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August 5, 2015

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URBANDALE-WINDSOR HEIGHTS SANITARY DISTRICT
WASHINGTON AVENUE SANITARY SEWER
SUMMARY OF ANALYSIS

This letter is to provide a summary of the analysis of the Washington Avenue sanitary sewer between 73rd Street and 69th Street. The more detailed evaluation of the sewer is set forth in the writer's letter of August 4, 2015.

The sewer averages 9 feet to 10 feet deep and would generally be 2 feet to 4 feet below the basement elevation.

The Sewer System Evaluation Survey completed in 1978 projected the flows exceeded the capacity of the sewer. The recent sewer surcharging and basement backups would confirm the flow in the sewer exceeds its capacity, but by a much lower degree than projected in 1978.

The reach of sewer between 73rd Street and 69th Street is approximately 1,690 feet long and almost all of the flow enter at 69th Street. This reach of sewer will experience fairly significant surcharging even when flow rates are not significantly greater than the 1.46 mgd capacity. For example, at a flow rate of 1.8 mgd the sewer at 69th Street and Washington Avenue could surcharge to the ground surface. At a flow rate of 1.8 mgd the flow in the sewer would be considered within the average range of what has been observed in similar residential areas throughout the Des Moines area.

The existing sewer along Washington Avenue between 73rd Street and 69th Street is a 10-inch pipe. The sewer has a capacity of 1.46 mgd, or 1,010 gpm. Any surcharging at 69th Street and School more than a couple of feet is likely to cause basement backups especially in the eastern half to the reach of sewer.

The problem appears to be isolated to the sewer on Washington Avenue as the sewer on 73rd Street south of Washington Avenue appears to have adequate capacity to convey the flow south to the connection to the WRA sewer at Del Matro.

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There are two alternatives to address the overloading of the sewer. One alternative would be to initiate a program to remove footing or foundation drains connected to the sanitary sewer. Other means of reducing flow, such as eliminating infiltration and inflow, would be beneficial, but are not likely to eliminate surcharging potential without removing the footing drain connections.

A footing drain removal program would require the City to institute a program that would require individual property owners to disconnect foundation drains and to pump their foundation drain flow to the storm sewer or to their yard area.

Foundation drain removal programs can be effective in reducing flow levels by the level that appears to be necessary to significantly reduce the potential for surcharging and basement backups. However, this type of program has varying degrees of success and is not certain method of eliminating surcharging potential. It takes time to develop and implement the program.

The second alternative is to construct a relief sewer along Washington Avenue between 73rd Street and 69th Street. There are three options for the relief sewer construction, including the disruptive open cut construction and two less disruptive methods of tunneling. If the desire is to pursue a relief sewer, additional analysis is necessary to determine the preferred method of construction and cost.

The relief sewer provides more definitive relief as the problem is eliminated at the completion of construction of the project. The primary disadvantage of the relief sewer is the cost for implementing the project.

The next step in the process would appear to be a determination whether the problem will be addressed through a flow reduction program or through the construction of a relief sewer.

If you have any questions or comments concerning the project, please contact the writer at 225-8000.

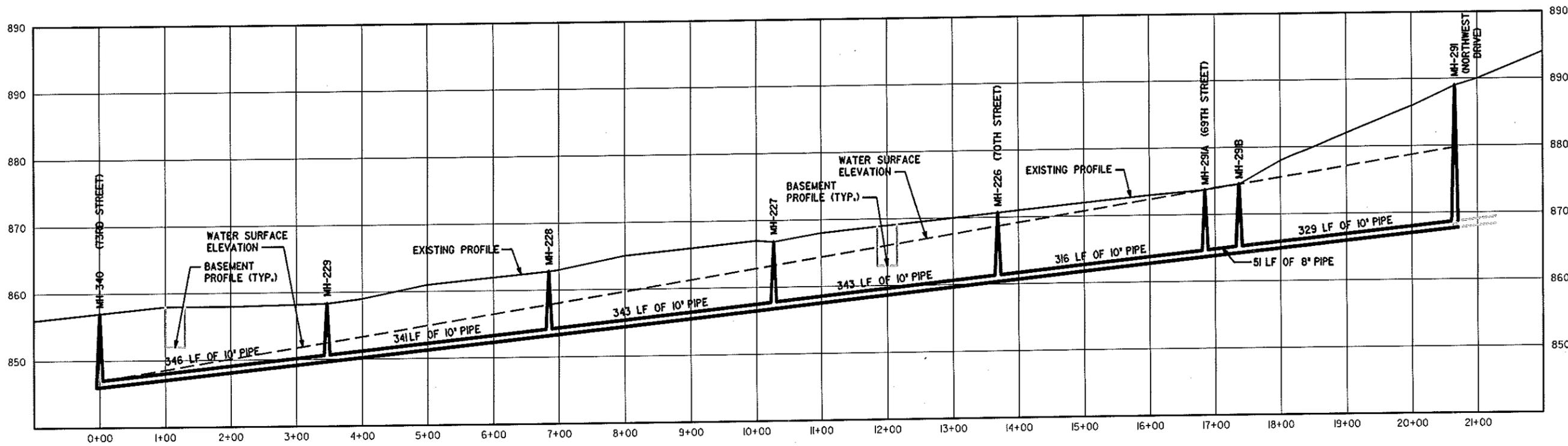
VEENSTRA & KIMM, INC.

Original Signed By
H.R. Veenstra Jr.
H. R. Veenstra Jr.

HRVJr:pjh
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Enclosure

cc: Brett Klein, Windsor Heights - w/enclosure



WASHINGTON AVENUE SANITARY SEWER PROFILE

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VEENSTRA & KIMM, INC.

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August 4, 2015

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URBANDALE-WINDSOR HEIGHTS SANITARY DISTRICT
WASHINGTON AVENUE SANITARY SEWER
PRELIMINARY ANALYSIS

This letter is a follow up to the discussion at the July 21, 2015 meeting of the Board of Trustees of the Urbandale-Windsor Heights Sanitary District relative to the surcharging issues experienced along the Washington Avenue sanitary sewer. The reported surcharging issues are between the 7100 block and the 6900 block of Washington Avenue.

Enclosed is a copy of a map showing the service area tributary to the sanitary sewer on Washington Avenue.

The Washington Avenue sanitary sewer serves the northeast area of the City of Windsor Heights with the service area generally being located north of College Avenue and easterly of 69th Street. The service area for the Washington Avenue sanitary sewer extends easterly of 63rd Street into a small area located in the City of Des Moines.

The service area in Des Moines extends as far east as Merle Hay Road and encompasses an area from approximately Hickman Road south to Lincoln. Within the service area located in the City of Des Moines it is not believed all of the residences are connected to the sanitary sewer that flows westerly into Windsor Heights. In this area there are sewers that flow northerly and westerly and sewers that flow southerly.

The most comprehensive evaluation of the area tributary to the Washington Avenue sanitary sewer was completed in 1977 and 1978 as part of the Urbandale-Windsor Heights Sanitary District's Sewer System Evaluation Survey. In most of the area tributary to the Washington Avenue sewer the changes in the area since the late 1970s would have minimal impact on the evaluation of the sanitary sewer. Some of the background information used in this letter was taken from the 1978 report on the Sewer System Evaluation Survey.

The Washington Avenue sanitary sewer starts with a connection to the original Urbandale-Windsor Heights Sanitary District Trunk Sewer at 73rd Street and Washington Avenue. The Urbandale-Windsor Heights Sanitary District Trunk Sewer at Washington Avenue is an 18-inch pipe that flows southerly.

As part of the Wastewater Reclamation Authority's construction of the WRA Common Trunk a diversion sewer was constructed at 73rd Street and Del Matro to divert all of the flow in the 18-inch trunk sewer westerly to the WRA Common Trunk. As part of the WRA Common Trunk all of the flow in the Urbandale-Windsor Heights Sanitary District Trunk north of Hickman Road was diverted to the WRA Common Trunk.

The 18-inch sewer on 73rd Street north of Del Matro currently serves on the Washington Avenue sanitary sewer and the lateral sewers that flow westerly to 73rd Street from Jefferson north to Hickman Road. The capacity of the 18-inch trunk sewer south of Washington Avenue is a minimum of 2.52 mgd. Based on the size of the tributary area to the trunk sewer it is not believed this reach of the 18-inch trunk sewer is overloaded. Available information would suggest the trunk sewer is not a contributing factor to the sewer surcharging experienced along Washington Avenue.

The sanitary sewer along Washington Avenue from 73rd Street easterly to 69th Street is a 10-inch pipe at a uniform slope of 1.08%. The capacity of the sewer is 1.46 mgd, or 1,010 gpm.

The sanitary sewer along Washington Avenue from 73rd Street easterly to 69th Street averages approximately 10 feet in depth. The depth of the sewer at the various manholes along this reach of Washington Avenue is as follows:

<u>Manhole</u>	<u>Depth</u>
340	11.0 feet
229	8.7 feet
228	9.6 feet
227	10.0 feet
226	10.3 feet
291A	10.0 feet
291B	10.3 feet

Enclosed is a copy of a drawing showing the profile of the sewer along Washington Avenue from 73rd Street to 69th Street and continuing northerly on 69th Street to Northwest Drive.

The sewer along Washington Avenue is constructed at a uniform slope and a fairly uniform depth. At 69th Street and Washington Avenue there are two tributary sewers. One smaller sewer system continues east on Washington Avenue. The larger sewer system extends north on 69th Street to Northwest and continues northerly and easterly. From the intersection of 69th Street and Washington Avenue easterly and northerly the ground slopes upward and the sewer is generally more than 10 feet deep.

During and following major rainfall events it is reported the sewer on Washington Avenue surcharges. The available information indicates the greater depth of surcharging is farther to the east and the surcharging in the western part of the sewer closer to 73rd Street is less significant.

Almost all of the flow tributary to the sewer reaches the Washington Avenue Sewer at 69th Street. Any additional flow added along Washington Avenue and the lateral sewer on 70th Street is not considered a significant component of the flow.

With the sewer depth along Washington Avenue of approximately 10 feet, surcharging of the sewer of only a few feet can result in basement backups. It is anticipated in many areas along Washington Avenue the depth to the basement of the residences would be between 6 feet and 8 feet below the elevation of the street. The basement floor elevations are anticipated to be from 2 feet to 4 feet above the flow line of the sewer. When the sewer surcharges to a greater depth than this vertical separation the surcharging in the sanitary sewer will cause basement backups and flooding unless the individual property owner have installed a backwater prevention valve.

The figure showing the profile of the sewer along Washington Avenue includes illustration of what occurs when the flows in the sewer exceed the capacity of the pipe. The dashed line on the drawing shows the approximate water surface at a flow rate through the pipe of 1.8 mgd. Under this condition the pipe is operating under pressure. Whenever there is an opening that allows water to escape the pipe the water will rise to the level of the water surface. This is most easily observed in the manholes where the water will rise to the level of the water surface.

Unless a residence has a backwater prevention valve the plumbing is connected to the sewer system and the water level in the sewer service will rise to the water surface elevation. If there is a basement that extends below the water surface elevation water can flow into the basement through the plumbing fixtures. The drawing shows examples of two basements. In the area just east of 73rd Street the water surface elevation will not be significantly above the top of the pipe and the basements are likely to be above the water surface elevation and not experience basement backups. Basements farther to the east along Washington Avenue are more likely to extend below the water surface elevation and experience basement backups.

Even where the water surface elevation is above the top of the pipe not every residence will experience basement backups. Some residences may be protected by backwater valves. Also, the floor elevation of basements can vary from residence to residence, depending on the first floor elevation of the residence and the ceiling height of the basement. These factors can result in some basements having no backups, some basements having very minimal backup and some basements having more significant backup.

The capacity of a sanitary sewer is determined by its size and its slope. Based on the size and slope, the maximum capacity of the sewer can be determined. At maximum capacity water will flow through the sanitary sewer pipe without any surcharging. In the case of the Washington Avenue sanitary sewer this maximum capacity is 1.46 mgd, or 1,010 gpm.

While a sanitary sewer has a "maximum capacity", it is possible to push more water through a sanitary sewer than its maximum capacity. When more flow is trying to be pushed through the sewer, the sewer will "surcharge" to create the head necessary to push the flow. The surcharging, or additional head, is a linear relationship to the length of the pipe through which the flow is being pushed.

It is possible to calculate how much head or surcharge is necessary to push flow through the sanitary sewer. This head can be calculated as a percentage of slope similar to the slope on the sewer, or in total feet if the length of the sewer is known.

For the Washington Avenue sanitary sewer the critical location is 69th Street and Washington Avenue. East of 69th Street and Washington Avenue the flow splits to the north and to the east, meaning there is less flow in each of the tributary pipes. The ground elevation rises, meaning there is greater vertical separation between the pipe and the basements. When there is sufficient vertical separation between the pipe and the basement.

The length of sewer along Washington Avenue from 73rd Street to 69th Street is approximately 1,690 feet.

It is possible to determine the approximate flow through the Washington Avenue sanitary sewer based on the surcharging in the manhole at 69th Street and Washington Avenue. The following tabulation shows the flow rate in the sanitary sewer based on the degree of surcharging at 69th Street and Washington Avenue.

<u>Depth of Surcharge</u> <u>69th & Washington</u> (ft.)	<u>Maximum Flow Rate</u> (mgd)
0	1.46
2	1.55
4	1.63
6	1.70
8	1.77
10	1.84

The tabulation indicates at flows up to 1.46 mgd the sewer on Washington Avenue does not surcharge and there should be no reported basement backups. Once the flow rate exceeds 1.46 mgd surcharging will be experienced at 69th Street and Washington Avenue. If the manhole at 69th Street and Washington Avenue were to surcharge completely to the ground surface at the depth of surcharging of 10 feet the flow rate through the sewer would be about 1.84 mgd.

The tabulation indicates with the length and slope of the Washington Avenue sanitary sewer there is not a great deal of additional capacity that can be gained before major surcharging occurs in the sanitary sewer system. For example, if the flow rate exceeds the capacity of the sewer by only 26% (1.84 mgd vs. 1.46 mgd) the manhole at 69th and Washington can surcharge all the way to the street surface.

Because the sewer on Washington Avenue is known to surcharge it is fairly certain the flow rates under the peak events exceed 1.46 mgd.

On the June 25, 2015 rainfall event it is understood the City of Windsor Heights observed surcharging in the manhole at 69th Street and Washington Avenue, but did not undertake any bypass pumping. The water rose in the manhole, but began to recede before the City started to pump the manhole.

The writer's research indicates that in recent years the City of Windsor Heights Public Works staff would bypass pump during heavy rainfall events. During a heavy rainfall event, the Public Works staff initiated bypass pumping at 69th Street and Washington Avenue. This bypass pumping of flow reduced the flow in the Washington Avenue sewer and probably prevented the basement backups that might have occurred. Available information would indicate the number of events of bypass pumping was relatively small, probably less than five. However, the bypass pumping probably prevented backup problems that may have been experienced.

The flow in the sanitary sewer system generally consists of four components. The first component is the normal wastewater flow. The second component is referred to as infiltration. Infiltration is groundwater that leaks into pipe joints and other defects in the pipe. Infiltration is caused by groundwater and is only indirectly impacted by rainfall. The third component of flow is inflow, or rain water, that flows directly into the sanitary sewer system.

The fourth component of flow is foundation drain, or footing drain flow. Most houses constructed from the early 1950s through the early 1970s were constructed with a footing or foundation drain. The common practice at that time was to directly connect the foundation drain to the sanitary sewer service or to connect the foundation drain to a sump pump that is pumped to the sanitary sewer.

As part of the 1978 Sewer System Evaluation Survey a projection of the wastewater flow, infiltration, inflow and foundation drain flow was developed. That analysis indicated the infiltration and inflow into the sanitary sewer were much smaller components of the flow than the normal wastewater flow and the foundation drain flow.

The projection used in the 1978 Sewer System Evaluation Survey was based on relatively new information on the performance of foundation drains that was developed in the 1970s. The Sewer System Evaluation Survey projected the flow in the Washington Avenue sewer to be approximately 2.99 mgd, or slightly more than twice the capacity of the sewer.

Experience since the late 1970s has shown that foundation drain flow is typically the largest component of flow in a sanitary sewer system in an area with houses of an age similar to Windsor Heights. Also, the subsequent studies have indicated the foundation drain flow is generally at a lower rate than projected using the late 1970s modeling techniques.

This condition appears to be the case for the Washington Avenue sewer. In order to convey a flow of 2.99 mgd the 10-inch pipe would need to have an effective slope of 4%. The hydraulic grade line necessary to force 2.99 mgd of flow through the sewer could not be achieved without flow overtopping the manhole at almost every manhole along Washington Avenue. Assuming the manholes were an infinite depth, rather than a 10-foot depth, the degree of surcharge in the manhole at 69th Street and Washington Avenue necessary to force the flow rate projected in the 1978 study would be well in excess of 40 feet. All available evidence indicates the surcharging is not to the level that would be necessary to convey the flows projected in 1978.

To the best of the writer's knowledge there has been no detailed flow metering of the flows in the Washington Avenue sanitary sewer. As a result, there is no hard data available to project the flow rates.

The WRA has been metering the flows in a significant number of locations in the WRA system since the early 1990s. The original system included slightly more than 40 meters and that system has been expanded to over 100 meters. As flow metering data has been collected there have been several evaluations of the flow data to determine the level of flow in various areas of the sewer system in the Des Moines area.

One of the tools that has been used to measure flow rates is the determination of the peak flow in relationship to the average flow in a sewer system.

The 1978 study projected the population in the Washington Avenue sewer service area to be approximately 1,500 based on census data. Based on a count of residents in the area, the population is projected to be between 1,400 and 1,500. The typical average flow is about 100 gallons per capita per day, or about 0.15 mgd. Based on the population peak flow from wastewater flow is about three times the average flow, or about 0.45 mgd.

Under normal flow conditions, the average flow in the Washington Avenue sewer from just water usage is projected to be about 10% of the sewer capacity. The peak flow that would occur during the early morning hours may approach one-third of the pipe capacity. The balance of the flow in the sewer system is from extraneous flow, including infiltration, inflow and foundation drain flow.

Based on the data that has been collected throughout the WRA system, the following general guidelines have been identified for flow rates based on a ratio of the peak flow to the average flow:

<u>Peak to Average Ratio</u>	<u>Description</u>
Less than 4:1	Very dry
4.5:1 - 7:1	Below average
7:1 - 8.5:1	Low average
8.5:1 - 10:1	Average
10:1 - 12.5:1	High average
12.5:1 - 15:1	Above average
Greater than 15:1	Excessive

In most areas with residential housing stock of the 1950s through the mid-1970s the peak sewer system flows tend to be in the average range, of 10:1 to 12.5:1 peak to average ratio.

If it is assumed the average flow in the Washington Avenue sewer is 0.15 mgd, a 10:1 peaking factor would project a maximum flow of 1.5 mgd, or just at the maximum pipe capacity. A peak flow of 12:1 the projected peak flow in the Washington Avenue sewer would be about 1.8 mgd. At 1.8 mgd the slope on the hydraulic grade line would cause the surcharge at 69th Street and Washington Avenue would be estimated to be about 9.5 feet, or the water level would be just below the street surface.

The historical observations of surcharging would suggest the water at 69th Street and Washington Avenue was close to the street surface. That information would suggest the peak flow to average flow ratio is in the range of 12:1. That analysis would tend to indicate the flows in the Washington Avenue service area would be considered typical of this type of area throughout the metro area.

Assuming the peak flows are 1.8 mgd it would be necessary to reduce the peak flow to less than 1.46 mgd to avoid the surcharging. The level of flow reduction that would be necessary would be at least 25% of the current projected peak flow. Given the likely sources of extraneous flow in the tributary area to Washington Avenue, the only method of reducing the flow by 25% would be to reduce the number of foundation drains connected directly to the sanitary sewer system. Other methods, such as lining the sewer to eliminate infiltration and replacing manhole covers that may have exposed pick holes, would assist in achieving the goal of flow reduction, but by themselves would probably not be successful in reducing the peak flow by 25%.

Experience in other communities, such as Indianola and Norwalk has shown it is possible to reduce the flow rates by more than 25% by eliminating foundation drain connections to the sanitary sewer system. To eliminate the foundation drain flow connections it is necessary to develop and implement a program of requiring the disconnection of foundation drains. There needs to be an ongoing monitoring and enforcement program to ensure the foundation drains remain disconnected.

In areas where foundation drains can be connected directly to a storm sewer the likelihood of those foundation drains being reconnected to the sanitary sewer is relatively small. In areas without storm sewers where the foundation drains or sump pumps must be discharged on the ground surface, the potential for those disconnected foundation drains to be reconnected is much higher. In the area tributary to the Washington Avenue sewer there is a mix of areas with storm sewer and areas with little or no storm sewer.

When the flows exceed the capacity of the sewer there are only two alternatives to consider. One alternative is to reduce the flow in the sanitary sewer system to within the pipe capacity. If the Urbandale-Windsor Heights Sanitary District and the City of Windsor Heights wish to address the surcharging through flow reduction, the most effective mechanism would be to develop and implement a program that would require the disconnection of foundation drains. This program can be effective if it is implemented in a comprehensive manner. Implementation of the program requires a degree of diligence and effort as the work must be undertaken on a property by property basis based on a program of foundation drain removal.

The other alternative is to construct additional pipe capacity to convey the flow downstream. The limitation on this alternative is there must be a downstream sewer location that can accommodate the additional flow. In this instance, there is additional downstream capacity available, either in the 18-inch trunk sewer along 73rd Street, or at the WRA Common Trunk, or WRA Diversion Sewer at North Walnut Creek or at 73rd and Del Matro. This alternative would involve a relief sewer that would provide additional sewer capacity between 73rd Street and Washington Avenue and 69th Street and Washington Avenue. The relief sewer alternative involve approximately 1,690 feet of new sewer.

The only corridor available for construction of the relief sewer would be along Washington Avenue. While the relief sewer concept provides a quicker and more assured solution to the surcharging and basement backup issues it does have a cost component.

There are three basic approaches that could be considered for a relief sewer. The first approach would be to construct the sewer in a traditional manner involving open cut construction. The sewer would be constructed along a corridor parallel to and at a similar depth to the existing sewer. This project would involve sewer construction as well as street and driveway removal and replacement. This construction procedure causes significant disruption to the residents along Washington Avenue. From a total cost of construction perspective this type of construction along a residential street averages about \$400 a foot, or a projected cost in the range of \$675,000.

The second approach would be to tunnel a sewer using conventional grade control tunneling procedures. This procedure significantly reduces the extent of disruption and pavement replacement. The tunneling procedure is more costly than the open cut procedure. On recent projects this type of tunneled construction has costs in the range of \$350 to \$400 per foot, or only slightly less than the conventional open cut construction.

A third approach that could be considered would be directionally boring a relief sewer in place. The directionally bored sewer would be installed using the modern directional boring procedure that is less costly than conventional tunneling procedure.

The disadvantage of the directional bored procedure is the grade control is not as precise. While directional boring accuracy has improved greatly over the last decade it is still not as precise as conventional tunneling or open cut procedures. Typically, directionally boring of sanitary sewers is not utilized for slopes less than about 1% due to the concern regarding grade control. In recent years the accuracy of grade control has improved sufficiently that it is possible to consider directional boring for slightly flatter slopes potentially in the range of 0.7%.

The directional boring procedure has the potential to significantly reduce the project cost. Directionally boring an 8-inch pipe in place has a cost that is generally less than \$200 per foot for the total project cost. However, there are some significant logistical issues that would need to be addressed before directional boring could be considered.

The available information does not allow for a determination whether the logistical issues associated with directional boring can be overcome to allow this procedure to be implemented. If the preferred solution is a directionally bored relief sewer some additional analysis would be necessary before it can be determined this alternative is viable.

In summary, the available information would indicate the flow tributary to the Washington Avenue sanitary sewer exceed the capacity of the sewer by at least 25%. Due to the long flat nature of the sewer along Washington Avenue, even this relatively minor degree of overloading results in significant surcharging.

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There are two basic alternatives to consider to controlling the surcharging. One alternative is to implement a flow reduction program that would involve requiring individual property owners to disconnect their foundation drains from the sanitary sewer system. The success of this approach in reducing the surcharging is directly tied to the success in eliminating the foundation drain connections. The problem would not be solved until a sufficient number of foundation drains have been disconnected from the sewer. This approach tends to be less costly, but somewhat more time consuming and less certain in its ability to eliminate the surcharging.

The other alternative to eliminating the surcharging is to construct an additional or relief sewer along Washington Avenue from 73rd Street to 69th Street a distance of approximately 1,690 feet. There are three different approaches that can be considered for construction of the relief sewer. The conventional open cut construction is the most costly and disruptive to the neighborhood. There are two tunneling procedures, one involving traditional grade control tunneling and the other involving directional boring. The traditional grade control tunneling is slightly less costly than the open cut construction, but significantly reduces the disruption from the relief sewer construction. The directional boring has the potential to be significantly less costly if some of the logistical constraints can be overcome. This method of construction also has minimal impact on the neighborhood.

If the Urbandale-Windsor Heights Sanitary District and the City of Windsor Heights wish to take steps to reduce the potential for surcharging the first step would be to determine whether the problem will be addressed by flow reduction, or by construction of a relief sewer. Once that general decision has been reached the next step is to determine how to implement the program, either through a rehabilitation program or through one of the three methods of sewer construction.

If you have any questions or comments concerning the project, please contact the writer at 225-8000.

VEENSTRA & KIMM, INC.

Original Signed By
H.R. Veenstra Jr.

H. R. Veenstra Jr.

HRVJr:pjh
19435

Enclosure

cc: ✓Brett Klein, Windsor Heights - w/enclosure