to continue to raise the level of service for Village customers, and also to eliminate potential SSO's in the future.

Continued Dye Testing

We believe the Village should consider additional dye testing in another area of the Village during spring wet weather season to compare the results to what we experienced performing the dye testing during dry weather conditions. Both the chance of higher groundwater and rain events will change the conditions of the ditch lines and sewers we are working in, and may lead to the discovering additional leaks.

APPENDIX A
SUMMARY EXHIBITS

W COUNTY LINE RD
HANSON PARK, A.C.
Beaver Creek
BROWN DEER VILLAGE PARK
BROWN DEER MALL
Milwaukee River
57
100
N GREEN BAY RD
VILLAGE OF BROWN DEER
DYE TESTING STUDY AREA
W DEAN RD
N 60TH ST
South Branch Creek
W GRADLEY RD
N SHERMAN BLVD
N TEUTONIA AVE
BROWN DEER PARK
N 19RD ST
BROWN DEER PARK
GOOD HOPE RD
VILLAGE OF BROWN DEER
Darnel Ave
Dye Testing Study Project
Location Map
0
800
1,600
1 inch = 1,600 feet
R.A. Smith National
Beyond Surveying and Engineering
1140177
May 22, 2014

W Arch Ave
W Tower Ave
W Tower Ave
N Grandview Dr
W Goodrich Ln
W Bradley Rd
N 66th St
N 65th St
N 64th St
N 62nd St
N 61st St
N 60th St
DEAD END
4167
4168
4169
4153
4154
4159
4155
4156
4157
4158
4148
4130
4129
4128
4131
4147
4146
4145
4144
4143
4117
4134
4133
4132
4118
4135
4136
4137
4138
4139
4140
4141
4142
4119
4120
4121
4122
4123
4124
4125
4126
VILLAGE OF BROWN DEER
CITY OF MILWAUKEE
VILLAGE OF BROWN DEER
Darnel Ave
Dye Testing Study Project
Village of Brown Deer, WI
Total Sewer
Lateral Connections
353
Total Sewer
Mainline Length
16,733 ft
Water Main
Fire Hydrant
Sanitary Sewer Mainline
Sanitary Sewer Manhole
N
0
75
150
Feet
R.A. Smith National
Beyond Surveying and Engineering
July 25, 2014

W Darnell Ave
W Villa Ln
W Fairlane Ave
W Arch Ave
W Tower Ave
N Grandview Dr
N 61st St
N 60th St
DEAD-END
4102
4103
4104
4105
4106
4107
4108
4109
4110
4111
4112
4113
4114
4115
4116
4117
4143
4144
4145
4146
4149
4150
4151
4152
4153
4159
4161
4162
4163
4164
4165
4166
4167
4168
4169
330.1'-8"
260.4'-8"
263.7'-8"
211.6'-8"
300.2'-8"
253.8'-8"
273.2'-12"
331.1'-12"
330.6'-8"
340.5'-8"
100.0'-8"
113.9'-8"
254.7'-8"
266.6'-8"
358.5'-8"
179.7'-8"
185.0'-8"
320.4'-6"
219.4'-8"
100.6'-8"
150.3'-8"
235.7'-8"
289.9'-8"
299.8'-8"
331.1'-8"
329.4'-10"
330.3'-12"
320.6'-8"
320.1'-8"
319.9'-8"
319.9'-8"
316.7'-8"
129.7'-8"
330.5'-8"
251.0'-8"
250.0'-8"
249.7'-8"
150.6'-8"
3.5'
7.5
Darnel Ave
Dye Testing Study Project
Village of Brown Deer, WI
Water Main
Fire Hydrant
Sanitary Sewer Mainline
Sanitary Sewer Manhole
Total Sewer
Lateral Connections
353
Total Sewer
Mainline Length
16,733 ft
N
0 75 150
Feet
R.A. Smith National
Beyond Surveying and Engineering
July 25, 2014

Darnel Ave Dye Testing Study Project
Village of Brown Deer, WI

Legend

- Manhole with Leak
- Blockage
- Leak Location
- Sanitary Sewer Manhole
- Sanitary Main with Dye
- Property with Dye Water Entry Through Lateral into Sanitary Sewer
- Property Where Lateral Teevising Performed
- Sanitary Sewer

Total Sewer Lateral Connections
353

Total Sewer Mainline Length
16,460 ft

Estimated Leaks (gpm)	
Public Leaks	Private Leaks
11.7	142.6

N

0 100 200
Feet

R.A. Smith National
Beyond Surveying and Engineering

February 27, 2015

APPENDIX B
SUMMARY SPREADSHEET

2014 Sanitary Sewer Dye Testing Project
Village of Brown Deer

Upstream Manhole	Downstream Manhole	Sanitary Mainline Street	Televised Sanitary Lateral Address	Pipe Size (in)	Pipe Material	Length Surveyed (ft)	Date Inspected	Total MH with I/I	MH I/I (gpm)	Total Sewer Mainline with I/I	Sewer Mainline I/I (gpm)	Number of Laterals Leaking (per gpm rate)					Total Lateral I/I (gpm)	Comments (All measurements in feet from US MH, unless stated otherwise)
												0 - 5	6 - 10	11 - 15	16 - 20	21 +		
4127	4126	W GOODRICH LN		8	VITRIFIED CLAY PIPE	71.5	9/8/2014			1	0							REVERSE SETUP. DRIP 2 FEET FROM DOWN STREAM MANHOLE 4126
4126	4125	W GOODRICH LN		8	VITRIFIED CLAY PIPE	327.3	9/8/2014					3					1.1	CLEAR LATERAL LEAK AT 79.6 FEET. CLEAR LATERAL LEAK AT 145.7. CLEAR LEAK IN LATERAL CONNECTION AT 293.9 FEET.
4125	4124	W GOODRICH LN		8	VITRIFIED CLAY PIPE	328.2	9/8/2014			1	0	3					4	DRIPPER 1.4 FEET IN AT JOINT WITH INTERMEDIATE DYE. INTERMEDIATE DYE LEAKS IN LATERALS AT 38.7, 189 AND 265.1 FEET
4124	4123	W GOODRICH LN		8	VITRIFIED CLAY PIPE	327.4	9/9/2014			1	0.1	4					3.4	CLEAR LATERAL LEAK AT 70.3. MEDIUM LATERAL LEAK AT 218.5 AND 250.1 FEET. DARK LATERAL LEAK AT 293.6 FEET. DRIPPER AT 294.8 FEET JOINT
4124	4123	W GOODRICH LN	6329	6	VITRIFIED CLAY PIPE	35	9/9/2014											LEAKS LOCATED IN LATERAL JOINTS AT 4.6 AND 32.4 FEET
4124	4123	W GOODRICH LN	8025	6	VITRIFIED CLAY PIPE	35.3	9/9/2014											LEAKS LOCATED IN LATERAL JOINTS AT 18.8, 22.8, AND 30.9 FEET
4124	4123	W GOODRICH LN	6309	6	VITRIFIED CLAY PIPE	74	9/9/2014											LEAKS LOCATED INLATERAL JOINTS AT 29.3 AND 34.4 FEET
4123	4122	W GOODRICH LN		8	VITRIFIED CLAY PIPE	298.3	9/9/2014			1	0	6					7.5	DRIPPER IN MAIN LINE JOINT AT 56 FEET. LATERAL LEAKS LOCATED AT 39.2 (MEDIUM), 78.9, 115.2 (DARK), 188.10 (DARK), 218.2 (DARK) AND 263.6 (DARK) FEET
4123	4122	W GOODRICH LN	6209	6	VITRIFIED CLAY PIPE	27.6	9/9/2014											LEAK IN LATERAL JOINT AT 27.6 FEET
4123	4122	62ND ST	8025	6	VITRIFIED CLAY PIPE	70.8	9/9/2014											LEAK IN LATERAL JOINT AT 40.1 AND 60.7
4123	4122	W GOODRICH LN	6229	6	VITRIFIED CLAY PIPE	42	9/9/2014											LEAK IN LATERAL JOINT AT 33.4. DRY DYE ON LATERAL JOINT AT 38 FEET.
4122	4121	W GOODRICH LN		8	VITRIFIED CLAY PIPE	328.3	9/9/2014					4					4.8	LATERAL LEAKS AT 41.8, 114.4, 189.9, 262.9 FEET
4158	4157	N 66TH ST		8	VITRIFIED CLAY PIPE	318.4	9/10/2014			1	0	5					2.2	DRIPPER IN JOINT AT 203.3 FEET. INTERIOR LATERAL LEAKS AT 0, 22.5, 64.1 FEET. LATERAL CONNECTION LEAK AT 204.9 FEET
4157	4156	N 66TH ST		8	VITRIFIED CLAY PIPE	159.2	9/10/2014											NO LEAKS NO DYE
4156	4155	N66TH ST		8	VITRIFIED CLAY PIPE	177.8	9/10/2014					2					0.4	MEDIUM DYE LEAK IN LATERAL CONNECTION AT 15.4 FEET. CLEAR INSIDE LATERAL LEAK AT 15.4 FEET
4159	4155	W TOWER AVE		8	VITRIFIED CLAY PIPE	110.5	9/10/2014					2					4	REVERSE SETUP. INTERMEDIATE LEAK IN LATERAL 89.7 FEET FROM DOWNSTREAM MH. CLEAR LEAK IN LATERAL AT MH 4159.
4160	4159	W TOWER AVE		8	VITRIFIED CLAY PIPE	70.9	9/10/2014					1					2	CLEAR LATERAL LEAK AT MH 4160.
4155	4154	N 66TH ST		8	VITRIFIED CLAY PIPE	198.6	9/10/2014					1					3	DARK DYE LATERAL LEAK AT 19.4 FEET
4154	4153	N 66TH ST		8	VITRIFIED CLAY PIPE	297.5	9/10/2014					3					9	DARK LATERAL LEAKS AT 84.2, 93 AND 165.7 FEET.
4155	4154	N 66TH ST	8112	6	VITRIFIED CLAY PIPE	37.9	9/10/2014					1						GUSHER IN JOINT AT 29.6 FEET.
4154	4153	N 66TH ST	8142	6	VITRIFIED CLAY PIPE	36.4	9/10/2014											GUSHER IN JOINT AT 24.1 FEET. RUNNERS IN JOINTS AT 26.9, 30.0, 33.3 FEET.

2014 Sanitary Sewer Dye Testing Project
Village of Brown Deer

Upstream Manhole	Downstream Manhole	Sanitary Mainline Street	Televised Sanitary Lateral Address	Pipe Size (in)	Pipe Material	Length Surveyed (ft)	Date Inspected	Total MH with I/I	MH I/I (gpm)	Total Sewer Mainline with I/I	Sewer Mainline I/I (gpm)	Number of Laterals Leaking (per gpm rate)					Total Lateral I/I (gpm)	Comments (All measurements in feet from US MH, unless stated otherwise)
												0 - 5	6 - 10	11 - 15	16 - 20	21 +		
4154	4153	N 66TH ST	8145	6	VITRIFIED CLAY PIPE	42.1	9/10/2014											GUSHER IN JOINT AT 20.7 FEET. RUNNERS IN JOINTS AT 23.8 AND 33.8 FEET.
4154	4153	N 66TH ST	8154	6	VITRIFIED CLAY PIPE	40.7	9/10/2014											GUSHER IN JOINT AT 13.0 FEET. RUNNERS IN JOINTS AT 7.0, 17.9, 21.1, 21.2, 31.2, 34.6.
4153	4152	W FAIRLANE AVE		8	VITRIFIED CLAY PIPE	319.2	9/11/2014					8					2	LEAKS INSIDE LATERALS AT 0 (MD), 80.6 (MD), 141 (MD), 152 (CLR), 223.8 (MD), 298.8 (CLR) AND 319.2 (IT) FEET. LEAK IN LATERAL CONNECTION AT 235.7 FEET (MD)
4152	4151	W FAIRLANE AVE		8	VITRIFIED CLAY PIPE	182.8	9/11/2014					5					6.7	LEAKS IN LATERALS AT 44.9 (MD), 105.3 (DK), 124.4 (DK). ALSO AT MH 4151 TWO LATERALS ARE LEAKING TO THE NORTH (DARK) TO THE SOUTH INTERMEDIATE.
4152	4151	W FAIRLANE AVE	6352	6	VITRIFIED CLAY PIPE	35	9/11/2014											TWO RUNNER LEAKS IN JOINTS AT 18 AND 22 FEET. DRIPPER IN JOINT AT 13 FEET.
4152	4151	W FAIRLANE AVE	6364	6	VITRIFIED CLAY PIPE	58.8	9/11/2014											RUNNER LEAKS IN JOINTS AT 25.3, 26.9, 30.5, 31.2, 39.5 FEET
4152	4151	W FAIRLANE AVE	6379	6	VITRIFIED CLAY PIPE	52.3	9/11/2014											GUSHER AT 24.2 FROM CRACK. RUNNERS IN JOINTS AT 24.3, 27.6, 30.4, 33.3, 48.7 FEET. CRACK WITH RUNNER AT 48.7 FEET
4151	4150	W FAIRLANE AVE		8	VITRIFIED CLAY PIPE	179.1	9/11/2014					3					1	LEAK LIN LATERAL AT 85.6 (DARK), 100.9 (CLEAR) AND 158.9 (MEDIUM) FEET
4150	4149	W FAIRLANE AVE		8	VITRIFIED CLAY PIPE	298.4	9/11/2014					4					0.5	LATERAL LEAKS AT 104.3 (CLEAR), 119.8 (CLEAR) AND 196.2 (CLEAR) FEET. DRIPPER AT LATERAL CONNECTION AT 184.1 FEET
4149	4116	W FAIRLANE AVE		8	VITRIFIED CLAY PIPE	328.9	9/11/2014			3	0.1	2					1.1	DIPPER IN MAIN AT 107. 5(INTERMEDIATE) FEET. LEAK IN MAIN JOINT AT 159.2 LEAK IN LATERAL AT 44.6 AND 264.9 FEET.
4130	4129	N 65TH ST		8	VITRIFIED CLAY PIPE	128.7	9/15/2014					2					0.3	LEAK IN LATERAL AT 0 (DARK) AND 128.7 (INTERMEDIATE) FEET
4129	4128	N 65TH ST		8	VITRIFIED CLAY PIPE	170.1	9/15/2014			1	1	1					0.5	LATERAL LEAK AT 61.9 (MEDUIUM). JOINT LEAK IN MAIN AT 112 FEET. (NOT ON VIDEO)
4128	4125	N 65TH ST		8	VITRIFIED CLAY PIPE	327.9	9/15/2014					4					2.2	LEAKS IN LATERALS AT 105.5 (MEDIUM), 180.9 (CLEAR/INTERMEDIATE), 190.0 (MEDIUM) AND 253.3 (CLEAR) FEET
4148	4147	N 65TH ST		8	VITRIFIED CLAY PIPE	279.7	9/15/2014					4					0.8	LEAK IN LATERAL AT MH 4148 (MEDIUM). LEAK IN LATERAL CONNECTION AT 129.8 (INTERMEDIATE). LEAK IN LATERALS AT 205 (CLEAR) AND 217.8 (CLEAR) FEET.
4147	4146	W ARCH AVE		8	VITRIFIED CLAY PIPE	336.3	9/15/2014					7					3.3	LEAK IN LATERALS AT 62.1 (MEDIUM), 74.1 (INTERMEDIATE), 137.6 (CLEAR), 149.6 (MEDIUM), 213.0 INTERMEDIATE), 291.9 (INTERMEDIATE) AND 303 (MEDIUM) FEET.
4146	4145	W ARCH AVE		8	VITRIFIED CLAY PIPE	114.8	9/15/2014					3					2.3	LEAK IN LATERALS AT 15.7 (INTERMEDIATE), 70.5 (CLEAR), AND 82.4 (CLEAR) FEET.
4145	4144	W ARCH AVE		8	VITRIFIED CLAY PIPE	149.6	9/15/2014					2					2.2	LEAK IN LATERALS AT 36 (DARK), AND 107.9 (CLEAR) FEET.
4144	4143	W ARCH AVE		8	VITRIFIED CLAY PIPE	234.7	9/16/2014					5					1.5	LEAKS IN LATERALS AT 80.6 (CLEAR), 90 (CLEAR), 145.1 (CLEAR), 156.1 (CLEAR), 234.7 (INTERMEDIATE).
4143	4117	W ARCH AVE		8	VITRIFIED CLAY PIPE	287.9	9/16/2014			1	0	4					1	LEAKS IN LATERALS AT 63.5 (CLEAR), 75.8 (DARK), 214.8 (DARK) AND 223.8 (CLEAR) FEET. JOINT LEAK IN MAIN AT 113.6 (DRIPPER)
4131	4124	N 64TH ST		8	VITRIFIED CLAY PIPE	288.3	9/16/2014					4					1.2	LEAK IN LATERALS AT 61 (INTERMEDIATE), 70.2 (INTERMEDIATE), 144.8 (CLEAR), 220.2 (CLEAR).

2014 Sanitary Sewer Dye Testing Project
Village of Brown Deer

Upstream Manhole	Downstream Manhole	Sanitary Mainline Street	Televised Sanitary Lateral Address	Pipe Size (in)	Pipe Material	Length Surveyed (ft)	Date Inspected	Total MH with I/I	MH I/I (gpm)	Total Sewer Mainline with I/I	Sewer Mainline I/I (gpm)	Number of Laterals Leaking (per gpm rate)					Total Lateral I/I (gpm)	Comments (All measurements in feet from US MH, unless stated otherwise)
												0 - 5	6 - 10	11 - 15	16 - 20	21 +		
4137	4136	N 64TH ST		8	VITRIFIED CLAY PIPE	119.1	9/16/2014											NO LEAKS NO DYE
4136	4135	N 64TH ST		8	VITRIFIED CLAY PIPE	218.7	9/16/2014					2					0.4	LEAKS IN LATERALS AT 86.4 (CLEAR), AND 149.6 (INTERMEDIATE) FEET.
4135	4134	W TOWER AVE		8	VITRIFIED CLAY PIPE	278.7	9/16/2014	1	0.1			3					4.2	LEAKS IN LATERALS AT 75.4, 138.1, 216.3 FEET. LEAK IN MH 4134 2 FEET ABOVE NORTHERN LATERAL.
4134	4133	W TOWER AVE		8	VITRIFIED CLAY PIPE	84.9	9/16/2014											NO LEAKS NO DYE
4140	4139	N GRANDVIEW DR		8	VITRIFIED CLAY PIPE	297	9/17/2014					5					4.4	LEAKS IN LATERALS AT 74.1 (CLEAR), 87.9 (MEDIUM), 148.9 (CLEAR), 173.7 (MEDIUM), 253.3 (DARK) FEET.
4139	4138	N GRANDVIEW DR		8	VITRIFIED CLAY PIPE	105.5	9/17/2014					2					0.4	LEAKS IN LATERALS AT 55.2 (CLEAR) AND 79.2 (INTERMEDIATE) FEET.
4138	4135	N GRANDVIEW DR		8	VITRIFIED CLAY PIPE	153.2	9/17/2014											NO LEAKS NO DYE
4135	4134	N GRANDVIEW DR	8096	6	VITRIFIED CLAY PIPE	66.3	9/17/2014											LEAK IN LATERAL JOINT AT 21.6 FEET. CRACKS WITH DYE AT 29.3 AND 33.7 FEET.
4140	4139	N GRANDVIEW DR	8064	6	VITRIFIED CLAY PIPE	65	9/17/2014											LEAKS IN LATERAL JOINTS AT 32.3, 45.6 AND 61 FEET. CRACKS IN LATERAL AT 48.4 AND 60.2 FEET.
4133	4132	W TOWER AVE		8	VITRIFIED CLAY PIPE	175	9/17/2014					1					0.2	LEAK IN LATERAL AT 61.3 (INTERMEDIATE) FEET.
4132	4118	W TOWER AVE		8	VITRIFIED CLAY PIPE	327.9	9/17/2014					1					2	LEAK IN LATERAL AT 184.4 (MEDIUM) FEET.
4142	4141	N 62ND ST		8	VITRIFIED CLAY PIPE	363.8	9/17/2014					3					0.8	LEAKS IN LATERALS AT 65.2, 171.2, AND 256.4 FEET.
4141	4132	N 62ND ST		8	VITRIFIED CLAY PIPE	362.5	9/18/2014			1	0	1					0.5	LEAK IN LATERAL AT 200.6 (MEDIUM) FEET. LEAK IN MAIN JOINT AT 244.2 (DRIPPER) FEET.
4121	4120	N 61ST ST		8	VITRIFIED CLAY PIPE	298.5	9/18/2014					2					0.5	LEAKS IN LATERALS AT 145.3 (CLEAR), AND 298.5 (MEDIUM)
4120	4119	N 61ST ST		8	VITRIFIED CLAY PIPE	288	9/18/2014					4					0.7	LEAK IN LATERALS AT 62 (INTERMEDIATE/CLEAR), 69.1 (MEDIUM), 143.4 (CLEAR), AND 218.3 (CLEAR) FEET.
4119	4118	N 61ST ST		8	VITRIFIED CLAY PIPE	293.6	9/18/2014					4					1.5	LEAK IN LATERALS AT 71.3 (CLEAR), 78.2 (CLEAR), 145.8 (INTERMEDIATE), AND 220.4 (MEDIUM) FEET.
4118	4117	N 61ST ST		8	VITRIFIED CLAY PIPE	328.1	9/18/2014					4					0.8	LEAKS IN LATERALS AT 75.8, 146.1, 217.8, AND 293.9 FEET.
4117	4116	N 61ST ST		8	VITRIFIED CLAY PIPE	327.5	9/18/2014					3					2.3	LEAKS IN LATERALS AT 38.7 (CLEAR), 190.6 (MEDIUM), 263.4 (MEDIUM) FEET.
4169	4168	N IVY ST		8	VITRIFIED CLAY PIPE	99.5	9/22/2014					2					0.2	LEAKS IN LATERALS AT 42 (CLEAR) AND 49 (CLEAR) FEET. DRIPPER IN MAIN JLINT AT 86.6 FEET.
4168	4167	N IVY ST		8	VITRIFIED CLAY PIPE	217.5	9/22/2014					5					6	LEAKS IN LATERALS AT 9.1 (MEDIUM), 64.5 (MEDIUM), 75.5 (MEDIUM), 139 (MEDIUM) AND 149 (MEDIUM) FEET.
4168	4167	N IVY ST	8269	6	VITRIFIED CLAY PIPE	41.2	9/22/2014											GUSHER IN JOINT AT 26.1 FEET. RUNNER IN JOINT AT 32.3 FEET.
4168	4167	N IVY ST	8181	6	VITRIFIED CLAY PIPE	50	9/22/2014											RUNNER IN JOINTS AT 24.4 , 27.7, 30.8, 33.6 AN 39.9 FFET. DRIPPER IN JOINT AT 43 FEET.

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Upstream Manhole	Downstream Manhole	Sanitary Mainline Street	Televised Sanitary Lateral Address	Pipe Size (in)	Pipe Material	Length Surveyed (ft)	Date Inspected	Total MH with I/I	MH I/I (gpm)	Total Sewer Mainline with I/I	Sewer Mainline I/I (gpm)	Number of Laterals Leaking (per gpm rate)					Total Lateral I/I (gpm)	Comments (All measurements in feet from US MH, unless stated otherwise)
												0 - 5	6 - 10	11 - 15	16 - 20	21 +		
4168	4167	N IVY ST	8176	6	VITRIFIED CLAY PIPE	32.3	9/22/2014											RUNNERS IN JOINTS AT 1.1, 11.2, 18.4, 21.9, AND 32.2 FEET.
4167	4166	N IVY ST		8	VITRIFIED CLAY PIPE	357.3	9/22/2014					6					2.8	LEAKS IN LATERALS AT 70.4 (MEDIUM), 82.3 (INTERMEDIATE), 144.9 (MEDIUM), 220.6 (DARK), 276.5 9INTERMEDIATE)), AND 295.4 (INTERMEDIATE) FEET.
4166	4165	N IVY ST		8	VITRIFIED CLAY PIPE	267.3	9/22/2014	1	0			3					0.8	LEAKS IN LATERALS AT 86.7 (MEDIUM), 161.3 (MEDIUM), 233.6 (CLEAR/INTERMEDIATE) FEET. DRIPPER IN MH4165 ABOVE LATERAL.
4165	4164	N IVY ST		8	VITRIFIED CLAY PIPE	252.8	9/22/2014					3					4.1	LEAKS IN LATERALS AT .1 (INTERMEDIATE), 2 (DARK) AND 2 (MEDIUM)
4164	4163	W VILLA LN		8	VITRIFIED CLAY PIPE	118.3	9/22/2014											NO LEAKS NO DYE PRESENT
4163	4162	W VILLA LN		8	VITRIFIED CLAY PIPE	99.1	9/22/2014					1					0.3	LEAK IN LATERAL AT 46.0 (CLEAR) FEET
4162	4161	W VILLA LN		8	VITRIFIED CLAY PIPE	339	9/23/2014					7					3.2	LEAKS IN LATERALS AT 70.3 (MEDIUM), 82.2 (CLEAR), 145.5 (CLEAR), 154.5 (CLEAR), 229.7 (MEDIUM), 295.9 (MEDIUM) AND 304.9 (CLEAR)
4161	4115	W VILLA LN		8	VITRIFIED CLAY PIPE	328.7	9/23/2014					3					0.3	LEAKS IN LATERALS AT 32.1 (CLEAR), 41.2 (CLEAR), 104.1 (CLEAR) FEET.
4116	4115	N 61ST ST		12	VITRIFIED CLAY PIPE	328.7	9/23/2014					3					2.7	LEAKS IN LATERALS AT 72.9 (DARK), 145.7 (DARK), AND 219.3 (CLEAR) FEET.
4115	4102	N 61ST ST		12	VITRIFIED CLAY PIPE	327.6	9/23/2014					3					0.4	LEAKS IN LATERALS AT 112.3 (MEDIUM), 188.1 (INTERMEDIATE), AND 264.4 (INTERMEDIATE) FEET.
4102	15039	W DARNELL AVE		12	VITRIFIED CLAY PIPE	270.5	9/23/2014			1	10	2					5.6	LEAKS IN LATERALS AT 52.7 (CLEAR), AND 127.7 (CLEAR) FEET. DRIPPER AT 131.8 FEET. LEAK IN MAIN FROM THE TOP AT 268.3 (DARK) FEET.
4111	4110	N GRANDVIEW DR		8	VITRIFIED CLAY PIPE	129.7	9/24/2014	1	0.2			3					0.7	LATERAL LEAKS AT 49 (CLEAR), 91.2 (INTERMEDIATE/CLEAR), AND IN LATERAL AT MH4110 (MEDIUM). ADDITIONAL LEAK IN MAN HOLE AT MH4110.
4110	4109	N GRANDVIEW DR		8	VITRIFIED CLAY PIPE	247.6	9/24/2014					3					5.3	LEAKS IN LATERALS AT 79.6 (CLEAR), 139 (DARK), AND 181 (CLEAR) FEET.
4109	4108	N GRANDVIEW DR		8	VITRIFIED CLAY PIPE	327.8	9/24/2014					7					9.5	LEAKS IN LATERALS AT 40.8 (DARK), 104.8 (CLEAR), 115.6 (DARK), 191 (CLEAR), 198.6 (CLEAR), 266.2 (DARK), 285 (MEDIUM).
4112	4108	N GRANDVIEW DR		8	VITRIFIED CLAY PIPE	129	9/24/2014					1					0.2	LEAK IN LATERAL AT 47 (MEDIUM) FEET.
4108	4107	W DARNELL AVE		8	VITRIFIED CLAY PIPE	327.9	9/24/2014					2					1.5	LEAKS IN LATERALS AT 71.6 (MEDIUM) AND 148.9 (MEDIUM) FEET.
4114	4113	N 65TH ST		8	VITRIFIED CLAY PIPE	248.8	9/24/2014					4					4.3	LEAKS IN LATERALS AT 54.9 (INTERMEDIATE), 66.9 (MEDIUM), 141.3 (CLEAR), AND 213.4 (DARK) FEET.
4113	4107	N 65TH ST		8	VITRIFIED CLAY PIPE	248.9	9/24/2014					1					2	LEAK IN LATERAL AT 39.5 (DARK) FEET.
4107	4106	W DARNELL AVE		8	VITRIFIED CLAY PIPE	259.1	9/25/2014					2					0.8	LEAKS IN LATERALS AT 58.8 (CLEAR/INTERMEDIATE) AND 138.9 (MEDIUM) FEET.
4106	4105	W DARNELL AVE		8	VITRIFIED CLAY PIPE	262.1	9/25/2014					1					0.5	LEAK IN LATERAL AT 93.9 (DARK) FEET.
4105	4104	W DARNELL AVE		8	VITRIFIED CLAY PIPE	210.6	9/25/2014					2					0.2	LEAK IN LATERAL AT 70.5 (CLEAR) AND 79.5 (CLEAR) FEET.
4104	4103	W DARNELL AVE		8	VITRIFIED CLAY PIPE	297.8	9/25/2014					7					4.4	LEAKS IN LATERALS AT 10.5 (MEDIUM), 40.8 (MEDIUM), 85.7 (DARK), 113 (DARK), 158.1 (MEDIUM), 233.5 (MEDIUM), 263.6 (MEDIUM).

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												0 - 5	6 - 10	11 - 15	16 - 20	21 +		
4103	4102	W DARNELL AVE		8	VITRIFIED CLAY PIPE	251.8	9/25/2014					1					0.1	LEAK IN LATERAL AT 233.8 (MEDIUM) FEET.
					Totals	**17,452**		**3**	**0.3**	**12**	**11.2**	**200**	**0**	**0**	**0**	**0**	**142.6**	